

# Impact of a day of leisure

## - Lifecycle performance of product systems -

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Benoit Prudhomme-Lacroix, Guillaume Keusch, Jade Therras

## Contents

<b>1</b>	<b>Introduction and goal definition</b>	<b>3</b>
<b>2</b>	<b>LCA methodology</b>	<b>4</b>
2.1	Function and functional unit, References flow . . . . .	4
2.2	Key parameters . . . . .	4
2.3	System and system boundaries . . . . .	4
2.4	Software and database . . . . .	5
<b>3</b>	<b>Evaluation of the impacts in terms of climate change (CO<sub>2</sub>e)</b>	<b>6</b>
3.1	Indicator . . . . .	6
3.2	Life cycle inventory analysis . . . . .	6
3.3	Life Cycle Impact Assessment Results . . . . .	9
3.4	Comparison of the scenarios . . . . .	11
<b>4</b>	<b>Interpretation</b>	<b>12</b>
4.1	Reading a Book . . . . .	12
4.2	Watching a Movie . . . . .	12
4.3	Skiing in Verbier . . . . .	12
4.4	General findings . . . . .	13
<b>5</b>	<b>Discussion</b>	<b>13</b>
5.1	contrasting with the average Swiss citizen . . . . .	13
5.2	Impacts if Everybody Behaved Similarly in Switzerland . . . . .	13
5.3	Potential Solutions to Reduce Impacts . . . . .	14
<b>6</b>	<b>Conclusion</b>	<b>15</b>
<b>7</b>	<b>Annex</b>	<b>16</b>

## List of Figures

1	Summary of the system boundaries . . . . .	5
2	best case scenario - travel by bike . . . . .	9
3	worst case scenario - travel by car . . . . .	9
4	best case scenario - travel by bike . . . . .	9
5	worst case scenario - travel by car . . . . .	9
6	Worst case scenario - travel by car . . . . .	10
7	travel by bike . . . . .	10

8	DVD visioned ones . . . . .	10
9	DVD visioned 5 times . . . . .	10
10	Impact of a day of ski in kg . . . . .	11
11	Impact of a day of ski in percent . . . . .	11
12	Book, worst case . . . . .	16
13	Book, best case . . . . .	16
14	Numerical book . . . . .	16
15	Streaming . . . . .	17
16	DVD . . . . .	17
17	Theater . . . . .	17
18	Impact of a day of ski by car . . . . .	18
19	Impact of a day of skiing by train and bus . . . . .	18
20	Repartition of the impact without transport . . . . .	18

## List of Tables

1	Range of impact for each scenario . . . . .	12
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# 1 Introduction and goal definition

In a day of leisure in Switzerland, a lot of activities can be envisaged. Each activity will have a different environmental impact and contribute to the total impact of each individual.

This study aims to assess and compare the impact of different scenarios for a day of leisure of a Switzerland citizen. This LCA is part of an exercise in the context of an EPFL course and has been done by students. The recipient is the professor, teaching assistants and possibly other students.

Three different scenarios, with variants, will be compared.

- Environmental impacts of reading a book on paper versus on an iPad/laptop.
- Environmental impacts of watching a streaming movie vs on a DVD vs in a theatre movie.
- Environmental impacts of a ski day in Verbier, going there by train and bus or with a car, skiing the whole day.

Following the LCA methodology, functional units, parameters and system boundaries will be defined. The impact of each scenario will be inventoried, analysed and compared. Finally, possible alternatives to reduce the impact of each activity will be discussed.

## 2 LCA methodology

### 2.1 Function and functional unit, References flow

The function of leisure is to provide rest, relaxation, stress reduction and entertainment. Overall, a day of leisure is an opportunity to prioritize self-care, happiness, and personal fulfilment amidst the demands of everyday life.

According to the Cambridge Dictionary, leisure is "the time when you are not working or doing other duties". [1] While the measure of the effect on the person is complex and subjective, leisure is related to a notion of time, which is a measurable parameter.

In this study, the functional unit will be an hour of leisure.

Each of the scenarios presented before will account for a different time. To be able to compare them, the average amount of time of leisure provided by each scenario will be estimated and returned to one functional unit.

The time of leisure provided will account only for the time of the action. For example, for the movie, the time of leisure is the time of the movie. The transport will be taken into account on the impact assessment but not in the time of leisure. This is important to not minimize the impact of the action in case of a long or low impactful transport. Transport and other time spent to reach leisure time always have an added impact on that study.

- The time needed to read a book depends mainly on the speed of reading and the size of the book. For English silent reading, the average speed is 238 words per minute. [2] The average number of the world in a book is between 90,000 to 120,000 [3, 4]. Overall, the time needed to read a book could be estimated between 6h18min and 8h24min. We can therefore consider the average time of leisure provided by a book to be 7h22min. It could be reasonable to round this number to 8h as most people aren't reading all at the same speed but take pauses during the lecture.
- The movie's time will depend on the genre and the place where the movie is produced. Overall, the average movie length is between 90 and 120 minutes. Considering a movie lasts for 110min on average. [5, 6]
- Skiing is a whole day activity. For this LCA, only the time spent on the ski trail will be considered activity time. This duration is highly dependent on the person and the station, usually between 4 and 10 hours. [7]. In Verbier, the average opening hour of the infrastructure is between 9 am and 5 pm [8], giving 8 hours of possible activity. If accounting only for the skiing time, the range will be between 3 to 5 hours. If we account for all the time spent in the station, 6 to 8 hours is reasonable.

