



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Department of the Environment, Transport,
Energy and Communications DETEC
Swiss Federal Office of Energy SFOE
Energy Research and Cleantech

SWEET Call 1-2021: SWEET Lantern

Deliverable report

Deliverable n°	9.1
Deliverable name	Decision-support tools on energy impacts of tourism destinations
Authors The authors bear the entire responsibility for the content of this report and for the conclusions drawn therefrom.	Andrea Salmi, HES-SO Valais Wallis, andrea.salmi@hevs.ch Jakob Rager, HES-SO Valais Wallis, jakob.rager@hevs.ch Ivan Minguez, HES-SO Valais Wallis, ivan.minguez@hevs.ch Tristan Loloum, HES-SO Valais Wallis, Tristan.loloum@hevs.ch
Reviewers	Ricardo Lima Roger Baer Francesca Celina Fiona Zimmermann
Delivery date	September 2024



Table of Contents

List of Tables	3
List of Figures.....	3
Summary	5
1 Introduction and Context	6
2 Methodological Approach	7
2.1 The Living Lab Approach	7
2.1 2.2 Decision-Support Tools for Low-Carbon Tourism Planning	9
3 Energy and Climate Impacts of Tourism Destinations	10
3.1 3.1 Overview of Emissions in the Tourism Sectors	11
3.2 3.2 Carbon Assessments in Val de Bagnes	12
3.2.1 3.2.1 Mountain Riders Report.....	13
3.2.2 3.2.2 Navitas Consilium Platform & 2000 Watts Society Report.....	14
3.2.3 3.2.3 Smart Altitude Report.....	14
3.2.4 3.2.4 Téléverbier SA Annual Report.....	15
4 The Tourist Carbon Profile Tool	15
4.1 4.1 State of the art	15
4.2 4.2 The Tourist as the Unit of Analysis	18
4.3 4.3 The Personas and AI-generated Travel Plan	18
4.4 4.4 The Transdisciplinary Sectors of Tourism	19
4.5 4.5 User-Friendly Design	20
4.6 4.6 Tourist Carbon Profile Tool.....	21
4.6.1 4.6.1 Description.....	21
4.6.2 4.6.1 Use	23
4.6.3 4.6.1 User Instructions.....	24
4.7 4.7 Potential Development and Limitations	24
5 The Mountain Tourism Fresk: a Gaming Approach to Low-carbon Tourism Planning	25
5.1 5.1 Gamification to Raise Awareness About Climate Change and Trigger Action.....	25
5.2 5.2 The Case of the Climate Fresk	26
5.3 5.3 The Mountain Tourism Fresk.....	27
5.3.1 5.3.1 Test Phase	29
5.3.2 5.3.2 Detailed Description of the Workshop	32
5.3.3 5.3.3 Spotlight Application	35
5.3.4 5.3.4 Future Developments	36
6 Conclusion.....	36
7 Bibliography	36
8 Annexes	41
8.1 8.1 Tourist Persona Descriptions.....	41
8.2 8.2 Example of AI-generated Travel Plan from Persona	44
8.3 8.3 Tool Visualisation Examples.....	46



8.4	8.4 Mountain Tourism Fresk Deck of Cards	50
8.5	8.5 Mountain Tourism Fresk Participants Survey.....	50
Appendix		51

List of Tables

Table 1: Summary of the energetic assessment of Val des Bagnes in 2021 by 2000 Watts Society, Navitas Consilium.	14
Table 2: Summary of energy consumption and GHG emissions across activities related to the ski resort managed by Téléverbier SA.	15
Table 3: Examples of widely used tourism accommodation labels at international level, for Europe and Switzerland.....	17
Table 4: Preliminary list of Carbon Footprint platforms to calculate tailored emissions after generated travel plans.....	20
Table 5: Climate Fresk benefits and limitations.	27
Table 6: List of Personas tested with the Tourist Carbon Profile Tool.	41

List of Figures

Figure 1: WP9.2 Theory of Change, developed with the support of WP10.	7
Figure 2: WP9.2 Living Lab Integrative Process.	8
Figure 3: Schema of Tourist Carbon Profile Tool.....	22
Figure 4: Persona sheet of Tourist Carbon Profile Tool.....	22
Figure 5: Emission inventory sheet of the Tourist Carbon Profile Tool.....	22
Figure 6: Carbon footprint sheet and outputs of Tourist Carbon Profile Tool.	23
Figure 7: A Climate Fresk workshop at EPFL Sion (2024).	26
Figure 8: Verbier Tourism Map used to support the Fresk.	28
Figure 10: Tourism strategy workshop for Pays d'Enhaut, Château d'Oex, 19.06.2024, 19 participants, 3 facilitators.	30
Figure 11: Moving Mountains Forum, 21-22.08.2024, Les Diablerets, 30 participants, 2 facilitators ..	30
Figure 12: SWEET Conference, Bern, 04.09.2024, 15 participants, 2 facilitators.	31
Figure 13: National Open Innovation Camp, Sion 12.09.2024, 5 participants, 2 facilitators.	31
Figure 14: SWEET Lantern Site Visit, Sion 13.09.2024, 8 participants, 2 facilitators.....	32
Figure 15: "Moving Mountain Tourism".	35
Figure 16: "La Bonne Voie".	35
Figure 17: Presentation of personas in Val des Bagnes. Images were generated after the profiles from persona descriptions. The holiday destination was predetermined as Val des Bagnes.....	47
Figure 18: Tourist Carbon Profile Tool output visualisation for four Personas with predetermined holidays in Val des Bagnes with a fixed time duration of one weekend (two nights).....	47
Figure 19: Tourist Carbon Profile Tool output visualisation for four Personas with predetermined holidays in Val des Bagnes with a variable duration across Personas.....	48



Figure 20: Four Personas brief descriptions with predetermined holidays in Chateaux d'Oex with a variable duration across Personas.....	48
Figure 21: Tourist Carbon Profile Tool output visualisation per sector for four Personas with predetermined holidays in Chateaux d'Oex with a variable duration across Personas.....	49
Figure 22: Tourist Carbon Profile Tool output for four Personas with predetermined holidays in Chateaux d'Oex with variable duration across Personas (first two profiles)	49
Figure 23: Tourist Carbon Profile Tool output for four Personas with predetermined holidays in Chateaux d'Oex with variable duration across Personas (second two profiles)	50



Summary

This document presents the deliverable D9.1 for the project SWEET Lantern, which focuses on developing and implementing innovative tools to support sustainable tourism planning in the Swiss Alps. The project addresses the urgent need to decarbonise the tourism industry and reduce energy demand, particularly during the peak winter season. Tourism is a vital economic driver in mountain regions and a significant contributor to greenhouse gas (GHG) emissions. This deliverable introduces two essential tools: the “Tourist Carbon Profile tool” and the “Mountain Tourism Fresk” developed within WP9 to support climate action and decision-making towards low-carbon tourism. Both tools incorporate important facts on energy impacts to inform and trigger a systematic and transdisciplinary understanding of climate challenges in tourism destinations. These tools are aimed at tourism operators, decision-makers in recreational cities, tourism students and wider tourism stakeholders (NGOs, local residents, second-home owners, etc.). The development of D9.1 focuses on addressing knowledge on energy impacts of GHG emissions in the tourism sector, using GHG estimates and climate facts as a key driver towards sustainability.

These tools have been initially developed and tested with partners from Val de Bagnes, a municipality from Valais known for its famous mountain resort, Verbier. Val de Bagnes is a picturesque valley known for its rugged mountains, lush meadows, and charming alpine villages, making it a popular destination for outdoor enthusiasts. Renowned for its well-preserved traditional Swiss culture and tranquil atmosphere, it offers a more intimate and authentic alpine experience, constituting a relevant example of alpine tourism. Val de Bagnes's territory and tourism activities have already been screened concerning different projects to support future sustainable development. The reports rely on existing data, both private and public, delivering information about the system's energy consumption and emissions across multiple sectors and subjects (Page **Erreur! Signet non défini.**
Erreur! Signet non défini.). However, the available reports regarding methods and datasets are not transparent. There are discrepancies in results due to the variety of methods used, and the data is insufficient to build up a representation of the tourist destination's carbon footprint.

After studying the issues of data lack and quality in tourism sectors, including mountain tourism and the case study, we tailored this deliverable by focusing on the development of tools. The latter includes factsheets of generic mountain tourism activities from relevant literature or creates data to optimise the information.

During the development of D9.1, we created the Tourist Carbon Profiles Tool to support activities by providing examples of the carbon emissions of different types of tourists depending on their travel plans. This tool created ready-to-use data during activities, thus delivering part of the content for the factsheet on energy impacts. The tool's characteristics include persona creation, AI travel plan generation, and a user-friendly design, making it a valuable resource for stakeholders through ready-to-use carbon footprint information. The tool allowed us to forge emission profiles for fictional tourists, which we applied during several activities such as workshops, meetings with cooperation partners, courses and within the Mountain Tourism Fresk. The tool allowed us to tailor the outputs for the specific activities, delivering a shared understanding of the energy impacts to participants. More potential uses of the tool are proposed, such as its internal use for small and medium enterprises and the tourism activity scoring for marketing information.

The Mountain Tourism Fresk was also prototyped within WP9.2 to raise awareness about climate change implications in alpine destinations and promote behavioural change. The project addresses adaptation and root causes of tourism-related emissions (including inbound/outbound tourism, construction, food, equipment). With this tool, participants actively engage to increase their climate literacy and co-create solutions for their tourism destination. This tool proved effective to construct a common understanding of climate change in the tourism industry and spark collaborative action amongst stakeholders. The solutions proposed by participants during each edition of the Fresk will be systematised and presented to cooperation partners from Verbier in the beginning of November.



1 Introduction and Context

The Swiss Alps, renowned for their stunning landscapes and vibrant tourism industry, face significant challenges due to climate change. As the demand for sustainable tourism grows, there is an urgent need to decarbonise the tourism industry and lower energy demand, especially in winter, when the skiing industry is at its peak. Tourism is a significant economic driver in mountain regions, contributing significantly to local economies. However, it also accounts for greenhouse gas (GHG) emissions. While contributing 10% to global GDP and employing 320 million people globally, tourism also contributes to approximately 8% of global GHG emissions (Lenzen et al., 2018). In the Swiss context, the tourism sector must adapt to mitigate its environmental impact while maintaining its economic benefits. Switzerland aims to reduce GHG emissions by 50% by 2030 compared to 1990 (Federal Office for the Environment, 2021).

This Deliverable presents two tools – the “Tourist Carbon Profile tool” and the “Mountain Tourism Fresk” – developed within WP9 to support sustainable tourism planning in the Swiss Alps. Their common goal is to raise awareness about the magnitude of climate change in (mountain) tourism destinations and spark action on the causes and consequences of energy and climate impacts. These tools were developed as part of Task 9.2 (Low-carbon tourism planning), which explores decarbonisation pathways in alpine destinations. This task aims for the following outputs: reduce dependency on long-haul tourism by targeting proximity tourist demand, implement low-carbon incentive frameworks, increase local attractiveness and added value, decarbonise marketing strategies, develop clean energies and improve energy-efficiency of the tourism infrastructure.

WP10 Integrated Impact Assessment outlines the approach to measuring how the tools support the changes in the outputs described above. These outputs are key features of WP9.2 Theory of Change, which aims to reduce per capita energy consumption linked with recreational activities and foster energy sufficiency as a guiding principle in tourism planning and marketing strategies. Figure 1 outlines how WP9.2 is expected to lead to the desired outcomes based on a causal analysis.

WP9 designed questionnaires (e.g., Annex 11.5) to collect data about the tools' impact on the specific tasks' and the work package's overall goals.

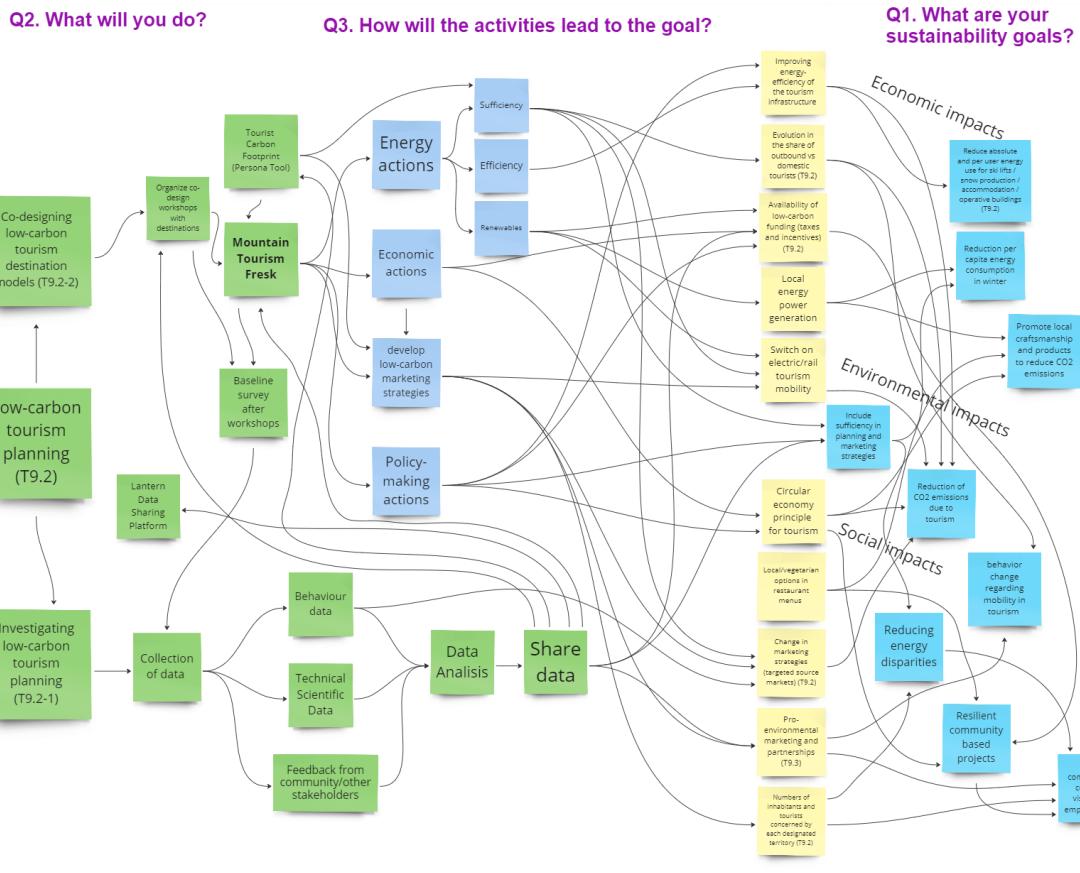


Figure 1: WP9.2 Theory of Change, developed with the support of WP10.

2 Methodological Approach

2.1 The Living Lab Approach

The methodological approach of SWEET Lantern aims to apply a living lab approach, particularly the Living Lab Integrative Process (LLIP). The lack of decision-making tools for low-carbon tourism planning was already identified as a need through the preparation of the proposal. These decision-making tools as well as other complementary methods and tools proposed to be applied in WP9, were initially mapped out against the LLIP and helped to guide the activities with the various stakeholders at the micro, meso and macro levels (Figure 2).

