Report

Circular Economy: The impact of circular choices in holidaymaking and mobility

Final version, 15-11-2021

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Monitoring and Evaluation Circular Economy

This report has been produced in the context of the Work Programme on Monitoring and Evaluation Circular Economy 2019–2023. This programme is a collaboration between Statistics Netherlands, the Institute of Environmental Sciences (Leiden University), CPB Netherlands Bureau for Economic Policy Analysis, the National Institute for Public Health and the Environment, Netherlands Enterprise Agency, *Rijkswaterstaat* ((government service for roads and waterways) and the Netherlands Organisation for Applied Scientific Research (TNO), under supervision of PBL Netherlands Environmental Assessment Agency. The Dutch Government aims to achieve a fully circular economy by 2050. The purpose of the Work Programme is to monitor and evaluate the progress made towards that objective and to provide the necessary knowledge for an informed policy process. For more information on this Work Programme, please see www.pbl.nl/en.

Acknowledgements:
The English has been proofread by Esther Kupers, BUas.
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Executive Summary and Main Findings

Summary

In this study we used the R-ladder to determine the environmental impact reduction for holidays and daily mobility. Six different categories were analysed for holidays, and five trip purposes and two types of vehicle ownership (car and bicycle) for daily mobility. Impacts presented are CO_2 emissions, GWP and Land Use. The mobility impacts were described per person per year. For holidays we provided the impacts per holiday trip per person, because holidays have a rather low frequency, which makes per-year values depend heavily on the frequency assumption for each specific type of holiday.

We used a mixed methods approach based on detailed annual holiday and mobility statistics, as well as CO2 emission calculations based on emission factors and models from our own experience and the scientific literature. To assess GWP and Land Use, we made use of methods provided by the EAP (Environmental Analysis Program) model. The study showed that only two R-options are applicable to holidays: R0 (avoid) and R2 (reduce). Mobility may benefit additionally from R1 (rethink) and R4 (repair).

Main findings on holidays

We assessed the CO_2 and GHG emissions and Land Use for six typical 'default trips' varying from a city trip to Berlin to a 22-day tour of Western USA. The carbon footprint of the trips ranged from 269 kg (Berlin city trip) to 2,782 kg (Western USA tour) per person per trip. Only two R-ladder options were identified: R0 (don't consume) and R2 (reduce). R0, stay at home, proved very effective in all default trips and for all three indicators, leading to reductions of between 90% and 96% for CO_2 emissions and GWP and reductions of 70 to 76% for Land Use. Reducing by switching to a closer destination or travelling less often but staying longer also turned out to be very effective for CO_2 emissions and GWP. For Land Use, in some cases switching transport modes generated a negative impact of up to 24% more land use needed. Changing accommodation and transport modes revealed the largest percentual reduction for short-haul trips, while for long-haul trips such an accommodation shift reduced the total carbon footprint by less than 10%. Some detailed findings are:

- The most important determinant for the carbon footprint of holidays is the distance to the destination. High-footprint holidays invariably involve long-haul flights. Such trips can only shift substantially to more environmentally-friendly transport modes when the home-destination distance is reduced to less than some 1,000 km one-way.
- Changing transport modes is the second best option to reduce CO_2 emissions. For a city trip from Amsterdam to Berlin, changing from car to bus or train provides a more than 40% reduction in emissions for the whole trip (i.e. transport plus accommodation emissions) and a more than 70% reduction in emissions, when only looking at transport emissions.
- Travelling less often but staying longer decreases emissions by between 25.5% and 41%.
- Staying at home decreases CO_2 emissions by between 89% and 96%, depending on the travel distance. While accommodation itself may sometimes have lower emissions than staying at home, the transport makes the difference.
- On average, accommodation choice has a smaller impact on CO_2 emissions than transport. However, for short-haul trips, accommodation choice becomes more relevant. The tent has the lowest emissions of all accommodation types.
- The percentual differences in Global Warming Potential are similar to those in CO_2 emissions, because both the default and R-option GWP are calculated with the same constant GWP factor. This is not true when the transport mode is changed from aviation to another mode because aviation has a much higher GWP factor.
- For trips of over 3,000 km return distance, the land use of cars, buses and trains becomes much higher than the land use for flights. This is due to the fact that aircraft only need space for take-off and landing at airports and not for the distance in between.

Main findings on mobility

Findings on mobility circular options were categorised into two main group: a) circular options in mode choice for trip purposes and, b) circular options for buying new vehicles. The impact of the default options was based on individual car ownership and use, except for the circular options for bicycle ownership. The base values regarding vehicle ownership and use were calculated using the ODiN database. Furthermore, the acceptance factor of proposed mobility alternatives was set at 100%. This means that all calculations and results of the alternatives for trip purposes and buying new vehicles were based on the assumption that 100% of the respondents will shift to the behaviour in the alternative circular option.

a) Circular options in mode choice for trip purposes

- In general, the reduction in emissions is highest for shopping and visiting trips. The absolute impact for sports/hobbies and tour trips is more limited due to the smaller number of kilometres travelled by car for these purposes.
- For shopping trips, the highest reductions can be achieved by reducing trip frequencies and choosing closer destinations. The highest reduction percentage is related to the 'online shopping' option with a 70% reduction in emission production and land use. Furthermore, choosing closer destinations has a significant reduction potential (42% to 49%) The effects of the 'changing mode to cycling and/or walking' options are fairly small (11% and 2% respectively), as only short-distance car trips are substituted by cycling and walking trips.
- For visiting trips, the large absolute reduction in emissions stems from the high number of kilometres travelled for this purpose. The option of 'changing mode to public transport' for visiting trips has the highest absolute reduction in CO_2 and GWP.
- Looking at the impact of the different options across all trip purposes, the 'changing mode to public transport' and 'closer destination' options show the highest reduction in emissions. For 'changing mode to public transport' the impact ranges between 30% and 39%. This is considerably more compared to the impact of the walking and cycling options, as public transport (potentially) also enables substitution of larger distance car trips. 'Closer destination' options also have significant effects on reducing emission production and land use. The share of reduction in emission production for these alternatives ranges between 40% and 54%.

b1) Circular options for buying new car

- Among the options for buying a new car, switching to 'public transport' has the highest effect in terms of reduction of emission production (85%).
- The impact of the 'good maintenance' option is limited. As the effect of lower fuel efficiency of older cars is not taken into account, this option does not seem very promising.
- While the 'electric car' is the second best option in emission reduction by around 45%, switching to this option will increase land use by 130%.
- In comparison between 'shared car' and 'smaller car', the latter is slightly more effective in the reduction of emission production and land use.
- Regarding the 'parking' part in 'land use' measure, only switching to 'public transport' and 'shared car' could decrease the need for parking, by 100% and 30% respectively. In the other alternatives, because the number of cars used does not change, land use for parking does not change either.

b2) Circular options for buying new bike

- The circular options for buying a new bike are limited, because buying a sustainable mode of transport (bike) can hardly be improved by the other options. However, the effect of a 'shared bike' scheme is significantly higher than the 'good maintenance' option. The 'shared bike' could decrease emission production and land use by 30%, whereas the effect of the other option is less than 10%.

Contents

1 Introduction

1.1 Background

The global use of natural resources has increased by a factor eight over the past century, and is expected to triple in the future based on current trends (UNEP, 2011). As a result, critical resources become scarce, ecosystem services degrade, and man-made pollution and waste become difficult to absorb (Steffen et al., 2015). Approaches "such as the circular economy – promoting business models based on renewable resources, longer and diverse product life cycles, shared consumption and interconnected value chains – can play a significant role when designing and improving resource management systems not only in the tourism sector, but also for the sustainable development of destinations" (UNWTO-UNDP, 2017, p. 94). This general insight is valid for and applied in almost all sectors. In addition to food, clothing, leisure, etc., holidays and mobility are part of the consumption domains PBL (Netherlands Environmental Assessment Agency) is interested in. For all domains, PBL wants to map the environmental benefits of circular products and behavioural alternatives. This report deals with the areas of holiday consumption and daily mobility. For both, the possible behavioural changes as indicated by the R-ladder (Hanemaaijer et al., 2018) are assumed.

PBL is the initiator of the Work Programme on Monitoring and Management of the Circular Economy 2019-2023. This work programme is a collaboration between CBS, CML, CPB, RIVM, TNO, UU. The government aims for a fully circular economy by 2050. The aim of the work programme is to be able to monitor and evaluate the direction set by the government towards 2050 and to provide the government with the knowledge necessary for the design or adjustment of policy. As a part of this work programme, PBL has identified the environmental impact of behavioural alternatives on consumers.

The **aim** of this study is to calculate the environmental gains per person per year of the various circular behavioural options for both holiday behaviour and daily mobility. This is based on the principles of *life-cycle analysis* and *input-output analysis* as applied, among other things, in the EAP calculation tool of the University of Groningen (R. Benders et al., 2021). However, because of the level of detail required for the calculations, we used not only EAP, but also other models and sources. The results are being used by PBL to develop a questionnaire about circular behaviour and as a basis for communicating with consumers about environmental impact.

Two subsectors form the main topic of this study: holidays and daily mobility. The holiday part was supplied by the Centre for Sustainability, Tourism and Transport (CSTT) of the BUas Academy for Tourism (AfT). The mobility part was carried out by the professorship in Urban Intelligence of the Academy for Built Environment & Logistics (ABEL). Seeing that the methods as well as the results differ for both subsectors, we have divided the chapters into sections covering holidays (2.2, 3.1), mobility (2.3, 3.2), and general (1, 2.1).

1.2 Research Question and Scope

The research question for this study project is:

- What is the environmental impact of various circular (behavioural) options around 1) holidays and 2) passenger mobility?

The scope of the study is the consumer perspective:

- For holidays, transportation and accommodation were included, but not food, attractions visited and holiday activities. Moreover, business travel and travel for visiting friends and relatives were excluded.
- For mobility, only the circular options of passenger transport and private means of transport were included (i.e. freight transport was excluded). Travel motives included were shopping and leisure trips, so business and commuting were also **not** included.

Of the many environmental impacts, we only took the following impacts separated into holidays (V) and mobility (M) into account:

- CO_2 emissions (V and M)
- Global Warming Potential (GWP, for M and for V; note: there is no undisputed GWP value for aviation)
- Land use (for M and where possible V)

As far as land use for holidays is concerned, we expected that a full quantitative analysis would not be possible and to some extent less meaningful. For aviation in particular, 99% of the environmental effects occur during the use phase and in other forms of collective transport this easily adds up to 95% or more. In hotels and restaurants, some larger material flows are to be expected and we tried to get some insight into this through EAP. However, we took land use into account for the production of fuels and electricity. We also presented an indication of land use for infrastructure like roads, railways, and airports.

It should be mentioned that this study is too concise to develop any new methods. Therefore, we generated the results based on existing models and data, and we were occasionally forced to make an expert estimate. These estimates were documented and, where possible, supported by scientific literature.

2 Method

2.1 General

The starting point of the project was the R-ladder described by (Hanemaaijer et al., 2018), reproduced in Table 1. The R-ladder describes different levels of circular consumption. Not using a product (R0), e.g. staying at home instead of going on holiday, is the highest form of circularity, while using and incinerating products (including energy recovery) yields the lowest circularity (R9). Dumping or incinerating products without energy recovery are non-circular practices and therefore not part of the R-ladder.
While the R-ladder was originally designed for products, it can be applied to services to a limited extent. For holidays, for example, the greatest environmental burden is caused by the use phase, in other words, using a mode of transport or staying at the accommodation. The choice of more circular options is hence limited to narrowing the loop: refuse (R0), rethink (R1) and reduce (R2) the CO_2 emissions, Global Warming Potential (GWP) and Land Use through alternative options of transport and accommodation. Other, lower-level R-ladder levels are not applicable. The same holds for shopping and recreational trips for daily mobility. For vehicle ownership, the repair option (R4) is taken into account additionally.

Table 1: The R-ladder and the priority for increased circularity (based on Hanemaaijer et al., 2018).

	R strategies	*Consumption cycle*		
		Acquisition phase	*Use phase*	*Disposal/handover phase*
Narrow the loop	*R0 refuse*	*Not purchase a product (sufficiency)* *Purchase a digital alternative to a product*	-	-
	R1 rethink	*<u>Ownership:</u>* *Purchase a multifunctional product* *Co-own a product* *<u>Service:</u>* *Borrow, rent, or lease a product (sequential use)* *Co-use a product of someone else (simultaneous use)*	*Lend or rent out a product (sequential use)* *Co-use a product with others (simultaneous use)*	-
	R2 reduce	*Purchase a product made of less virgin materials/less environmental impact* *Purchase less of a product* *Purchase a product that uses less materials in its use phase*	*Use a product efficiently*	-
Slow the loop	*R3 reuse*	*<u>First use phase:</u>* *Purchase a long-lasting product* *Purchase a reusable product* *<u>Second use phase:</u>* *Purchase a second-hand product instead of a new one*	*Use a product with more care* *Maintain a product*	*Sell or donate a product for reuse by others*
	R4 repair	*Purchase a modular/repairable product*	*Repair a product or get it repaired*	-

	R strategies	*Consumption cycle*		
		Acquisition phase	*Use phase*	*Disposal/handover phase*
	R5 refurbish	*Purchase a refurbished product instead of a new one*	-	*Sell or donate a product for refurbishment*
	R6 remanufacture	*Purchase a remanufactured product instead of a new one*	-	*Sell or donate a product for remanufacturing*
	R7 repurpose	*Purchase a repurposed product instead of a new one*	*Give a product a new purpose*	*Sell or donate a product for repurposing*
Close the loop	*R8 recycle*	*Purchase a product made of recycled materials instead of virgin materials* *Purchase a recyclable product*	-	*Separate waste for recycling*
	R9 recover	-		-

Before defining more circular options, we first needed to determine the current default options for local mobility, holiday transport and accommodation. Based on statistical cluster methods, our databases on travel and mobility behaviour were used to determine the most common behavioural choices of consumers. The databases also gave an idea as to which alternative options were already used by consumers. In consultation with the client, additional assumptions were made on other alternative options that may not be included in the data sets. Therefore, the work proceeded as follows:

1. Definition of default options based on data sets,
2. Selection of alternative options according to R-ladder,
3. Calculation of environmental impact gains per alternative option,
4. Reporting on key insights.

As the implementation of these steps differs between holidays and mobility, you will find an elaborate explanation of methods in Section 2.2 (holidays) and Section 2.3 (mobility). The data sets used are described in Sections 2.2.2 (holidays) and 2.3.3 (mobility). The selection of default options is described in Section 2.2.3 (holidays) and Section 2.3.2 (mobility). The calculation methods are described in Sections 2.2.5 and 2.2.6 (holidays) and 2.3.3 and 2.3.4 (mobility). Chapter 3 then proceeds with the results.
For emission calculations many transport studies distinguish between the emissions that originate from burning fuels in a car or aircraft and those emissions for producing and distributing the fuels and energy. This is translated into Well-to-Tank (WtT for emissions caused by producing and distributing fuel or electricity), Tank-to-Wheel (TtW for emissions caused during the trip) and Well-to-Wheel (WtW which is the sum of WtT and TtW). Note that for electric transport (trains, electric cars) all emissions occur during the production of electricity and TtW is normally zero. In addition, not every model and database applies the WtW principle in the same way using the same factors. In this study we applied the principle as follows:

- Holidays:
  - CO_2 emissions for non-electric transport and accommodation are all WtW with an older WtW factor of about 10%, while the latest study by CE Delft (Klein et al., 2021) gives factors of up to 30%.
  - CO_2 emissions for electric transport are WtW because TtW is assumed to be zero.
  - CO_2 emissions for accommodation are excluding WtW regarding non-electric energy sources and including WtW for electric energy.
- Mobility:
  - CO_2 emissions for mobility are WtW.

2.2 Holiday Method

2.2.1 Introduction

To assess the default holiday trips and the impact of the R options, we made use of a suite of data and models. The direct CO_2 emissions were taken from the Travelling Large (TL) reports (last version is Eijgelaar et al., 2021). These reports use the CVO (Continuous Holiday Survey) for which BUas developed a method to calculate the holiday CO_2 emissions (latest version is P. M. Peeters, 2020). The results of the TL method were then extended with Global Warming Potential (GWP) and land-use data based on conversion factors from the EAP calculation tool (R. Benders et al., 2021; R. M. Benders et al., 2001).
In Section 2.2.2 the Traveling Large (TL) Database is introduced including its calculation formulas. We refrain from introducing the EAP model which is part of PBL’s database. Section 2.2.3 describes the selection of the default trip and the R-ladder options to be considered. We have left carbon offsetting out of ten R-ladder options for reasons described in 2.2.4. Section 2.2.5 describes the process of defining the GWP and Land Use based on the EAP model while Section 2.2.6 zooms in on the likelihood of behavioural change and alternative adoption. Finally, Section 2.2.7 compares the CO_2 emissions in the TL Database with those provided by CO2emissiefactoren.nl (2021).