### 2.2 Key parameters

We expect transport as the main parameter, including the mean, the number of people and the length of the trip.

Secondary parameters could be the use of electronic devices including power and production, numerical storage and product production such as books and computers.

### 2.3 System and system boundaries

This LCA aims to compare different leisure scenarios. The production, distribution, use phase and end of life will be considered. Figure.1 summarize the system boundaries and the steps con-

sidered for all scenarios. The resource acquisition won't be directly considered, the production (resources and manufacturing) impact will be based on precedent LCA studies. The distribution and transport phase will be considered only want the impact is significant. Secondary scopes, such as the production of the cinema part or the computer won't be considered.

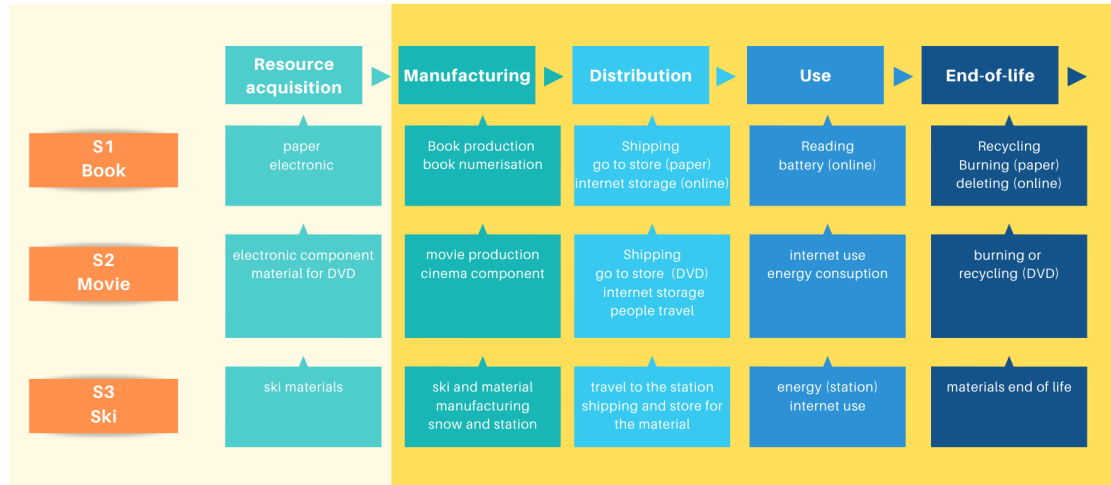


Figure 1: Summary of the system boundaries

## 2.4 Software and database

The computations were done using Microsoft Excel. Ecoinvent was the main database, a full list of the minor sources can be found in the references.

The interactive Excel book can be found [here](#).

### 3 Evaluation of the impacts in terms of climate change (CO<sub>2</sub>e)

#### 3.1 Indicator

#### 3.2 Life cycle inventory analysis

CO<sub>2</sub> equivalent is a standard indicator to assess environmental impact.

Some sources of impact are shared between the different scenarios, which will be discussed here

- **Impact of transport** An individual can travel by different means. In this LCA, we considered that an individual can travel by car, public transport, bike or foot. We also considered that a product can be shipped from the production site to the home. The impact of each mean of transport comes from the Ecoinvent database [9].
- **Impact of Electronic Devices** The life cycle of a computer has been accessed and weighted for one hour of use, It is assumed that a computer has a lifetime of 4 years (35040 hours) so the once per laptop lifetime costs (production and transports) will be weighted by this value.
- **Impact of data centre storage and transmission** Both movie and numerical book need to be stored online, and transmitted before use. It has been difficult to find a good source for data storage impact, external source range from 7KWH to 0.06 KWH per GB of transmitted data, depending on the efficiency of the system [10, 11, 12, 13]. We have recalculated the impact estimating that 1GB of data consumes 0.5 kWh of electricity while storing and 0.2 kWh while transferring, and use an average carbon footprint for a kWh of electricity in Switzerland [9].

#### Scenario 1: reading a book

The environmental impact of reading will be made assuming a 300-page book on read on both a laptop and a physical book. A numerical book is typically between 1 and 2 MB. [14]

##### 1. Production phase

- **book production** assuming a 450g book made of printed paper
- **Laptop** the laptop should be weighed as it has many other uses in its life than reading
- **numerical storage:** We assumed one download per hour of the book as in [15] to calculate the impact of storage. However, the amount of emission for such a small download was so small that it was neglected for the rest of the analysis

##### 2. Distribution/transport phase

- In both cases we assume that the user will buy the book or laptop in a shop 5km away. The customer can move using all the discussed means of transport.
- **numerical transfer** transferring data from the data centre to the local electronic device is considered

##### 3. Use phase

- **book** no emissions are made in this phase of the book life
- **laptop** It is assumed that the laptop will be used at 68% of its capabilities. [9] and the download of the text is considered negligible.