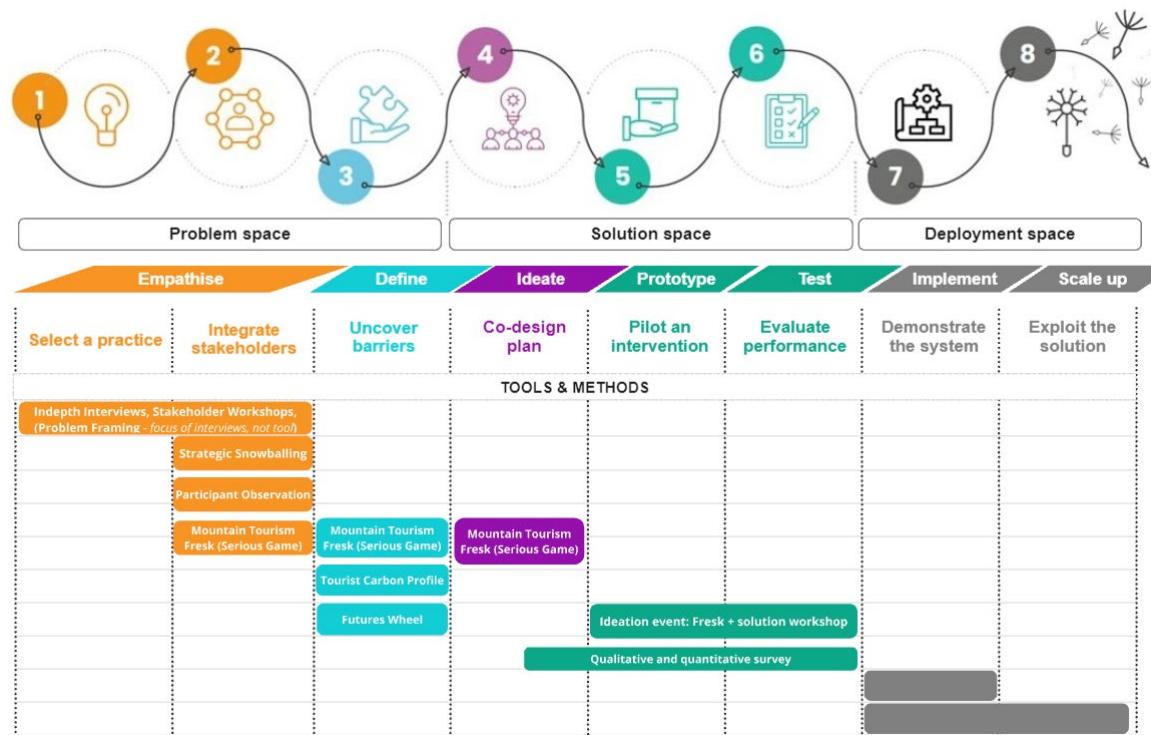


Figure 2: WP9.2 Living Lab Integrative Process.

The problem definition activities included extensive interviews with various stakeholders to help understand and define the problem associated with sustainable tourism in the ski resort. Collecting key data on energy and climate in the region was also important. The learnings from the interviews were outlined in a draft article on energy sufficiency (to be submitted soon) and communicated to the stakeholders through the workshops.

Three stakeholder workshops were carried out to understand further and validate the problems associated with low-carbon tourism in the resort. The innovation-orientated workshop design was inspired by the research of Bertella et al. (2021), where stakeholder and values mapping and persona tools were used in a comprehensive programme to build a shared vision and stimulate action-orientated outcomes with impact. The futures wheel was also used in one of the workshops to help explore the interlinkages between the causes and consequences of climate change. The 3rd workshop incorporated the prototypes of both tools (the Mountain Tourism Fresk and the Tourist Carbon Profile Tool).

The Tourist Carbon Profile tool was developed by Andrea Salmi and Jakob Rager (HES-SO, ex-CREM) after the generalised lack of transdisciplinary data about tourism emissions and after the food industry sector's approach to delivering carbon emission information. The first triggered the search for carbon footprint estimations from the multiple sectors related to tourism activities, thus the integration of sectorial emission inventories and carbon assessment tools. The second is the example of user-friendly scores optimised by marketing in the food industry, which deliver relevant information to the final consumer precisely while planning. The design of the tool output was tested during activities with cooperation partners (Verbier Tourism, Commune of Val de Bagnes, Altis SA and Téléverbier SA) to ensure its user-friendliness while addressing the complex transdisciplinarity of tourism activities.

The Mountain Tourism Fresk was developed by Ivan Minguez and Tristan Loloum (HES-SO) with the support of Anne-Sophie Fioretto and Fiona Zimmermann. Cooperation partners (Verbier Tourism, Commune of Val de Bagnes, Altis SA and Téléverbier SA) were also involved in the co-design and first tests of the tools. Pilot versions were also tested during public events: Tourism planning workshop in Château d'Oex (June 2024), Moving Mountains (August 2024), National Open Innovation Camp, SWEET Lantern Sion Site Visit and SWEET National Conference (September 2024).



The outcome of the workshops which used the tools helped the research team to understand the relative priorities of the various stakeholders. Initially it was thought that an ideation event would help to bring the actors together however it became evident that diverse approaches to sustainability and strategic tourism planning required a different approach. A review of the methodological approach at the meso level is currently being undertaken for WP9, in order to support the decision support tools for low carbon planning. The work undertaken in Val de Bagnes represented a project using participative methods and tools, however given that there is no formal Living Lab entity with activities at the macro level, and only one project at the meso level, the transformative potential of the tools in Val de Bagnes are limited to the role of fostering a collaborative environment where tourism planners and stakeholders could dialogue, share their views, and learn from one another. Future application of the tools could be aligned with stakeholder ecosystems who are more evolved on the macro level (established common vision, governance model) are committed to investing in innovation projects at the meso level. The Mountain Tourism Fresk was further tested in Chateau d'Oex and at the Moving Mountain Forum to help identify potentially suitable contexts for scale up. Aligning the bottom-up approach using the tools with the top-down vision and governance helps to ensure an active and dynamic innovation culture which can maximise the benefit and outcome of the decision support tools for low carbon tourism planning, such as those developed with SWEET Lantern.

2.1 2.2 Decision-Support Tools for Low-Carbon Tourism Planning

Recent scientific literature provides valuable insights into low-carbon tourism planning. For instance, Zeng et al. (2023) developed a framework for analysing tourists' low-carbon travel intentions, which can be adapted to the Swiss Alps. This framework emphasises the role of perceived convenience in promoting low-carbon transport among tourists. Several decision-making tools are instrumental in promoting low-carbon tourism. For example, the Low-Carbon Travel Promotion (LTP) Index assesses a city's ability to promote low-carbon travel among tourists. This tool can be adapted in the Swiss Alps to evaluate and enhance sustainable tourism practices (Zeng et al., 2023). Another valuable tool is the Tourism Satellite Account (TSA), a statistical framework that helps gather and share tourism data, enabling better decision-making for sustainable tourism management.

In the context of tourism planning, traditional decision-making tools often face limitations in their practical application. Research indicates that decision-makers frequently do not rely solely on these tools due to their complexity and the dynamic nature of tourism environments (McLoughlin, Maguire, & Hanrahan, 2023). Instead, there is a growing recognition of the value of participatory approaches that involve stakeholders directly in the planning process. This participatory or co-design approach incorporates diverse perspectives and local knowledge, leading to more robust and contextually relevant outcomes (Mak, Cheung, & Hui, 2017).

Given these insights, and the outcome of the workshops where diverse priorities were uncovered, our project did not aim to develop conventional decision-making tools. Instead, we sought to foster a collaborative environment where tourism planners and stakeholders could dialogue, share their views, and learn from one another. This led to the Mountain Tourism Fresk, a climate education tool facilitating collective learning and decision-making. The tool emphasises collaboration and the co-creation of knowledge rather than relying on top-down, expert-driven tools.

Adopting a gaming approach in tourism planning can effectively engage stakeholders in understanding low-carbon tourism in a non-directive manner. This method reduces resistance to top-down recommendations by allowing stakeholders to independently identify and comprehend core issues. Research indicates that participatory and game-based learning can enhance stakeholder engagement and facilitate a deeper understanding of complex environmental challenges (Mayer, 2016).

The tools we have developed, such as the Mountain Tourism Fresk, highlight structural problems in a gameful way. These include dependencies on long-haul tourists, reliance on thermal cars, and other energy-intensive travel habits such as meat consumption, ski lifts, and second-home usage. By simulating real-world scenarios and encouraging collaborative problem-solving, these tools help stakeholders recognise and address the environmental impacts of tourism activities. This approach



aligns with the principles of evidence-based planning, which emphasise integrating scientific knowledge with stakeholder input to address energy and climate factors in tourism decisions (McLoughlin, Maguire, & Hanrahan, 2023).

The Mountain Tourism Fresk is a decision-support tool that provides an interactive platform for stakeholders to explore the complexities of low-carbon tourism planning. By simulating real-world scenarios and encouraging participants to work together, the tool helps build a shared understanding of the challenges and opportunities associated with sustainable tourism. This approach aligns with the principles of evidence-based planning, which emphasise the importance of integrating scientific knowledge with stakeholder input to address energy and climate factors in tourism decisions (McLoughlin et al., 2023).

Furthermore, it is crucial to consider the carbon footprint of tourism activities across all scopes (1, 2, and 3). Scope 1 includes direct emissions from owned or controlled sources, Scope 2 covers indirect emissions from the generation of purchased electricity, and Scope 3 encompasses all other indirect emissions that occur in the value chain. Addressing these emissions comprehensively is essential for responsible tourism planning, as it highlights the sector's role in contributing to global greenhouse gas emissions (Lenzen et al., 2018). For this matter, we consistently included scope 1, 2 and 3 carbon estimates in the tools developed here.

The Tourist Carbon Profile and the Mountain Tourism Fresk are valuable tools for evidence-based low-carbon planning. They provide concise, easily accessible information to help stakeholders make informed decisions. The tools have already been used to inform the new Strategic tourism master plan for Pays d'Enhaut. Although it was initially proposed to develop factsheets, it was decided to integrate the facts into the tools since factsheets can sometimes oversimplify complex issues, potentially leading to misunderstandings or misinterpretations. Unlike a static document that provides information in a straightforward, linear manner, in our work, a fact-based tool like The Mountain Tourism Fresk is dynamic and interactive, engaging participants in a hands-on learning experience. While this can be more time-consuming and resource-intensive to implement, it often results in a deeper and more lasting understanding of the material. As these tools can be applied to other contexts, we believe they will also facilitate the replication and scaling up of solutions across tourism sectors.

3 Energy and Climate Impacts of Tourism Destinations

Human activities are widely recognised as the primary driver of environmental changes impacting human life and other forms of life (IPCC, 2023). Tourism is a complex phenomenon encompassing multiple human activities outside of the residence, accounting for 10% of global GDP and employing 320 million people (UNWTO, 2019; World Economic Forum. The impact of such activities is heterogeneous across tourism activities, such as different forms of pollution, which require specific insight on a case-by-case basis. A common and relevant impact across all human activities affecting the environment, including tourism, is the impact on climate change through GHGs. Therefore, GHG estimate is the most used transdisciplinary method across sectors for monitoring climate change contribution and perhaps the most used indicator of environmental sustainability nowadays (Dong & Michael Zwicky, 2017; Lenzen et al., 2018a; UNEP, 2023).

Moreover, tourism is directly bound with climate change by being a relevant contributor while being impacted by (UNWTO, 2019). This interrelation is specifically crucial for mountain tourism, in particular in the Alpine region (UNWTO, 2018). The adaptation to climate change, thus reducing impacts on the tourism sector, requires specific adaptation that can be embraced by local governance in sectors mainly outside of tourism. Instead, the mitigation of climate change, thus the reduction of emissions that cause climate change, needs to be embraced by tourism activities (IPCC, 2023; UNWTO, 2019).

Given the everyday use of GHG as a standard estimate of sustainability, the complex sectorial nature of tourism, and the potential to contribute to climate change mitigation, the development of D9.1 mainly



addresses GHG related to the tourism sector(s). Impacts or adaptations to climate change are included secondarily in emissions and specific contexts.

By monitoring emissions across sectors, it is possible to optimise action to drive change across all sectors related to tourism (UNWTO, 2019; WTTC, 2021). The allocation of emissions requires understanding emissions across complex networks by understanding direct and indirect emissions. When dealing with carbon assessment, three different scopes group emissions sources as follows (WTTC, 2021):

- Scope 1: Direct emissions from a business's operations, including fuel combustion, vehicle use, and fugitive emissions.
- Scope 2: Indirect emissions arising from generating electricity, heating, cooling, or steam business purchases.
- Scope 3: Indirect emissions within a business's value chain, encompassing purchased goods and services, business travel, employee commuting, waste disposal, transportation (both upstream and downstream), investments, leased assets, and franchise activities.

The understanding of emissions across scopes and a coherent allocation of emissions responsibility is crucial to addressing climate change mitigation effectively (UNWTO, 2019). The effort to address sustainable change across sectors usually merges multiple strategies, such as adopting new regulations, researching new technologies, or promoting sustainable change in all sectors. The core of the Lantern project is transdisciplinary promotion through real-life user-centred experiments for a sustainable future. Indeed, D 9.1 focuses on delivering accessible and transdisciplinary information on carbon emissions to support the tourism sectors.

3.1 3.1 Overview of Emissions in the Tourism Sectors

The UNTWO, by reviewing the carbon assessment in the tourism sector, recognise the generalised lack of data and underlines how as it is a critical driver for addressing climate change (UNWTO, 2019). The scientific literature generally reports the same concept while showing a positive change in emission data collection (Crespi et al., 2021; Lenzen et al., 2018a, 2018a; Sun et al., 2020; World Economic forum, 2024; WTTC, 2021). Tourism emissions are estimated to reach up to 8% of global emissions yearly (UNWTO, 2019; World Economic forum, 2024).

The estimate provided by Sustainable Travel International displays the share across sectors of activities related to tourism (Sustainable Travel International, 2024). They report that almost half of tourism emissions are related to transportation (49%), whereas smaller shares are related to food, accommodation, leisure and goods shopping. While transportation is estimated to cause 16% of all human activities, its share for the tourism sectors is significantly higher (UNWTO, 2019; World Economic forum, 2024), and it is expected to increase by 25% before 2030 compared to 2016 levels (UNWTO, 2019).

The understanding of tourism emissions at the global level can partially leverage and inform local tourism, which is supposed to be characterised by local specificities, such as mountain regions (UNWTO, 2018).

The UNTWO reviewed the contextual interrelation between sustainability and tourism while reviewing the mountain tourism industry. Mountain ecosystems, particularly in Alpine regions, are integral to the success of mountain tourism. They provide essential resources, including climate and topography, crucial for various tourism activities like skiing and hiking. However, tourism growth in these areas has significant environmental impacts, especially concerning GHGs (UNWTO, 2018).

Tourism development in mountain regions involves building infrastructure for accommodation, like other types of tourism, and other infrastructure to access relatively remote areas, such as cable cars and ski lifts. The energy-intensive nature of these activities, especially during the winter, significantly increases



GHGs, i.e., artificial snowmaking, which exacerbates the emissions while trying to fix their impacts. The negative impacts are even worse when sustainability assessment is extended to other aspects than GHG, constituting a paradox between tourism development and environmental conservation (UNWTO, 2018).

Historically, mountain tourism development began with elite visitors in the 19th century, eventually growing into a mass tourism phenomenon by the mid-20th century. This boom in tourism was facilitated by industrialisation, which brought infrastructure and wealth to the regions surrounding the Alps. However, as tourism matured, it faced challenges from global trends, including the rise of other types of tourism and the declining popularity of winter activities. These changes, aggravated by the high costs of maintaining winter tourism infrastructure, have shifted from mass tourism to niche markets in the last decades (UNWTO, 2018). For example, the UNWTO estimates the number of skiers to be 115 million globally, with 14% of international tourism (UNWTO, 2018).

The sustainability of mountain tourism is deeply tied to preserving its natural environment. Although mountain tourism is not a significant contributor to global environmental degradation in terms of direct emissions, it suffers from the effects of climate change. Warmer winters due to global warming threaten the viability of ski resorts as snowfall becomes less consistent and less predictable, increasing the reliance on artificial snow and, therefore, emissions. The need to cover fixed costs by a minimum occupancy rate contrasts with the reliability of climate. Moreover, the innovation need required by the tourism market increased the investment in winter infrastructures. These phenomena cause a deeper intrusion of mountain infrastructure in the mountain ecosystem, betting the infrastructure investment to catch up with the declining winter industry (UNWTO, 2018).

According to UNTWO, mountain resorts must prioritise energy efficiency and reduce their reliance on fossil fuels to mitigate these impacts. Public administrations play a crucial role by setting regulations and providing incentives for sustainable practices, such as promoting renewable energy sources for resort operations or limiting the visual and environmental pollution caused by overdevelopment. While mountain tourism is essential for the economic well-being of many remote areas, its long-term sustainability depends on balancing development to address climate change threats with environmental preservation.