2.2.2 Travelling Large (TL) Database

In this study, the Travelling Large (TL) Database was used to calculate tourism trip emissions. The basic data set, the Continuous Holiday Survey (CVO) containing 20,000 records every year (NBTC-NIPO, 2011), is maintained by the Netherlands Board of Tourism and Conventions (NBTC). Since 2002, Breda University of Applied Sciences has added direct CO_2 emissions (Well-to-Wheel) to the data. The first TL report dates back to 2009 and contains data for 2002, 2005 and 2008 (de Bruijn et al., 2009). Since 2009, annual reports have been provided, with the one by (Eijgelaar et al., 2021) being the most recent one. The TL reports contain elaborate trip details (e.g. length of stay, accommodation, holiday type, mode of transport) of Dutch holidaymakers travelling within the Netherlands and abroad. For reporting on the CO_2 emissions, three trip compartments are distinguished: accommodation, transportation between home and destination, and activities including local transport.
For accommodation, emission factors are used, which range from 2.0 kg per night for a tent to 20.6 kg per night for a stay in a hotel. These emission factors are multiplied by the length of stay to derive the accommodation emissions per trip. A wide range of 20 accommodation types is included in the data set, including privately owned properties (house owned by family or friends, apartments), accommodation types in holiday parks (holiday homes, tents, camper vans, and so on), boats (sea or river cruises, sailboats), and common accommodation types such as hotels or bed & breakfasts. The emissions of electricity production are included in the emission factors.
For the transportation of holidaymakers between home and the destination, 18 transport modes are distinguished. Land vehicles (car, bicycle, bus, or train), water vehicles, such as cruise ships or boats, and the airplane are part of the data set. Transportation emissions are calculated based on the mode that holidaymakers covered the most distance with during that trip.
To determine the transport emissions ($CF_{transport}$), use is made of the great circle distance, detour factor, emission factor and occupancy rate. The great circle distance is the shortest distance between two points on the surface of a sphere (Swartz, 2020), in this case the distance between the tourist’s home and destination. As the tourist travels from home to the destination and back home, the great circle distance is multiplied by two. Since travelling the shortest distance between home and destination is impossible in practice, a detour factor is added which differs per mode of transport. The add-on factor is added to account for extra emissions caused by holidaymakers driving with a caravan, a roof box, or a bicycle rack. The emission factor is based on CO_2 emissions per person-kilometre and differs per transport mode.
For land and water vehicles, the production and use of common fuels are included in the emission factor. For public transport, buses and touring cars, the average occupancy rate is also included, for trains the production of electricity is included, and for sleeper trains there are additional emissions due to the accommodation provided. For airplanes, distance categories, fleet renewal, technological advancements, and the effect of indirect flights are also taken into account. For all road-transport modes (bus, coach, car,

motorcycle, moped) the emission factors are updated for each year TL was calculated based on the fleet averages in the Netherlands as published by CBS (2020a). For transport over water and rail, the original international values have not been updated since 2009. Since we need emission factors expressed in passenger kilometres, private transport modes (car, motorcycle, etc.) are recalculated from vehicle kilometres and seat occupancy rate to generate the 'per person-kilometre' figures. The average occupancy numbers of Dutch holidaymakers vary across transport modes (since the average number of people in a car is different from that on a motorcycle).

$$CF_{transport} = \frac{2 * Distance_{Great-circle} * Detour\ factor * Add-on\ factor * Emission\ factor}{Occupancy}$$

The TL reports also assess Well-to-Wheel CO_2 emissions of local transport involved to visit tourism activities at the destination. For the distances travelled for these activities, a 2009 survey is used. Out of a selection of activities respondents are asked to define their holiday activities and to define the distances they travelled and mode of transport they used for these activities. The combination leads to a per day figure for each type of activity, which range from nature-based trips (1.9 kg/day) to city trips (7.9 kg/day). For the CVO data set respondents define their most important activity (which we assume for the whole trip) and the per-day figures are multiplied by the length of stay.

2.2.3 Default trips and R-ladder Options

To define the default trip options, several steps were taken and outlined in the following.
The data set contains more than 60,000 entries of holidaymakers from 2017 to 2019. To cover the different travel distances, and therefore levels of environmental impact though transportation, distance categories were established. These are < 4000 km return trip distance (short), 4000-10,000 km return trip distance (medium) and >10,000 km return trip distance (long), therefore covering trips in Europe, the adjoining countries, and long-haul trips respectively. Within each distance category, the most common holiday type(s) in the TL data set were determined (see Appendix 1 for details on the share of each trip type within each distance category). This led us to six trip clusters, combining distance and holiday type: city trip (short, long), beach trip (short, medium, long) and tour (long). Next, the data set was filtered for a common destination, the most common transport mode, accommodation type and lengths of stay (LOS) within each trip cluster. Finally, six default trip options were determined:

- City trip to Berlin/Germany, 4 days, hotel, car
- City trip to Dubai/UAE, 8 days, hotel, air travel
- Beach holiday at the Costa Blanca/Spain, 8 days, hotel, air travel
- Beach holiday in Antalya/Turkey, 8 days, hotel, air travel
- Beach holiday in Curaçao,12 days, hotel, air travel
- Touring through Western USA, 22 days, hotel, air travel

Within this destination and holiday type, we determined the additional trip details (transport mode, accommodation type, length of stay) that were the most common.
For each default we then defined alternative options in line with the R-ladder classifications (Hanemaaijer et al., 2018). For each alternative listed, only one variable was changed at a time, while keeping the rest at default. Therefore, the direct impact of this change in behaviour can be determined, e.g. using a train instead of a car. The alternative options were defined based on alternative actual trips taken by respondents in the data set. If no alternative options were listed available in the data set, options deemed possible based on the destination, holiday type and distance were calculated using (P. M. Peeters, 2020) and marked with an *.
We included a relatively small range of R-ladder options, since R-ladder options other than R0 and R2 are not relevant when looking at the consumption side of tourism (see Section 2.1). Options we considered include changing transport modes or accommodation types, changing travel distances or staying at home. An often advocated way to 'reduce' travel emissions is by offsetting these emissions (R9). However, there

are many issues with offsetting, of a theoretical, practical and ethical nature, which makes it extremely difficult to assess its impacts (see text box below). Therefore, offsetting was not included in this analysis.

R-ladder calculations. The R-ladder calculations are based on the CO_2 emissions of each default trip and its alternatives. The GWP and Land Use calculations are based on these CO_2 emissions and the EAP model (see Section 2.2.5). This section explains how the CO_2 emissions and the special options of 'Staying at home' and 'Travel less but longer' were calculated.

Distance. For calculating the transport emissions, we needed to determine the travel distance. The distance is based on the Great Circle Distance (GCD) between Schiphol Airport and the international airport of the destination country's capital city and the detour factor of the mode of transport used (see the definition of GCD and detour factor in Section 2.2.2).

CO_2 emissions. The CO_2 emissions for each trip are based on sum of the total emissions of transport, accommodation, and local transport. The emissions data is derived from the Traveling Large data sets (2017-2019). If there was no data on a specific alternative in the data set, the transport emissions were calculated based on P. M. Peeters (2020) method using the GCD, detour factor and occupation rates. For accommodation types, the emission factors of P. M. Peeters (2020) were used. In this process, no distinction was made between destinations despite local differences. Separately calculated cases, as opposed to cases included in the data sets, are marked with an '*'.

Option: Stay at home. Stay at home is based on home energy usage and domestic passenger travel. According to Milieucentraal (2020) average emissions of energy per household are 3,800 kg CO_2. With an average household size of 2.2 persons, this adds up to 1,727 kg CO_2 per person per year and 4.73 kg per day. Furthermore, CBS (2021) figures show emissions for domestic passenger transportation of 16,648 Mton per year, which totals 963.4 kg CO_2 per person per year and 2.64 kg per day. Therefore, the daily energy and transport emissions per person are 7.4 kg CO_2 per person, which are generally avoided when on holiday.

Option: Travel less often but longer. This option displays the CO_2 savings if a person stays at the destination twice as long instead of taking the trip twice. Therefore, the initial emissions are higher than the default option. However, the CO_2 /GWP/Land Use savings column displays the gain compared to ***two*** default trips, assuming the annual number of holidays is a given constant for most people.
There are quite some uncertainties around whether this option is favourable for holidaymakers. Figure 1 shows the rather striking relationship between CO_2 emission per person per day and length of stay as found for all trips in the 2017-2019 CVO data set for LOS up to 50 days. The figure shows that longer stays increase the emissions per day between one and ten days. Between 10 and 25 days the average is constant and above 25 days starts to reduce. In all cases, the variance is large.

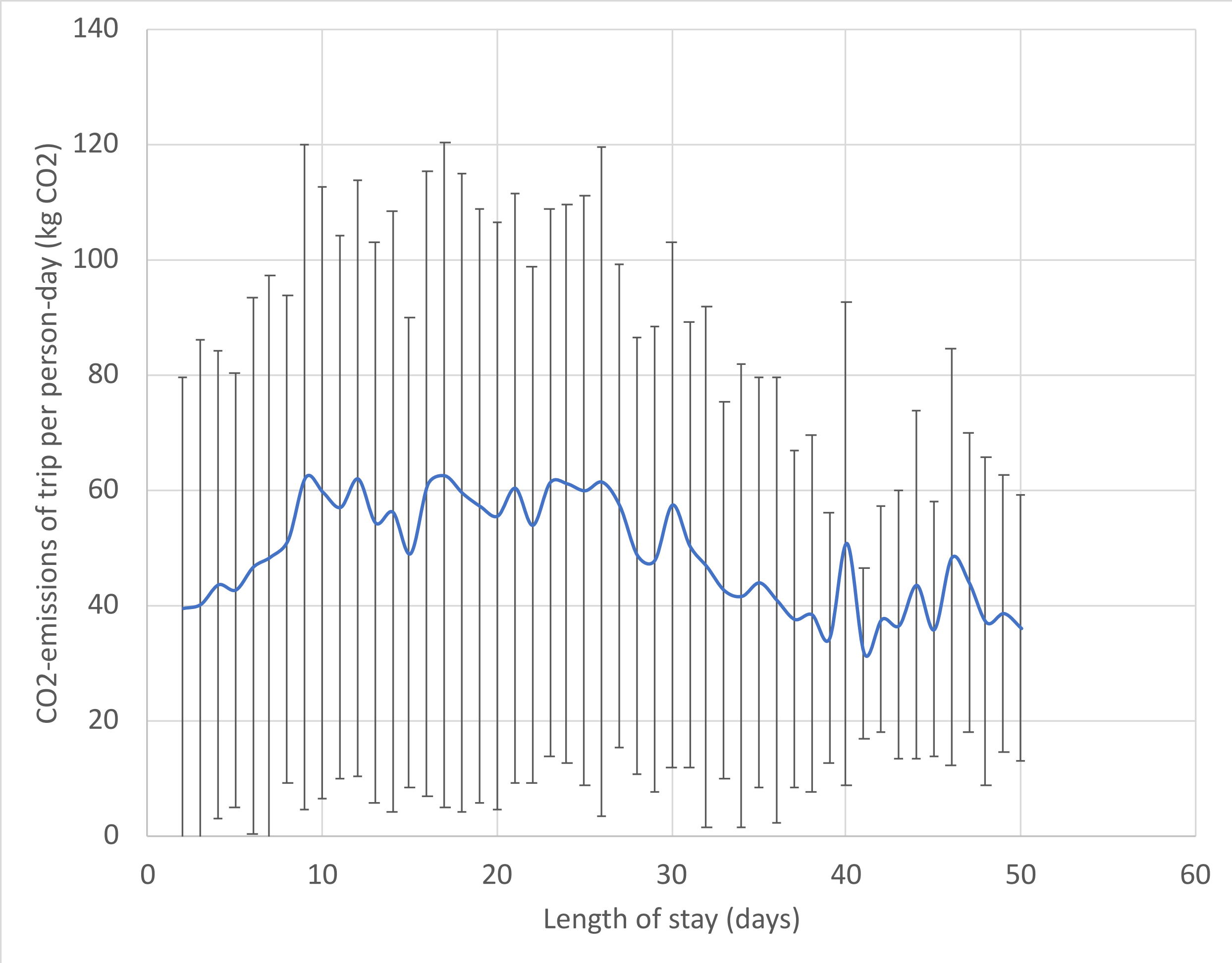

Figure 1: relationship between length of stay in days (horizontal axis) and average CO_2 emissions per person per day (vertical axis)

2.2.4 Why offsetting CO_2 emissions is not considered to be part of the R-ladder

Air travel is one of a few sectors that heavily relies on offsetting, or carbon compensation, of CO_2 emissions or GWP. The cause of this is that aviation is considered to be one of the 'harder-to-abate' sectors (Energy Transitions Commission (ETC) 2018) which might have been a driver for choosing offsetting as a cheap alternative to reducing aviation's own emissions. Offsetting is based in the Clean Development Mechanism (CDM) of the Kyoto protocol (UNFCCC, 1998). UNFCCC (1998) introduced a mechanism whereby Annex I countries 'rich countries') provide funds to Annex II countries ('poor countries') to reduce their emissions cheaper than Annex I countries could. It is widely advertised to both companies and the public, to become 'carbon neutral'. This mechanism, however, is not useful to reduce emissions to zero, as required in 2050 by the Paris Agreement (UNFCCC, 2015) because the net result is the same emissions. It also caused a disincentive for Annex I countries to reduce their own emissions (Cames et al., 2016).
Offsetting is an 'open-emissions trading' system, which means that there is no regulated 'cap' to the total emissions of all participants, but emissions are traded in an open market that is self-regulated without government interventions. Such an open system is contrary to emission trading systems such as the EU Emission Trading System (ETS), which is a closed system with a regulated cap on total emissions in a certain year, and only limited allowed between the entities (industries, companies) within the system. For an open system two requirements are essential to create valid certified emission reductions: the reduction must be calculated in a correct way and it needs to be 'additional'. This 'additionality' means that without the financial input from the reduction certificate, the offset, the project would not have happened. Cames et al. (2016) found that only 2% of 5,700 offset projects certainly fulfilled both requirements, while 85% certainly failed one or both. The remainder were unclear.

The off-set industry is seeing increased critics in the press for instance:

- “Top airlines’ promises to offset flights rely on ‘phantom credits’” (Clarke & Barratt, 2021)
- “Carbon offsets used by major airlines based on flawed system, warn experts” (Greenfield, 2021)
- “10 myths about net zero targets and carbon offsetting, busted” 41 scientists warn (Skelton et al., 2020)
- The CDM has been replaced by the ‘Article 6’ mechanism, but that still has many flaws, including a large reservoir of old CDM credits to be thrown on the market by countries like Brazil (Climate Home News, 2019).
- There are several schemes that try to improve the performance of carbon credits like the Golden Standard. However, (Drupp, 2011) could not find that GS credits perform better for the same types of projects.
- As early as in 2011, a study revealed that the CDM did also not “deliver the promised benefits with regard to development objectives in rural areas” (Subbarao & Lloyd, 2011, p. 1600).
- With respect to the ICAO international aviation offsetting scheme CORSIA, (Warnecke et al., 2019, p. 218) observe “If the scheme allows airline operators the unlimited use of offset credits from already implemented projects, it will result in no notable emissions reductions beyond those that would occur anyway and neither offer incentives for new investments nor reward previous investments in offset projects.”

Another issue is the price per ton of CO_2 of offsets, which starts at only €2 to €3 per ton CO_2, while economists agree that climate change can only be solved with carbon prices ranging from €30 per ton in 2015 up to €100 in 2075 (van der Ploeg, 2018). One cause for the low prices of offsets is that the marginal cost deficit, the part of a project that is covered by certificates, is divided by the total CO_2 reductions of the project. So, with a financial deficit of 10%, the cost is ten times lower than the marginal additional CO_2 covered directly by the certificates (based on Cames et al., 2016). This is highly problematic because it competes with direct emission reductions in travel, such as the use of expensive alternative synthetic fuels or distance reductions, and it gives the public and enterprises the impression that mitigating climate change has a low cost and thus climate change is not such a big problem. The final problem is that just paying for some reduction elsewhere does not fit any of the R-ladder stages.

2.2.5 EAP: Global Warming Potential and Land Use

The Global Warming Potential and Land Use were calculated using the EAP data set (based on PBL data of 2017; according to EAP model description). The model is based on data from EcoInvent (2021). Unfortunately, the data, methods and background of this extensive data set are not publicly available. Therefore, the data set is not transparent and the data need to be used with care. To determine the GWP and Land Use of each default option and circular alternative option, the CO_2 emissions calculated with the TL method were used. First, the CO_2 emissions were divided by the CO_2 intensity per euro from EAP to determine a representative ‘trip price’ compatible with the EAP database. This trip price was then multiplied by the GWP/Land Use ratios for impact per euro for transport, and accommodation and activities respectively. The GWP/Land Use for transport is based on the intensities for international flights, trains, buses, and average cars respectively. The intensity of car emissions is based on the weighted average of emissions from gasoline, diesel, and LPG cars. The GWP/Land Use for accommodation is based on the intensity of hotels, motels, and inns. The difference between the intensity for bungalows and camping compared to hotels in EAP is very small and can therefore be neglected. The GWP/Land Use for activities is based on local transport emissions by car or train if the main transport mode of the trip is the train.

2.2.6 Constancies and Likelihood

To give an indication of how likely holidaymakers are to choose an alternative option, we used the TL data sets to determine behavioural constancies and likelihoods.

$$Likelihood = \frac{general\ constancy + cluster\ constancy}{2}$$

The general constancies of various trip characteristics (transport mode, accommodation type, holiday type, etc.) were calculated to arrive at a more substantiated judgement of the likelihood that an alternative R-option is chosen. The constancy is a number between 0 and 1 and looks at the number of transport modes, accommodation types, or countries that holidaymakers have used or travelled to, relative to the number of trips they have undertaken between 2017 and 2019. Numbers close to 1 indicate a high constancy (put bluntly: a smaller chance this person is open to change, based on past travel behaviour) and figures close to 0 indicate a low constancy (thus a relatively large chance a person is open to change). These constancies provide insights into the extent to which a person makes use of different modes of transport, for example, but does not shed light on the specific modes of transport this person varies between. In order to get useful results, holidaymakers with fewer than three trips were excluded from the constancy calculations.

Table 2: Overview of the constancies

General Constancies	City Trip	Beach Trip	Touring
Transport	0.3978	0.4386	0.3695
Accommodation	0.3410	0.3352	0.3491
Country	0.3491	0.3491	0.3491

Based on: TL merged data set

For example, the transport mode (TM) constancy is calculated as follows:

$$General\ Constancy\ (TM)\ person\ X = \frac{\left(\frac{Number\ of\ trips\ with\ Most\ Used\ TM}{Number\ of\ TM}\right)}{Number\ of\ trips}$$

The transport mode constancy of a person who has travelled 4 times between 2017 and 2019, 3 times by car and once by plane, will therefore look as follows:

$$General\ Constancy\ (TM) person\ x = \frac{\left(\frac{3\ (trips\ with\ most\ frequently\ used\ mode)}{2\ (number\ of\ modes)}\right)}{4\ (number\ of\ trips)} = .375$$

The formulas for the other trip characteristics are the same, albeit with the use of the number of accommodation types, holiday types, etc. The general constancies therefore determine how likely a holidaymaker is to switch away from their default travel choice. However, looking at the data set we can estimate more precisely how likely it is that a tourist within each trip cluster will choose the proposed alternative. To do so, we determined the share of the respective accommodation types or transport modes in the selected cluster. If no trip was recorded for that accommodation type or transport mode, a constant of 0.05 was used, representing the relevance threshold for statistical calculations.

$$Cluster\ Constancy = \frac{number\ of\ trips\ using\ alternative\ choice\ in\ cluster}{number\ of\ trips\ in\ cluster}$$

The general constancies are based on 60,000 cases which makes them reliable. The cluster constancies are based on far fewer cases and are therefore less reliable, although they do give more detailed information. Therefore, the likelihood of each alternative travel choice was determined using both constancies.