#### 4. End of life

- **book** the book is assumed to be recycled with paper, the transport to the recycling facility in a 21-ton lorry is considered negligible
- **laptop** the market for used computers is considered and its lifetime is assumed to be 4 years

### Scenario 2: watching a movie

Let's break down the environmental impacts of watching a movie in different scenarios: streaming movies, DVDs and theatre movies.

An important parameter will be the movie's weight. According to [7], if stored in HD the movie will be worst case 1.65GB. If full-HD, around 2.5GB, and if 4K up to 40GB.

We assumed the movie is visioned in HD.

#### 1. Production phase

- **movie production** Assuming the same movie is watched in the three scenarios, the impact of the movie production is the same. According to [16] the impact of the average movie production is 500 000 tonnes.CO<sub>2</sub>eq, but the impact of watching a single movie should be weighted by the approximate number of watching in his life.
- **streaming movie** A computer or TV is needed, this impact is calculated as said before. The movie is also stored in a local data centre. As for the book we assumed one download per hour to calculate the impact of storage. [15]
- **DVD** The production of the DVD support should be taken into account and weighted by the number of uses. The impact of the production has been calculated in previous studies such as [17] (conducted in the USA). Where the average number of watching a DVD is estimated to be 1 time per 5 for 5 years of the expected lifetime (could be up to 20 times per year for a rented movie, but it will be used for fewer years). The life expectancy of a DVD depends more on the handling and storage than on the number of watches.
- **theatre movie** We assumed the impact of one movie represents a negligible use of the materials of a theatre. It includes the screen, projector and sound system. It also includes digital support for the movie if needed.[18]

#### 2. Distribution/transport phase

- **streaming movie** transferring data from the data centre to the local electronic device is considered.
- **DVD** The support needs to be shipped to the citizen or the shop. Previous studies have estimated the distance from the DVD factory to a shop in America [17] as well as the travel of the citizen to pick up the DVD taken into account. For this study, we considered shipping by a light commercial vehicle in Switzerland [9] for an estimated average distance between the production site and the store in Switzerland.
- **Theatre movie** the transport of people (back and forward) is taken into account, for the case of a car, public transport (bus), bike and by foot [9] for an average distance.

#### 3. Use phase

- **Streaming movie** requires internet connection and batteries. The impact of the use of the computer has been estimated using the ecoinvent database. [9]

- **DVD** also requires a similar batterie than streaming if the DVD is watched on a computer, but no need for the internet.
- **Theatre movie** The impact of watching a movie at the theatre is dominated by the energy consumption for the projector and the sound system. We estimated using a standard system consumption [19, 20] and weighted by the number of people in the room, estimated at around 200 persons. [7] As an additional impact, typical food can be bought at the theatre. We included a portion of popcorn. [21]

#### 4. End of life

- **Streaming movie** The impact of the end of life of a numerical movie is assumed negligible, the movie is just deleted from the computer.
- **DVD** The support will be destroyed at the end of life, weighted by the number of uses. The support has been considered incinerated in Switzerland, and the waste travel from the home to the incineration site for an estimated distance has been taken into account [9] (looking at the disposition of incineration site around Switzerland)
- **Theatre movie** The impact is also negligible. We suppose the impact to be dominated by the end of life of the projector and sound system, weighted by the number of users and the number of people.

### Scenario 3: Skiing a day at Verbier

The environmental impacts of a ski day in Verbier, whether travelling by train and bus or by car, can be significant and multifaceted. Let's break it down:

#### 1. Production phase:

- **Ski lift** Assuming a ski lift operates for 20 years and serves an average of 20,000 skiers per day, the total carbon footprint over its lifetime is estimated to be 80 tonnes of COeq [22].
- **Ski clothes** Assuming that a complete set of ski equipment, including clothing and skis, has a carbon footprint of 8 kg CO equivalent [23].
- **Transport** For cars, trains, and boats, production impacts are accounted for directly in the distance travelled.

#### 2. Use phase :

- **Train and Bus** We have fixed the transport from Lausanne to Verbier using both train and bus. The train is used from Lausanne to Le Chables VS (round trip) around 130 km and the bus is used from Le Chables VS to the ski resort of Verbier around 10 km.
- **Car** The individual car used is a standard one with only one person inside. The highway from Lausanne to Verbier (round trip) is around 200 km.
- **Energy use** According to the article [24] the impact of skiing activities is measured by the electricity consumption of a day of skiing by a person who is around 7.2 Kwh.
- **Food** A burger is ordered in a restaurant on the slopes. According to this [25] a burger is 5.4 kg CO2eq.
- **Snow groomer** The snow groomer is considered equivalent to a diesel truck for calculations.



- **Internet Use** Booking tickets, checking weather forecasts, and sharing experiences represent around 1 hour of use of the internet.

### 3. End-of-Life:

Ski equipment is negligent and end of life of infrastructure also due to the number of uses of a ski installation.

The waste of a skiing day is estimated to be 1 kg.

## 3.3 Life Cycle Impact Assessment Results

Overall, human transport has been show to represent most of the impact in each scenario. It overpasses all other components. The detailed impact can be found in the Annex[7]

### Scenario 1: reading a book

For the physical book, most of the impact comes from transport and production depending on the means of transport.

The laptop has a Co2 emission 20 times lower than the physical book (0,005kg/h for the laptop and 0,093kg/h for the book with the buyer going by car).