In the context of winter sports, Switzerland was the sixth country in terms of visitors in 2014, even considering the stagnation of the market observed in the last four decades. Swiss winter tourism was also the third most international after Andorra and Austria, with 50% of international visitors. Worldwide, western European countries lead the travel demand for mountain tourism internationally (UNWTO, 2018).

Understanding the carbon footprint at the local level is crucial for addressing sustainability in mountain tourism (UNWTO, 2018) by presenting the environmental impacts of a known reality to local stakeholders. The reduction potential can be assumed to be higher in the Swiss territory due to its high degree of development, including the international tourism market. Moreover, the Swiss context, not only about tourism, is often perceived as an optimal case study for the quality and quantity of available data.

In the following section, we review carbon footprint reports for Val des Bagnes's specific case study, which provides insight into the local context.

3.2 3.2 Carbon Assessments in Val de Bagnes

Val de Bagnes territory, located in the Swiss Alps, is composed of a stunning valley known for its picturesque landscapes, characterised by rugged mountains, lush meadows, and charming alpine villages. Its natural beauty and diverse terrain make it a popular destination for outdoor enthusiasts, offering skiing, hiking, and mountain biking activities. The region is renowned for its well-preserved traditional Swiss culture and architecture, which attract tourists seeking an authentic alpine experience.



Its integration with tourism supports the local economy, making it an ideal study case for Alpine tourism. While Val des Bagnes's tourist activities encompass most of the Alpine region's tourism activities, Val de Bagnes stands out from other Alpine destinations with its blend of authentic Swiss village charm and expansive outdoor activities. Unlike commercial resorts, it offers a more tranquil and less crowded experience. Its emphasis on preserving traditional culture and integrating wellness with adventure tourism sets it apart, while its lesser-known status provides a more intimate and authentic alpine experience compared to the bustling, high-profile destinations in the Alps (Office du Tourisme de Val des Bagnes, 2024; Wikipedia, 2023).

Val des Bagnes's territory and tourism activities have already been assessed concerning different projects to support future sustainable development (e.g. Smart Altitude). The reports shown in this paragraph rely on existing data, both private and public, delivering information about the system's energy consumption and emissions across multiple sectors and subjects. Overall, the available reports regarding methods and datasets are not transparent. As stated by one of our research participants, a municipal energy advisor, "*Calculation methods evolve and are not routinely adapted....There are many discrepancies and differences in the results between one office and another due to the variety of methods*". At the same time, their results, recommendations, and strategies are coherent with the summary provided by UNTWO for tourism carbon footprint (UNWTO, 2019) and mountain tourism (UNWTO, 2018). The relevant information from Mountain Riders (2010) reports Navitas Consilium platform and 2000W society, Smart Altitude, and Téléverbier is presented hereunder.

3.2.1 3.2.1 Mountain Riders Report

The report produced by Mountain Riders in 2010 (Mountain Riders, 2010) is the most comprehensive carbon footprint for the case study area regarding sectors assessed, sound methods, and databases. It provides an estimate of the carbon footprint for the whole territory of Val des Bagnes, with a detailed focus on skiing activities. The report compares the estimated carbon footprint of Val des Bagnes with the carbon footprint of other mountain destinations (a "comparable" mountain destination(s) of the French Alps), which were not clearly defined.

The territory of Val des Bagnes has significantly higher total emissions per resident, specifically for agriculture and households, and lower for industry and services. When the carbon footprint is calculated per resident and tourist, emissions are higher for agriculture and lower for transportation (probably thanks to the high quality of Swiss public transport, which easily reaches Val des Bagnes).

Regarding skiing activities, Val des Bagnes's emissions are higher for mobility (scope 1), up to more than 1.4t CO2e per bed. In absolute terms, across means of transportation, the first source of emissions is related to cars. Still, regarding emissions per tourist, planes (extra European and then European) are logically more impactful than cars. Skiing activities do not show significant differences in CARBON FOOTPRINT for Val des Bagnes.

The report underlines the lack of consistent data for the carbon footprint of Val des Bagnes, as confirmed in the tourism sector from UNWTO (UNWTO, 2019). The suggestions are similar to those in the UNTWO report (focus on transportation and housing). The tailored suggestion does not go into detail and generally calls for rethinking multiple Val des Bagnes or carbon footprint compensation activities. However, this paper provides insight into the top emitter profiles, the air transportation within Switzerland, such as Heli-ski. They estimate that the cost of CO2 compensation for Heli-ski activities is a small share (1-2%) of the service cost, suggesting that the added cost is likely to be accepted by customers.

This report has two main strengths. First, it uses a standard approach from the French government's ADEME to estimate carbon footprint. Second, it employs a multisectoral approach; thus, it estimates carbon footprint across sectors for the territory of Val des Bagnes, such as agriculture, mobility, commercial activities, waste, and buildings.



The report was limited due to three factors. The study was tailored to data availability in Val des Bagnes but did not screen all activities within the case study. However, this presents an opportunity for future assessments to be more comprehensive. Then, the carbon footprint estimation is performed mainly in scope 1, thus with a lack of understanding of indirect emissions. This also highlights an area for improvement in future assessments. Ultimately, the report and methodology are not transparent, and the carbon footprint lacks actual quantification, even if it was shown as an estimate rather than an assessment.

3.2.2 3.2.2 Navitas Consilium Platform & 2000 Watts Society Report

The Navitas Consilium platform (Navitas Consilium, 2024) provides, from federal data, an insight into heating emissions across Swiss communes. For Val des Bagnes, a mean of 27 kg of CO₂e per year per m² of heated surface is estimated. Furthermore, renewable energy sources (including wood) are estimated to cover 42% of heating consumption, and heating energy sources rely 60% on imported sources.

In 2023, Navitas Consilium produced a tailored assessment for Val des Bagnes about the project 2000 Watts Society (EPFZ, 2024) of the EPFZ (the latter addresses reducing energy consumed per person across all sectors to a target of 2000 Watts per day). The report estimates the energy consumed in Val des Bagnes in 2021 by significant sectors and GHG in each scope. The report and methodology are not transparent; they merge governmental data employed in their web platform with local data and carbon inventories to calculate the carbon footprint for the territory of Val des Bagnes. According to the report, in 2021, Val des Bagnes emitted 72 kt CO₂e, where 31.6 kt CO₂e were related to heating, 40 kt CO₂e to mobility, and 0.6 kt CO₂e to electricity consumption, where fossil sources provided 54% of the total energy. Heating consumption corresponds to 3 kt/person, which is highly impacted by heating oil, which covers 36% of heating consumption while causing 82.6% of emissions. The electricity consumption corresponds to 0.1 t/resident, which is mainly employed for heating and sourced mainly from hydropower sources (both local and imported). Ultimately, the mobility sector's carbon footprint corresponds to 3.9 t/resident, where 72% belongs to car transportation, 21% to air transportation, and 4.7% to snow grooming. Almost all local and tourism vehicles accessing Val des Bagnes are based on fossil fuels (93%).

Sector	Kt CO ₂ e	t CO ₂ e / resident	Top source	Top use	Scope 1	Scope 2	Scope 3
Mobility	40	3.9	oil	car	62.5%	2.7%	33.2%
Heating	31.6	3	oil	housing	72.7%	6.3%	22.1%
Electricity	0.6	0.1	hydropower	heating	-	99.9%	-
Total	72	7.2	oil	mobility	66.6%	5.5%	27.7%

Table 1: Summary of the energetic assessment of Val des Bagnes in 2021 by 2000 Watts Society, Navitas Consilium.

3.2.3 3.2.3 Smart Altitude Report

The project Smart Altitude in Val des Bagnes provides insight into the principal enterprise carbon footprint of the ski resort through its report produced by CREM (Polderman et al., 2021). The project explored different components of the ski resort activities, highlighting the impact of snow grooming among the many, as summarised in the following table.



	Energy consumption	GHG emission
Snow grooming	37%	77%
Ski lift	35%	19%
Buildings	21%	3%
Snowmaking	7%	1%

Table 2: Summary of energy consumption and GHG emissions across activities related to the ski resort managed by Téléverbier SA.

3.2.4 3.2.4 Téléverbier SA Annual Report

The local ski resort's enterprise, Téléverbier SA (Téléverbier, 2023), also reports information related to energy and carbon footprint of its activity. For example, in the season 2021-2022, the resort welcomed more than 1.1 million visitors (1 124 769 skiing days). Through the Smart Altitude project, Téléverbier SA reported that in the 2018-2019 season, the carbon footprint was equal to 2 597 t CO₂e, of which 77% was related to snow grooming. (Téléverbier, 2023). This allows us to roughly estimate the emission per skier per day as 2.3 kg CO₂e. Similarly, The Ecollective platform (Ecollective, 2024) collects auto-reported carbon footprint of ski resort activities in Scopes 1 and 2. The available dataset shows an average emission of 1.25 kg CO₂e per skiing day for a dataset of 17 skiing resorts (or groups of skiing resorts).

4 The Tourist Carbon Profile Tool

During the development of D9.1, we created a tool to support activities by providing examples of the carbon emissions of different types of tourists depending on their travel plans. The tool allowed the creation of ready-to-use data during activities, thus delivering part of the factsheet(s) content. In the following paragraphs, we first introduce state-of-the-art carbon footprint methods. Then, we describe the tool and its characteristics (the persona, the AI travel plan generation, the tourist as a unit, the transdisciplinary, the user-friendly design), potential use, development, and limitations.

4.1 **4.1 State of the art**

The CARBON FOOTPRINT can be approached using bottom-up or top-down methods (Sun et al., 2020). Generally, in carbon footprint analysis (IPCC, 2019), bottom-up and top-down approaches differ in methodology and scope. The bottom-up approach calculates emissions by aggregating data from specific sources or activities, providing detailed and accurate insights for specific entities, like products or processes. It requires granular data collection, such as energy usage or material consumption, and is often used in Life Cycle Assessment (LCA) (IPCC, 2019). In contrast, the top-down approach estimates emissions using aggregated, large-scale data, such as national energy statistics or economic input-output tables. This method offers a broader perspective and is suitable for assessing carbon footprints at the national or sectoral level, but it has less detail and accuracy for specific items (IPCC, 2019). The bottom-up approach is more detailed but complex, while the top-down approach is broader and quicker. Both approaches are often used together for comprehensive carbon footprint analysis (IPCC, 2019).



Both methods mainly employ two data types: emission at a granular level (bottom-up) or indirect proxies (top-down). The emission data of items related to tourism activities are collected in the Emission Inventory (EI). They are tailored to the local context, e.g., the heating system used by an accommodation. The proxy data used by top-down methods employ averages for territory with TSA data. Both types of data are available differently across tourism sectors. The first is directly collected by environmental-aware tourism activities and their respective assessments, while the second is estimated by governmental monitoring of financial activities or large enterprises at national and international scale (Sun et al., 2020).

UNWTO has identified five macro-sector activities of tourism: *transport, food, stay, leisure, and shopping* (UNWTO, 2019). The collection and availability of both types of data across each macro-sector are heterogeneous (UNWTO, 2019).

For example, since the transportation sector is the main contributor to GHG, carbon footprint calculation tools and respective EIs are widely available and precise (UNWTO, 2019). While the calculation is accessible and transparent, the emission responsibility is difficult to allocate to tourism activities since its estimation relies on sensible data. Therefore, carbon footprint assessments of transport emissions are mainly addressed for large-scale entities, such as at the national level (UNWTO, 2019). Besides transportation, the food sectors provide open-source data and tools to estimate carbon footprint not precisely for tourism, for example, the My Emission food emissions calculator (My Emission, 2024; UNWTO, 2019). Similarly to transportation, carbon footprint assessment is feasible but rarely performed at the level of tourism activities (UNWTO, 2019). The hotel industry widely explores its carbon footprint through labels (Crespi et al., 2021). The explicit relation of tourism activity and its infrastructure allows a straightforward allocation of responsibility and, consequently, carbon footprint assessment. The Table 3 displays an example of widely used accommodation labels. The latter lists international and local labels (regarding the European and Swiss context), briefly giving an overview of the label and the criteria behind its conception. Crespi et al. criticise the proliferation of labels and their business-centred model about their efficiency in triggering a change towards sustainability for the accommodation sector as well as in other tourism sectors (Crespi et al., 2021).

Label	Overview and reach	Criteria considered
Green Key (Green Key, 2024)	International eco-label awarded to various tourism establishments. Reach: 60 countries.	Environmental management, guest information, water and energy conservation, waste management, CSR
EarthCheck (EarthCheck, 2024)	Scientific benchmarking, certification, and advisory group for travel and tourism. Reach: 70 countries.	Energy efficiency, water usage, waste management, greenhouse gas emissions, social and cultural impacts
LEED (LEED, 2024)	Green building certification system focused on environmental performance. Reach: unavailable for tourism.	Energy efficiency, water savings, CO2 emissions reduction, indoor environmental quality.
Green Globe (Green Globe, 2024)	International certification for sustainable tourism operations and management. Reach: 90 countries.	Energy and water efficiency, waste management, social responsibility, biodiversity conservation
Travelife (Travelife, 2024)	Sustainability certification for hotels and accommodations. Reach: mainly European countries.	Sustainability management, staff training, guest information, energy and water use, waste management, and social responsibility.
EU Ecolabel (EU Ecolabel, 2024)	European environmental excellence label. Reach: mainly European countries.	Energy and water savings, waste management, use of renewable resources, reduction of hazardous substances.
Biosphere (Biosphere, 2024)	Certifies tourism businesses according to the UN's Sustainable Development Goals (SDGs). Reach: Spain and Latin America.	Environmental, cultural, social, and economic sustainability dimensions.
GSTC (GSTC, 2024)	Global Sustainable Tourism Council accredits certification bodies. Reach: global.	Environmental impact, cultural heritage preservation, social equity, and economic viability.



IBEX Fairstay (IBEX Fairstay, 2024)	Swiss-specific sustainable and responsible tourism accommodations certification. Reach: Switzerland.	Management, environment, social issues, regional value creation, financial stability.
Swisstainable (Tourismus, 2024)	National program promoting sustainability in the Swiss tourism sector. Reach: Switzerland.	Environmental management, community involvement, guest communication.
Minergie (Minergie, 2024)	Swiss building standards focus on energy efficiency and sustainability in buildings, including hotels. Reach Switzerland; unavailable for tourism.	Low energy consumption, renewable energy use, and high indoor comfort.

Table 3: Examples of widely used tourism accommodation labels at international level, for Europe and Switzerland.

Furthermore, since carbon footprint assessment requires intensive data collection, labels may leverage qualitative information and evaluations based on strategies and implementation rather than impacts to be more accessible to enterprises.

The consumption of goods besides food is highly complex. While we have EI related to shopping, the relationship between shopping activities and tourism is unclear and usually roughly estimated through tourism satellite accounts with top-down methods (TSAs) (Sun et al., 2020; UNWTO, 2019). The last macro-sector of tourism activities is the leisure sector. Leisure activities can be highly variable, but destinations focusing on specific activities, such as skiing resorts, will likely be better understood and monitored (UNWTO, 2018, 2019).

Across all sectors, due to their more significant visibility and impact, larger enterprises are likely to publish open reports compared to SMEs, facilitating the estimation of carbon footprint for tourism-related activities. Instead, data sources at local levels may be collected but owned by private local actors (UNWTO, 2019).

Therefore, the literature widely agrees on the frequent lack of data across tourism sectors (Lenzen et al., 2018b; Sun et al., 2020; UNWTO, 2019; WTTC, 2021), including the case of mountain tourism (UNWTO, 2018).

The heterogeneous availability of data is interrelated with the lack of standardised methods to address carbon footprint in tourism (UNWTO, 2019). The latter is supposed to foster a backwards lack of data collection, reinforcing a lack and a delay of action towards sustainability (UNWTO, 2019). Methods can generally be grouped for their approach, bottom-up or top-down (Sun et al., 2020), or for the responsibility allocation, which is strictly related to the boundary attribution (Lenzen et al., 2018b).