2.2.7 Data Comparison with CO2emissiefactoren.nl

The emission data used in this study is based on the Travelling Large Longitudinal study (Eijgelaar et al., 2021). This set of emissions was deemed most relevant due to its level of detail. It measures emissions of various specific travel modes, accommodation types, and holiday activities. Furthermore, it takes into account the specific uses of, for instance, transport modes. Just think of the car, which will have a higher average occupation rate on holidays than in daily traffic, while at the same time larger and heavier cars will be used on holidays. After all, when a household has two or more cars, the largest one will likely be used for the holiday. Furthermore, the local transport emissions partly depend on the transport mode used to reach the destination of the holiday. If people travel by car from home, chances are high that they will also use that car at the destination. TL therefore allows for the most differentiated analysis. An overview of the differences between the emission factors in Travelling Large and CO2emissiefactoren.nl can be found in Appendix 2.

2.3 Mobility

2.3.1 Introduction

The OViN (CBS, 2021b)and ODiN (CBS, 2021a)databases provide the backbone for the calculation of the effect of circular economy options for mobility. For the sake of comparability, we aligned our data with the holiday analyses and included data from 2017, 2018 and 2019. These national Travel Surveys include 40,000 to 50,000 respondents on an annual basis and provide a representative picture of travel behaviour and vehicle ownership in the Netherlands. These data were used to determine default/base mobility options and to define realistic switching options according to the R-ladder. To translate the current behaviour into CO2 emissions or GWP, data from the EAP model and the co2emissiefactoren were used and combined to provide a solid reference. Lastly, additional sources were used to support important assumptions such as the lifespan of vehicles and the reduction of car use due to shared mobility services.

2.3.2 Mobility Aspects and R-ladder Definition

Figure 2 provides the overall analyses schedule for the mobility analyses. Circular options for mobility were calculated for shopping and recreational activities and for vehicle ownership. Based on the classifications in the ODiN database, the following subcategories were included in the analysis:

- Shopping:
  - Grocery shopping
  - Non-grocery shopping (shopping for fun)
- Recreational trips:
  - Visiting relatives, friends, and family
  - Sports and hobbies
  - Touring/hiking

For all trip purposes, the car is considered as the default mode of transport. For vehicle ownership, buying a new car or bicycle is considered as a default. For the default options, the initial CO2 emissions, GWP and Land Use were calculated. and subsequently, the effect of more sustainable options according to the R-ladder was determined. The reduction in environmental impact of the alternatives was determined by taking the difference between the default choices and the alternatives (see Figure 2). This involves:

- For trip purposes:
  - R0 refuse: switch to walking, cycling or using public transport.
  - R1 rethink: lower frequency: less often/more online.
  - R2 reduce distance: more nearby destination.
- For vehicle ownership:
  - R0 refuse: use public transport or rental car.

- R1 rethink: purchase smaller or electric car.
- R2 reduce: car sharing.
- R4 repair: better maintenance to increase lifespan.

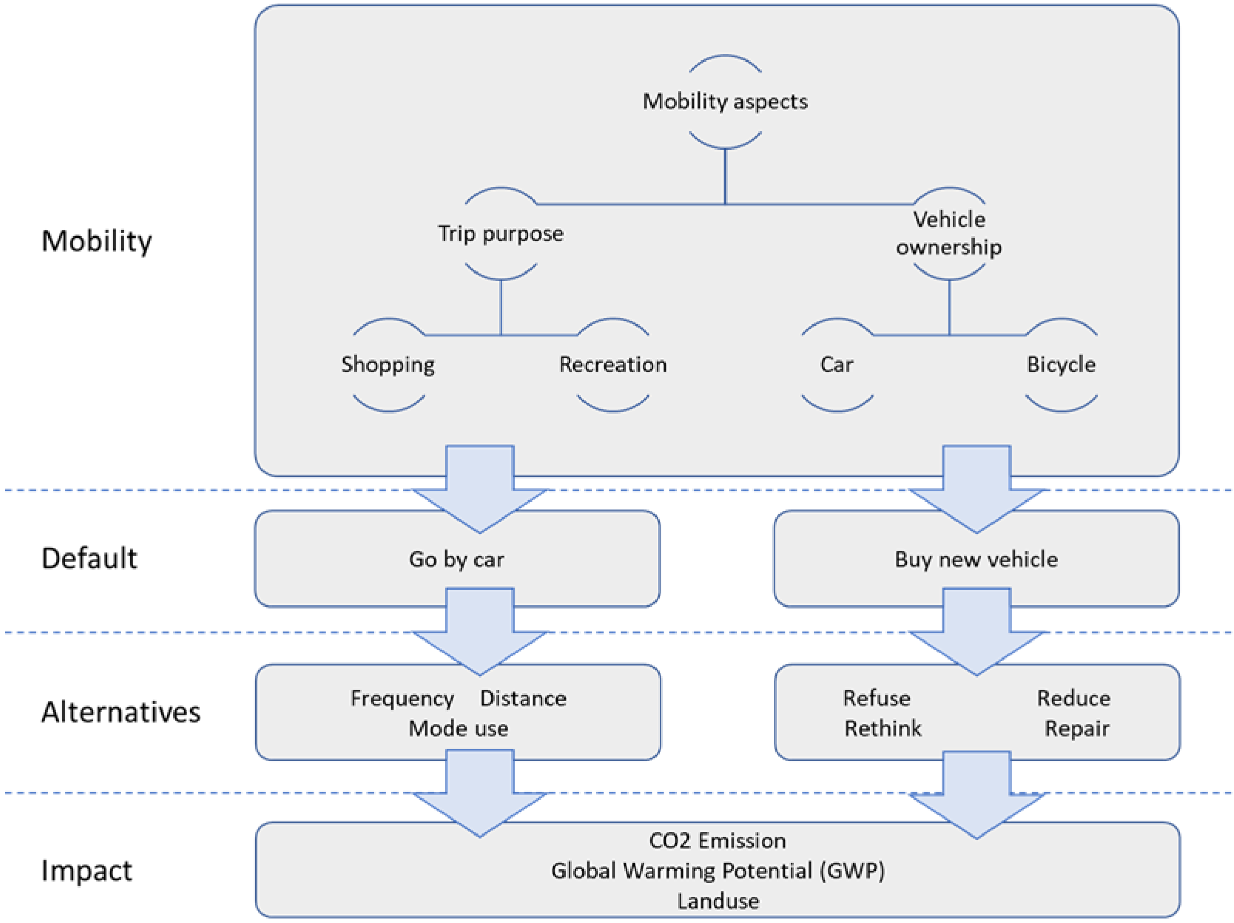

Figure 2: Overview of mobility analyses

2.3.3 Emission and Land Use Factors

Table 3 presents the factors used in this study to determine the environmental impact of the different mobility options. Most factors originate from the EAP model and the website co2emissiefactoren.nl. In some cases, factors from both sources were combined to determine the environmental input for the desired unit of analysis. If neither data source provided sufficient information, additional literature reviews were conducted and expert judgements were sought to determine the best possible factors for our analysis. A complete overview of the emission factors and complementary base values are available in Appendix 3 (Table A 2 and Table A 3).

Table 3: CO_2 emissions, GWP, and Land Use factors for mobility

Item	Unit	CO_2 (kg/unit)	GWP (kg/unit)	Land Use (m^2/unit/year)
New Gasoline Average Car	Vehicle	4,338	4,642	186
New Electric Car	Vehicle	7,424	7,950	342
New Gasoline Small Car	Vehicle	2,905[1]	3,109[1]	125[1]

Item	Unit	CO_2 (kg/unit)	GWP (kg/unit)	Land Use (m^2/unit/year)
Car Tire	4 Rings	164	176	5
Engine Oil	m^3	1,650	1,733[2]	12[3]
Car Repair and maintenance[4]	time	33	35	1.2
New Regular Bike		96	102	6
Bike Tire	2 Rings	9	10	1
Bike Repair and maintenance[5]	time	1	1	0.03
Consumption of Gasoline car (WTW) [6]	1000 km	168	180	0.6
Consumption of small Gasoline car (WTW) [7]	1000 km	133	143	0.4
Consumption of average Electric car (WTW) [6]	1000 km	76	78	5.7
Consumption of public transport (WTW) [8]	1000 passenger-km	14	15	N/A

1: Based on the weight of a small car compared to an average car (Table A 2)
2: Using CO_2 emissions as the basis and applying the GWP/CO_2 ratio for Gasoline (WTT) from EAP (Table A 2 in the Appendix 3)
3: Using the value of Gasoline (WTT) from EAP (Table A 2)
4: Applying the Repair and Maintenance Cost (Table A 3) to values from EAP (Table A 2)
5: Emissions related to bike repair -maintenance (RM) were calculated based on car RM values. The ratio of emissions related to car RM and car production was calculated and then multiplied by the emissions of regular bike production. Assuming that: $\left(\frac{Car\ R-M\ emission}{Car\ Production\ emission}\right) = \left(\frac{Bike\ R-M\ emission}{Bike\ Production\ emission}\right)$
6: Using the value from co2emissiefactoren.nl for GWP and calculating the other factors, based on the GWP ratio (co2emissiefactoren.nl)/GWP(EAP) (Table A 2).
7: Applying the consumption ratio of Toyota Aygo/ VW Golf (Table A 3) to the values of Gasoline car (WTW)
8: The available data for public transport CO_2 emissions, GWP and Land Use are in the unit of 'euro', based on EAP and only for GWP in the unit of 'passenger-km' based on the other sources (Table A 2). To calculate the emission factor of public transport in the unit of 'passenger-km' for all factors, the GWP ratio from co2emissiefactoren.nl in the unit of 'passenger-km' divided by GWP from EAP in the unit of euro. Then this ratio was multiplied to the value of CO_2 from EAP (Table A 2). For the Land Use factor this approach was deemed inappropriate and due to the absence of other reliable sources it was decided to exclude this factor.

2.3.4 R-ladder Calculation

To calculate the environmental impact of the circular options per person per year, we derived additional information from the OViN/ODiN databases, the EAP model, co2emissiefactoren.nl and additional literature sources. Table 4 presents the key figures regarding the average distance travelled by car per year, vehicle lifespan, and average vehicle ownership and occupancy levels. In addition, key figures for the alternative options were included. For instance, online shopping reduces car kilometres driven and consequently the environmental impact. However, this is partially offset by the additional emissions from the delivery services (30% for shopping in general). Furthermore, reductions in vehicle ownership and use were assumed when shared vehicles become available.

Table 4: Overall travel characteristics and key figures

	Item	Unit	Amount	Source
Overall travel characteristics	Average Travel Distance per car in the Netherlands	km	14,360	OViN/ODiN (CBS, 2021a, 2021b)
	Average occupancy of passenger car	person/car	1.39	CO2emissiefactoren.nl (2021)
	Average car ownership	Private car /person	0.5	CBS (2019)
Key figures on trip	Delivery equivalent emission for grocery shopping	Percent	15%	Weideli and Cheikhrouhou (2013)
	Delivery equivalent emission for all shopping	Percent	30%	Weideli and Cheikhrouhou (2013)
Key figures on vehicle ownership	Reduction in car ownership due to car sharing	Percent	30%	Nijland et al. (2015)
	Reduction in bike ownership due to bike sharing	Percent	30%	Expert Judgement (based on car sharing value)
	Reduction in car use due to car sharing	Percent	17%	Nijland et al. (2015)
	Lifespan of average car	Year	18	Bovag-RAI (2019)
	Lifespan of average bike	Year	13	RAI Vereniging (2021)

Calculation steps for trip purposes

Figure 3 provides an overview of the four-step calculation process for the trip purposes. In the first step, general travel behaviour indicators are determined which provide the input for the base option and realistic alternative options. For instance, a complete modal shift from the car towards cycling for all shopping trips is not realistic, as longer-distance car trips cannot be substituted by cycling trips. Therefore, we analyse the distribution of current shopping trips by bicycle. In the second step we only consider a modal shift from car to bicycle for trips that are within a reasonable cycling distance. In the third step, the environmental impact for the base options is determined by multiplying the car kilometres driven by the car emission factors per kilometre. The reduction in environmental impact in the alternative options is based on the trade-off between the reduction in car kilometres driven and the additional environmental impact caused by the new behaviour (for instance using public transport). Both are calculated and added together to determine the total impact of the alternative options. In the fourth step, the absolute and relative reductions in impact are determined by comparing the outcomes of the base and alternative options.

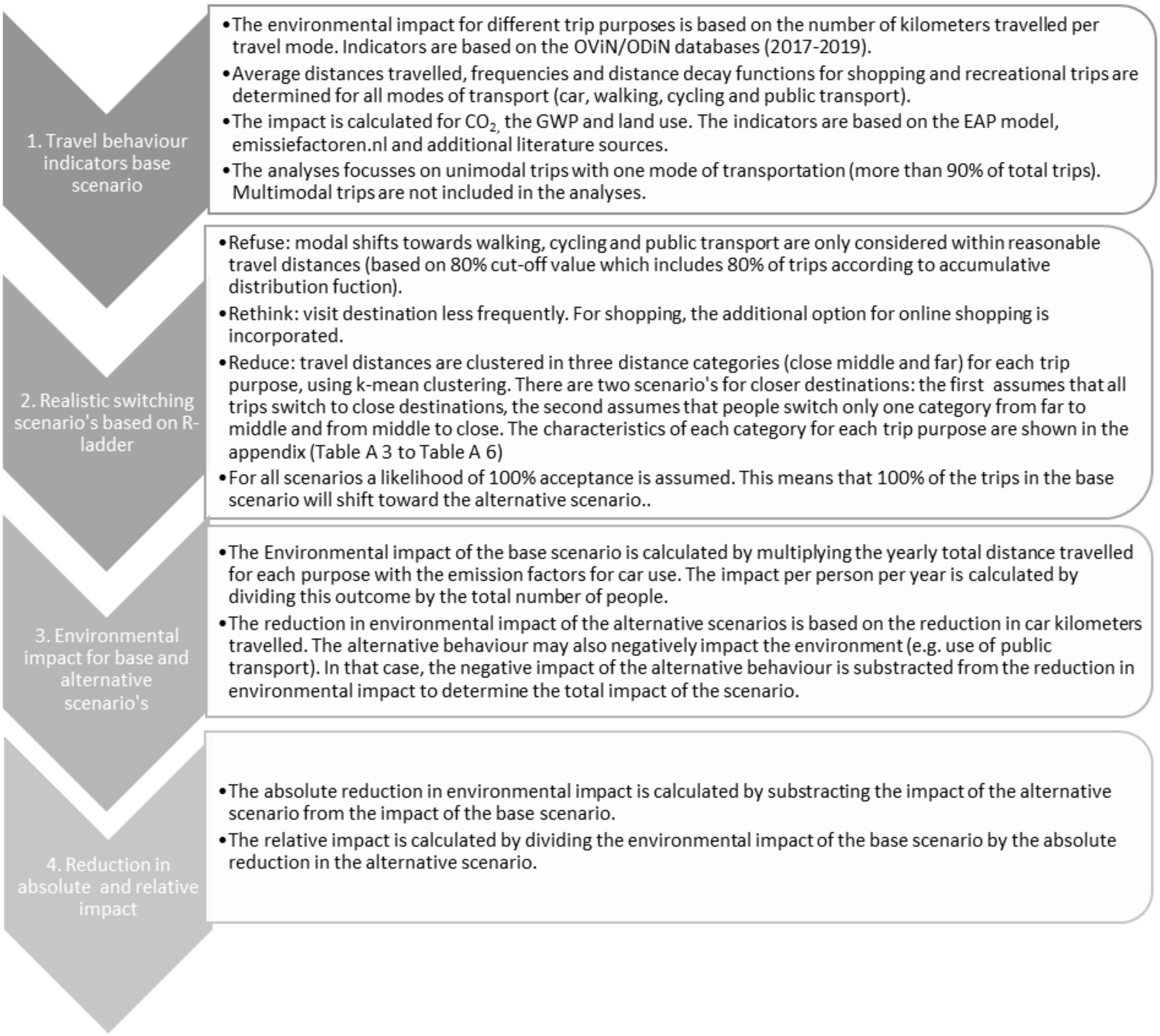

Figure 3: R-ladder calculations for trip purposes

Example for trip purposes: modal shift option from car to bicycle for shopping (for CO_2)
In the first step, the current travel behaviour for shopping purposes is analysed for all modes of transport (car, public transport, cycling and walking). In the second step, the baseline environmental impact for car use is determined by multiplying the total distance by car for shopping by the emissions per kilometre and dividing this by the number of respondents.

Emissions production for car base option: $\frac{(Travelled\ distance\ by\ car * petrol\ emission\ (wtw))}{Number\ of\ respondents} = \frac{10{,}652*10^6*0.168}{16.3*10^6} = 109.7\ kg/person/year$

Subsequently, the 'reasonable bicycle distance' (RBD) for shopping is determined based on the 80% value of the distribution function (Figure 4). This is 2.9 kilometres (see Table A 4). The share of car distance travelled on trips closer than this RBD value equals 11% of the total car distance travelled for this purpose (Table A 4). For the modal shift option, it is assumed that all car trips within the RBD will be substituted by bicycle trips.

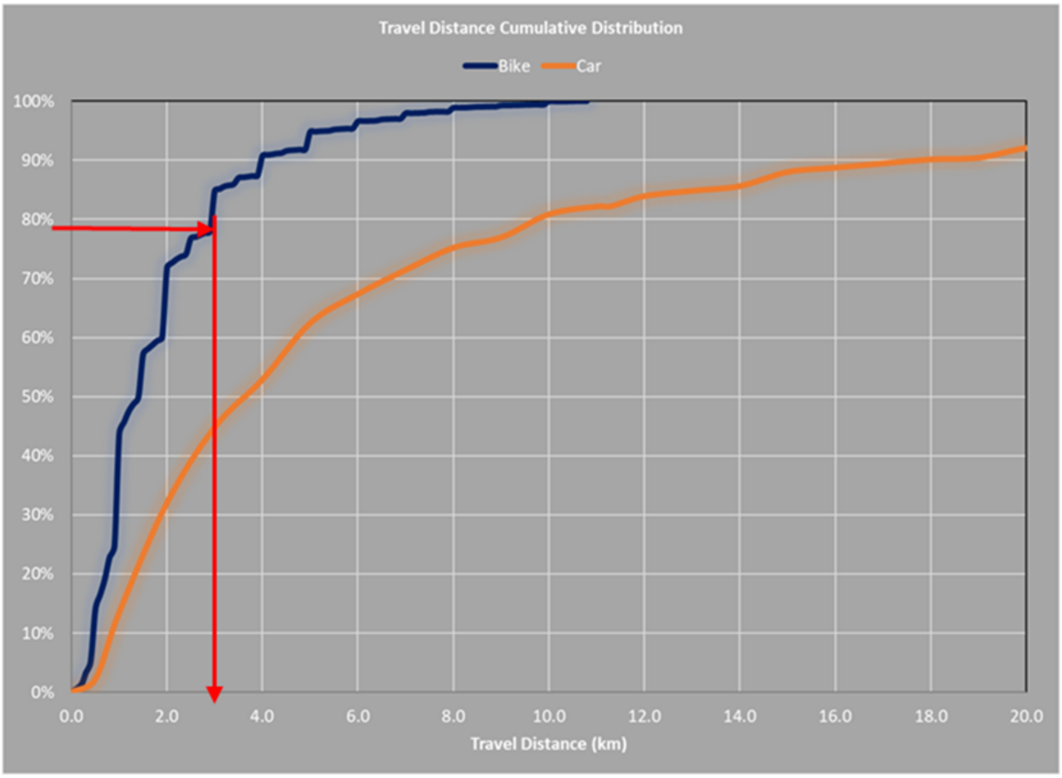

Figure 4: Accumulative function of trip length for shopping purposes.