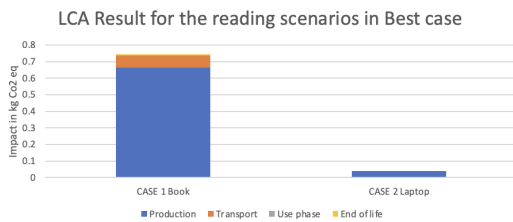


Figure 2: best case scenario - travel by bike

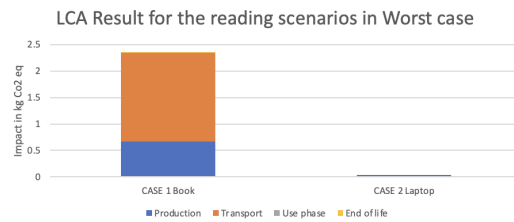


Figure 3: worst case scenario - travel by car

absolute values

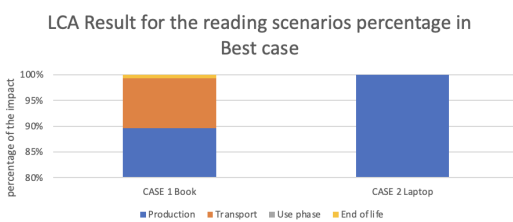


Figure 4: best case scenario - travel by bike

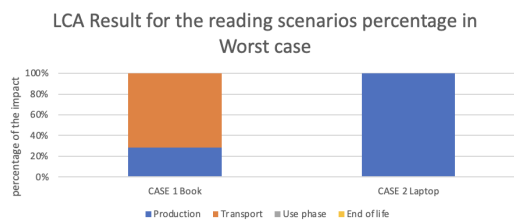


Figure 5: worst case scenario - travel by car

percent of emissions

Overall, the impact of reading a book stands between **0.005 kg.CO2eq/hour**, in the best case scenario for all cases, and **0.59 kg.CO2eq/hour**, in the worst case.

### Scenario 2: watching a movie

As expected, transport represents a majority of the impact. In the worst case in terms of transport (by car) [6], the transport will represent more than 90% of the impact of the activity.

Less impactful transport means have also been considered. Interestingly, by using bike [7] each scenario has a similar impact, with theatre being the most impactful, then DVD and streaming, then DVD and lastly streaming.

Without transport (walking) the impact of theatre movies is lower.

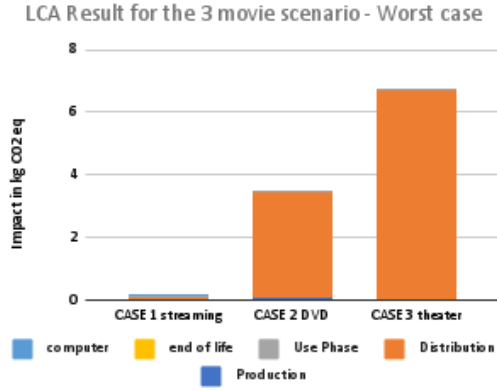


Figure 6: Worst case scenario - travel by car

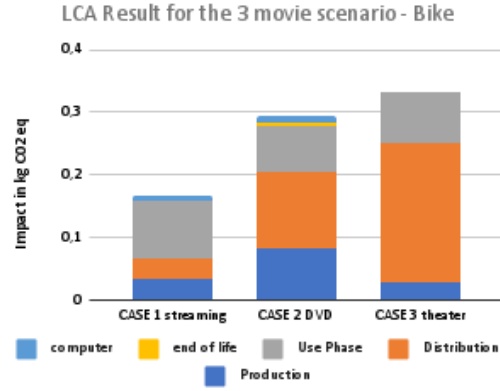


Figure 7: travel by bike

Highlight of the impact of transport

The impact of the DVD depends a lot on the number of uses. If watched only ones [8], streaming and DVD have a similar impact. However, if used more than 5 times [9] a DVD can have a lower impact than streaming.

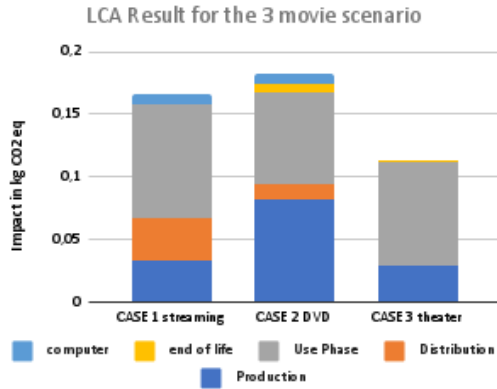


Figure 8: DVD visioned ones

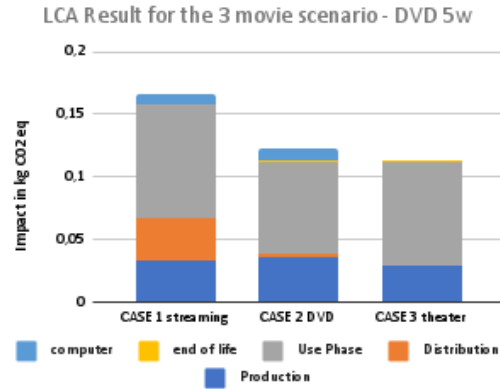


Figure 9: DVD visioned 5 times

Highlight of the impact of multiple use of DVD

Again not considering human transport, the subsequent figure details the impact of each scenario. Streaming impact [15] is dominated by the use of the computer during watching, followed by the impact of data transmission and storage. DVD impact [16] (5 times watched) is also dominated by computer use followed by the impact of movie production. Finally, the impact of watching the movie in the theatre [20] other than transport is almost negligible. In that scenario, pop-corn is more impactful than all of the other steps of the activity after transport.