The paper of Sun et al. (Sun et al., 2019), which provides a complete review of responsibility allocation and describes the advantages of studying carbon footprint from the point of view of inbound and outbound tourism, as well as whether or not international emissions are included. These variations of settings are relevant for carbon footprint and are considered to be a significant factor in carbon footprint assessment (Sun et al., 2019, 2020). While the literature does not agree on a specific method, it agrees that the best boundary to address carbon footprint analysis is the destination (Lenzen et al., 2018b; Sun et al., 2019; UNWTO, 2019). The destination perspective captures the full range of tourism-related activities, such as transportation, accommodation, and local services. This approach provides a comprehensive view of the environmental impact at the local level, allowing for targeted strategies to reduce emissions where they are most significant. It also supports local governments in developing sustainable tourism policies, engages visitors in sustainability efforts, and enables benchmarking against other destinations. This holistic and localised focus ensures that mitigation efforts are adequate and relevant to the destination's specific challenges.

An alternative approach merges the issue of data lack with the marketing approach by employing the tourist as a unit of analysis for carbon footprint (Aiping et al., 2023; Becken & Simmons, 2008). The



latter leverages promotion as a soft form of responsibility allocation, thus embracing a more liberal approach, which is better discussed in the following paragraph.

4.2 4.2 The Tourist as the Unit of Analysis

The tourist itself can be the unit to represent the carbon footprint for tourism activities (Aiping et al., 2023; Becken & Simmons, 2008). We identified different advantages related to the use of tourists as a unit for carbon footprint estimation:

- The carbon emission per person is relevant information rather than absolute emission for sectors, enterprises, or destinations. Only by optimising this number can tourism evolve toward sustainability while remaining accessible. The information is relevant when optimising sustainability across multiple tourism management approaches. A common strategy to cut emissions by impacting fewer tourists requires understanding the emissions per tourist to address the top emitter groups (UNWTO, 2019).
- Information on carbon footprint emission for a tourist is presumed to optimise its understanding by a tourist compared to labels or similar information at other scales, i.e. enterprise scale. The tourist is a relevant decision-maker who can influence the tourism market (Abegg et al., 2019; Aiping et al., 2023; Strobl et al., 2015). Information about tourist emissions to the tourist itself can be provided precisely while making the decision, increasing the likelihood of acknowledging the emission impact similar to product scores (Becken & Simmons, 2008; UNWTO, 2019).
- If data about tourism-related activities is lacking, the tourist accounting data is generally available across enterprises, consortiums, or destinations. In this case, the carbon footprint can be estimated by multiplying the average emission obtained from a tourist sample by the tourist count. When the transportation data are collected (as most accommodations), the most relevant source of emissions can be estimated (UNWTO, 2019).

4.3 4.3 The Personas and AI-generated Travel Plan

The generalised lack of data at local and transdisciplinary levels does not allow for most tourism destinations, including our case study, the direct carbon footprint assessment. This necessity can be addressed by supporting tourism activities to estimate emissions. To provide local and transdisciplinary data on tourism emissions, we created fictional tourists who adequately represent the tourism market for the case study. After choosing the tourist as the unit of analysis, we opted to forge travel plans from fictional tourist profiles, also named persona.

Indeed, the Persona generated for deliverable D9.1 belongs to two groups. The tool described in the following paragraphs also allows users to create new fictional Personas, generate new travel plans, or test on real cases.

The first group of personas represent national tourists, such as tourists who are residents of Switzerland and who choose a tourist destination in the Swiss Alps. The WP3 provided the Persona employed here after designing them to represent the heterogeneity of the Swiss population from national datasets (crossref). The Persona created by WP3, represented through visualisations, required an additional description (text) to generate a heterogeneous response from AI-generated travel plans across different personas. The WP3 has reviewed the additional description to ensure coherence with the source data. In addition, integrating the WP3 persona boosts the translation of methods and results beyond this deliverable, fostering extension eco-transition outside tourism sectors.



The second group of persona represents international tourists, such as tourists outside Switzerland performing a holiday in the Swiss Alps. This group of Persona is exclusive to WP9, and multiple profiles designed by WP9 were collected. The criteria chosen for creating international tourist Personas is to represent the heterogeneity of tourism-related activities rather than the size of tourist groups performing those activities. This choice is related to the need to represent minorities of tourists that can show both positive and negative examples of tourism's carbon footprint. We also employed the data of Tourorbs as an input source for the design of the international tourists' persona (Observatoire Valaisan du Tourisme, 2024)

The persona descriptions (text) were then used to generate a travel plan employing AI. In brief, the persona text description followed by a generic question pasted to the AI-platform prompt to obtain a random travel plan that fits the profile. Four free AI platforms were tested: ChatGPT (OpenAI, 2024), Gemini (Google, 2024a), Copilot (GitHub, 2024), and Forgemytrip (Forgemytrip, 2024). The ChatGPT platform was chosen for its highly detailed plan. Otherwise, Copilot and Gemini allowed the creation of a tabular output that could be easily pasted into the Excel tool presented here. Forgemytrip offered a user-friendly platform supported by images but lacked adequate travel time planning.

To conclude, the tool tested 12 Personas (6 per group) and generated with AI 12 travel plans, one per each persona. The Annex* provides the full description of a Persona, and an example of an AI-generated travel plan is shown in the *Annex.

4.4 4.4 The Transdisciplinary Sectors of Tourism

The UNWTO identified the tourism destination as the best system for assessing carbon footprint compared to enterprises and sectors (UNWTO, 2019). The destination is also considered as the actor that carries the responsibility of carbon footprint compared to other responsibility attribution models (Lenzen et al., 2018b). This convergence is achieved through a network of activities that create the touristic offer. While the driving activity on offer may be mono-sectorial, e.g., skiing, the network of activities is more complex, merging multiple sectors within and outside the destination. A transdisciplinary approach to tourism's carbon footprint is necessary to represent this complex network and identify strategies to reduce carbon footprint in the context of mountain tourism (UNWTO, 2018).

Following this approach, a tourist's travel plan choices are presented for each activity performed during the vacancy, regardless of their carbon footprint. The tool also provides a multi-criteria summary, allowing the understanding of cumulative emissions for five sectors of activities: Food, Stay, Leisure, Transport, and Shopping (UNWTO, 2019).

Understanding and comparing emissions across sectors allows us to identify trade-offs between the most relevant sources of emissions and decision-making power. From the point of view of the tourist destination, transportation is the sector characterised by the highest GHGs, while decision-making power within the destination is lacking, in addition to internal mobility. This incoherence may be addressed after converging tourism stakeholders, i.e. a coalition of destination activities to demand change actors external to the destination. The UNWTO report describes the potential of approaching carbon footprint at the destination level (UNWTO, 2019). Otherwise, destination management can concentrate efforts on top GHG emitters to optimise interventions and maintain the accessibility to tourism activities (UNWTO, 2019).

To address the transdisciplinary carbon footprint of a destination for a fictional tourist, the tool designed for D9.01 employs existing mono-sectorial platforms and EIs rather than "reinventing the wheel." In this way, the tool presented here is a collection of tourism tools and open-source data. When available, the EI has been tailored to the local contexts, e.g., for local public transportation or skiing activities. The following table lists a preliminary selection of platforms and tools identified for the Swiss context.



The authors reviewed multiple open-source tools and platforms to identify those that respected the following criteria:

- User-friendliness: a non-formed user can use the open-source platform.
- Precise tailoring: the platform can estimate carbon footprint after providing the most details.
- Avoid cost-based platforms: cost-based carbon footprint is helpful for national analysis only, while analysis at the local level based on spending is likely to penalise sectors already engaged in climate change mitigation(UNWTO, 2019).

The EI includes other data after grey literature and scientific literature searches, as shown in Figure 5.

Platform/Tool	Sector	Overview
My Emissions (My Emission, 2024)	Food	It estimates meals starting from the recipe across all scopes from international inventories.
Ecocalculator SBB (SBB, 2024)	Transport (public)	The travel search of Swiss public transportation integrates the emission calculator, which estimates emissions and compares them with average car travel (Scopes 1 and 2).
Via Michelin (Michelin, 2024)	Transport (private)	Travel search by private vehicle can be tailored after entering the vehicle model, and costs and emissions for the chosen trip can be provided across all scopes.
Hotelfootprint (GreenView, 2024)	Accommodation	The carbon footprint estimation depends on national EI provided internationally and is tailored to hotel class, structural and occupational characteristics.
My Climate (Myclimate, 2024)	Transport (Flight)	Flight emissions are calculated after the travel route, aircraft model, and class.
Google Flight (Google, 2024b)	Transport (Flight)	Travel search display emission occurs after defining the travel route and class, automatically tailoring the estimation to the aircraft model and company characteristics.

Table 4: Preliminary list of Carbon Footprint platforms to calculate tailored emissions after generated travel plans.

4.5 User-Friendly Design

Tourism activities gather multiple sectors and heterogeneous stakeholders, thus requiring transdisciplinary approaches to foster broad strategies at the destination level (Lenzen et al., 2018b; SBB, 2024). As introduced in the previous paragraph, the authors assumed that accessibility and user-friendliness were critical characteristics of boosting communication at the local level, a concept employed after the use of labels in sustainability communication (Crespi et al., 2021).

The authors employ Excel as a widely used software across stakeholders. Then, the Excel tool was designed for easy use by non-technical users, such as enterprise managers, local governance personnel, and tourists. First, the tool employs widely used software and user-free platforms, like AI and carbon footprint free web platforms. Then, instructions (displayed above each calculation sheet), calculations, and results are all gathered in a single file without extensions.

Regarding tool use, the EI has been designed to sum up emissions for ready-to-use units. For example, the tool provided in the EI lists the emission of a fondue meal rather than the weight of the meal or the weight of each ingredient. Similarly, an emission is provided for leisure activity in terms of hours or days, e.g., skiing day. Another example is the emission calculated for a horse ride of one hour; after calculating



the yearly emission, the utility in a lifetime and yearly occupation. This pre-calculation reduces the resources and knowledge required by the user. Otherwise, the user can perform more tailored calculations employing platforms or adding new items to EI.

Ultimately, the tool directly presents the outputs through visuals, absolute numbers, and proportions and compares them with another carbon footprint. For example, the daily GHG emission per tourist is compared to a Swiss citizen's daily emission or an international flight from Zurich to New York. More comparisons may be added to boost the understanding of the output.

4.6 4.6 Tourist Carbon Profile Tool

4.6.1 4.6.1 Description

The *Tourist Carbon Profile* tool created for D9.1 estimates the carbon footprint of fictional tourists, also named Persona, for all tourism-related activities in a travel plan (Fig. ref).

The tool developed for D9.1 employs a bottom-up approach, thus directly emission factors from EI to build up the carbon footprint after the travel plan of a tourist-type (Becken & Simmons, 2008). The tool indirectly addresses carbon footprint analysis at the level of Val des Bagnes tourism destinations since it collects platforms and emissions factors for most of Val des Bagnes tourism activities. It allows them to estimate carbon footprint at the level of enterprises and destinations after employing TSA(s) or any other generic accounting data.

The tool starts with a Persona and its description, asking the user to generate a chosen travel plan or generate it using open-source AI to simulate a holiday's planning activity. The tool has a set of 12 persona descriptions.

Then, the user precisely defines the activities related to an EI, like choosing the number of meals or nights in one accommodation. Indeed, the tool collects easy-to-understand carbon inventories related to tourism activities or provides the user with a list of selected sources to calculate or identify new activities and their related emissions.

Following the definition of the travel plan, the estimate of carbon footprint is automatically calculated, providing the equivalent emission for the vacancy, the emission per day and person, the share of emissions across five subjects (Stay, Transport, Food, Leisure, Shopping), and compared the emission to the emission of a Swiss citizen.

The tool has been designed to estimate the carbon footprint of Swiss Alps tourists, but it can be customized to be used in other geographic contexts by adding new activities to the EI.

The tool's function is simple. It is like a travel plan cost assessment, which estimates emissions across all tourism-related activities rather than spending.

As anticipated in the previous paragraphs, the subjects listed hereunder were integrated into the tool design to address relevant topics related to carbon footprint in the tourism sectors and coherently with the case study:

1. Lack of data
2. Data ownership and privacy
3. Lack of technical knowledge
4. Lack of resources to address environmental sustainability,
5. Transdisciplinary approaches in the carbon footprint of tourism,
6. Integration of marketing approaches,



7. Designed to foster carbon footprint for destinations and SMEs.

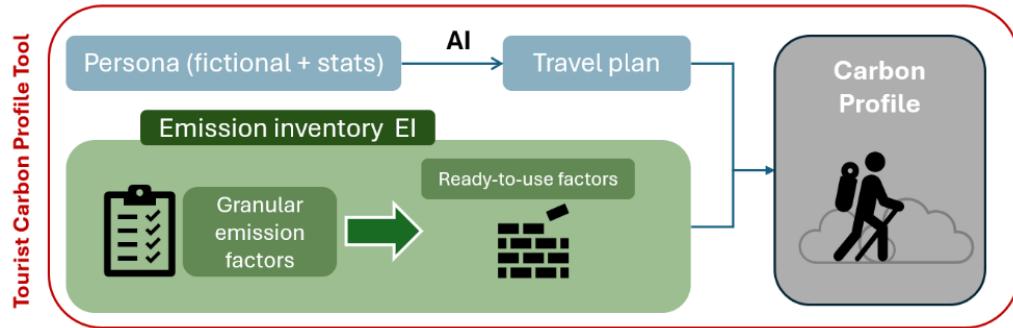


Figure 3: Schema of Tourist Carbon Profile Tool.

A	B	C	D	E	F	G	
1	Instructions						
2	General instructions: please follow the instruction of the sheet "persona", then follow the respective instructions for the sheet "emission factors" and "carbon assessment".						
3	Instructions >> (1) Enter the persona name, description, and number of people if not provided; (2) define the number of days, the origin and destination(s)						
4	Persona	Description	Nº people	Nº days	Origin	Destination	Destination 2 (optional)
5	Eco-friendly Eliza	Eliza leads an environmentally conscious and efficient lifestyle, prioritising simplicity and quality, with altruistic solid and biospheric values, and is willing to make financial sacrifices for sustainability despite being less engaged in broader social and environmental activism. Eliza's family comprises her, her girlfriend, and her retired dad; they are between 50 and 55 years old and her dad is 85. They live in Zurich and have a shared income of 290,000 CHF annually. For work, they do counselling in sustainability and work in a bookshop. Eliza has a PhD; she is socially active and eco-conscious, focused on sufficiency and efficiency, emphasizing repair over replacement, comfort, and quality, and making sensitive food choices with interest in new diets and regional, seasonal foods. She commutes by public transport, cycling or walking, and uses the car only when needed. During her free time, she loves reading books at the book club, cooking, meeting with friends, and going to the aqua gym. She likes to be in nature when there is good weather. Otherwise, she opts for theatre and other cultural activities.	2	7	Zurich	Engadina	Diavolazza
6	Individualistic Idris	Idris leads a frugal, status-averse life with inconsistent environmentally relevant behaviour, moderate sufficiency and efficiency, highly considerate food management, and limited mobility, resulting in spending much time at home. Idris's family comprises her and her husband; they are between 60 and 70 years old. They live close to Chur and have an annual shared income of 150,000 CHF. For work, she develops web platforms, and he is retired. Eliza has a master's in informatics; she is an average consumer of goods, does little action for the environment, doesn't like meat, and loves cheese. She travels half the time by car; at other times, she uses public transportation but does not like to travel far. She loves watching television, tasting wine, and walking in the countryside in her free time. She has also loved	2	7	Chur		

Figure 4: Persona sheet of Tourist Carbon Profile Tool.