In the third step, the bicycle trips are assumed to be zero emissions. This means that the environmental impact of this option is defined by the remaining travelled distance by car. This means:

Switch to bike option emissions production: $\frac{(Remaining\ travelled\ distance\ by\ car * petrol\ emission\ (wtw))}{Number\ of\ respondents} = \frac{9506*10^6*0.168}{16.3*10^6} = 97.9\ kg/person/year$

Comparing the base and alternative options shows that the absolute reduction in environmental impact for the modal shift from car to the bicycle is 11.8 kg/person/year, which equals a reduction of 11%.

Calculation steps for vehicle ownership

Figure 5 provides an overview of the four-step calculation process for vehicle ownership. The basic approach is comparable. An important difference is that the environmental impact of vehicle ownership relies on a multitude of factors, including impact related to the materials and production of the vehicles, maintenance and repairs, and fuel/energy consumption. Key figures for these calculations are derived from the EAP model and emissiefactoren.nl. The options for private car ownership encompass diverse circular options according to the R-ladder. For the bicycle this is more limited as this is already a sustainable transport mode. Circular options for cycling are limited to a shift towards more shared bikes and increasing the lifespan by good maintenance. The reduction in environmental impact is based on the reduction in car/bicycle ownership in the alternative options. Of course, the impact of the alternative behaviour is also taken into account.

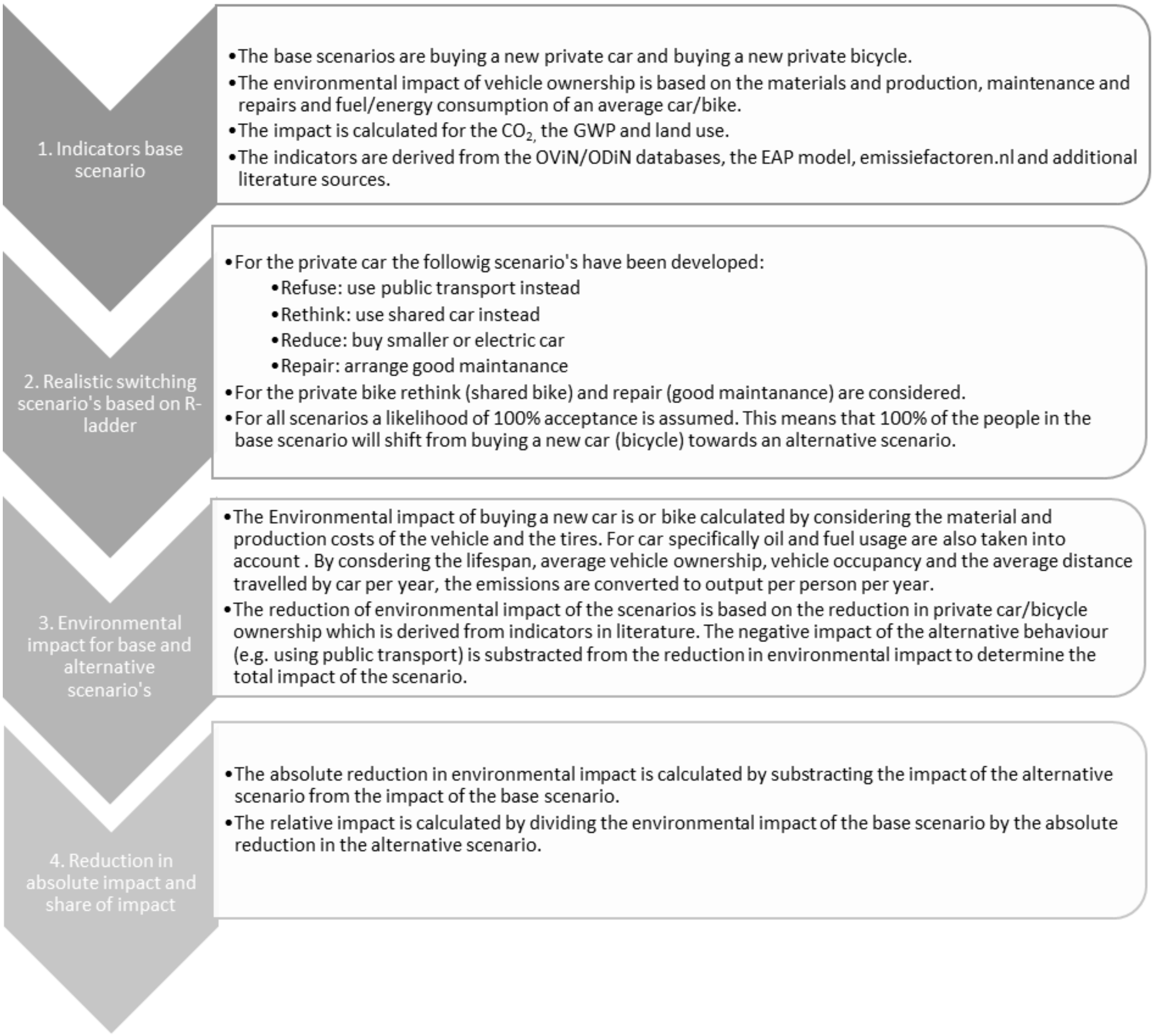

Figure 5: R-ladder calculations for vehicle ownership

Example for vehicle ownership: option shift from private car to shared car (for CO_2)
The environmental impact of the base option (buying a new private car) includes the impact of the materials and production of the car, the maintenance, and the fuel. This is calculated using the following procedure and key figures:

- Materials and production:
  - **Car**: $\frac{emissions}{average\ car\ lifespan} * average\ car\ ownership = \frac{4{,}338.35}{18} * 0.481 = 115.93\ \ kg/person/year$
-
  - **Tire**: $emissions * number\ of\ car\ wheels * \frac{average\ travelled\ distance\ per\ year}{average\ car\ tire\ lifespan\ in\ km} * average\ car\ ownership = 40.92 * 4 * \left(\frac{14{,}360}{60{,}000}\right) * 0.481 = 18.84\ \ kg/person/year$
-
  - **Engine oil**: $emissions * \frac{Engine\ oil\ volume}{Engine\ oil\ durabililty} * average\ car\ ownership = 1.650 * \left(\frac{4}{1}\right) * 0.481 = 3.17\ \ kg/person/year$

- Maintenance:
    - **Maintenance:** $emissions * number\ of\ checks\ (normal\ maintenance) * average\ car\ ownership = 33.180 * 1 * 0.481 = 15.96\ \ kg/person/year$
-
- Fuel:
    - **Using average gasoline car**: $\frac{average\ travelled\ distance\ per\ year * petrol\ emission\ (wtw)}{average\ occupancy\ of\ passenger\ car} = \frac{14{,}360 * 0.168}{1.39} = 1730.8\ \ kg/person/year$
- Total:
    - **Total emissions:** $115.93 + 18.84 + 3.17 + 15.96 + 1730.8 = 1{,}884.7\ \ kg/person/year$

The environmental impact of the alternative option (shared car) is calculated in the same way. An important assumption is the 100% acceptance factor. In other words, we assume that all people will switch to the alternatives (in this example: sharing a car). It shows the maximum potential of alternatives to reduce the production of emissions and land use. The environmental impact of car sharing is derived from the effects on car ownership and the effects on car use. Additional key figures from literature are used to calculate these effects. This leads to the following calculation:

- Materials and production:
    - **Car**: $\left[\frac{emissions}{average\ car\ lifespan} * average\ car\ ownership\right] * (1 - Reduction\ in\ car\ ownership\ due\ to\ car\ sharing) = \left[\frac{43{,}38.35}{18} * 0.481\right] * (1 - 30\%) = 81.15\ \ kg/person/year$
-
    - **Tire**: $\left[emissions * number\ of\ car\ wheels * \frac{average\ travelled\ distance\ per\ year}{average\ car\ tire\ lifespan\ in\ km} * average\ car\ ownership\right] * (1 - Reduction\ in\ car\ ownership\ due\ to\ car\ sharing) = \left[40.92 * 4 * \left(\frac{14{,}360}{60{,}000}\right) * 0.481\right] * (1 - 30\%) = 13.19\ \ kg/person/year$

    - **Engine oil**: $\left[emissions * \frac{Engine\ oil\ volume}{Engine\ oil\ durabililty} * average\ car\ ownership\right] * (1 - Reduction\ in\ car\ ownership\ due\ to\ car\ sharing) = \left[1.650 * \left(\frac{4}{1}\right) * 0.481\right] * (1 - 30\%) = 2.22\ \ kg/person/year$
- Maintenance:
    - **Maintenance:** $[emissions * number\ of\ checks\ (normal\ maintenance) * average\ car\ ownership] * (1 - Reduction\ in\ car\ ownership\ due\ to\ car\ sharing) = [33.180 * 1 * 0.481] * (1 - 30\%) = 11.17\ kg/person/year$

- Fuel:
    - **Using shared car:** $\left[\frac{average\ travelled\ distance\ per\ year * petrol\ emission\ (wtw)}{average\ occupancy\ of\ passenger\ car}\right] * (1 - Reduction\ in\ car\ use\ due\ to\ car\ sharing) = 1{,}730.8 * (1 - 17\%) = 1{,}437\ \ kg/person/year$

- Total:
    - **Total emissions:** $81.15 + 13.19 + 2.22 + 11.17 + 1436.57 = 1{,}544\ \ kg/person/year$

3 Results

3.1 Holidays

3.1.1 Overview of Main Findings for Holidays

We assessed the CO_2 and GHG emissions and land use for six typical 'default trips' varying from a city trip to Berlin to a 22 days tour of Western USA. The carbon footprint of the trips ranged from 269 kg (Berlin city-trip) to 2782 kg (Western USA tour) per person per trip. Only two R-ladder options were identified: R0 (not consuming) and R2 (reduce). R0, stay at home, is very effective in all default trips and for all three indicators with reductions of between 90% and 96% for CO_2 emissions and GWP and reductions of 70-76% for Land Use. Reduce by switching to a closer destination or travel less often but stay longer can also be very effective for CO_2 emissions and GWP. For Land Use, in some cases switching transport mode has a negative impact of up to 24% more land use needed. Changing accommodation and transport mode is most effective - show the largest percentual reduction - for short-haul trips, while for long-haul trips such an accommodation shift reduces the total carbon footprint by less than 10%. Some detailed findings are:

- The most important determinant for the carbon footprint of holidays is the distance to the destination. High-footprint holidays invariably involve long-haul flights. Such trips can only shift substantially to more environmentally-friendly transport modes when distances between home and destination are reduced to less than some 1,000 km one-way.
- Changing transport modes is the second best option to reduce the CO_2 emissions. For a city trip from Amsterdam to Berlin, changing from car to bus or train provides a more than 40% reduction in emissions for the whole trip (i.e. transport plus accommodation emissions) and a more than 70% reduction in emissions, when only looking at transport emissions.
- Travelling less often but staying longer decreases emissions by between 25.5% and 41%.
- Staying at home decreases CO_2 emissions by between 89% and 96%, depending on the travel distance. While accommodation itself may sometimes have lower emissions than staying at home, the transport makes the difference.
- On average, accommodation choice has a smaller impact on CO_2 emissions than transport. However, for shorth aul trips, accommodation choice becomes more relevant. The tent has the lowest emissions of all accommodation types.
- The percentual differences in Global Warming Potential are similar to those in CO_2 emissions, because both the default and R-option GWP are calculated with the same constant GWP factor. This is not true when the transport mode is changed from aviation to another mode because aviation has a much higher GWP factor.
- For trips of over 3,000 km return distance, the land use of cars, buses and trains becomes much higher than the land use for flights. This is due to the fact that aircraft only need space for take-off and landing at airports and not for the distance in between.

3.1.2 How to read the tables

There are two kinds of tables for each default trip choice: (1) the circular options and reductions per trip (trip tables), and (2) the trip emissions per person per year (year tables) (Sections 3.2.3 – 3.2.8). The trip tables show the average emissions of the default trip choices and their alternatives. As mentioned previously, each default travel choice consists of six types (stay home, trip type, distance, length of stay, transport mode, accommodation type) in which always only one travel choice is changed within each alternative. Each of these alternatives are more circular than the default trips, hence they are also called circular options. The CO_2 emissions, GWP and Land Use needs of each circular option are given for transport, accommodation, and local transport separately as well as summed up for the trip.

The trip tables show two percentages of impact reduction. The 'Reduction for whole trip' refers to the emissions of the whole trip (therefore including transport between home and destination, accommodation, and local transport to main activity). For example, in cluster 1, choosing the train saves 42.9% of the trip's CO_2 emissions. This means that the total trip emissions are reduced by 42.9%. The 'Reduction for the changed trip element' refers to either transport or accommodation type. In the same example, the reduction for the trip element (here: transport) is 71.3%, meaning that the train emits 71.3% fewer CO_2 emissions per person than the car on this trip.

To determine the impact of each travel choice in the annual carbon footprint per person, the average number of trips taken per person per year was determined. The TL data (TL data 2017-2019) shows that the average number of trips per year differs greatly across trip types. Therefore, in addition to the number of beach trips taken per year by a tourist (number of beach trips/number of total trips), we also present how many beach trips are taken by tourists per year that are known to have taken at least one beach trip. As not all Dutch tourists take beach trips, the former emission calculation is therefore, although quantitatively correct, misleading. These factors were derived from dividing the number of, for example, beach trips by the number of unique respondents that took a beach trip. The emissions, GWP and Land Use of each travel choice are determined per person per year.

Table 5: Some general characteristics per main trip type

	Number of trips out of total	Number of trips, by trip type
Description	Number of trips of trip type divided by the total number of trips between 2017-2019	Number of trips of trip type divided by number of unique respondents who took this type of trip
Beach trip	14.4mln/119 mln = 12.1%	1.723 trips = 0.574 p.p.p.y.
Round trip	5.3mln/119mln = 4.5%	1.45 trips = 0.483 p.p.p.y.
City trip	15.3mln/119mln = 12.9%	1.942 trips = 0.647 p.p.p.y.
Total	100%	119 mln/24 mln = 4.841 trips = 1.614 p.p.p.y.

3.1.3 City Trip to Berlin

Table 6 provides an overview of the default option and R-ladder options for the city trip to Berlin. The first row provides the default option data. The following rows show the effects of the R-ladder options for each of the three indicators. Reduction percentages are presented in the columns of ‘Reduction for whole trip’ (referring to emissions of the whole trip) and ‘Reduction for the changed trip element’ (for the element of the trip that is changed). For example, for the ’Closer to home: Paris’ option, the overall emission reduction of the trip is 16.4%, based on the 269 kg CO_2 of the default trip, and the element of the trip that is reduced, the transport emissions of 139 kg, is reduced by 31.5%.
Table 6 shows that changing the transport mode is the most effective way to reduce CO_2 emissions for this specific trip. Although the travel distance of this trip is relatively low, opting for a more sustainable transport mode, such as the bus or train, still reduces emissions more (42.9 to 48.1% CO_2 reduction on the whole trip) than opting for a more sustainable accommodation type would (2.4 to 24.7 % CO_2 reduction on the whole trip). The CO_{2eq} and land use show similar results, apart from the slightly higher land use when taking a train, which can be attributed to more local transportation.

Table 6: Impacts per trip - default option Berlin city trip (car, hotel, 2 persons, 4 days)

Sub-function level 2	R-strategy	Circular option	Travel distance (km)	CO2 emissions (kg) - TL				Reduction for whole trip	Reduction for the changed trip element	GWP (kg CO2eq) - EAP				Reduction for whole trip	Reduction for the changed trip element	Land use (m^2) - EAP				Reduction for whole trip	Reduction for the changed trip element
				Transport	Accommodation	Local transport	Trip			Transport	Accommodation	Local transport	Trip			Transport	Accommodation	Local transport	Trip		
Default option	None	Car & hotel	1,160	139	82	47	269			150	94	51	295			3.42	9.38	1.16	13.96		
Destination choice	R0	Stay at home*	0		30		30	89.0%		0	30	0	30	89.7%		0.00	3.38	0.00	3.38	75.8%	
	R0, R2	Closer to home: Paris	798	95	82	47	225	16.4%	31.5%	103	94	51	248	16.1%	31.5%	2.34	9.38	1.16	12.88	7.7%	31.5%
	R0, R2	Closer to home: Brussels	316	38	82	47	167	37.8%	72.9%	41	94	51	185	37.2%	72.9%	0.93	9.38	1.16	11.46	17.9%	72.9%

Sub-function level 2	R-strategy	Circular option	Travel distance (km)	CO2 emissions (kg) - TL				Reduction for whole trip	Reduction for the changed trip element	GWP (kg CO2eq) - EAP				Reduction for whole trip	Reduction for the changed trip element	Land use (m²) - EAP				Reduction for whole trip	Reduction for the changed trip element
				Transport	Accommodation	Local transport	Trip			Transport	Accommodation	Local transport	Trip			Transport	Accommodation	Local transport	Trip		
Transport	R2	Travel by train		40	82	31	154	42.9%	71.3%	43	94	34	171	42.2%	71.3%	2.90	9.38	2.27	14.54	-4.2%	15.1%
	R2	Travel by bus		26	82	31	140	48.1%	81.1%	29	94	33	156	47.3%	81.0%	1.92	9.38	0.76	12.05	13.7%	44.0%
	R0, R2	Travel less often but longer*		139	165	94	399	25.9%		150	188	102	440	25.5%		3.42	18.75	2.32	24.49	12.3%	
Accommodation	R2	Apartment		139	76	47	263	2.4%	7.8%	150	86	51	288	2.5%	7.8%	3.42	8.65	1.16	13.23	5.2%	7.8%
	R2	Private home		139	16	47	203	24.7%	80.6%	150	18	51	220	25.6%	80.6%	3.42	1.82	1.16	6.40	54.1%	80.6%
	R2	Staying with family or friends*		139	16	47	203	24.7%	80.6%	150	18	51	220	25.6%	80.6%	3.42	1.82	1.16	6.40	54.1%	80.6%
	R2	Guesthouse/B&B*		139	32	47	218	18.9%	61.7%	150	36	51	237	19.6%	61.7%	3.42	3.60	1.16	8.18	41.4%	61.7%

**) Indicates that the alternative is not found in the data set, but is deemed a reasonable alternative to the default trip*

The 14.3 million city trips between 2017 and 2019 were undertaken by 7.89 million different travellers. This means that in this period the average city tripper took 1.9 city trips, which is 0.65 city trips per year. This factor was used to derive the 'per city tripper/year' figures. City trips make up 12.9% of the total Dutch travel market. Therefore, this factor was used to derive the figures of 'per tourist/year' in the third column of each topic. The difference between 'per city tripper/year' and 'per tourist/year' are described in Table 7.