Overall, the impact of watching a movie stand between **0.06 kg.CO2eq/hour**, in the best case scenario for all cases, and **3.70 kg.CO2eq/hour**, in the worst case.

### Scenario 3: Skiing

As expected, transport has a major impact. In the worst case in terms of transport (going alone to Verbier, by car), the transport will represent more than 70% of the impact of the activity.

In the best case in terms of transport, le secondary parameters have a higher impact than transport.

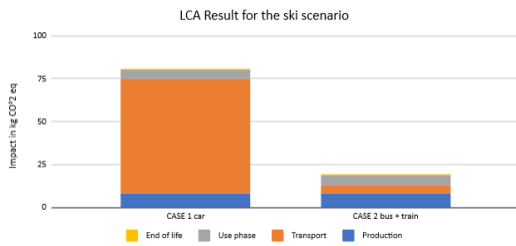


Figure 10: Impact of a day of ski in kg

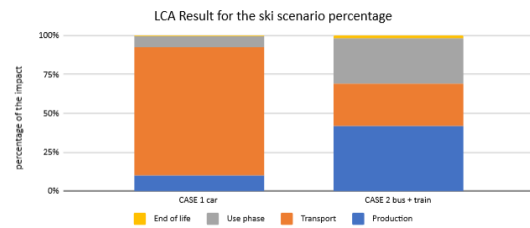


Figure 11: Impact of a day of ski in percent

#### Highlight of the impact of transport on a skiing day

Secondary parameters are ski clothes and food. Interestingly, the impact of the bus part of the travel is 4 times higher than the train part, even if the bus distance is 3 times smaller, highlighting how much the train reduces the global impact.

In that case, electricity waste collection and internet connection are negotiable.

Overall, the impact of skiing in Verbier stands between **2.38 kg.CO2eq/hour**, in the best case scenario for all cases, and **10,06 kg.CO2eq/hour**, in the worst case.

### 3.4 Comparison of the scenarios

Transport is a key factor when talking about CO2 equivalent impact. It represents a major part of each scenario. The production phase, computer use and data centre represent also a non-negotiable part of the impact.

Reading a book is a low-impactful activity, especially with an ebook. However, if the book is bought at the bookstore going by car, then read only once and recycled it becomes more impactful than watching a movie.

Watching a movie is also a relatively low-impactful activity, especially when using low to medium-quality files and streaming. Watching a movie at the cinema is even less impactful by itself but if going to the cinema alone with a car it becomes highly impactful, even more than skiing.

Skiing has a relatively high impact, but this impact can be monitored by using public transport from a factor of 5.

Scenario		Book	Movie	Ski
Impact	Lower bound	0.005	0.06	2.38
kgCO <sub>2</sub> eq/h	Higher bound	0.59	3.70	10.06

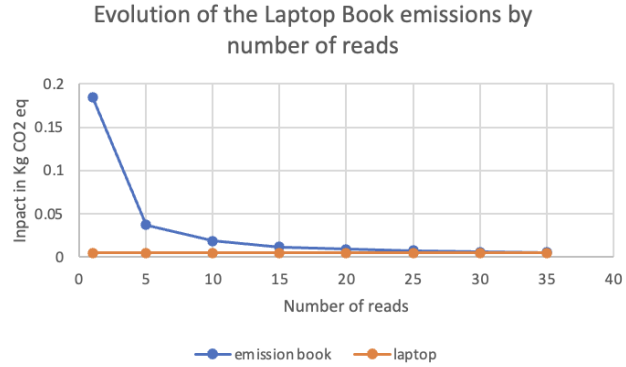
Table 1: Range of impact for each scenario

## 4 Interpretation

### 4.1 Reading a Book

Reading a physical book has a significantly higher impact than using a laptop for reading, which produces about 0.005 kg of CO<sub>2</sub> per hour of use. If read one in the worst case, the impact of the book is 100 times higher than the impact of the numerical book.

If the car is used, the biggest impact is transport. In that scenario, a numerical book will almost always be more sustainable than a physical book. If the bike is used, the impact of transport is significantly reduced. Book production had a major impact. In that case, reading more than one book will reduce the global impact, However, more than 35 readings are needed to have a similar impact as a numerical book.



This comparison highlights the substantial environmental benefits of digital media.

### 4.2 Watching a Movie

For the streaming scenario, most of the impact comes from the use phase, as expected as computers require a lot of energy. The impact of data centre and transfer is shared with different users but stays non-negligible as shown in the impact of distribution and storage.

The DVD production in itself represents less than 25% of the impact of the product when used 5 times. This part of the impact is highly modulable with the number of uses. In this case, also, more than half of the impact comes from the use of the computer. Interestingly, the transport from the production to the show has a really small impact despite the distance, but this is reasonable as trucks transport a big amount of product and full capacity has been considered.