A	B	C	D	E	F	G	H	I	J	K	L
1	Field	Activity	Description	Unit	kgCO2e	Scope	Source	Instructions & recommended platforms			
2	Transport	suv hybrid Milan-Verbier	average hybrid suv emissions	trip	26	1	viamichelin	Instructions >> if you need to add an emission factor for a new activity >> Enter the generated activities in the left table (1) Choose a field, (2) define the activity, and if possible, a brief description (3) Set a unit ready to be used by a tourist, for example trip rather than km, or meal rather than kg; (4) enter the emission. Use a recommended platform (green table on the right) or other sources to identify the emission in kg CO2e for the activity you entered.			
3	Leisure	resort emission: downhill ski in Verbier	average emission per person per day for down days		2.2	1	televerbier				
4	Stay	3* hotel, room of 60m2	service based, based in Switzerland, room si nights		15.7	3	hotel footprint				
5	Leisure	heliski trip (single engine)	heliski single engine, example	hour	550	1	swiss federation guidance				
6	Transport	flight london - geneva, business	flight london - geneva, business	trip	2477	1	carbon footprint				
7	Food	meal (heavy meat)	meal	meal	50	3	carbon footprint				
8	Transport	Zurich- Pontresina	SBB, 2nd class train	trip	1.3	1	eccalculator SBB				
9	Stay	average hostel stay	mean of emission per one bed	bed - night	2.6	1	Hostelworld				
10	Transport	Diavolezza- Pontresina	SBB, 2nd class, train and funicular	trip	0.6	1	eccalculator SBB				
11	Food	Raclette	raclette 300g, potatoes 200g, pickles 100g with meal	meal	5.2	1	mymission.co food				
12	Food	hiking snacks	dry fruit, apple, protein bar, chocolate 50g ea	snack	0.7	1	mymission.co food				
13	Food	vegetarian egg sandwich	generic	meal	0.7	1	eating better				
14	Food	freight emission of mountain refuge	emission per helicopter trip, 50 km, 1h	trip	500	3	SBB helicopter standards				
15	Food	heavy - meat meal beef	beef steak and vegetables	meal	50	1	mymission.co food				
16	Food	low meat meal	50g pork, vegetables bread	meal	5	1	mymission.co food				
17	Food	large beer	large beer	drink	1	1	mymission.co food				
18	Food	breakfast generic	pastry, yogurt, coffee, fruit	breakfast	1	1	mymission.co food				
19	Shopping	Book generic- illustrated		item	7.5	3	jetbooks				
20	Leisure	Horse ride per day	Horse ride emission, one year emission on 1 ride		20	3	grey literature				
21	Leisure	Streaming	One hour emission range 55-120g	hour	0.1	3	grey literature				
22	Leisure	Internet Data transfer	Consumption related to the use of data	Gb	3	3	8billiontrees.com				
23	Transport	Business flight NY- Zurich	Business class JFK-ZHU	round-trip	9000	3	myclimate				
24	Transport	Train Zurich airp-Verbier		trip	2.3	1	eccalculator SBB				
25	Food	Tomato risotto		meal	0.55	1	myclimate				
26	Leisure	Ski equipment	range between 0.5 (500d use) to average 100	day	7	2	gray literature				
27	Leisure	paraglide equipment / 50 uses	rough estimate	day	5	1					
28	Shopping	hiking equipment		set	100	1					

Figure 5: Emission inventory sheet of the Tourist Carbon Profile Tool.

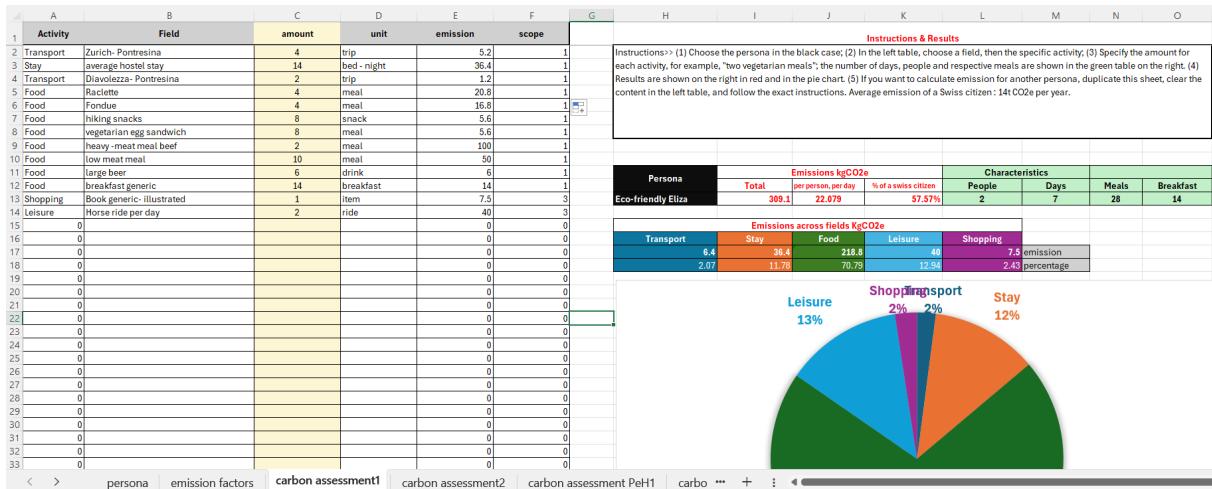


Figure 6: Carbon footprint sheet and outputs of Tourist Carbon Profile Tool.

4.6.2 4.6.1 Use

The tool has been designed for practical use in multiple activities within and outside the Lantern project. The tool has three main uses:

- Provide data support during project activities that clearly show emission contribution across the multiple sectors related to tourism activities. The tool's input and output are designed to be understood by a heterogeneous audience. This easily accessible information aims to trigger discussion from a common and holistic starting point. In addition, the tool can also be tailored during activities, such as by co-designing the tourist persona or travel plans during the project activities or by asking participants to guess the persona's carbon footprint before proving the estimation calculated by the tool.
- Provide information as a green marketing tool, thus clearly describing the carbon footprint of tourism-related activities to tourists. The tool can deliver this information to tourists when they make relevant decisions, like when they access information on many propositions at tourism offices.
- Provide an estimation of carbon footprint to tourism-related enterprises that do not collect data for carbon footprint, do not have the resources to address carbon footprint, and are unwilling to share sensitive data. After sharing the tool, enterprises can internally assess their carbon footprint and understand their role compared to other enterprises. For the study case, the Val des Bagnes community is willing to understand its carbon footprint better internally to manage sustainability development within the tourist destination.

Only the first proposed use has been tested in the following activities:

- Internal activity with project partners in Verbier
- Fresque Chateau d'Oex
- Lantern internal activities

The participants were provided with a brief persona description (coupled with AI-generated visualisation of the persona) and outputs for four personas. For the variant of the activity in Chateau d'Oex, travel plans were modified for the touristic destination, thus including activities like balloon flight and sightseeing with the helicopter.

Overall, the participants in these activities reported how the estimate provided by the tool was coherent with their experience and showed interest in the transdisciplinary point of view provided by the outputs in comparing different tourist types and their emissions. According to the authors, understanding the outputs was accessible, and the questions partially addressed detailed inputs for the tool. In addition,



the tool's outputs could trigger and stimulate a system view and thinking of sustainability. However, the discussion did not generate innovative ideas to implement sustainability across tourism sectors; instead, it underlined the relevance of a few soundproof strategies, i.e., four-season tourism and stay temporal extension.

For example, Figure , Figure , and Figure of the 8.3 Tool Visualisation Examples; show a visualisation of preliminary outputs tested in Val des Bagnes. The authors chose to compare four carbon profiles to foster a transdisciplinary discussion on sustainability implementation. Also, the two examples in Annex 8.3 Tool Visualisation Examples) provided a fixed duration of the holiday and a variable one to display the complementary information on per-day emissions after a more likely stay duration.

4.6.3 4.6.1 User Instructions

The tool requires an Excel file and a browser to access the Internet. It is indeed a platform that collects tools. To access new input data, users are encouraged to use existing platforms to calculate carbon emissions from sectorial emission inventories, whether they want to modify the input data or not. The detailed instructions are reported on each sheet, as shown in the multiple figures. The Excel tool is composed of three sheets.

- i) **The persona sheet** contains personas (fictional profiles), their descriptions, and the travel plan text. AI is necessary to create new travel plans to paste into this sheet. An example is provided in Figure 4.
- ii) **The emission inventory sheet** lists emissions from tourism-related activities and sources to add new emissions. A list of selected open-source web platforms is also included to create new emissions factors, such as in Figure 5.
- iii) **The carbon profiles sheet:** The user selects activities according to the travel plan and assigns the amount of activity consumed/Performed. This sheet simultaneously provides the results, such as in Figure 6. It can be duplicated to study emissions across multiple profiles to have multiple outputs.

4.7 **4.7 Potential Development and Limitations**

Multiple limitations affect the Tourist Carbon Profile Tool, such as intensive user action, reliance on external platforms, a limited list of emission factors, reduced outputs, and a lack of intervention support. The limitations are listed hereunder and related to respective potential development.

The tool requires multiple actions from the user. Employing an existing persona and travel plan, the user assigns a quantity of consumption for each activity. Otherwise, a user testing a new persona and plans and adding items to EI performs multiple actions within and outside the tool (using a web browser). The high number of actions increases the likelihood of errors and discourages users from using it. A more user-friendly tool could integrate and automatically perform multiple actions, reducing the cited consequences.

For example, creating new items in the EI requires the user to open a browser and calculate the emission of a new activity, such as a new meal. The EI list could be increased to prevent the user from creating new items for EI, or the tool could automatically integrate other platforms, for example, through a web tool (Yousif & Zakaria, 2022).

The EI list is limited to everyday activities in the Swiss Alps and lacks a carbon footprint for peculiar activities. The suggested platforms for adding new items to EI can partially cover missing activities, while others are unavailable in the current external open-source EIs. In those cases, a tailored carbon footprint procedure may be required. For example, this is the case of extreme sports, where LCA is frequently missing for the used gears. However, data for many activities are missing, and the EI, i.e. transportation, mainly covers the most relevant sectors. A relevant sector where carbon footprint may be highly



heterogeneous and complex to estimate is hotel or tourism stays. Open-source information mainly collects a list of implementations and actions rather than a form of carbon footprint, missing the opportunity to be transparent about sustainability.

Implementing more visuals and comparisons can improve the tool's output. Depending on the context, for example, the activity where the tool is used or presented, more insights can be provided regarding local needs.

The tool presented here does not follow outputs with suggestions or margins of improvement, but it performs an informative function. Indeed, the tool has been designed to identify topics, sectors, or tourist profiles to target, so, depending on the output and the user choice, a detailed strategy can be developed in a second moment.

The tool generally trades scientific rigour in calculation from a transdisciplinary point of view and user-friendliness. This choice promotes a faster perception of the responsibilities of climate change across all its key actors (Crespi, 2016).

5 The Mountain Tourism Fresk: a Gaming Approach to Low-carbon Tourism Planning

5.1 5.1 Gamification to Raise Awareness About Climate Change and Trigger Action

Climate change awareness is fundamental for prompting action and mitigating the effects of global warming (Flood et al., 2018). Conventional messaging approaches and methods have often failed to catalyse the necessary behavioural changes and educational shifts to address this global challenge. Games and gamification have emerged as a promising approach to foster both behavioural change and education around climate change (Barcena-Vazquez & Caro, 2019). They offer a unique and potentially powerful tool for raising awareness and promoting pro-environmental behaviour (Galeote et al., 2021).

Recent research has explored the potential of games to raise awareness and encourage action on climate change. A mapping review study identified 115 climate-focused games, revealing that most were designed for learning purposes and targeted diverse audiences such as students, professionals, and the general public (Gerber et al., 2021). These games covered various climate-related topics, from exploring the cause-and-effect relationships between human activities and environmental changes to simulating and implementing mitigation strategies and adaptation measures.

Climate change games: "The term refers to games that include climate change as an explicit and major aspect" (Gerber et al. 2021. P. 3)

The use of games for climate change engagement offers several advantages. As interactive and immersive experiences, games can enhance cognitive skills, capture attention, and increase motivation, making them a powerful tool for educating people about climate change's complex, multifaceted challenge (Barcena-Vazquez & Caro, 2019). Moreover, games can provide opportunities for social learning, enabling communities to collectively explore different climate futures and socialise adaptation priorities with diverse stakeholders (Flood et al., 2018).

However, a gap remains between public understanding, scientific knowledge, and tangible action to address climate change (Flood et al., 2018). To bridge this gap, researchers have emphasised the need for a combination of bottom-up and top-down initiatives, with games and gamification playing an essential role in fostering behavioural change and education (Galeote et al., 2021).



Several studies highlight the potential of games for climate change engagement. Both bottom-up and top-down initiatives are essential for effectively addressing climate change, and games offer an approach to fostering behavioural change and education. 'Serious games,' which are "entertaining games applied for education and learning purposes" (Gerber et al., 2021: 3) in particular, can bridge the gap between public understanding, scientific knowledge, and the behavioural changes needed for climate change adaptation (Flood et al., 2018).

5.2 5.2 The Case of the Climate Fresk

The game was created by Cedric Ringenbach in 2015, a French entrepreneur and climate change activist. To date, the game has achieved great success with volunteer facilitators, engaging 1.7 million participants worldwide. It has been translated into 45 languages and played in 162 countries. This serious game on climate change is a collaborative, co-design workshop lasting three hours, based on data from the IPCC report. The workshop is easy to set up, utilizing a set of 42 cards that represent various elements of climate change. With the guidance of a facilitator, a group of 3 to 10 participants uses collective intelligence to arrange the cards on the table in a cause-and-effect sequence. During the workshop, they create their own collage of climate change and give it a title (Figure below). Following this new understanding, the workshop continues with activities, discussions, and debriefings on emotions and potential solutions regarding climate change.



Figure 7: A Climate Fresk workshop at EPFL Sion (2024).

The workshops are accessible to the general public, with adult and kid versions of the game. By adopting a participatory design process, Climate Fresk leverages the expertise and perspectives of multiple stakeholders to develop games that resonate with target audiences and inspire them to engage with climate change in meaningful ways. The key to success lies in its ability to present complex climate science in an accessible and engaging format. Using a collaborative, game-based approach, the game empowers participants to actively explore the causes and effects of climate change, fostering a deeper understanding and a sense of ownership over the issue (Foltz et al., 2019).

A study analysing the effects of Climate Fresk at corporate levels found that participants demonstrated an increased understanding of climate change, felt more empowered to engage in their company's climate strategy, and expressed a greater willingness to take individual action (Nordin & Wahlström, 2022). The study highlights the importance of follow-up workshops and integration with corporate sustainability initiatives to maximise the impact of game-based interventions.

The Climate Fresk exemplifies and inspires how gaming can be a powerful tool for climate change education and engagement. However, some criticism exists about the game's limitations in driving



tangible behavioural change and its reductionist approach to a complex problem. The game assesses macro issues and general sectorial thematic/subjects but fails to address more specific solutions assessing local impacts and adaptation needs (Flood et al., 2018). Despite these limitations, the success of the Climate Fresk highlights the significant potential of this type of game-based approach to climate change engagement. It suggests that the tool could be adapted and applied in Swiss alpine tourism destinations to assess and enhance climate change awareness and understanding of the problem. By understanding the cognitive, emotional, and behavioural dimensions of engagement, the game could provide a shared vision of the complex ecosystem of private/public actors present in Swiss tourism.

CLIMATE FRESK BENEFITS	CLIMATE FRESK LIMITATIONS
Increased Understanding: Climate Fresk effectively boosts participants' understanding of climate change science and the interconnectedness of various factors.	Limited Long-Term Engagement: While Climate Fresk raises awareness, it doesn't necessarily translate to sustained engagement or action in the long term.
Engagement and Motivation: The game's interactive and collaborative nature makes learning engaging and enjoyable, potentially leading to greater motivation for action.	Produces anxiety: The complexity of the problem may cause the feeling usually known as "climate anxiety". Which results in stress withing participants inhibiting real action.
System Thinking: Climate Fresk encourages participants to think systemically about climate change and understand the complex relationships between causes and effects.	Scope for Improvement: The literature indicates room to enhance Climate Fresk, particularly in areas like promoting individual and collective action. Finding real solutions to adapt and attenuate impacts.

Table 5: Climate Fresk benefits and limitations.

In France, the success of The Climate Fresk has inspired the creation of numerous other workshops known as "[Fresques amies](#)" (friendly Fresks). These workshops follow a similar format but focus on more specific topics such as biodiversity, event management, migration, food, and the ocean. This trend is growing, with more people encouraged to create their games to address specific issues, thanks to increasingly accessible IT and AI tools.