Table 7: Impacts per person per year - default option Berlin city trip (car, hotel, 2 persons, 4 days)

Sub-function level 2	R-strategy	Circular option	CO2 emissions (kg)			GWP (kg CO2eq)			Land Use (m²)		
			per trip	per city tripper/year	per tourist/year	per trip	per city tripper/year	per tourist/year	per trip	per city tripper/year	per tourist/year
Default option	None	Car & hotel	269	174.1	34.70	295	174.1	38.07	13.96	9.03	1.80
Destination choice	R0	Stay at home*	30	19.2	3.82	30	174.1	3.93	3.38	2.19	0.44
	R0, R2	Closer to home: Paris	225	145.6	29.02	248	174.1	31.95	12.88	8.33	1.66
	R0, R2	Closer to home: Brussels	167	108.3	21.59	185	174.1	23.92	11.46	7.42	1.48
Transport	R2	Travel by train	154	99.4	19.82	171	174.1	22.02	14.54	9.41	1.88
	R2	Travel by bus	140	90.3	18.01	156	174.1	20.06	12.05	7.80	1.55
	R0, R2	Travel less often but longer*	399	257.9	51.43	440	174.1	56.75	24.49	15.85	3.16
Accommodation	R2	Apartment	263	169.9	33.88	288	174.1	37.13	13.23	8.56	1.71
	R2	Private home	203	131.1	26.14	220	174.1	28.33	6.40	4.14	0.83
	R2	Staying with Family or Friends*	203	131.1	26.14	220	174.1	28.33	6.40	4.14	0.83
	R2	Guesthouse/B&B*	218	141.2	28.15	237	174.1	30.62	8.18	5.29	1.05

**) Indicates that the alternative is not found in the data set, but is deemed a reasonable alternative to the default trip*

3.1.4 City Trip to Dubai

Table 8 shows that changing the destination to one close by is the most effective way to reduce emissions. Due to Dubai's location, no alternative transport modes are included in this table. The long-haul character of this default trip makes for a relatively small impact of switches in accommodation type, where the reduction of $CO_{2(eq)}$ is below 10% over the whole trip. However, switching from a hotel to a private home reduces the whole trip's land use by 55.6%.

Table 8: Impacts per trip - default option Dubai city trip (plane, hotel, 2 persons, 8 days)

Sub-function level 2	R-strategy	Circular option	Travel distance (km)	CO2 emissions (kg) - TL				Reduction for whole trip	Reduction for the changed trip element	GWP (kg CO2eq) - EAP				Reduction for whole trip	Reduction for the changed trip element	Land use (m^2) - EAP				Reduction for whole trip	Reduction for the changed trip element
				Transport	Accommodation	Local transport	Trip			Transport	Accommodation	Local transport	Trip			Transport	Accommodation	Local transport	Trip		
Default option	None	Plane & hotel	10,340	1,241	165	86	1492			1261	188	93	1541			6.32	18.75	2.12	27.19		
Destination choice	R0	Stay at home		0	59	0	59	96.0%		0	61	0	61	96.0%		0.00	6.75	0.00	6.75	75.2%	
	R0, R2	Closer to home: Casablanca	4,460	516	165	86	767	48.6%	58.4%	524	188	93	805	47.8%	58.4%	2.63	18.75	2.12	23.50	13.6%	58.4%
	R0, R2	Closer to home: Brussels	316	38	82	47	167	88.8%	97.0%	38	94	51	183	88.1%	97.0%	0.19	9.38	1.16	10.73	60.5%	97.0%
Transport	R0, R2	Travel less often but longer		1,241	330	172	1,743	41.6%		1,261	375	186	1,822	40.9%		6.32	37.50	4.23	48.05	11.6%	
Accommodation	R2	Apartment*		1,241	152	86	1,480	0.9%	7.8%	1,261	173	93	1,527	0.9%	7.8%	6.32	17.29	2.12	25.73	5.4%	7.8%
	R2	Private home*		1,241	32	86	1,360	8.9%	80.6%	1,261	36	93	1,390	9.8%	80.6%	6.32	3.64	2.12	12.08	55.6%	80.6%

**) Indicates that the alternative is not found in the data set, but is deemed a reasonable alternative to the default trip*

Like the first default trip, the 15.3 million city trips between 2017 and 2019 were undertaken by 7.89 million different travellers. This means that in this period the average city tripper took 1.9 city trips, which is 0.65 city trips per year. This factor was used to derive the 'per city tripper/year' figures. City trips make up 12.9% of the total Dutch travel market. Therefore, this factor was used to derive the figures of 'per tourist/year' in the third column of each topic. The difference between 'per city tripper/year' and 'per tourist/year' are described in Table 9.

Table 9: Impacts per person per year - default option Dubai city trip (plane, hotel, 2 persons, 8 days)

Sub-function level 2	R-strategy	Circular option	CO2 emissions (kg)			GWP (kg CO2eq)			Land Use (m²)		
			per trip	per city tripper/year	per tourist/year	per trip	per city tripper/year	per tourist/year	per trip	per city tripper/year	per tourist/year
Default option	None	Plane & hotel	1,492	965.6	192.5	1541	997.2	198.82	27.19	17.59	3.51
Destination choice	R0	Stay at home	59	38.2	7.6	61	39.4	7.86	6.75	4.37	0.87
	R0, R2	Closer to home: Casablanca	767	496.4	99.0	805	520.7	103.82	23.50	15.20	3.03
	R0, R2	Closer to home: Brussels	167	108.3	21.6	183	118.4	23.61	10.73	6.94	1.38
Transport	R0, R2	Travel less often but longer	1,743	1,128.0	224.9	1,822	1,178.7	235.01	48.05	31.09	6.20
Accommodation	R2	Apartment*	1,480	957.4	190.9	1,527	987.8	196.94	25.73	16.65	3.32
	R2	Private home*	1,360	879.7	175.4	1,390	899.4	179.32	12.08	7.81	1.56

**) Indicates that the alternative is not found in the data set, but is deemed a reasonable alternative to the default trip*

3.1.5 Beach Holiday at the Costa Blanca, Spain

Table 10 again shows a relatively high impact of transport on emissions. Travelling to the Costa Blanca by bus rather than plane reduces the CO_2 emissions and equivalents by around 50%. However, these reductions are significantly smaller when opting for a car rather than an airplane (2.6% CO_2 reduction on the whole trip). In terms of CO_{2eq} and land use the alternative option of the car is in fact less favourable, due to additional non-CO_2 emissions and extra road needed for such a trip (as runways for short-haul and long-haul do not differ much, if at all). Since transportation emissions play a smaller role in short-haul travel than long-haul travel, emission reduction percentages of accommodation choices are relatively high for the alternatives in this default trip. Land use reductions of these alternatives are even higher (6.5% when switching to an apartment to 75.6% when opting for a tent).

Table 10: Impacts per trip - default option of Beach Holiday at the Costa Blanca, Spain (plane, hotel, 2 persons, 8 days)

Sub-function level 2	R-strategy	Circular option	Travel distance (km)	CO2 emissions (kg) - TL				Reduction for whole trip	Reduction for the changed trip element	GWP (kg CO2eq) - EAP				Reduction for whole trip	Reduction for the changed trip element	Land use (m²) - EAP				Reduction for whole trip	Reduction for the changed trip element
				Transport	Accommodation	Local transport	Trip			Transport	Accommodation	Local transport	Trip			Transport	Accommodation	Local transport	Trip		
Default option	None	Plane & hotel	3,226	406	165	64	634			412	188	69	668			2.07	18.75	1.56	22.38		
Destination choice	R0	Stay at home		0	59	0	59	90.7%		0	61	0	61	90.9%		0.00	6.75	0.00	6.75	69.8%	
	R0, R2	Closer to home: Costa Brava	2,482	350	165	64	579	8.7%	13.7%	355	188	69	612	8.4%	13.7%	1.78	18.75	1.57	22.11	1.2%	13.7%
	R0, R2	Closer to home: Tuscany	2,118	291	165	64	520	18.1%	28.2%	296	188	69	552	17.4%	28.2%	1.48	18.75	1.56	21.80	2.6%	28.2%
Transport	R1	Travel by car*		390	165	64	618	2.6%	4.0%	420	188	69	677	-1.2%	-2.0%	9.56	18.75	1.56	29.88	-33.5%	-362.9%
	R2	Travel by bus*		73	165	64	302	52.4%	81.9%	79	188	69	336	49.8%	80.7%	5.33	18.75	1.56	25.65	-14.6%	-158.2%
	R0, R2	Travel less often but longer		406	330	127	863	32.0%		412	375	137	925	30.8%		2.07	37.50	3.13	42.69	4.6%	

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Sub-function level 2	R-strategy	Circular option	Travel distance (km)	CO2 emissions (kg) - TL				Reduction for whole trip	Reduction for the changed trip element	GWP (kg CO2eq) - EAP				Reduction for whole trip	Reduction for the changed trip element	Land use (m²) - EAP				Reduction for whole trip	Reduction for the changed trip element
				Transport	Accommodation	Local transport	Trip			Transport	Accommodation	Local transport	Trip			Transport	Accommodation	Local transport	Trip		
Accommodation	R2	Apartment		406	152	64	622	2.0%	7.8%	412	173	69	654	2.2%	7.8%	2.07	17.29	1.56	20.92	6.5%	7.8%
	R2	Private home		406	32	64	502	20.9%	80.6%	412	36	69	517	22.6%	80.6%	2.07	3.64	1.56	7.27	67.5%	80.6%
	R2	Home of family or friends		406	32	64	502	20.9%	80.6%	412	36	69	517	22.6%	80.6%	2.07	3.64	1.56	7.27	67.5%	80.6%
	R2	Caravan*		406	114	64	584	7.9%	30.6%	412	130	69	611	8.6%	30.6%	2.07	13.02	1.56	16.65	25.6%	30.6%
	R2	Tent*		406	16	64	486	23.5%	90.3%	412	18	69	499	25.3%	90.3%	2.07	1.82	1.56	5.45	75.6%	90.3%

**) Indicates that the alternative is not found in the data set, but is deemed a reasonable alternative to the default trip*

The 14.4 million beach trips between 2017 and 2019 were undertaken by 8.36 million different travellers. This means that in this period the average beach tripper took 1.7 beach trips, which is 0.57 beach trips per year. This factor was used to derive the 'per beach tripper/year' figures. Beach trips make up 12.1 per cent of the total Dutch travel market. Therefore, this factor was used to derive the figures of 'per tourist/year' in the third column of each topic. The difference between 'per beach tripper/year' and 'per tourist/year' are described in Table 11.

Table 11: Impacts per person per year - default option of Beach Holiday at the Costa Blanca, Spain (plane, hotel, 2 persons, 8 days)

Sub-function level 2	R-strategy	Circular option	CO2 emissions (kg)			GWP (kg CO2eq)			Land Use (m²)		
			per trip	per beach tripper/year	per tourist/year	per trip	per beach tripper/year	per tourist/year	per trip	per beach tripper/year	per tourist/year
Default option	None	Plane & hotel	634	410.4	76.8	668	432.4	80.87	22.38	14.48	2.71

Sub-function level 2	R-strategy	Circular option	CO2 emissions (kg)			GWP (kg CO2eq)			Land Use (m²)		
			per trip	per beach tripper/year	per tourist/year	per trip	per beach tripper/year	per tourist/year	per trip	per beach tripper/year	per tourist/year
Destination choice	R0	Stay at home	59	38.2	7.1	61	39.4	7.37	6.75	4.37	0.82
	R0, R2	Closer to home: Costa Brava	579	374.6	70.1	612	396.1	74.07	22.11	14.30	2.67
	R0, R2	Closer to home: Tuscany	520	336.3	62.9	552	357.2	66.80	21.80	14.10	2.64
Transport	R1	Travel by car*	618	399.9	74.8	677	437.7	81.87	29.88	19.33	3.62
	R2	Travel by bus*	302	195.4	36.5	336	217.1	40.61	25.65	16.59	3.10
	R0, R2	Travel less often but longer	863	558.2	104.4	925	598.2	111.88	42.69	27.62	5.17
Accommodation	R2	Apartment	622	402.1	75.2	654	423.0	79.11	20.92	13.54	2.53
	R2	Private home	502	324.5	60.7	517	334.6	62.58	7.27	4.70	0.88
	R2	Home of family or friends	502	324.5	60.7	517	334.6	62.58	7.27	4.70	0.88
	R2	Caravan*	584	377.8	70.7	611	395.3	73.93	16.65	10.77	2.01
	R2	Tent*	486	314.1	58.7	499	322.9	60.38	5.45	3.53	0.66

**) Indicates that the alternative is not found in the data set, but is deemed a reasonable alternative to the default trip*

3.1.6 Beach Holiday in Antalya, Turkey

It is interesting to observe that, although technically possible, travelling by car is less sustainable than going by airplane (see Table 12). As emissions are calculated not only based on driving emissions, but also the emissions of car maintenance, they exceed the air travel emissions. The only effective alternatives from the transport perspective are therefore the coach or staying at a destination closer to home. Opting for alternative accommodation types only slightly reduces the $CO_{2(eq)}$ emissions of the trip (around 17% maximum), but it reduces land use by a lot more (up to 72.1%). Since land use for trips by plane is only slightly dependent on the distance of the trip, compared to other transport modes, there are increases in land use for alternative transport modes.

Table 12: Impacts per trip - default option of Beach Holiday in Antalya, Turkey (plane, hotel, 2 persons, 8 days)

Sub-function level 2	R-strategy	Circular option	Travel distance (km)	CO2 emissions (kg) - TL				Reduction for whole trip	Reduction for the changed trip element	GWP (kg CO2eq) - EAP				Reduction for whole trip	Reduction for the changed trip element	Land use (m²) - EAP				Reduction for whole trip	Reduction for the changed trip element
				Transport	Accommodation	Local transport	Trip			Transport	Accommodation	Local transport	Trip			Transport	Accommodation	Local transport	Trip		
Default option	None	Air	5,316	619	165	64	848			629	188	69	886			3.15	18.75	1.57	23.48		
Destination choice	R0	Stay at home		0	59	0	59	93.0%		0	61	0	61	93.1%		0.00	6.75	0.00	6.75	71.2%	
	R0, R2	Closer to home: Greece	4,368	505	165	64	734	13.5%	18.4%	513	188	69	770	13.1%	18.4%	2.57	18.75	1.57	22.90	2.5%	18.4%
	R0, R2	Closer to home: Costa Blanca	3,226	406	165	64	635	25.2%	34.5%	412	188	69	669	24.5%	34.5%	2.07	18.75	1.57	22.39	4.6%	34.5%
Transport	R1	Travel by car*		642	165	64	871	-2.7%	-3.6%	693	188	69	949	-7.2%	-10.1%	15.76	18.75	1.57	36.08	-53.7%	-399.8%
	R2	Travel by bus*		121	165	64	350	58.7%	80.5%	131	188	69	387	56.2%	79.2%	8.79	18.75	1.57	29.11	-24.0%	-178.8%
	R0, R2	Travel less often but longer		619	330	128	1077	36.5%		629	375	138	1142	35.5%		3.15	37.50	3.15	43.80	6.7%	
Accommodation	R2	Apartment		619	152	64	835	1.5%	7.8%	629	173	69	871	1.6%	7.8%	3.15	17.29	1.57	22.02	6.2%	7.8%
	R2	Bungalow*		619	127	64	811	4.4%	22.8%	629	145	69	843	4.8%	22.8%	3.15	14.47	1.57	19.20	18.2%	22.8%
	R2	Caravan*		619	127	64	811	4.4%	22.8%	629	145	69	843	4.8%	22.8%	3.15	14.47	1.57	19.20	18.2%	22.8%
	R2	Staying with family or friends*		619	32	64	715	15.7%	80.6%	629	36	69	735	17.1%	80.6%	3.15	3.64	1.57	8.37	64.4%	80.6%
	R2	Private home*		619	32	64	715	15.7%	80.6%	629	36	69	735	17.1%	80.6%	3.15	3.64	1.57	8.37	64.4%	80.6%
	R2	Tent*		619	16	64	699	17.5%	90.3%	629	18	69	716	19.1%	90.3%	3.15	1.82	1.57	6.55	72.1%	90.3%

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**) Indicates that the alternative is not found in the data set, but is deemed a reasonable alternative to the default trip*

The 14.4 million beach trips between 2017 and 2019 were undertaken by 8.36 million different travellers. This means that in this period the average beach tripper took 1.7 beach trips, which is 0.57 beach trips per year. This factor was used to derive the 'per beach tripper/year' figures. Beach trips make up 12.1 per cent of the total Dutch travel market. Therefore, this factor was used to derive the figures of 'per tourist/year' in the third column of each topic. The difference between 'per beach tripper/year' and 'per tourist/year' are described in Table 13.