For the theatre, the impact comes mainly from transport. Even with particularly important electronics and a lot of energy needed, this impact is small for one person when considering a half to the full theatre room. In this case, individual impact as food is higher.

### 4.3 Skiing in Verbier

Skiing has one of the highest environmental impacts among leisure activities analyzed, but mainly because of transport. A day of skiing, including transportation by car, produces approximately 80.8 kg of CO<sub>2</sub>, whereas using public transport (train and bus) reduces this impact to

17.2 kg of CO<sub>2</sub>.

At the customer level, the impact of the station is low, because the construction is long-lasting and widely used. The number of skiers is high at Verbier and shares the impact.

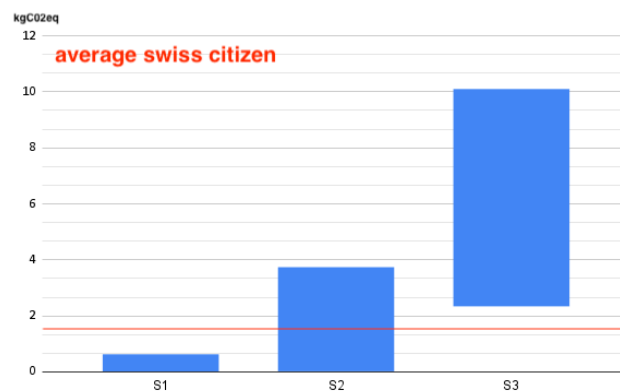
## 4.4 General findings

When a clear ranking from book to ski was expected from the lowest to the highest impact, the result highlights that depending on the parameter watching a movie can be more impactful than skiing and that reading a book can be as impactful as watching a movie.

# 5 Discussion

## 5.1 contrasting with the average Swiss citizen

According to precedent study [14], the impact of an average Swiss citizen is around 11.6 tonnes CO<sub>2</sub>eq per year, or **31.8 kgCO<sub>2</sub>eq** per day, **1.32 kgCO<sub>2</sub>eq** per hour. Our study only takes into account the activity of leisure, not another element that could impact the average impact of a citizen. Also, this value isn't representative as the consumption isn't constant for all our of the day. However, this comparison 5.1 put in perspective the impact of each scenario, highlighting that reading is below the mean, watching a movie around the mean and skiing far more impactful.



comparison to the average Swiss citizen

Considering just the activity of skiing, a skiing day is already 1 to 3 times more impactful than a regular day for a Swiss citizen. Assuming a citizen ski 20 days in a year, skiing represents between 3.3 and 13.9% of his impact, in less than 2% of the year.

In comparison, reading for the same amount of time a year will represent a maximum of 0.8% of the impact and for watching a movie, a maximum of 5.1%.

## 5.2 Impacts if Everybody Behaved Similarly in Switzerland

If every Swiss citizen engaged in high-impact leisure activities like frequent skiing, the cumulative environmental impacts would be considerable.

Switzerland has the second largest population of skiers in Europe, one in third Swiss citizens ski regularly. Imagine that all Swiss citizens start skiing 20 days a year tomorrow, considering the case of 80kgCO<sub>2</sub>eq for a ski day and a normal day at 20kgCO<sub>2</sub>eq, this would lead to an increase of around 5.85 million tonnes of CO<sub>2</sub>eq at the Swiss level.

To compare, it will be like duplicating the canton of Geneva (adding 0.5 million inhabitants).

Or like asking an A380 [26, 27] to make the 2282 earth orbit.

In comparison, now all the citizens who are skiing regularly decide to read paper books instead. We already considered that reading a book and skiing a day take approximately the same time and we neglect another impact. Therefore, it could save 4.4 million tonnes of CO<sub>2</sub>eq at the Swiss level.

In other words, make Tessino disappear, or save 1719 Earth orbit to an A380. (or let 17% of the Swiss population enjoy an earth orbit in an A380).

The results show how much different the global impact will be depending on the population's behaviour.

### 5.3 Potential Solutions to Reduce Impacts

To mitigate the environmental impacts of leisure activities, the following solutions could be proposed.

- **Promote Sustainable Transportation** Encourage the use of public transportation, carpooling, and electric vehicles to reduce carbon emissions from personal travel.
- **Energy sources** Invest in more sustainable energy sources, for powering personal and global devices.
- **Energy Efficiency** Invest in energy-efficient technologies for ski lifts and snowmaking to reduce energy consumption at ski resorts.
- **Waste Management** Implement robust recycling and waste reduction programs at leisure facilities to minimize landfill use.
- **Education and Awareness** Raise public awareness about the environmental impacts of leisure activities and promote responsible behaviour through educational campaigns.
- **Data center and file quality** Encourage the use of new data centre format to reduce their impact, watch and transfer in lower quality.
- **Reuse and share** Of course one of the best ways to reduce impact is to not use it. For books and DVDs reusing them and sharing them with others significantly reduces the impact.