Currently, there are Fresks in development on tourism and mountains. Our Fresk specifically addresses the challenges of tourism in mountain territories in the face of climate change, focusing on the Swiss Alps. While Fresks are proliferating in France, this initiative is one of the first in Switzerland.

5.3 5.3 The Mountain Tourism Fresk

The Mountain Tourism Fresk is a severe game developed as part of the SWEET Lantern research project, which aims to address the challenges of decarbonising tourism in mountain regions. Inspired by the success and methodology of Climate Fresk¹, this game focuses explicitly on the touristic causes and effects of climate change and the implementation of solutions in mountain destinations.

The tool was initially designed for the destination Verbier-Val de Bagnes, but its core mechanics can be adapted to other Swiss mountain tourism contexts. Unlike the Climate Fresk, which relies on a deck of cards, the Mountain Tourism Fresk incorporates both cards () and a visual representation of a mountain territory (Figure 8), allowing participants to visualise systemic solutions at the local level. The

¹ The authors are trained facilitators for the Climate Fresk association.



different items presented on the map serve as allegorical representations of tourism issues and climate challenges.

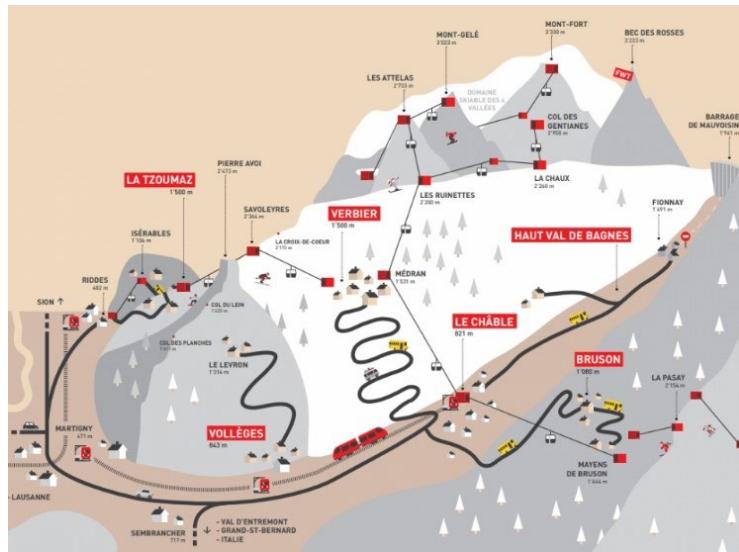


Figure 8: Verbier Tourism Map used to support the Fresk.

The Mountain Tourism Fresk aims to raise awareness about the implications of climate change in alpine destinations and initiate behavioural change. It was developed by the SWEET Lantern project's WP9 (Low-Carbon Tourism Planning) in collaboration with cooperation partners from Val de Bagnes (Verbier Tourism, Altis, Téléverbier, Commune Val de Bagnes), who provided feedback on early versions of the cards (through a shared Canva project) and tested the first version of the tool (March 2024).

While most efforts of mountain regions towards climate change focus on adaptation, the game also tackles the root causes of emissions linked to tourism (including inbound and outbound tourism, construction, food, sports equipment, etc), and includes mitigation measures. In this serious game, participants engage actively with others to increase their climate literacy and co-create specific solutions for their tourism destination. The game can empower key mountain destination stakeholders by giving them a deeper understanding of climate change and its impacts on the tourism industry.

It is composed of four main components: Tourist causes, Effects, Adaptation solutions, and Mitigation solutions. As in the Climate Fresk, the form and the content of the cards used in the workshop are based on the IPCC report, scientific literature, and grey literature. Participants are divided into teams of 4 to 10 people during the workshop. With the help of a facilitator, they explore the cards representing touristic causes, effects identifying hotspots in the tourism map and adaptation and mitigation measures specific to the destination. The goal is to build a shared understanding of the tourism system's effects on the specific territory and trigger action.

The tool relies on bottom-up and top-down approaches that foster active learning, encouraging participants to engage with climate change challenges and find solutions jointly rather than just presenting information. The visual representation of the map allows participants to position themselves and describe their points of view. Different interpretations and stakes of climate change usually exist depending on the position and role played at the tourism destination. Politicians, entrepreneurs, economic actors, tourism partners, tourists, property owners, seasonal labour, etc., do not necessarily share the same understanding and priorities. Through the game's facilitated discussions, participants are guided to reach a systematic understanding and debate on measures to mitigate and adapt to climate change. The game settles common ground between transversal actors discussing perspectives and interests at play in the tourism destination.

The development of the tool benefited from parallel research activities on decarbonisation in ski destinations (Salim, Loloum & Bonnemains, 2024) and energy sufficiency. The research titled "Framing Energy Sufficiency in Swiss Ski Resorts" uses Verbier, Val de Bagnes, as a case study to explore how local key stakeholders within the destination perceive the concept of energy sufficiency. Energy sufficiency, which involves reducing energy demand through behavioural and organizational changes,



faces significant challenges in a high-status destination like Verbier, frequented by economically powerful visitors with high carbon impact practices such as heliskiing. The study aims to identify different “Framing categories” assessing the challenges and opportunities of implementing energy sufficiency in a destination like Verbier.

The Mountain Tourism Fresk game introduces the concept of sufficiency transversally. The game incorporates elements for “Re-Framing Sufficiency” into different cards to address and shift stakeholders’ perceptions. These radical approaches are analyzed as mitigation solutions, emphasizing the importance of human behavior to reduce emissions rather than depending on the development of new technologies for renewable and efficient energies. By engaging participants in discussions and collaborative problem-solving, the game aims to make sufficiency a central principle in the planning and management of mountain tourism destinations.

5.3.1 5.3.1 Test Phase

The Mountain Tourism Fresk has been already tested and keeps evolving through transdisciplinary research.



Figure 9: Pilot workshop with cooperation partners (Altis, Verbier Tourism, Commune Val de Bagnes), Le Châble, 05.03.2024, 10 participants, 2 facilitators.



Figure 9: Tourism strategy workshop for Pays d'Enhaut, Château d'Oex, 19.06.2024, 19 participants, 3 facilitators.



Figure 10: Moving Mountains Forum, 21-22.08.2024, Les Diablerets, 30 participants, 2 facilitators.



Figure 11: SWEET Conference, Bern, 04.09.2024, 15 participants, 2 facilitators.



Figure 12: National Open Innovation Camp, Sion 12.09.2024, 5 participants, 2 facilitators.



Figure 13: SWEET Lantern Site Visit, Sion 13.09.2024, 8 participants, 2 facilitators.

The tool is a promising approach to engage critical stakeholders in mountain tourism destinations on climate change challenges. As highlighted by recent literature on the use of serious games for climate change adaptation, this type of interactive workshop can enhance social learning and collaboratively enable positive action (Galeote et al., 2021; Flood et al., 2018; Creutzig & Kapmeier, 2020). The game bridges the gap between scientific knowledge and public understanding by providing participants with an immersive and engaging experience (Foltz et al., 2019). The game's interactive and collaborative nature, combined with its focus on adaptation and mitigation, makes it a valuable tool for addressing the complex challenges of decarbonising tourism in mountain regions.

5.3.2 5.3.2 Detailed Description of the Workshop

A detailed description of the workshop is illustrated with figures and examples, such as Cards and pictures from the two application studies at Verbier and Chateaux d'Oex.

The game was designed with canva.com. There is an English (see annex 8.4) and a French version.

Materials needed:

- Four packs of cards “Mountain Tourism Fresk” (1-Causes, 2-Effects, 3-Adaptation, 4-Mitigation)
- Tourism map from the mountain destination²
- 1 facilitator per 10 participants
- Markers, Coloured Post-its

Workshop Structure:

Below we describe a workshop structure for the Mountain Tourism Fresk, which is indicative and can be adapted based on the host organisation's focus, participants, and time constraints. During the pilot phase, we tested several game mechanics. In Verbier, the first test combined the Mountain Tourism Fresk with a Fresk du Climat Workshop, which was informative but lengthy and exhausting for participants. The Mountain Tourism Fresk was more appreciated for its specific focus on tourism and its adaptation to the Val de Bagnes. In Château d'Oex, another version that mixed the Fresque du Climat approach, emphasising causal relationships, with the Mountain Fresk cards was developed. Participants first engaged with the cards and then worked on a destination map. This version was also lengthy, and some participants found the card play too abstract and tiring. The structure presented below was proposed during the Moving Mountains Forum in Les Diablerets, where the cards and the map were used simultaneously.

Overall concept: Groups are divided heterogeneously within different professions/actors of the tourism ecosystem placed around a table with a large paper stick to it within a tourism map of the territory, pencils, coloured sticky notes and a total of 34 cards split into 4 sets (Touristic Causes-Effects-Adaptation Measures- Mitigation Measures), which the facilitator hands out in turns. Every card has a front and back side that describes climate change elements regarding mountain tourism using pictures

² We currently use a detailed map of Verbier Val de Bagnes, but a generic illustrated map will be developed in future steps.



and text. When handing out the cards, the participants are to present and read out the text for other participants, discussing the territory which concerns the workshop. The facilitator has a supervising role, helping with clarification, but where the participants use their shared knowledge to clarify and relate the cards' content to their tourism system and territory. After every set of cards is laid out, the facilitator helps with clarification and then hands out the next set. The pencils and sticky notes are used to draw and write the connections between the cards and the tourism map. As the cards are laid out around the table, participants are asked to between the cards and the map.

The purpose of this structure is to link proven theory and facts within the territory and individuals, giving a better systemic understanding of climate change and its implications on both their territory and residents/civic/personal level. By doing this, we intend for the participants to take more climate action and spread climate implications and knowledge.

Introduction/Icebreaker (15 min)

This initial step aims to familiarize participants with the territory map, establish a personal connection with the area, and introduce themselves to each other.

- Map Exploration (5 min): Participants examine the map and identify items.
- Introduction (10 min): Each participant writes their name and organization/occupation on the map at a location reflecting their professional situation (e.g., at a tourist office, municipality, etc.) or/and personal residential place/affinities (e.g., in nature for hiking enthusiasts). Each person briefly explains to each other.

Lot 1: Touristic Causes of Climate Change (15 min)

This section identifies the most impactful elements of tourism on the climate, particularly transportation (air and car), equipment (clothing, ski gear), food (meat, cheese), accommodation (heating, buildings), and collective infrastructures (ski lifts).

- Card Distribution: The facilitator distributes a card to each participant, asks to read them and think of concrete manifestations on the map.
- Hotspots: one after the other, each participant explain the card to the group in his/her own words and chooses a GHG emission points on the territory (e.g., roads, buildings, airport), and writes it down using a marker. The card is then placed in a single row around the map and a **red sticky note** is placed next to the input, with a number corresponding to the card.
- *Optional (long version – 10-15 min):* With card 1.6 (inspired by the Tourist Carbon Profile), participants can guess which personas have the highest and lowest carbon footprint and explain why. The facilitator asks them how much is the average carbon annual footprint of a Swiss, and how this resonates with the figures of the card (on the daily footprint of tourists)

Lot 2: Effects of Climate Change (15 min)

This section highlights the impacts of climate change on mountain territories and tourist activities (skiing, mountaineering).

- Card Distribution: The facilitator distributes a card to each participant, asks to read them and think of concrete manifestations on the map.
- Hotspots: one after the other, each participant explain the card to the group in his/her own words and identifies the most vulnerable points on the territory to climate change (e.g., mid-mountain ski resorts, rivers, forests), and writes down the effect using a marker. The card is then placed in a single row around the map and a **blue sticky note** is placed next to the input, with a number corresponding to the card.

Lot 3: Mitigation Measures (15 min)

This section emphasizes various possible measures to reduce GHG emissions related to tourism activities, highlighting the difference between mitigation and adaptation.



- Card Distribution: The facilitator distributes a card to each participant, asks to read them and think of concrete manifestations on the map.
- Hotspots: one after the other, each participant explain the card to the group in his/her own words and identifies actions to reduce GHG emissions related to tourism, and writes down the action on a spot of the map using a marker. The card is then placed in a single row around the map and a **green sticky note** is placed next to the input, with a number corresponding to the card.
- *Option (long version):* based on card 3.9, participants take 5-10 min to think of what a “sustainable marketing” strategy could for this destination. More specifically, they can reflect on the implications of the discussions around card 1.6 in terms of communication and client targeting.

Lot 4: Adaptation Measures (15 min)

This section highlights various possible measures to adapt to the impacts of climate change on tourism activities.

- Card Distribution: The facilitator distributes a card to each participant, asks to read them and think of concrete manifestations on the map.
- Hotspots: one after the other, each participant explains the card to the group in his/her own words, outlines actions to adapt to climate change impacts, and writes down the action on a spot of the map using a marker. The cards are then placed above the Fresk in a single row around the map and an **orange sticky note** is placed next to the input, with a number corresponding to the card.

Conclusion and Discussion (15 min)

This concluding part aims to sketch a common and synthetic understanding of climate change and possible actions to be implemented, connecting them to participants' attachments to the territory. In a relaxed atmosphere participants share their thoughts and feelings.

- Vision and mission statement: The group agrees on a title that represents their Fresk and the challenges ahead. Participants together are asked to wire in sentence answering to the following question: “How do we get properly to 2050?”. They can agree on a subtitle explaining their mission to reach a desired vision of the future.
- Solution space: as a conclusion or a transition to another workshop, each participant identifies one or two action they would like to work on or develop. For this purpose, each participant takes responsibility for at least one action located close to where they wrote their name initially (during the introduction/icebreaker) then describes how these actions could be developed. In this way, we close the loop and each participants leaves the workshop with a collective and a personal mission regarding fight against climate change in the destination.

Follow-up Activities and Survey

The scientific literature (Nordin & Wahlström, 2022; Flood et al., 2018) has revealed that climate education tools - such as the Mountain Tourism Fresk and the Tourist Carbon Profile - have limited impact if not followed by concrete opportunities to act. Therefore, we recommend integrating the Mountain Tourism Fresk into larger climate actions, such as strategy workshops or public events. Collaboration with Anne-Sophie Fioretto, a professor at the Tourism, is crucial in this context. As a renowned consultant in tourist destinations in French-speaking Switzerland, she has frequent opportunities to interact with tourism stakeholders and engage them in strategic planning. The Fresk and the Tourist Carbon Profile are valuable tools to embed energy and climate goals at the core of strategic planning. The Fresk has already been successfully utilised in Château d'Oex to aid in developing the tourism strategy for the Pays d'Enhaut.



After the workshop, the Fresk can be enhanced with additional illustrations and retained by the host organisation as a permanent record of the discussions. Additionally, the Fresk can serve as a tool for data collection.

A follow-up survey (see Annex 8.5) is distributed to characterise the participants' socio-demographic and energy profiles, collect feedback and assess impact of the Fresk on their travel practices. The questions were designed based on WP10's recommendations and Deliverable 10.2 "Dataset specifications for user activities".



Figure 14: "Moving Mountain Tourism".



Figure 15: "La Bonne Voie".

5.3.3 5.3.3 Spotlight Application

Clima Now is a Swiss non-profit foundation in Zurich dedicated to driving climate action through innovation, policy advocacy, and community engagement. The **Clima Now Spotlight** campaign is an annual competition highlighting innovative solutions to climate change, particularly in mountain regions. This year's theme, "Making tourism in the Alps future-proof," aims to revolutionize tourism by promoting sustainable and energy-efficient solutions. Projects are showcased on the **"Wall of Fame,"** with public voting determining the finalists who present at the Pitch Night. Winners receive funding and support through the Horizon Program to implement and scale their solutions. The Mountain Tourism Fresk was



shortlisted among the top 15 projects positioning the tool as an example of innovative approaches to climate change mitigation and adaptation in mountain tourism. This achievement provided significant visibility and credibility. Expecting to attract support from mountain communities, tourism industry stakeholders, environmental organisations, and private partners such as the retailer of outdoor recreation clothing and equipment Patagonia.