Table 13: Impacts per person per year - default option of Beach Holiday in Antalya, Turkey (plane, hotel, 2 persons, 8 days)

Sub-function level 2	R-strategy	Circular option	CO2 emissions (kg)			GWP (kg CO2eq)			Land Use (m²)		
			per trip	per beach tripper/year	per tourist/year	per trip	per beach tripper/year	per tourist/year	per trip	per beach tripper/year	per tourist/year
Default option	None	Air	848	548.8	102.6	885.6	573.0	107.2	23.5	15.2	2.84
Destination choice	R0	Stay home	59	38.2	7.1	61	39.4	7.4	6.75	4.37	0.82
	R0, R2	Closer to home: Greece	734	475.0	88.8	770	498.0	93.1	22.90	14.81	2.77
	R0, R2	Closer to home: Costa Blanca	635	410.7	76.8	669	432.7	80.9	22.39	14.49	2.71
Transport	R1	Travel by car*	871	563.4	105.4	949	614.2	114.9	36.08	23.35	4.37
	R2	Travel by bus*	350	226.4	42.3	387	250.7	46.9	29.11	18.84	3.52
	R0, R2	Travel less often but longer	1077	696.9	130.3	1142	739.1	138.2	43.80	28.34	5.30
Accommodation	R2	Apartment	835	540.5	101.1	871	563.6	105.4	22.02	14.25	2.66
	R2	Bungalow*	811	524.5	98.1	843	545.3	102.0	19.20	12.42	2.32
	R2	Caravan*	811	524.5	98.1	843	545.3	102.0	19.20	12.42	2.32
	R2	Staying with family or friends*	715	462.9	86.6	735	475.2	88.9	8.37	5.41	1.01
	R2	Private home*	715	462.9	86.6	735	475.2	88.9	8.37	5.41	1.01
	R2	Tent*	699	452.5	84.6	716	463.4	86.7	6.55	4.24	0.79

**) Indicates that the alternative is not found in the data set, but is deemed a reasonable alternative to the default trip*

3.1.7 Beach Holiday in Curacao

As alternative transport modes to Curacao are not realistic, they were excluded from this study. Table 14 clearly shows the importance of transportation in emissions. Opting for a more nearby destination can reduce emissions by more than half (57.3% to 66.8% of the whole trip). Due to the long-haul character of the trip, the emission reductions of the whole trip due to alternative accommodation types are small (maximum of 9.9%), whereas the reductions within the trip part are substantial (up to 90.3% $CO_{2(eq)}$ reduction when opting for a tent). Another observation from the table is that all alternative options lead to reductions on all three topics. Moreover, due to the relatively high emissions of this trip, even small percentual reductions lead to substantial reductions in absolute terms (e.g. a minimum of 58 kg CO_2 or 64 kg CO_{2eq} reduction when choosing a bungalow or 2.19 m^2 reduction in land use when opting for an apartment).

Table 14: Impacts per Trip - default option of Beach Holiday in Curacao (plane, hotel, 2 persons, 12 days)

Sub-function level 2	R-strategy	Circular option	Travel distance (km)	CO2 emissions (kg) - TL				Reduction for whole trip	Reduction for the changed trip element	GWP (kg CO2eq) - EAP				Reduction for whole trip	Reduction for the changed trip element	Land use (m²) - EAP				Reduction for whole trip	Reduction for the changed trip element
				Transport	Accommodation	Local transport	Trip			Transport	Accommodation	Local transport	Trip			Transport	Accommodation	Local transport	Trip		
Default option	None	Air	15,674	1913	247	96	2256			1,943	281	104	2328			9.74	28.13	2.36	40.23		
Destination choice	R0	Stay at home		0	89	0	89	96.1%		0	91	0	91	96.1%		0.00	10.13	0.00	10.13	74.8%	
	R0, R2	Closer to home: Antalya	5316	619	247	96	963	57.3%	67.6%	629	281	104	1014	56.4%	67.6%	3.15	28.13	2.36	33.64	16.4%	67.6%
	R0, R2	Closer to home: Costa Blanca	3226	406	247	96	749	66.8%	78.8%	412	281	104	797	65.8%	78.8%	2.07	28.13	2.36	32.55	19.1%	78.8%
Transport	R0, R2	Travel less often but longer		1,913	494	192	2,600	42.4%		1,943	563	207	2,713	41.7%		9.74	56.25	4.72	70.71	12.1%	

Sub-function level 2	R-strategy	Circular option	Travel distance (km)	CO2 emissions (kg) - TL				Reduction for whole trip	Reduction for the changed trip element	GWP (kg CO2eq) - EAP				Reduction for whole trip	Reduction for the changed trip element	Land use (m²) - EAP				Reduction for whole trip	Reduction for the changed trip element
				Transport	Accommodation	Local transport	Trip			Transport	Accommodation	Local transport	Trip			Transport	Accommodation	Local transport	Trip		
Accommodation	R2	Apartment*		1,913	228	96	2,237	0.9%	7.8%	1,943	259	104	2,306	0.9%	7.8%	9.74	25.94	2.36	38.04	5.4%	7.8%
	R2	Staying with family or friends*		1,913	48	96	2,057	8.8%	80.6%	1,943	55	104	2,101	9.7%	80.6%	9.74	5.46	2.36	17.56	56.3%	80.6%
	R2	Bungalow*		1,913	191	96	2,200	2.5%	22.8%	1,943	217	104	2,263	2.8%	22.8%	9.74	21.71	2.36	33.81	16.0%	22.8%
	R2	Tent*		1,913	24	96	2,033	9.9%	90.3%	1,943	27	104	2,074	10.9%	90.3%	9.74	2.73	2.36	14.83	63.1%	90.3%

**) Indicates that the alternative is not found in the data set, but is deemed a reasonable alternative to the default trip*

The 14.4 million beach trips between 2017 and 2019 were undertaken by 8.36 million different travellers. This means that in this period the average beach tripper took 1.7 beach trips, which is 0.57 beach trips per year. This factor was used to derive the 'per beach tripper/year' figures. Beach trips make up 12.1 per cent of the total Dutch travel market. Therefore, this factor was used to derive the figures of 'per tourist/year' in the third column of each topic. The difference between 'per beach tripper/year' and 'per tourist/year' are described in Table 15.

Table 15: Impacts per person per year - default option of Beach Holiday in Curacao (plane, hotel, 2 persons, 12 days)

Sub-function level 2	R-strategy	Circular option	CO2 emissions (kg)			GWP (kg CO2eq)			Land Use (m²)		
			per trip	per beach tripper/year	per tourist/year	per trip	per beach tripper/year	per tourist/year	per trip	per beach tripper/year	per tourist/year
Default option	None	Air	2,256	1,460	273.0	2328	1506	281.6	40.23	26.03	4.87

Sub-function level 2	R-strategy	Circular option	CO2 emissions (kg)			GWP (kg CO2eq)			Land Use (m²)		
			per trip	per beach tripper/year	per tourist/year	per trip	per beach tripper/year	per tourist/year	per trip	per beach tripper/year	per tourist/year
Destination choice	R0	Stay at home	59	38.2	7.1	91	59.1	11.1	10.13	6.56	1.23
	R0, R2	Closer to home: Antalya	963	622.7	116.5	1014	655.9	122.7	33.64	21.76	4.07
	R0, R2	Closer to home: Costa Blanca	749	484.7	90.6	797	515.8	96.5	32.55	21.06	3.94
Transport	R0, R2	Travel less often but longer	2,600	1,682.0	314.6	2,713	1,755.1	328.2	70.71	45.75	8.56
Accommodation	R2	Apartment*	2,237	1,447.4	270.7	2,306	1,491.9	279.0	38.04	24.61	4.60
	R2	Staying with family or friends*	2,057	1,331.0	248.9	2,101	1,359.3	254.2	17.56	11.36	2.12
	R2	Bungalow*	2,200	1,423.4	266.2	2,263	1,464.5	273.9	33.81	21.87	4.09
	R2	Tent*	2,033	1,315.4	246.0	2,074	1,341.6	250.9	14.83	9.59	1.79

**) Indicates that the alternative is not found in the data set, but is deemed a reasonable alternative to the default trip*

3.1.8 Touring though Western USA

As alternative transport modes to the United States are not realistic, they were excluded from this study. Unsurprisingly, the biggest absolute and relative reductions come from alternative destination choices (see Table 16). Reductions range from 18.6% when going to Canada, to 49.0% when going to Andalucía, which would also be accessible by other transport modes. Similar to the previous default trip (Section 3.2.7), both absolute and relative reductions have a substantial impact.

Table 16: Impacts per Trip - default option of Touring through Western USA (plane, hotel, 2 persons, 22 days)

Sub-function level 2	R-strategy	Circular option	Travel distance (km)	CO2 emissions (kg) - TL				Reduction for whole trip	Reduction for the changed trip element	GWP (kg CO2eq) - EAP				Reduction for whole trip	Reduction for the changed trip element	Land use (m²) - EAP				Reduction for whole trip	Reduction for the changed trip element
				Transport	Accommodation	Local transport	Trip			Transport	Accommodation	Local transport	Trip			Transport	Accommodation	Local transport	Trip		
Default option	None	Air	15,106	1,842	453	486	2782			1871	516	525	2911			9.38	51.57	11.94	72.88		
Destination choice	R0	Stay at home		0	163	0	163	94.1%		0	167	0	167	94.2%		0.00	18.58	0.00	18.58	74.5%	
	R0, R2	Closer to home: Canada	11,000	1,324	453	486	2,264	18.6%	28.1%	1,345	516	525	2,385	18.1%	28.1%	6.74	51.57	11.94	70.25	3.6%	28.1%
	R0, R2	Closer to home: Andalusia	3,704	478	453	486	1,418	49.0%	74.0%	486	516	525	1,526	47.6%	74.0%	2.43	51.57	11.94	65.94	9.5%	74.0%
Transport	R0, R2	Travel less often but longer		1,842	906	973	3,721	33.1%		1,871	1032	1049	3,952	32.1%		9.38	103.1	23.88	136.4	6.4%	
Accommodation	R2	Apartment		1,842	418	486	2,747	1.3%	7.8%	1,871	476	525	2,871	1.4%	7.8%	9.38	47.56	11.94	68.88	5.5%	7.8%
	R2	Guesthouse/B&B*		1,842	172	486	2,500	10.1%	62.1%	1,871	195	525	2,591	11.0%	62.1%	9.38	19.52	11.94	40.84	44.0%	62.1%
	R2	Caravan*		1,842	350	486	2,679	3.7%	22.8%	1,871	398	525	2,794	4.0%	22.8%	9.38	39.80	11.94	61.12	16.1%	22.8%
	R2	Family and Friends*		1,842	88	486	2,417	13.1%	80.6%	1,871	100	525	2,496	14.3%	80.6%	9.38	10.01	11.94	31.33	57.0%	80.6%
	R2	Tent*		1,842	44	486	2,373	14.7%	90.3%	1,871	50	525	2,446	16.0%	90.3%	9.38	5.01	11.94	26.33	63.9%	90.3%

*) Indicates that the alternative is not found in the data set, but is deemed a reasonable alternative to the default trip

The 5.3 million round trips between 2017 and 2019 were undertaken by 3.69 million different travellers. This means that in this period the average round tripper took 1.45 round trips, which is 0.48 round trips per year. This factor was used to derive the 'per round tripper/year' figures. Round trips make up 4.5 per cent of the total Dutch travel market. Therefore, this factor was used to derive the figures of 'per tourist/year' in the third column of each topic. The difference between 'per round tripper/year' and 'per tourist/year' are described in Table 17.

Table 17: Impacts per person per year - Default option Touring through Western USA: plane, hotel, 2 persons, 22 days

Sub-function level 2	R-strategy	Circular option	CO2 emissions (kg)			GWP (kg CO2eq)			Land Use (m²)		
			per trip	per round tripper/year	per tourist/year	per trip	per round tripper/year	per tourist/year	per trip	per round tripper/year	per tourist/year
Default option	None	Air	2,782	1,344	125.2	2,911	1,406	131.0	72.88	35.20	3.28
Destination choice	R0	Stay home	59	28.5	2.7	167	80.9	7.5	18.58	8.97	0.84
	R0, R2	Closer to home: Canada	2,264	1,093	101.9	2,385	1,152	107.3	70.25	33.93	3.16
	R0, R2	Closer to home: Andalusia	1,418	684.8	63.8	1,526	737.1	68.7	65.94	31.85	2.97
Transport	R0, R2	Travel less often but longer	3,721	1,797.5	167.5	3,952	1,909	177.8	136.4	65.88	6.14
Accommodation	R2	Apartment	2,747	1,326.7	123.6	2,871	1,387	129.2	68.88	33.27	3.10
	R2	Guesthouse/B&B*	2,500	1,207.7	112.5	2,591	1,251.4	116.6	40.84	19.73	1.84
	R2	Caravan*	2,679	1,293.7	120.5	2,794	1,349.4	125.7	61.12	29.52	2.75
	R2	Family and Friends*	2,417	1,167.3	108.8	2,496	1,205.5	112.3	31.33	15.13	1.41
	R2	Tent*	2,373	1,146.0	106.8	2,446	1,181.3	110.1	26.33	12.72	1.18

*) Indicates that the alternative is not found in the data set, but is deemed a reasonable alternative to the default trip

3.2 Mobility

3.2.1 Overview of Findings

Findings of mobility circular options are categorised into two main group (Figure 2): a) circular options in mode choice for trip purposes and, b) circular options for buying new vehicles. A general note is that based on the calculations, the order of effects and importance of options/alternatives in producing CO_2 emission and GWP are the same, whereas effects for land use differ across options.
Background data, including the frequency and kilometres travelled and reasonable distances for walking, cycling and public transport for the different trip purposes are available in appendix 4 (Table A 4 to Table A 7) and the base values and underlying assumptions for the following result tables, are shown in Table 4. The basis of all calculations in this section is distance travelled by car per year for each trip purpose. These values were calculated using the ODiN database.
As mentioned previously, in the mobility part of the method section (Section 2.3.4), the acceptance factor of proposed mobility alternatives is 100%. This means that all calculations and results of the alternatives for trip purposes and buying new vehicle, are based on the assumption that 100% of the respondents will shift to the behaviour in the alternative circular option.

a) Circular options in mode choice for trip purposes

- In general, the reduction in emissions is highest for shopping and visiting trips. The absolute impact for sports/hobbies and tour trips is more limited due to the smaller number of kilometres travelled by car for these purposes.
- For shopping trips, the highest reductions can be achieved by reducing trip frequencies and choosing closer destinations. The highest reduction percentage is related to the ’online shopping’ option with a 70% reduction in emission production and land use. Furthermore, choosing closer destinations has a significant reduction potential (42%-49%) The effects of the ‘changing mode to bike/walk’ options is fairly small (11% / 2%) as only short-distance car trips are substituted by bike and walking trips.
- For visiting trips, the large absolute reduction in emissions stems from the high number of kilometres travelled for this purpose. The option of ’changing mode to public transport’ for visiting trips has the highest absolute reduction in CO2 and GWP.
- Looking at the impact of the different options across all trip purposes, the ’changing mode to public transport’ and ’closer destination’ options show the highest reduction in emissions. For ’changing mode to public transport’ the impact ranges between 30% and 39%. This is considerably more compared to the impact of the walking and cycling options as public transport (potentially) also enables substitution of larger distance car trips. ’Closer destination’ options also have significant effects on reducing emission production and land use. The share of reduction in emission production for these alternatives ranges between 40% and 54%.

b1) Circular options for buying new car

- Among the options for buying a new car, switching to ’public transport’ has the highest effect in terms of reduction of emission production (85%).
- The impact of the ’good maintenance’ option is limited. As the effect of lower fuel efficiency of older cars is not taken into account, this option does not seem very promising.
- While the ’electric car’ is the second-best option in emission reduction by around 45%, switching to this option will increase land use by 130%.
- In comparison between ’shared car’ and ’smaller car’, the latter is slightly more effective in the reduction of emission production and land use.
- Regarding the ’parking’ part in ’land use’ measure, only switching to ’public transport’ and ’shared car’ could decrease the need for parking, by 100% and 30% respectively. In the other alternatives, because the number of cars used does not change, land use for parking does not change either.

b2) Circular options for buying new bike

- The circular options for buying a new bike are limited, because buying a sustainable mode of transport (bike) can hardly be improved by the other options. However, the effect of a 'shared bike' scheme is significantly higher than the 'good maintenance' option. The 'shared bike' could decrease emission production and land use by 30%, whereas the effect of the other option is less than 10%.

3.2.2 Circular Options in Mode Choice for Trip Purposes

The detailed results of the circular options for trip purposes are included in Table 18 to Table 21. These tables consist of three parts describing the results for CO_2, GWP and land use respectively. In each part, the first row describes the emissions for the base option; using the car. The subsequent rows describe the emissions of the alternative options. The third column reveals the distance travelled by car for each option. Comparing the distance travelled for the base option and the circular option reveals the extent to which the alternative option substitutes car driving. The effect of this substitution on emissions and land use is displayed in the columns of 'car effect' and 'alternative effect'. The first reveals the emissions of the remaining car use, the second reveals the emissions related to the alternative option, e.g., the use of public transport.

The base option for all trip purposes is using an average gasoline car (Table A 3). The circular options are defined as follows:

- Online shopping: This option is only available for shopping purposes. Based on this option, respondents for all shopping trips by car will switch to online shopping. Due to this change, the distance travelled by car for shopping will decrease to zero, but the effect of delivery cars and packaging (alternative effect) was considered in calculations.
- Online grocery shopping: This option is only available for grocery shopping purposes. Based on this option, respondents' car trips will switch to online shopping. Due to this change, the distance travelled by car for grocery shopping will decrease to zero, but for non-grocery shopping trips by car, there is no change in emissions. The effect of delivery cars was considered in calculations.
- Less frequent: This option is available for all trip purpose. Based on this option, people will decrease the frequency of their trips by car by 25%. So, the car effect for this option shows 75% of the base option effect, whereas the alternative effect for this option is zero.
- Changing modes: These options are available for all trip purposes. Changing modes were divided into 3 different changes: walking, cycling and public transport. For each mode change, the reasonable travel distance for the specific mode was included in the calculations (refer to Section 2.3.4 and Figure 3 for more details). Based on the definition of these options, only the part of car trips where the distance travelled is less than the reasonable distance threshold will switch to the other modes. So, the car effect for these options shows the effect of the remaining car trips. For walk and bike options, the alternative effect is zero (no emissions for these modes), but for public transport, the effect of using public transport instead of the car for trips closer than the reasonable travel distance of public transport, was included in the results.
- Closer destination (scenario 1): This option is available for all trip purposes except 'visit trips'. Based on this option, all people will change their trip destinations to the destinations in close distance to their point of departure (refer to Figure 3 for more details). So, the car effect for this option shows the effect of reduction in distance travelled by car and because no new mode is involved to produce emissions, the alternative effect is zero.
- Closer destination (scenario 2): This option is available for all trip purposes except 'visit trips'. Based on this option, all people will change their trip destinations from far destinations to intermediate ones and from intermediate destinations to destinations in close distance to their point of departure (refer to Figure 3 for more details). So, the car effect for this option shows the effect of reduction in distance travelled by car. Because no new mode is involved to produce emissions, the alternative effect is zero.