Applied to each scenario :

- **Reading a Book** Switching to e-books and using energy-efficient devices can significantly reduce the environmental footprint of reading.
- **Watching a Movie** Streaming movies from optimized, energy-efficient data centres can lower the environmental impact compared to physical media.
- **Skiing in Verbier** Improving public transport access to ski resorts, incentivizing carpooling, and promoting electric vehicle use can substantially reduce the carbon footprint of skiing trips. Additionally, enhancing the energy efficiency of ski resort operations can further mitigate environmental impacts.

Overall, addressing the environmental impacts of skiing in Verbier requires a holistic approach involving collaboration among stakeholders, including government agencies, ski resorts, transportation providers, and tourists.

## 6 Conclusion

This report highlights the significant environmental impacts of leisure activities and provides a comparative analysis of the average Swiss citizen's footprint. By adopting sustainable practices and technologies, it is possible to mitigate these impacts. Continued efforts in public education, infrastructure improvements, and policy support are crucial for promoting more sustainable leisure activities.

This study particularly emphasizes the impact of transportation and how this essential aspect of our lifestyle should be addressed for a more sustainable future, even when choosing activities for a leisure day. It may seem trivial, yet it is far from negligible, to address the impact of travelling alone by car, for example.

However, this study has several limitations that need to be addressed. First, there were many approximations made when data was unavailable, such as the impact of movie production, ski clothes production, or theatre components. More accurate data could provide more precise results. Additionally, most of the transport distances are based on assumptions, and changing these values could significantly affect the study's outcomes.