5.3.4 5.3.4 Future Developments

Looking ahead, our Mountain Tourism Fresk aims to develop in several key areas. First, we plan to design an illustrated map of a generic mountain destination, highlighting all relevant issues for climate transition in alpine areas, such as natural risks, lift companies, tourism infrastructures, mobility, snowmaking, and accommodation. Second, we will focus on upscaling and disseminating the game, which includes creating a dedicated website and a comprehensive training program. Third, we will conduct an impact assessment to measure the success of our project. This will involve tracking the number of participants and facilitators, their level of engagement and understanding before and after participation, and the practical actions resulting from the game. Additionally, the diversity of destinations, institutions, and stakeholders involved will indicate success. A follow-up survey will be conducted to evaluate these indicators and assess the overall impact of the Fresk.

6 Conclusion

This deliverable aimed to develop tools to integrate information in project activities about sustainable tourism planning in the Swiss Alps, focusing on decarbonising the tourism industry and reducing energy demand. The authors introduce two main tools: the Tourist Carbon Profile tool, which helps quantify the carbon footprint of tourist activities, and the Mountain Tourism Fresk, an interactive game that facilitates a collaborative understanding of climate challenges and sustainable solutions in tourism. The tools have been tailored and designed after literature research and the local context of Swiss alpine tourism, and they have been tested multiple times with local stakeholders. These tools are crucial as they bring energy and climate data to the forefront, helping tourism stakeholders grasp the magnitude of ongoing changes transdisciplinary at the scale of a tourist destination. They also leverage collective intelligence, persona narratives, and a gaming approach to initiate transformation, moving away from traditional top-down expert knowledge and objectifying tools.

In line with the WP10 Integrated Impact Assessment framework, surveys are being distributed to project activity participants to demonstrate their transformative potential at both the personal and collective levels. It is important to note that the Tourist Carbon Profile and the Mountain Tourism Fresk are still experimental versions designed to complement applied research. Further pilots and demonstrators must be developed to disseminate these tools and increase their potential to activate the Swiss tourism industry toward environmental sustainability. The network of energy/urban living labs represented in the SWEET Lantern consortium offers promising opportunities for further developments and replications.

7 Bibliography

Abegg, B., Jänicke, L., Unger, R., & Mailer, M. (2019). Alpine winter tourists' view on climate change and travel mobility. Winter Tourism: Trends and Challenges, 82–91. <https://doi.org/10.1079/9781786395207.0082>

Aiping, Z., Wei, X., Feng, Z. X., & Ruiyi, W. (2023). Deconstructing consumers' low-carbon tourism promotion preference and its consequences: A heuristic-systematic model. Journal of Hospitality and Tourism Management, 57, 48–60. <https://doi.org/10.1016/j.jhtm.2023.08.020>



Barcena-Vazquez, J., & Caro, K. (2019). Designing a video game to support climate change awareness in a museum exhibition context. In Proceedings of the 2019 ACM International Conference on Interactive Surfaces and Spaces (pp. 1-5). ACM. <https://doi.org/10.1145/3358961.3358972>

Becken, S., & Simmons, D. (2008). Using the concept of yield to assess the sustainability of different tourist types. *Ecological Economics*, 67(3), 420–429. <https://doi.org/10.1016/j.ecolecon.2007.12.025>

Bertella, G., Lupini, S., Romanelli, C. R., & Font, X. (2021). Workshop methodology design: Innovation-oriented participatory processes for sustainability. *Annals of Tourism Research*, 89, 103251.

Biosphere. (2024). Biosphere Responsible Tourism. Biosphere Responsible Tourism. <https://www.biospheretourism.com/en>

Crespi, G., Becchio, C., Buso, T., & Corgnati, S. P. (2021). Carbon labels in tourism: Persuasive communication? Environmental Performances in Green Labels for Hotels – A Critical Review. In C. Bevilacqua, F. Calabò, & L. Della Spina (Eds.), *New Metropolitan Perspectives* (pp. 1176–1186). Springer International Publishing. https://doi.org/10.1007/978-3-030-48279-4_109

Crespi. (2016). Carbon labels in tourism: Persuasive communication? *Journal of Cleaner Production*, 111, 358–369. <https://doi.org/10.1016/j.jclepro.2014.08.067>

Dong, Y., & Michael Zwicky, H. (2017). Indicators for Environmental Sustainability. *Procedia CIRP*, 61, 697–702. <https://doi.org/10.1016/j.procir.2016.11.173>

EarthCheck. (2024). EarthCheck Certified. EarthCheck. <https://earthcheck.org/what-we-do/certification/earthcheck-certified/>

Ecollective. (2024). Ski Resort Carbon Footprints. Ecollective. <https://www.ecollectivecarbon.com/ski-resort-carbon-footprints>

EPFZ. (2024). 2000-Watt Society. 2000-Watt-Areale. <https://www.2000watt.swiss/english.html>

EU Ecolabel. (2024, May 27). EU Ecolabel -The environmental label you can trust. <https://eu-ecolabel.de/en/>

European Commission. (2021). Support to the tourism ecosystem: towards a more sustainable, resilient and digital tourism. Retrieved from https://commission.europa.eu/system/files/2021-06/b3_tourism.pdf

Federal Office for the Environment. (2021). Switzerland's climate policy. Retrieved from <https://www.bafu.admin.ch/bafu/en/home/topics/climate/info-specialists/climate-policy.html>

Galeote, D., Rajanen, M., Rajanen, D., Legaki, N., Langley, D., & Hamari, J. (2021). Gamification for climate change engagement: review of corpus and future agenda. *Environmental Research Letters*, 16(6), 063004. IOP Publishing. <https://doi.org/10.1088/1748-9326/abec05>

Flood, S., Cradock-Henry, N. A., Blackett, P., & Edwards, P. (2018). Adaptive and interactive climate futures: systematic review of 'serious games' for engagement and decision-making. *Environmental Research Letters*, 13(6), 063005. IOP Publishing. <https://doi.org/10.1088/1748-9326/aac1c6>

Foltz, A., Williams, C., Gerson, S. A., Reynolds, D. J., Pogoda, S., Begum, T., & Walton, S. (2019). Game developers' approaches to communicating climate change. *Frontiers in Communication*, 4, 28. <https://doi.org/10.3389/fcomm.2019.00028>

Forgemytrip. (2024). ForgeMyTrip. <https://www.forgemytrip.com/>



Galeote, D., Rajanen, M., Rajanen, D., Legaki, N., Langley, D., & Hamari, J. (2021). Gamification for climate change engagement: review of corpus and future agenda. *Environmental Research Letters*, 16(6), 063004. IOP Publishing. <https://doi.org/10.1088/1748-9326/abec05>

Gerber, A., Ulrich, M., Wäger, F. X., Roca-Puigròs, M., Gonçalves, J. S. V., & Wäger, P. (2021). Games on climate change: Identifying development potentials through advanced classification and game characteristics mapping. *Sustainability*, 13(4), 1997. Multidisciplinary Digital Publishing Institute. <https://doi.org/10.3390/su13041997>

[GitHub, M. \(2024\). Copilot.](#)

[Google, A. inc. \(2024a\). Gemini.](#)

[Google, A. inc. \(2024b\). Google flight. Google Flights. https://www.google.com/travel/flights](#)

[Green Globe. \(2024, August 30\). Green Globe certification. Green Globe. https://www greenglobe.com](#)

[Green Key. \(2024, July 2\). Green Key certificate. Green Key. https://www.greenkey.global](#)

[GreenView. \(2024\). Hotel Footprint Calculator. https://www.hotelfootprints.org/](#)

[GSCT. \(2024\). Global Sustainable Tourism Council \(GSTC\)—The international accreditation body for sustainable tourism certification. GSTC. https://www.gstcouncil.org/](#)

[IBEX Fairstay. \(2024\). IBEX Fairstay -The label for sustainable tourism. Ibex Fairstay. https://ibexfairstay.ch/en/](#)

[IPCC. \(2019\). Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/](#)

[IPCC. \(2023\). Synthesis Report. https://www.ipcc.ch/ar6-syr/](#)

[LEED. \(2024\). LEED rating system | U.S. Green Building Council. https://www.usgbc.org/leed](#)

Lenzen, M., Sun, Y. Y., Faturay, F., Ting, Y. P., Geschke, A., & Malik, A. (2018). The carbon footprint of global tourism. *Nature Climate Change*, 8(6), 522-528.

[Lenzen, M., Sun, Y.-Y., Faturay, F., Ting, Y.-P., Geschke, A., & Malik, A. \(2018a\). The carbon footprint of global tourism. Nature Climate Change, 8\(6\), 522–528. https://doi.org/10.1038/s41558-018-0141-x](#)

[Lenzen, M., Sun, Y.-Y., Faturay, F., Ting, Y.-P., Geschke, A., & Malik, A. \(2018b\). The carbon footprint of global tourism. Nature Climate Change, 8\(6\), Article 6. https://doi.org/10.1038/s41558-018-0141-x](#)

Mak, B. K. L., Cheung, L. T. O., & Hui, D. L. H. (2017). Community participation in the decision-making process for sustainable tourism development in rural areas of Hong Kong, China. *Sustainability*, 9(10), 1695.

Mayer, I. S. (2016). Towards a comprehensive methodology for the research and evaluation of serious games. *Procedia Computer Science*, 15, 233-247.

McLoughlin, E., Maguire, K., & Hanrahan, J. (2023). Barriers to evidence-based sustainable planning for tourism: Perspectives from Ireland's local authorities. *Sustainability*, 15(23), 16274.



Michelin. (2024). Route planner: Route calculation, detailed journey cost. ViaMichelin. <https://www.viamichelin.com/routes>

Minergie. (2024). Schweizer Baustandard. Minergie. <https://www.minergie.ch/de/>

Mountain Riders. (2010). BILAN CARBONE DE VERBIER : POUR UNE APPROCHE GLOBALE DE LA NEUTRALITÉ CARBONE.

My Emission. (2024). Food carbon footprint calculator. My Emissions. <https://myemissions.co/resources/food-carbon-footprint-calculator/>

Myclimate. (2024). Flight emission calculator. https://co2.myclimate.org/en/flight_calculators/new/

Navitas Consilium. (2024). Neutralité Carbone. NCSA. <https://www.navitas-consilium.com/zero-carbone>

Nordin, B., & Wahlström, M. (2022). Games for change exploring the effects of the game Climate Fresk at Schneider Electric and the climate engagement potential for employees. [Master's thesis, KTH Royal Institute of Technology]. DiVA Portal. <http://www.diva-portal.org/smash/record.jsf?pid=diva2:1669522>

Observatoire Valaisan du Tourisme. (2024). [Tourobs.ch.](http://c15txvbkoda.preview.infomaniak.website/index.html) <http://c15txvbkoda.preview.infomaniak.website/index.html>

OpenAI. (2024). ChatGPT 3.5. <https://chat.openai.com/>

Polderman, A., Haller, A., Pellegrini, C., Viesi, D., Tabin, X., Cervigni, C., Sala, S., Trebušak, B., Daragon, Q., Ramette, D., Bidault, Y., Baldessari, G., Bender, O., Branca, D., Crema, L., Giorgi, A., Janša, N., Janša, J., Reinert, M.-E., & Vidović, J. (2021). Smart Altitude. Verlag der Österreichischen Akademie der Wissenschaften. <https://doi.org/10.1553/smart-altitude>

SBB. (2024). The SBB online portal for timetable, trains and public transport. The SBB Online Portal for Timetable, Trains and Public Transport. <https://www.sbb.ch/en>

Schuurman, D., De Marez, L., & Ballon, P. (2015). Living Labs: a systematic literature review. Open Living Lab Days 2015, Proceedings. Presented at the Open Living Lab Days 2015, Istanbul, Turkey

Spyckerelle, M. (2022). Game-based approaches to climate change education: a lever for change? The case of Climate Fresk-Sverige. [Master's thesis, University of Gothenburg]. DiVA Portal

Strobl, A., Teichmann, K., & Peters, M. (2015). Do mountain tourists demand ecotourism? Examining moderating influences in an Alpine tourism context. *Tourism: An International Interdisciplinary Journal*, 63(3), 383–398.

Sun, Y.-Y., Cadarso, M. A., & Driml, S. (2020). Tourism carbon footprint inventories: A review of the environmentally extended input-output approach. *Annals of Tourism Research*, 82, 102928. <https://doi.org/10.1016/j.annals.2020.102928>

Sun, Y.-Y., Lenzen, M., & Liu, B.-J. (2019). The national tourism carbon emission inventory: Its importance, applications and allocation frameworks. *Journal of Sustainable Tourism*, 27(3), 360–379. <https://doi.org/10.1080/09669582.2019.1578364>

Sustainable Travel International. (2024). Carbon Footprint of Tourism. <Https://Sustainabletravel.Org/>. <https://sustainabletravel.org/issues/carbon-footprint-tourism/>



Téléverbier. (2023). Rapport d'activité 2018-2109. <https://rapportannuel.televerbier.ch>

Tourismus, S. (2024). Swisstainable – sustainable travel in Switzerland. Switzerland Tourism. <https://www.myswitzerland.com/en-ch/planning/about-switzerland/sustainability/>

Travelife. (2024). Travelife Sustainability Certification. Travelife Sustainability Certification. <https://travelifesustainability.com/>

UNEP, U. N. (2023). Emissions Gap Report 2023 | UNEP - UN Environment Programme. <https://www.unep.org/resources/emissions-gap-report-2023>

UNWTO, I. T. F. (2019). Transport-Related CO2 Emissions of the Tourism Sector – Modelling Results. <https://www.e-unwto.org/doi/book/10.18111/9789284416660>

UNWTO. (2018). Sustainable Mountain Tourism? Opportunities for Local Communities. 1–4. <https://doi.org/10.18111/9789284420261>

World Economic forum. (2024). Travel & Tourism Development Index. <https://www.weforum.org/publications/travel-tourism-development-index-2024/>

WTTC. (2021). A Net Zero Roadmap for Travel & Tourism. A Net Zero Roadmap for Travel & Tourism. <https://action.wttc.org/climate-environment>

Yousif, O. S., & Zakaria, R. (2022). Web-Based Big Data Integration Visualisation Solutions. In M. Fadhil Md Din, N. Eliza Alias, N. Hussein, & N. Syamimi Zaidi (Eds.), Sustainability Management Strategies and Impact in Developing Countries (Vol. 26, pp. 103–117). Emerald Publishing Limited. <https://doi.org/10.1108/S2040-726220220000026009>

Zeng, Y., Filimonau, V., Jingjing, Y., Linsheng, Z., & Ling-en, W. (2023). A research framework for analyzing tourists' low-carbon travel intention: an empirical analysis in China. Environment, Development and Sustainability. Retrieved from <https://link.springer.com/article/10.1007/s10668-023-04166-0>



8 Annexes

8.1 8.1 Tourist Persona Descriptions

This Annex presents the list of Tourist personas for both national and international tourism.

National tourism persona	International Tourism persona
Eco-friendly Eliza	Mr. & Ms. Frostington
Individualistic Idriss	Mr. Vinrød
Optimising Ollie	Mr. Kostas
Pleasure-seeking Patrice	Von Steinberg family
Techie Theo	Mr Nube and his friends
Traditional Tom	Al-Bajari family

Table 6: List of Personas tested with the Tourist Carbon Profile Tool.

Eco-friendly Eliza

Eliza leads an environmentally conscious and efficient lifestyle, prioritising simplicity and quality, with altruistic solid and biospheric values, and is willing to make financial sacrifices for sustainability despite being less engaged in broader social and environmental activism. Eliza's family comprises her, her girlfriend, and her retired dad; they are between 50 and 55, and her dad is 85. They live in Zurich and have a shared income of 290,000 CHF annually. For work, she does counselling in sustainability. Eliza has a PhD; she is socially active and eco-conscious, focused on sufficiency and efficiency, emphasising repair over replacement, comfort, and quality, and making sensitive food choices with an interest in new diets and regional, seasonal foods. She commutes by public transport, cycling or walking, and uses the car only when needed. During her free time, she loves reading books at the book club, cooking, meeting with friends, and going to the aqua gym. She likes to be in nature when there is good weather. Otherwise, she opts for theatre and other cultural activities.