Table 18: Emission and land use reduction for circular alternatives to shopping trips

Option		Travelled distance by car (Million km/year)	CO_2 (kg/person/year)				Share of reduction	GWP (kg/person/year)				Share of reduction	Land Use (m^2/person/year)				Share of reduction
			Fuel/Power		Total Production	Total Reduction		Fuel/Power		Total Production	Total Reduction		Fuel/Power		Total Usage	Total Reduction	
			Car Effect	Alternative Effect[1]				Car Effect	Alternative Effect				Car Effect	Alternative Effect			
Base	Using Car	10,650	109.7	0.0	109.7			117.8	0.0	117.8			0.363	0.000	0.363		
Alternative	R1: Online Shopping	-	0.0	32.9	32.9	76.8	**70%**	0.0	35.3	35.3	82.5	**70%**	0.000	0.109	0.109	0.254	**70%**
	R1: Online Grocery Shopping[2]	7,201	74.1	5.3	79.5	30.2	**28%**	79.7	5.7	85.4	32.4	**28%**	0.245	0.018	0.263	0.100	**28%**
	R1: Less Frequent[3]	7,989	82.3	0.0	82.3	27.4	**25%**	88.4	0.0	88.4	29.5	**25%**	0.272	0.000	0.272	0.091	**25%**
	R0: Changing mode[4] (Walk)	10,485	108.0	0.0	108.0	1.7	**2%**	116.0	0.0	116.0	1.8	**2%**	0.357	0.000	0.357	0.006	**2%**
	R0: Changing mode[4] (Bike)	9,506	97.9	0.0	97.9	11.8	**11%**	105.2	0.0	105.2	12.7	**11%**	0.324	0.000	0.324	0.039	**11%**
	R0: Changing mode[4] (Public Transport)	5,906	60.8	5.6	66.4	43.2	**39%**	65.3	6.1	71.4	46.4	**39%**	-	-	-	-	-
	R2: Closer Destination (Scenario 1[5])	5,419	55.8	0.0	55.8	53.9	**49%**	59.9	0.0	59.9	57.9	**49%**	0.185	0.000	0.185	0.178	**49%**
	R2: Closer Destination (Scenario 2[6])	6,171	63.5	0.0	63.5	46.1	**42%**	68.3	0.0	68.3	49.6	**42%**	0.210	0.000	0.210	0.153	**42%**

1: Switching to each alternative apart from decreasing the base option emissions may also produce some emissions

2: For this alternative, the base option is using the car only for grocery shopping which has led to distance travelled of 2,588 million kilometres annually

3: For this alternative, the reduction in shopping trips frequency is 25%

4: The mode is only changed for the trips closer than the reasonable distance by specific mode. Due to the absence of reliable sources for land use input data for this option, this factor is excluded from the results table (see Table 3)

5: All destinations switch to close destinations

6: Far destinations switch to intermediate destinations, and intermediate destinations switch to close destinations

Table 19: Emission and land use reduction for circular alternatives to visit trips

Option		Travelled distance by car (Million km/year)	CO_2 (kg/person/year)				Share of reduction	GWP (kg/person/year)				Share of reduction	Land Use (m^2/person/year)				Share of reduction
			Fuel/Power		Total Production	Total Reduction		Fuel/Power		Total Production	Total Reduction		Fuel/Power		Total Usage	Total Reduction	
			Car Effect	Alternative Effect				Car Effect	Alternative Effect				Car Effect	Alternative Effect			
Base	Using Car	25,410	261.6	0.0	261.6			281.0	0.0	281.0			0.866	0.000	0.866		
Alternative	R1: Less Frequent[1]	19,056	196.2	0.0	196.2	65.4	**25%**	210.8	0.0	210.8	70.3	**25%**	0.649	0.000	0.649	0.216	**25%**
Alternative	R0: Changing mode[2] (Walk)	25,367	261.2	0.0	261.2	0.4	**0%**	280.6	0.0	280.6	0.5	**0%**	0.864	0.000	0.864	0.001	**0%**
Alternative	R0: Changing mode[2] (Bike)	24,804	255.4	0.0	255.4	6.2	**2%**	274.4	0.0	274.4	6.7	**2%**	0.845	0.000	0.845	0.021	**2%**
Alternative	R0: Changing mode[2] (Public Transport)	16,239	167.2	10.9	178.1	83.5	**32%**	179.6	11.7	191.4	89.7	**32%**	-	-	-	-	-

1: For this alternative, the reduction in visiting trips frequency is 25%

2: The mode is only changed for the trips closer than the reasonable distance by specific mode. Due to the absence of reliable sources for land use input data for this option, this factor is excluded from the results table (see Table 3)

Table 20: Emission and land use reduction for circular alternatives to sports/hobby trips

Option		Travelled distance by car (Million km/year)	CO_2 (kg/person/year)					GWP (kg/person/year)					Land Use (m^2/person/year)				
			Fuel/Power					Fuel/Power					Fuel/Power				
			Car Effect	Alternative Effect	Total Production	Total Reduction	Share of reduction	Car Effect	Alternative Effect	Total Production	Total Reduction	Share of reduction	Car Effect	Alternative Effect	Total Usage	Total Reduction	Share of reduction
Base	Using Car	6,907	71.1	0.0	71.1			76.4	0.0	76.4			0.235	0.000	0.235		
Alternative	R1: Less Frequent[1]	5,180	53.3	0.0	53.3	17.8	**25%**	57.3	0.0	57.3	19.1	**25%**	0.176	0.000	0.176	0.059	**25%**
	R0: Changing mode[2] (Walk)	6,723	69.2	0.0	69.2	1.9	**3%**	74.4	0.0	74.4	2.0	**3%**	0.229	0.000	0.229	0.006	**3%**
	R0: Changing mode[2] (Bike)	6,355	65.4	0.0	65.4	5.7	**8%**	70.3	0.0	70.3	6.1	**8%**	0.217	0.000	0.217	0.019	**8%**
	R0: Changing mode[2] (Public Transport)	4,408	45.4	3.0	48.3	22.8	**32%**	48.8	3.2	52.0	24.4	**32%**	-	-	-	-	-
	R2: Closer Destination (Scenario 1[3])	3,717	38.3	0.0	38.3	32.8	**46%**	41.1	0.0	41.1	35.3	**46%**	0.127	0.000	0.127	0.109	**46%**
	R2: Closer Destination (Scenario 2[4])	4,169	42.9	0.0	42.9	28.2	**40%**	46.1	0.0	46.1	30.3	**40%**	0.142	0.000	0.142	0.093	**40%**

1: For this alternative, the reduction in sports/hobbies trips frequency is 25%

2: The mode is only changed for the trips closer than the reasonable distance by specific mode. Due to the absence of reliable sources for land use input data for this option, this factor is excluded from the results table (see Table 3)

3: All destinations switch to close destinations

4: Far destinations switch to intermediate destinations, and intermediate destinations switch to close destinations

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Table 21: Emission and land use reduction for circular alternatives to tour trips

Option		Travelled distance by car (Million km/year)	CO_2 (kg/person/year)				Share of reduction	GWP (kg/person/year)				Share of reduction	Land Use (m^2/person/year)				Share of reduction
			Fuel/Power		Total Production	Total Reduction		Fuel/Power		Total Production	Total Reduction		Fuel/Power		Total Usage	Total Reduction	
			Car Effect	Alternative Effect				Car Effect	Alternative Effect				Car Effect	Alternative Effect			
Base	Using Car	1,997	20.6	0.0	20.6			22.1	0.0	22.1			0.068	0.000	0.068		
Alternative	R1: Less Frequent[1]	1,498	15.4	0.0	15.4	5.1	**25%**	16.6	0.0	16.6	5.5	**25%**	0.051	0.000	0.1	0.0	**25%**
	R0: Changing mode[2] (Walk)	1,944	20.0	0.0	20.0	0.5	**3%**	21.5	0.0	21.5	0.6	**3%**	0.066	0.000	0.1	0.0	**3%**
	R0: Changing mode[2] (Bike)	1,337	13.8	0.0	13.8	6.8	**33%**	14.8	0.0	14.8	7.3	**33%**	0.046	0.000	0.0	0.0	**33%**
	R0: Changing mode[2] (Public Transport)	1,310	13.5	0.8	14.3	6.3	**30%**	14.5	0.9	15.4	6.7	**30%**	-	-	-	-	**-**
	R2: Closer Destination (Scenario 1[3])	914	9.4	0.0	9.4	11.1	**54%**	10.1	0.0	10.1	12.0	**54%**	0.031	0.000	0.0	0.0	**54%**
	R2: Closer Destination (Scenario 2[4])	1,113	11.5	0.0	11.5	9.1	**44%**	12.3	0.0	12.3	9.8	**44%**	0.038	0.000	0.0	0.0	**44%**

1: For this alternative, the reduction in tour trips frequency is 25%

2: The mode is only changed for the trips closer than the reasonable distance by specific mode. Due to the absence of reliable sources for land use input data for this option, this factor is excluded from the results table (see Table 3)

3: All destinations switch to close destinations

4: Far destinations switch to intermediate destinations, and intermediate destinations switch to close destinations

3.2.3 Circular Options for Buying New Car

Table 22 to Table 24 show the results of circular options for buying a new car. The emissions for each option are based on two main categories:

- The emission production related to materials, production process and maintenance of the vehicle, which does not show, explicitly, the level of usage of the vehicle, and
- The emission production related to consumption and production of fuel or power, which explicitly shows the level of usage of the vehicle.

The emission production of the base option reveals that the share of fuel/power is on average more than 90% of total emission production. This is based on the average travel distance of a car in the Netherlands in one year (Table 4). For the land-use results table, apart from the two mentioned sources of effect, the use of land for parking of vehicles was included additionally. To calculate this effect, the number of cars - not size and type of car - was considered as parking spaces usually have standardised dimensions.

The base option for the calculations was buying a new average gasoline car (Table A 3). The alternative options for buying a new car are as follows:

- Public transport: This alternative shows that people will use public transport instead of buying a new average car. This decision leads to a decrease in emission production for all factors to zero, except for fuel and power. We do not assume an increase in the public transport fleet size as this relies on too many uncertain factors. To compensate for the effect of neglecting emissions related to the materials and production of vehicles, the increase in emissions due to fuel consumption and production for public transport is completely included (less than it would be in reality, the emissions of full trains and half-loaded trains are the same). Additionally, it should be noted that the emissions related to fuel are 10 times more than those of the materials and production of the vehicle. So, the reduction would ultimately not be very different. As mentioned previously for the circular options in mode choice for trip purposes, due to the absence of reliable sources for land use input data for public transport, this factor was excluded from the calculations and the results table (see Table 4)
- Shared car: By choosing this alternative, users will join a shared car scheme instead of buying a new average car. Accepting this option will lead to a decrease in car ownership by 30% and car use by 17% (Table 4). This means that the emissions related to fuel/power and materials and maintenance will decrease by 17% and 30% respectively.
- Smaller car: This alternative decreases the total emission production by decreasing both fuel/power and materials/maintenance parts. The fuel consumption of a smaller car is almost 20% less than that of an average car and because it is lighter than the average car, the materials/maintenance-related emissions also less than an average car by around 30%.
- Electric car: Buying an electric car instead of an average gasoline car, changes the production of emissions in both parts. Materials and production of an electric car produce more emissions compared to an average gasoline car but by considering the fuel/power effect, to total production of emissions is less than that of the gasoline car. The remarkable thing of this option concerns the land-use effect. In both the materials and fuel/power part, more land is needed for an electric car than for a gasoline car. The main effect is related to the land needed for electricity production, which is around 10 times of needed land for fuel production, per kilometre travelled.
- Good maintenance: This option shows the effect of good maintenance compared to regular maintenance on emissions and land use. The only effect considered for this option was increasing the lifespan of car due to good maintenance by 20%. Potential reduction in vehicle efficiency over time was not taken into account. By this definition, choosing this option will decrease emission production related to materials and production of vehicles per year, increase the emissions related to maintenance, and have no effect on fuel/power emission production. So, it will slightly change the production of emissions and use of land.

Table 22: CO_2 emission reduction for circular alternatives to buying new car

Option		CO_2 (kg/person/year)							Share of reduction
		Materials and production			Maintenance and repair	Fuel/Power	Total Production	Total Reduction	
		Car	Tire	Engine Oil					
Base	Buy new gasoline car	115.9	18.8	3.2	16.0	1,731	1,885	-	-
Alternative	R0: Public transport	0.0	0.0	0.0	0.0	277	277	1,608	**85%**
	R2: Shared car	81.2	13.2	2.2	11.2	1,437	1,544	341	**18%**
	R1: Smaller car	77.6	18.8	3.2	16.0	1,370	1,486	399	**21%**
	R1: Electric Car	198.4	18.8	0.0	16.0	784	1,017	868	**46%**
	R4: Good Maintenance	96.6	18.8	3.2	31.9	1,731	1,881	4	**0%**

Table 23: GWP reduction for circular alternatives to buying a new car

Option		GWP (kg/person/year)							Share of reduction
		Materials and production			Maintenance and repair	Fuel/Power	Total Production	Total Reduction	
		Car	Tire	Engine Oil					
Base	Buy new gasoline car	124.0	20.1	3.4	17.0	1,859	2,024	-	-
Alternative	R0: Public transport	0.0	0.0	0.0	0.0	299	299	1,725	**85%**
	R2: Shared car	86.8	14.1	2.4	11.9	1,543	1,659	365	**18%**
	R1: Smaller car	83.1	20.1	3.4	17.0	1,472	1,596	428	**21%**
	R1: Electric Car	212.4	20.1	0.0	17.0	806	1,055	969	**48%**
	R4: Good Maintenance	103.4	20.1	3.4	34.0	1,859	2,020	4	**0%**

Table 24: Land use reduction for circular alternatives to buying a new car

Option		**Land use for production, maintenance and consumption** (m^2/person/year)								**Land use for parking** (m^2/person)		
		Materials and production			Maintenance and repair	Fuel/Power	Total Usage	Total Reduction	Share of reduction	Total Usage	Total Reduction	Share of reduction
		Car	Tire	Engine Oil								
Base	Buy new gasoline car	89.63	2.33	0.02	0.58	5.73	98.3			14.43		
Alternative	R0: Public transport[1]	-	-	-	-	-	-	-	-	0.00	14.43	**100%**
	R2: Shared car	62.74	1.63	0.02	0.40	4.75	69.5	28.7	**29%**	10.10	4.33	**30%**
	R1: Smaller car	60.02	2.33	0.02	0.58	4.53	67.5	30.8	**31%**	14.43	0.00[2]	**0%**
	R1: Electric Car	164.3	2.33	0.00	0.58	58.99	226.2	-127.9	**-130%**	14.43	0.00[2]	**0%**
	R4: Good Maintenance	89.63	2.33	0.02	1.15	5.73	98.9	-0.6	**-1%**	14.43	0.00[2]	**0%**

1: Due to the absence of reliable sources for land use input data for this option, this factor is excluded from the results table (see Table 3)

2: Because the number of cars in this alternative does not change, the land use for parking does not change either

3.2.4 Circular Options for Buying New Bike

Table 25 to Table 27 show the results of calculations for circular options for buying a new bike. The effect of circular options on emissions production is limited to materials/production and maintenance/repair. The numbers for the base option show that the main effect is related to materials and production of bikes. The base values and assumptions for these options are shown in the appendix (Table A 3).
As a regular bike is already a sustainable mode of transport, options for this mode of transport are limited to the following:

- Shared bike: This alternative is similar to the shared car scheme. To calculate the effects of this option on emission reductions, all assumptions and variables of the shared car scheme were applied.
- Good maintenance: The effect of this alternative for bikes is similar to the same alternative for cars: decrease in annual emissions related to materials and production of a bike due to good maintenance and increase in annual emissions related to maintenance and repair by increase the frequency of maintenance per year have been considered.

Table 25: CO_2 emission reduction for circular alternatives to buying new bike

Option		CO_2 (kg/person/year)					Share of reduction
		Materials and production		Maintenance and repair	Total Production	Total Reduction	
		Bike	Tire				
Base	Buy new regular bike	7.36	1.93	0.37	9.7	-	-
Alternatives	R2: Shared bike	5.15	1.35	0.26	6.8	**2.9**	**30%**
	R4: Good Maintenance	6.13	1.93	0.73	8.8	**0.9**	**9%**

Table 26: GWP reduction for circular alternatives to buying new bike

Option		GWP (kg/person/year)					Share of reduction
		Materials and production		Maintenance and repair	Total Production	Total Reduction	
		Bike	Tire				
Base	Buy new regular bike	7.88	2.07	0.39	10.3	-	-
Alternatives	R2: Shared bike	5.52	1.45	0.27	7.2	**3.1**	**30%**
	R4: Good Maintenance	6.57	2.07	0.78	9.4	**0.9**	**9%**

Table 27: Land Use reduction for circular alternatives to buying new bike

Option		Land Use (m^2/person/year)					Share of reduction
		Materials and production		Maintenance and repair	Total Production	Total Reduction	
		Bike	Tire				
Base	Buy new regular bike	0.46	0.12	0.02	0.60	-	-
Alternatives	R2: Shared bike	0.32	0.09	0.01	0.42	**0.18**	**30%**
	R4: Good Maintenance	0.38	0.12	0.04	0.54	**0.06**	**9%**