## 7 Annex

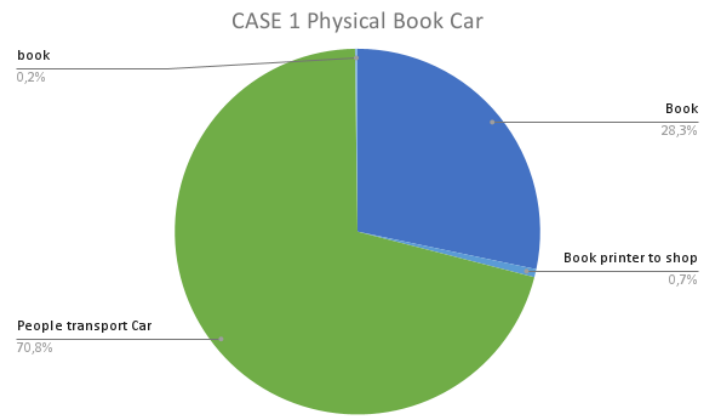


Figure 12: Book, worst case

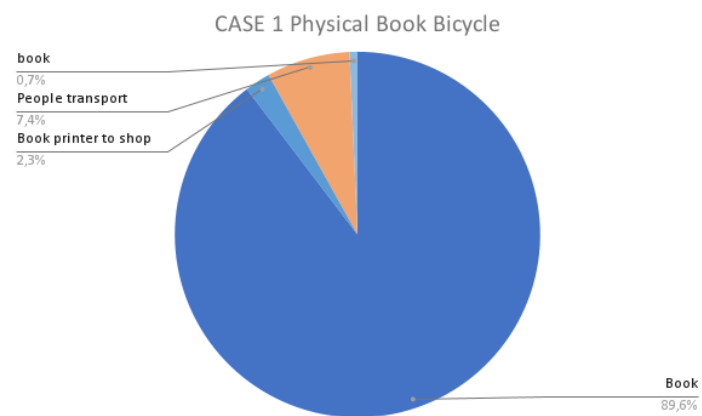


Figure 13: Book, best case

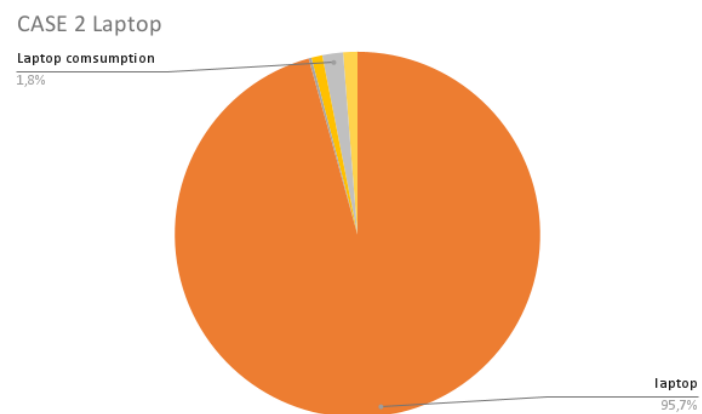


Figure 14: Numerical book

Detailed impact of the three scenarios of books



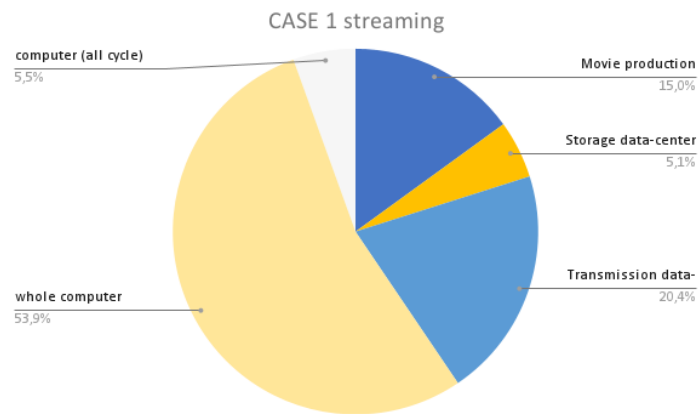


Figure 15: Streaming

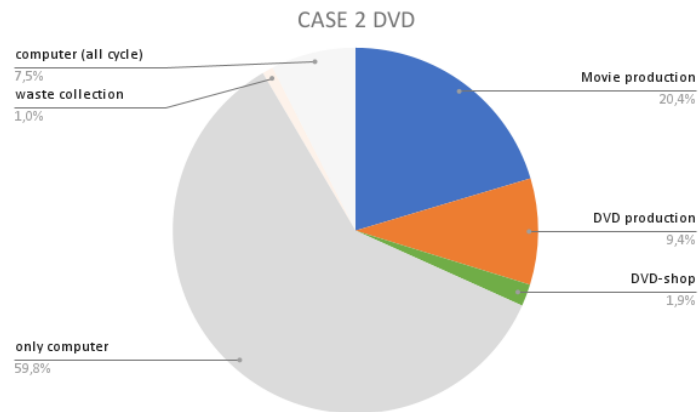


Figure 16: DVD

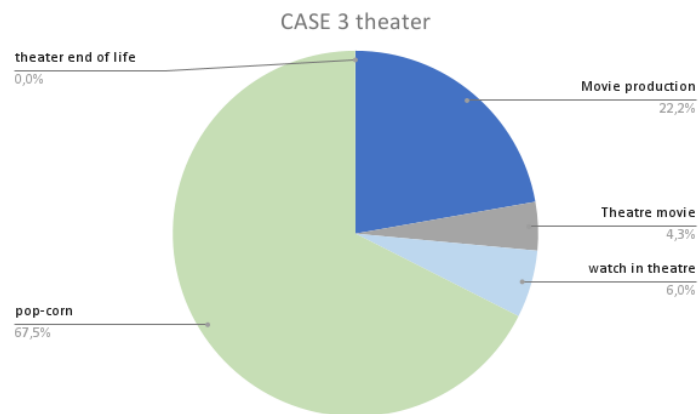


Figure 17: Theater

Detailed impact of the three scenarios without transport

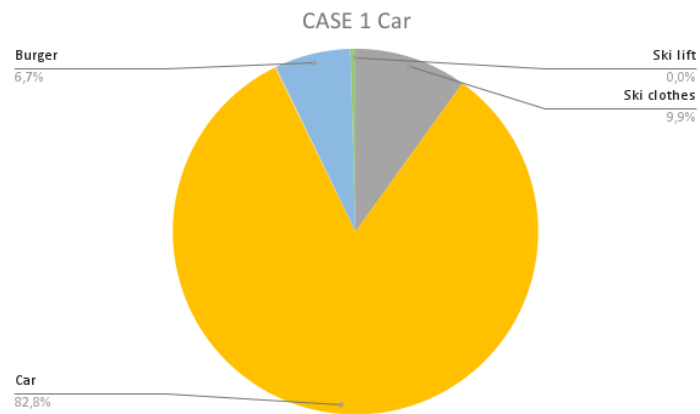


Figure 18: Impact of a day of ski by car

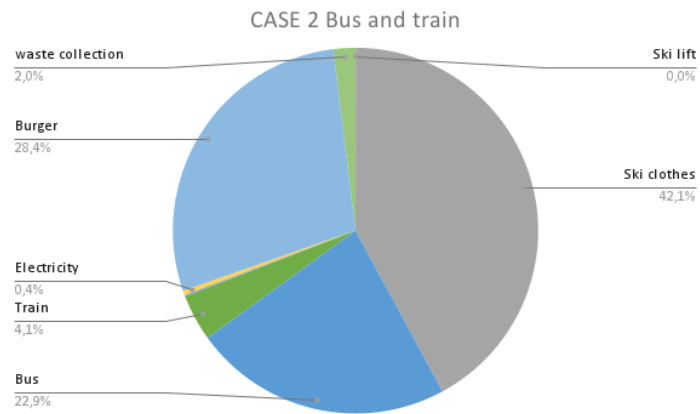


Figure 19: Impact of a day of skiing by train and bus

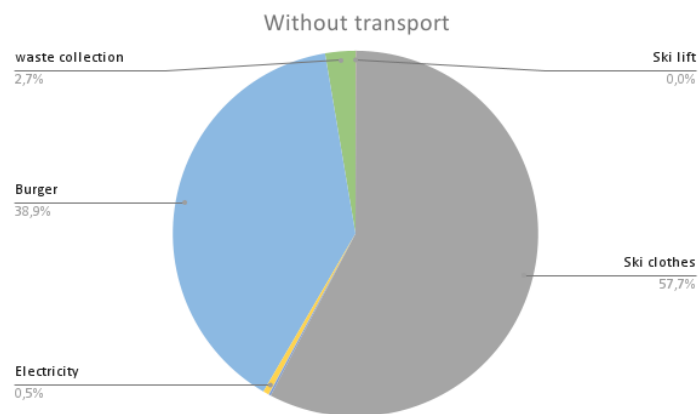


Figure 20: Repartition of the impact without transport

Detailed repartition of the impact on a skiing day

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