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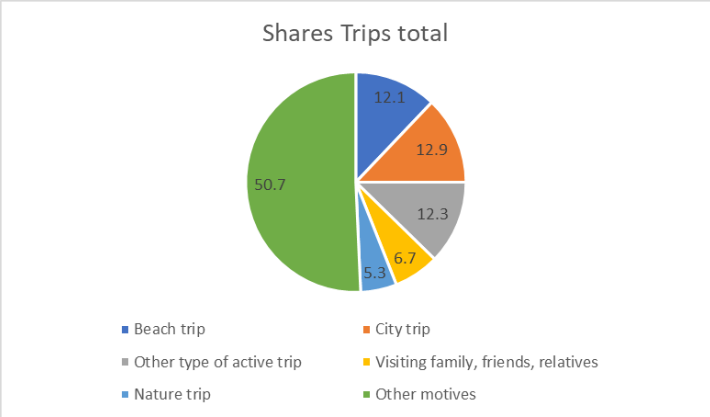
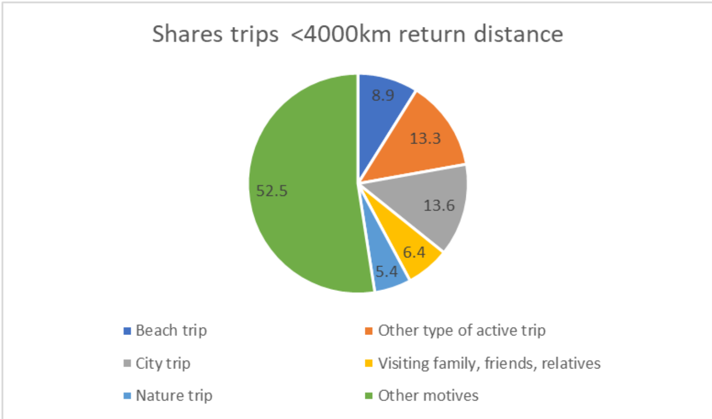
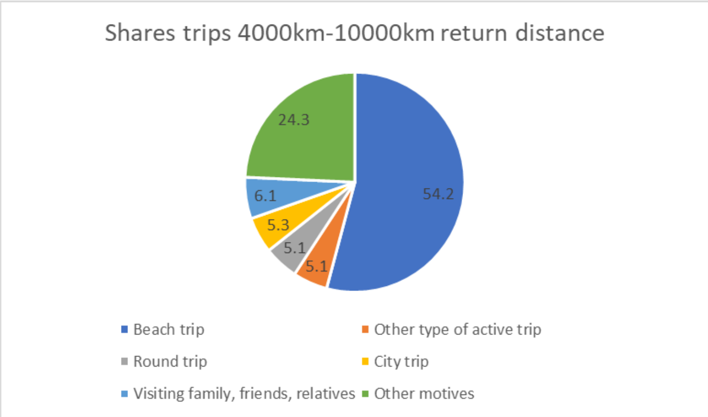
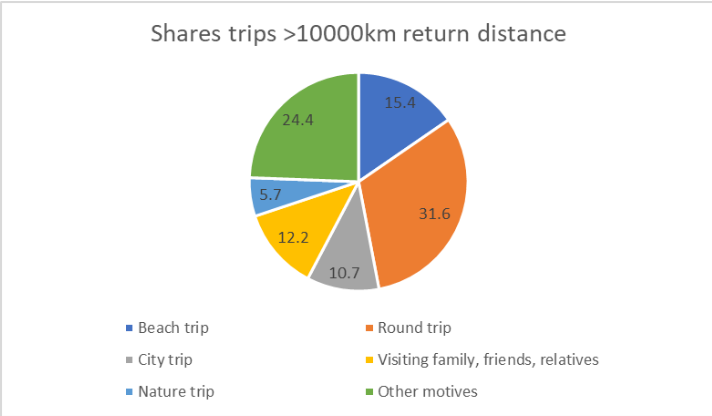
Appendix 1: Trip types per distance category









Appendix 2: Comparison of TL and CO2emissiefactoren.nl

The Traveling Large emissions are based on CBS Opendata for fleet-emission factors (CBS, 2020b). Still, it is useful to compare the direct emission factors used in TL with those officially provided by CO2emissiefactoren.nl (2021). A problem with CO2emissiefactoren.nl (2021) is that they provide all data in CO_{2eq}, thus including the impact of non_CO_2 greenhouse gases. Moreover, these numbers include what are called 'well-to-tank' (WTT) emissions that are caused by producing and distributing the energy source (petrol, kerosene, etc.). Unfortunately, it is not entirely clear what Global Warming Potential rates, non-CO_2 emission factors and WTT factors have been used for each transport mode given by CO2emissiefactoren.nl (2021). We have tried to include the WTT in the TL emission factors and to remove the GWP from those in CO2emissiefactoren.nl (2021) based on the ratios given by the EAP. In addition, the seat-occupation rates of, for instance, trains and coaches are unclear in CO2emissiefactoren.nl (2021). The differences are shown in Table A 1. The biggest differences occur with aviation (TL is up to 42% higher). A recent study by P. Peeters and Reinecke (2021) showed that the CO2emissions.nl data for long haul travel was too low.

Table A 1: Overview of differences in emission factors of Traveling Large and Co2emissions.nl

Transport mode	Special corrections	Detour factor	CO2-factor 2005		CO2emissiefactoren	GWP factor CO2emissiefactoren	Clean emission factor CO2emissiefactoren	Diff TL/ CO2emfactoren
Unit	-	-	Year	Kg CO2 /pkm	kg CO2eq/pkm	-	CO2/pkm	%
Own car	1.232	1.15	2019	0.171	0.163	1.079	0.151	92%
Rental Car	1.232	1.15	2019	0.171	0.163	1.079	0.151	92%
Campervan	1.232	1.15	2019	0.319	n/a			
Rental Campervan	1.232	1.15	2019	0.319	n/a			
Airplane								
500 km	1.068	2.124	2019	0.104	0.278	1.9	0.146	141%
500–1000 km	1.068	1.593	2019	0.104	n/a	1.9		
1000–1500 km	1.068	1.339	2019	0.104	n/a	1.9		
1500–2000 km	1.068	1.175	2019	0.104	0.178	1.9	0.094	122%

Transport mode	Special corrections	Detour factor	CO2-factor 2005		CO2emissiefactoren	GWP factor CO2emissiefactoren	Clean emission factor CO2emissiefactoren	Diff TL/ CO2emfactoren
>2000 km	1.068	1.05	2019	0.104	0.137	1.9	0.072	142%
Sleeper train + car		1.15	2019	0.045	n/a	1.9		
Train		1.15	2019	0.03	0.026	1.080	0.024	125%
Regional bus		1.15	2019	0.071	0.071	1.080	0.066	108%
Coach		1.15	2019	0.020	0.027	1.080	0.025	79%
Motor bike		1.15	2019	0.133	n/a			
Moped		1.15	2019	0.080	n/a			

Appendix 3: Base values of factors for mobility calculations

Table A 2. Original emission and land use factors

Item	Unit	CO_2 (kg/unit)	GWP (kg/unit)	Land Use (m^2/unit)	Source
Electricity	1000 euro	2,896	2,978	218	EAP
New Car (Gasoline)	piece	4,339	4,642	186	EAP
New Car (Electric)	piece	7,423	7,950	342	EAP
Car Tire	piece	41	44	1.2	EAP
Regular Bike	piece	96	102	6	EAP
Bike Tire	ring	4.8	5.2	0.3	EAP
Gasoline (WTT*)	m^3	517	556	12	EAP
Repair and Maintenance	1000 euro	166	177	6	EAP
Combination of Passenger Transport	1000 euro	489	528	36	EAP
Gasoline (E10 Blend) (WTT)	m^3		643		co2emissiefactoren.nl
Electricity (Unknown Source)	MWh		475		co2emissiefactoren.nl
Gasoline Car (Less Than 1.6 L) (WTT)	1000 Vehicle-km		29		co2emissiefactoren.nl
Gasoline Car (Less Than 1.6 L) (TTW)**	1000 Vehicle-km		151		co2emissiefactoren.nl
Electric Car (Average Power Mix)	1000 Vehicle-km		78		co2emissiefactoren.nl
Public Transport in General (Vehicle Type Unknown)	1000 Passenger-km		15		co2emissiefactoren.nl
Engine Oil (Synthetic Oil)	liter	1.65			(Ishizaki & Nakano, 2018)

*: Well-To-Tank
**: Tank-To-Wheel

Table A 3. Complementary base values

Item	Unit	Amount	Source
Average Gasoline Car		VW golf VARIANT 1.0 TSI 110PK COMFORTLINE	EAP
Average Gasoline Car Weight	kg	1,217	EAP
Average Gasoline Car Consumption	litre/100km	4.8	autoweek.nl (2021b)
Engine Oil Volume	litre	4	autoweek.nl (2021b)
Engine Oil Durability	year	1	Volkswagen (2020)
Average Electric Car		VW eGolf	EAP
Average Electric Car Power Consumption	MWh/km	168	Car Catalogue
Small Gasoline Car*		TOYOTA AYGO 1.0 VVT-I X	Bovag-RAI (2019)
Small Gasoline Car Weight	kg	815	autoweek.nl (2021a)
Small Gasoline Car Consumption	litre/100km	3.8	autoweek.nl (2021a)
Decrease in Car Production Emission Due to Switch to Smaller Cars**	Percent	33%	Based on the weight ratio of Toyota Aygo/ VW Golf
Repair and Maintenance Cost Per Year (Average Gasoline Car)	Euro	200	Volkswagen (2020)
Number of Checks (Normal Maintenance)	time/year	1	Expert judgment
Number of Checks (Good Maintenance)	time/year	2	Expert judgment
Average Tire Lifespan	km	60,000	Different websites
Average Car Lifespan	Year	18	Bovag-RAI (2019)
Increase in Average Car Lifespan	Percent	20%	Expert judgment
Parking Space	m^2	30	Geometric Design Guidelines
Average Bike Lifespan	Year	13	RAI Vereniging (2021)
Average Bike Tire Lifespan	Year	5	Expert judgment
Increase in Bike Lifespan	Percent	20%	Expert judgment
Number of Bike Checks (normal maintenance)	time/year	0.5	Expert judgment
Number of Bike Checks (good maintenance)	time/year	1	Expert judgment

** Most popular small car (less than 1 Ton) in the Netherlands (Bovag-RAI, 2019)*

*** Based on the weight ratio of Toyota Aygo/ VW Golf*

Appendix 4: Base calculations for circular options of different trip purposes

Table A 4. Base calculations for circular options of shopping trips

Item	Unit	Amount	Source
Average Travel Distance (Total Shopping by Car)	km	7.5	ODiN data base Analysis
Trips (Total Shopping by Car)	trip/person/year	88	ODiN data base Analysis
Average Travel Distance (Close Shopping by Car)	km	3.8	ODiN data base Analysis
Trips (Close Shopping by Car)	trip/person/year	72	ODiN data base Analysis
Average Travel Distance (Intermediate Shopping by Car)	km	18.8	ODiN data base Analysis
Trips (Intermediate Shopping by Car)	trip/person/year	13	ODiN data base Analysis
Average Travel Distance (Far Shopping by Car)	km	47.3	ODiN data base Analysis
Trips (Far Shopping by Car)	trip/person/year	3	ODiN data base Analysis
Average Travel Distance (Grocery Shopping by Car)	km	5.6	ODiN data base Analysis
Trips (Grocery Shopping by Car)	trip/person/year	38	ODiN data base Analysis
Reasonable Walking Distance* (Shopping)	km	1.0	ODiN data base Analysis
Reasonable Cycling Distance (Shopping)**	km	2.9	ODiN data base Analysis
Reasonable Public Transport Distance* (Shopping)**	km	11.7	ODiN data base Analysis
Distance travelled by car closer than RWD* (Shopping)	Million km/year	167	ODiN data base Analysis
Share of distance travelled by car closer than RWD* (Shopping)	Percent	2%	ODiN data base Analysis
Distance travelled by car closer than RCD (Shopping)**	Million km/year	1,145	ODiN data base Analysis
Share of distance travelled by car closer than RCD (Shopping)**	Percent	11%	ODiN data base Analysis
Distance travelled by car closer than RPTD* (Shopping)**	Million km/year	4,746	ODiN data base Analysis
Share of distance travelled by car closer than RPTD* (Shopping)**	Percent	45%	ODiN data base Analysis

** Reasonable Walking Distance: the longest distance which is acceptable by 80% of travellers to walk (based on the cumulative distribution of walking trips for Shopping). The mode is only changed for smaller distances than the Reasonable Walking Distance.*

*** Reasonable Cycling Distance: the longest distance which is acceptable by 80% of travellers to use bike (based on the cumulative distribution of bike trips for Shopping). The mode is only changed for smaller distances than the Reasonable Cycling Distance.*

**** Reasonable Public Transport Distance: the longest distance which is acceptable by 80% of travellers to use public transport (based on the cumulative distribution of public transport trips for Shopping). The mode is only changed for smaller distances than the Reasonable Public Transport Distance.*

Table A 5. Base calculations for circular options of Visit trips

Item	Unit	Amount	Source
Average Travel Distance (Total Visits by Car)	km	25.28	ODiN data base Analysis
Trips (Total Visit by Car)	trip/person/year	62	ODiN data base Analysis
Average Travel Distance (Close Visits by Car)	km	9.9	ODiN data base Analysis
Trips (Close Visits by Car)	trip/person/year	48	ODiN data base Analysis
Average Travel Distance (Intermediate Visits by Car)	km	56.49	ODiN data base Analysis
Trips (Intermediate Visits by Car)	trip/person/year	10	ODiN data base Analysis
Average Travel Distance (Far Visits by Car)	km	126.8	ODiN data base Analysis
Trips (Far Visits by Car)	trip/person/year	4	ODiN data base Analysis
Reasonable Walking Distance* (Visits)	km	1.0	ODiN data base Analysis
Reasonable Cycling Distance (Visits)**	km	4.4	ODiN data base Analysis
Reasonable Public Transport Distance* (Visits)**	km	40.0	ODiN data base Analysis
Distance travelled by car closer than RWD* (Visits)	Million km/year	41	ODiN data base Analysis
Share of distance travelled by car closer than RWD* (Visits)	percent	0.2%	ODiN data base Analysis
Distance travelled by car closer than RCD (Visits)**	Million km/year	604	ODiN data base Analysis
Share of distance travelled by car closer than RCD (Visits)**	percent	2.4%	ODiN data base Analysis
Distance travelled by car closer than RPTD* (Visits)**	Million km/year	9,169	ODiN data base Analysis
Share of distance travelled by car closer than RPTD* (Visits)**	percent	36.1%	ODiN data base Analysis

**: Reasonable Walking Distance: the longest distance which is acceptable by 80% of travellers to walk (based on the cumulative distribution of walking trips for Visits).*

*** Reasonable Cycling Distance: the longest distance which is acceptable by 80% of travellers to use bike (based on the cumulative distribution of bike trips for Visits).*

**** Reasonable Public Transport Distance: the longest distance which is acceptable by 80% of travellers to use public transport (based on the cumulative distribution of public transport trips for Visits).*

Table A 6. Base calculations for circular options of Sports/Hobbies trips

Item	Unit	Amount	Source
Average Travel Distance (Total Sports/Hobbies by Car)	km	11.2	ODiN data base Analysis
Trips (Total Sports/Hobbies by Car)	trip/person/year	38	ODiN data base Analysis
Average Travel Distance (Close Sports/Hobbies by Car)	km	6.0	ODiN data base Analysis
Trips (Close Sports/Hobbies by Car)	trip/person/year	31	ODiN data base Analysis
Average Travel Distance (Intermediate Sports/Hobbies by Car)	km	26.7	ODiN data base Analysis
Trips (Intermediate Sports/Hobbies by Car)	trip/person/year	5	ODiN data base Analysis
Average Travel Distance (Far Sports/Hobbies by Car)	km	67.5	ODiN data base Analysis
Trips (Far Sports/Hobbies by Car)	trip/person/year	1	ODiN data base Analysis
Reasonable Walking Distance* (Sports/Hobbies)	km	2.5	ODiN data base Analysis
Reasonable Cycling Distance (Sports/Hobbies)**	km	4.0	ODiN data base Analysis
Reasonable Public Transport Distance* (Sports/Hobbies)**	km	13.6	ODiN data base Analysis
Distance travelled by car closer than RWD* (Sports/Hobbies)	Million km/year	184	ODiN data base Analysis
Share of distance travelled by car closer than RWD* (Sports/Hobbies)	percent	3%	ODiN data base Analysis
Distance travelled by car closer than RCD (Sports/Hobbies)**	Million km/year	551	ODiN data base Analysis
Share of distance travelled by car closer than RCD (Sports/Hobbies)**	percent	8%	ODiN data base Analysis
Distance travelled by car closer than RPTD* (Sports/Hobbies)**	Million km/year	2,499	ODiN data base Analysis
Share of distance travelled by car closer than RPTD* (Sports/Hobbies)**	percent	36%	ODiN data base Analysis

** Reasonable Walking Distance: the longest distance which is acceptable by 80% of travellers to walk (based on the cumulative distribution of walking trips for Sports/Hobbies). The mode is only changed for smaller distances than the RWD.*

***: Reasonable Cycling Distance: the longest distance which is acceptable by 80% of travellers to use bike (based on the cumulative distribution of bike trips for Sports/Hobbies). The mode is only changed for smaller distances than the RCD.*

**** Reasonable Public Transport Distance: the longest distance which is acceptable by 80% of travellers to use public transport (based on the cumulative distribution of public transport trips for Sports/Hobbies). The mode is only changed for smaller distances than the RPTD.*

Table A 7. Base calculations for circular options of Tour trips

Item	Unit	Amount	Source
Average Travel Distance (Total Tours by Car)	km	21.4	ODiN data base Analysis
Trips (Total Tours by Car)	trip/person/year	5.7	ODiN data base Analysis
Average Travel Distance (Close Tours by Car)	km	9.8	ODiN data base Analysis
Trips (Close Tours by Car)	trip/person/year	4.1	ODiN data base Analysis
Average Travel Distance (Intermediate Tours by Car)	km	40.9	ODiN data base Analysis
Trips (Intermediate Tours by Car)	trip/person/year	1.2	ODiN data base Analysis
Average Travel Distance (Far Tours by Car)	km	84.3	ODiN data base Analysis
Trips (Far Tours by Car)	trip/person/year	0.4	ODiN data base Analysis
Reasonable Walking Distance* (Tours)	km	4.9	ODiN data base Analysis
Reasonable Cycling Distance (Tours)**	km	25.0	ODiN data base Analysis
Reasonable Public Transport Distance* (Tours)**	km	27.1	ODiN data base Analysis
Distance travelled by car closer than RWD* (Tours)	Million km/year	53	ODiN data base Analysis
Share of distance travelled by car closer than RWD* (Tours)	percent	3%	ODiN data base Analysis
Distance travelled by car closer than RCD (Tours)**	Million km/year	660	ODiN data base Analysis
Share of distance travelled by car closer than RCD (Tours)**	percent	33%	ODiN data base Analysis
Distance travelled by car closer than RPTD* (Tours)**	Million km/year	687	ODiN data base Analysis
Share of distance travelled by car closer than RPTD* (Tours)**	percent	34%	ODiN data base Analysis

** Reasonable Walking Distance: the longest distance which is acceptable by 80% of travellers to walk (based on the cumulative distribution of walking trips for Tours). The mode is only changed for smaller distances than the RWD.*

*** Reasonable Cycling Distance: the longest distance which is acceptable by 80% of travellers to use bike (based on the cumulative distribution of bike trips for Tours). The mode is only changed for smaller distances than the RCD.*

**** Reasonable Public Transport Distance: the longest distance which is acceptable by 80% of travellers to use public transport (based on the cumulative distribution of public transport trips for Tours). The mode is only changed for smaller distances than the RPTD.*

Games

Media

Hotel

Facility

Built Environment

Logistics

Tourism

Leisure & Events

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