Individualistic Idris

Idris leads a frugal, status-averse life with inconsistent environmentally relevant behaviour, moderate sufficiency and efficiency, considerate food management, and limited mobility, resulting in spending much time at home. Idris's family comprises her and her husband; they are between 60 and 70 years old. They live close to Chur and have an annual shared income of 150,000 CHF. For work, she is a florist, and he is retired. Idris has a bachelor's in sociology; she is an average consumer of goods, does little action for the environment, doesn't like meat, and loves cheese. She travels half the time by car; at other times, she uses public transportation while she flies very rarely. She loves watching television, tasting wine, and walking in the countryside in her free time. She has also loved skiing and practising Judo since she was young. She likes quiet places, being alone, and stunning landscapes. She doesn't like to sweat and crowded places. She is into "do it yourself" hobbies.

Optimising Ollie

Ollie, a sustainability champion, is deeply engaged in the cause through innovative technologies and behaviours. He actively supports pro-environmental policies and is both socially and environmentally active. His eco-consciousness is evident, but his frequent flying is a testament to his motivation being more about optimisation than idealism. Ollie's family comprises him, his wife and three kids; they are between 45 and 50 years old, and their kids are 5 to 13. They live in Winterthur and have an annual shared income of 390,000 CHF. For work, he manages an innovative small biotechnology company, and she is a civil engineer. Ollie has two master's and one PhD in biotechnology; Ollie practices highly conscious consumption with a strong focus on sufficiency and efficiency, prioritises repairing over buying, values comfort and quality of goods, and is open to various diets. He commutes by bicycle, opts



for public transport for further daily destinations, and uses his electric car when needed. For work and leisure, he often flies across the world. In his free time, he likes to do yoga and running, fish, travel, and take multiple extreme adventures, from bungee jumping to rafting and skydiving. He loves to interact with people and have adventures.

Pleasure-seeking Patrice

Patrice is hedonistic and prioritises personal pleasure and self-indulgence, while being price-conscious, partially believes in the impact of her actions and often chooses the most enticing options without considering their environmental implications. Patrice is 24 years old. She lives alone with a cat but often spends time with her large family and friends from school. She lives in Lausanne and has an annual income of 55,000 CHF. She works as a secretary for a beauty centre and is trying to become an influencer. Patrice completed a professional apprenticeship and some management courses before starting to work. Patrice engages in self-centred consumption with a high eagerness to consume, places moderate importance on comfort and quality, and prefers traditional food choices, showing indifference toward new diets and quality labels. She commutes to work by car and uses public transport to meet friends in the town centre or to see her family since parking is too expensive. Lower prices drive her travel behaviour. In her free time, she goes to the gym and swimming pool to stay in shape, sunbathe, and meet friends for coffee or clubbing. She is also into social media and often looks for the trendiest spot to create virtual content. She spends most of her time far from her neighbours and loves to gather at festivals, parties, and other social events.

Techie Theo

Theo prioritises technological solutions and high social status, is highly engaged in social and environmental initiatives, and is open to new mobility, nutrition, and working practices but is reluctant to adopt sufficiency behaviours. Theo is 29 years old. He lives with his family, which consists of his parents, three sisters (one of them with a small kid), his grandmother, and two dogs. He lives in the periphery of Bern with his family, trying to retire early with a salary of 95,000 CHF per year. He works as a mechanical engineer remotely (either at home or in a coworking space). Theo has a bachelor's degree in informatics and started a master's without ending it. Theo exhibits inconsistent sufficiency towards environmental sustainability, prefers technological solutions over reduced consumption, and consumes a lot of meat and fish but is open to various diets. When working remotely in the city, he commutes by public transport and uses his hybrid car to meet clients. When he can, he travels to new places to mix remote working with travel, usually choosing central but cheap solutions, like hostels. He plays football and tennis with his friends in his free time, plays board and video games, and watches TV series. He loves architecture and technology. He sings and plays the bass in a small band, which he sometimes hires for local events. He understands the importance of environmental sustainability, which is second only to his comfort.

Traditional Tom

Tom demonstrates minimal interest in environmentally relevant behaviour, lacks identification with the environment, prioritises comfort and self-indulgence, resists new experiences, strongly opposes lifestyle-affecting regulations, doubts the effectiveness of his actions, and remains uninvolved in his neighbourhood. Tom is 43 years old. He lives with his family: his second wife, two kids, aged 3 and 6, and one dog. He also spends time with his two kids, aged 10 and 15, who live with his first wife. They live in Lax with their family, and the salary is 115,000 CHF per year for the whole family. Theo works for the railway company in Sion as a senior ticket controller. Theo completed high school before starting a short professional football career, which ended due to an injury. Tom engages in self-centred consumption, preferring buying over repairing. He also prefers traditional food choices while indifferent



to new diets and quality labels. Tom commutes daily by car to Sion for work and to take his daughter to school. He loves to travel with his family by plane once a year; otherwise, he always travels with his pickup truck. He spends time with his family in his free time, usually hiking, harvesting mushrooms, and playing raclette. He loves to follow sports events live and is active in his small local community. Less frequently, he spends time with his old friend hunting, but sometimes, he can't afford to do it.

Mr. Vinrød's

Mr. Vinrød, a 49-year-old from Denmark, embraces a life of tradition and simplicity. Residing in a rustic cottage near Aarhus, he finds joy in hiking, gardening, and savouring traditional Danish cuisine. As a professor specialising in European history, he studies and preserves cultural heritage. His home reflects his love for classic literature and philosophy, and his garden provides both sustenance and tranquillity. An avid hiker and forager, Mr. Vinrød enjoys exploring Denmark's landscapes and incorporating wild herbs and berries into his cooking. He is also a wine connoisseur, preferring classic European vintages from small, family-owned vineyards. His lifestyle blends a deep respect for the past with a commitment to self-sufficiency and intellectual engagement, including participation in local cultural events and discussions with students.

Mrs. & Mr Frostington

Mr and Mrs Frostington, a dynamic couple in their late 40s from the UK, lead an adventurous lifestyle centred around thrill-seeking and outdoor activities. With a combined income of £350,000, they reside in a modern chalet-style home in the Scottish Highlands, perfectly suited to their love for excitement and rugged terrains. Mr. Frostington, an entrepreneur in the luxury automotive industry, and Mrs. Frostington, an event planner specializing in high-end, adventure-themed events, share a passion for 4x4 vehicles and off-road expeditions. The Frostingtons frequently travel to snowy, remote destinations like the Alps, Norway, and Canada, where they indulge in extreme sports such as heli-skiing, snowboarding, and ice climbing. Their vacations are luxurious yet adventurous, often involving driving tours in their customized 4x4s. Focused on business success, they enjoy hosting exclusive gatherings, participating in motorsport events, and always seeking new business opportunities aligned with their interests. Their lifestyle is a blend of high-octane excitement and business acumen, embracing both risk and reward.

Mr. Kostas

Mr. Kostas, a 57-year-old consultant from Greece, balances work and a love for the outdoors. Living in a picturesque Peloponnese village, he enjoys moderate hiking, cycling, and wildlife photography, drawing inspiration from the stunning landscapes around him. His remote work allows him to explore Greece's diverse scenery while advising clients across industries. Passionate about tradition, Mr. Kostas attends local cultural events, especially balloon festivals, and enjoys authentic Greek cuisine at local tavernas. His lifestyle reflects a deep appreciation for nature, adventure, and the simple pleasures of village life.

Von Steinberg family

The Von Steinberg family from Konstanz, Germany, embraces an active, family-oriented lifestyle centred around outdoor activities and quality time together. Consisting of two parents and four children aged 4 to 15, they are passionate about skiing, hiking, cycling, and swimming, often spending their winters in the Alps. Both parents work in flexible careers—Mr. Von Steinberg in mechanical engineering and Mrs. Von Steinberg as a part-time speech therapy teacher—allowing them to prioritize family adventures. They enjoy traditional German comfort food, especially cheese dishes, and emphasise sustainability in their everyday choices, focusing on eco-friendly products and locally sourced, organic foods. The family loves camping, board games, and exploring nature, fostering a deep connection with the environment. Their travels are tailored to include both adventure and relaxation, ensuring enjoyable experiences for



all family members. The Von Steinbergs value tradition, outdoor exploration, and the simple joys of family life, creating lasting memories together.

Al-Bayari family

The Al-Bayari family from Arabia enjoys a lifestyle centred around luxury, elegance, and exclusivity. Comprised of Mr and Mrs Al-Bayari, their two children, aged 22 and 25, and Mrs Al-Bayari's 78-year-old mother, the family lives a life of sophistication supported by an annual income of 2.3 million USD. Mr. Al-Bayari is a prominent entrepreneur in the fashion industry, while Mrs. Al-Bayari manages luxury brand partnerships and philanthropy projects. Their children are studying in Europe, one in business in Paris and the other in art history in Milan. The Al-Bayaris are highly social and cosmopolitan, frequently attending elite events and cultural gatherings. They prioritise luxury in every aspect of life, from home decor to fashion. Their love for travel takes them to destinations like the Maldives, St. Tropez, and Dubai, where they indulge in first-class experiences such as private yacht charters and Michelin-starred dining. While they embrace modern luxury, they also honour tradition, hosting lavish gatherings that blend contemporary elegance with Arabian hospitality. The family enjoys refined activities in their free time, like attending art exhibitions, wine tastings, and exclusive shopping experiences. Although not deeply involved in environmental activism, they support sustainability by choosing luxury brands committed to ethical practices. The Al-Bayaris' lifestyle is a blend of luxury, tradition, and a commitment to enjoying life's finest offerings.

Mrs Nube and her friends

Mrs Nube and her friends, aged 18 to 25, live a vibrant life focused on socializing, creativity, and seizing the moment. They balance university studies with a passion for social media, turning their love for partying, festivals, and sports into a lucrative side hustle. Festival enthusiasts attend diverse music events and local sports, sharing their experiences online. Savvy with their money, they enjoy budget-friendly food and thrift shopping, combining vintage finds with current trends. When not at events, they explore hidden city spots, from cafes to underground venues, often featuring these in their content. Though busy with studies in marketing, media, and the arts, they maintain a flexible approach, drawing inspiration from their experiences. Environmentally conscious, they favour second-hand shopping and local food, aiming for a small footprint. Always seeking new adventures, they travel to music festivals and sports events and explore fresh hangout spots, living in the moment and sharing their journey with a growing online audience.

8.2 8.2 Example of AI-generated Travel Plan from Persona

Generic question: “Can you suggest one week of holidays in Switzerland that match this profile? List a few activities, like leisure, meals, and accommodations for each suggestion, such as a real travel plan. I would like you to answer using a table for the content. Hereunder the profile: “

Persona: Eco-friendly Eliza



AI Output:

“Based on the profile provided, here is a tailored one-week holiday plan around the Engadine region in Switzerland. The plan is designed to align with Eliza's values, interests, and family structure. This plan focuses on sustainability, comfort, quality, and cultural experiences, while offering opportunities for relaxation and connection with nature.

| **Day** | **Activities**
Meals
Accommodation

| **Day 1** | **Arrival & Slow Travel to Sils Maria**: Take the train from Zurich to St. Moritz, then a short bus ride to Sils Maria. Check into the eco-friendly hotel. | **Lunch**: Sustainable farm-to-table restaurant in St. Moritz.
 Dinner: Hotel's organic, locally sourced dinner menu. | **Hotel Waldhaus Sils** - A historic, family-run hotel with a strong focus on sustainability, offering stunning views and comfort. |

| **Day 2** | **Exploring Sils Maria & Lake Sils**: Morning walk around Lake Sils, followed by reading or meditation in nature. Afternoon visit to the Nietzsche House Museum. | **Breakfast**: Organic and seasonal at the hotel.
 Lunch: Picnic by the lake with regional produce.
 Dinner: Vegan/vegetarian dinner at a local bistro. | **Hotel Waldhaus Sils** |

| **Day 3** | **Day Trip to Pontresina & Morteratsch Glacier**: Gentle hike to the glacier with an educational twist, learning about climate impact. Visit the Bernina Glaciers Visitor Center. | **Breakfast**: Hotel.
 Lunch: At a mountain hut offering local, seasonal dishes.
 Dinner: Organic dining back at the hotel. | **Hotel Waldhaus Sils** |

| **Day 4** | **Leisure Day in St. Moritz**: Visit the Segantini Museum, then explore the local markets for eco-friendly souvenirs. Afternoon at a wellness center focusing on sustainable practices. | **Breakfast**: Hotel.
 Lunch: Local vegetarian restaurant.
 Dinner: Sustainable fine dining at a restaurant specializing in local ingredients. | **Hotel Nira Alpina** - A modern, eco-conscious hotel located near St. Moritz with direct access to the mountain cable car. |

| **Day 5** | **Exploring Lower Engadine: Guarda & Scuol**: Explore the charming village of Guarda. Afternoon at the eco-friendly spa in Scuol, using natural mineral waters. | **Breakfast**: Hotel.
 Lunch: Regional specialties in Guarda.
 Dinner: Regional dishes at a slow-food restaurant in Scuol. | **Hotel Belvédère Scuol** - A historic, eco-friendly hotel with access to the spa and stunning views of the Lower Engadine region. |

| **Day 6** | **Nature & Culture in Zernez**: Visit the Swiss National Park and its visitor center. Afternoon of quiet reflection or gentle hiking. | **Breakfast**: Hotel.
 Lunch: Picnic with local, organic foods.
 Dinner: Traditional Engadine cuisine in Zernez. | **Hotel Belvédère Scuol** |

| **Day 7** | **Return to Zurich**: Morning relaxation and local exploration before taking a scenic train back to Zurich. | **Breakfast**: Hotel.
 Lunch: Local café in St. Moritz before departure. | **Home Sweet Home** |



Additional Notes:

- **Transportation**: Public transport and eco-friendly options (like walking and cycling) are emphasized to minimize environmental impact.
- **Activities**: A mix of nature, culture, and relaxation, ensuring comfort and accessibility for Eliza's elderly father.
- **Dietary Considerations**: Meals focus on regional, seasonal, and organic produce, catering to Eliza's food preferences and sustainability focus.
- **Accommodations**: Chosen hotels are known for their sustainability practices, comfort, and quality."

This plan balances leisure and cultural activities with an emphasis on sustainability, catering to Eliza's lifestyle and values.

8.3 Tool Visualisation Examples

This annex presents some visualisations employed to test the preliminary outputs of the Tourist Carbon Profile Tool. Persona does not correspond to the list previously provided. The visualisations presented here were used during an event in Val de Bagnes (Figs) and Chateaux d'Oex (Figs*).

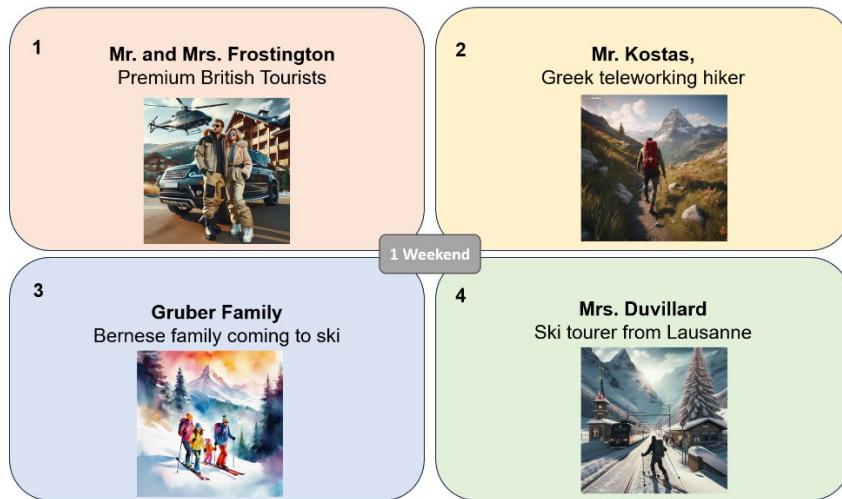


Figure 16: Presentation of personas in Val des Bagnes. Images were generated after the profiles from persona descriptions. The holiday destination was predetermined as Val des Bagnes.

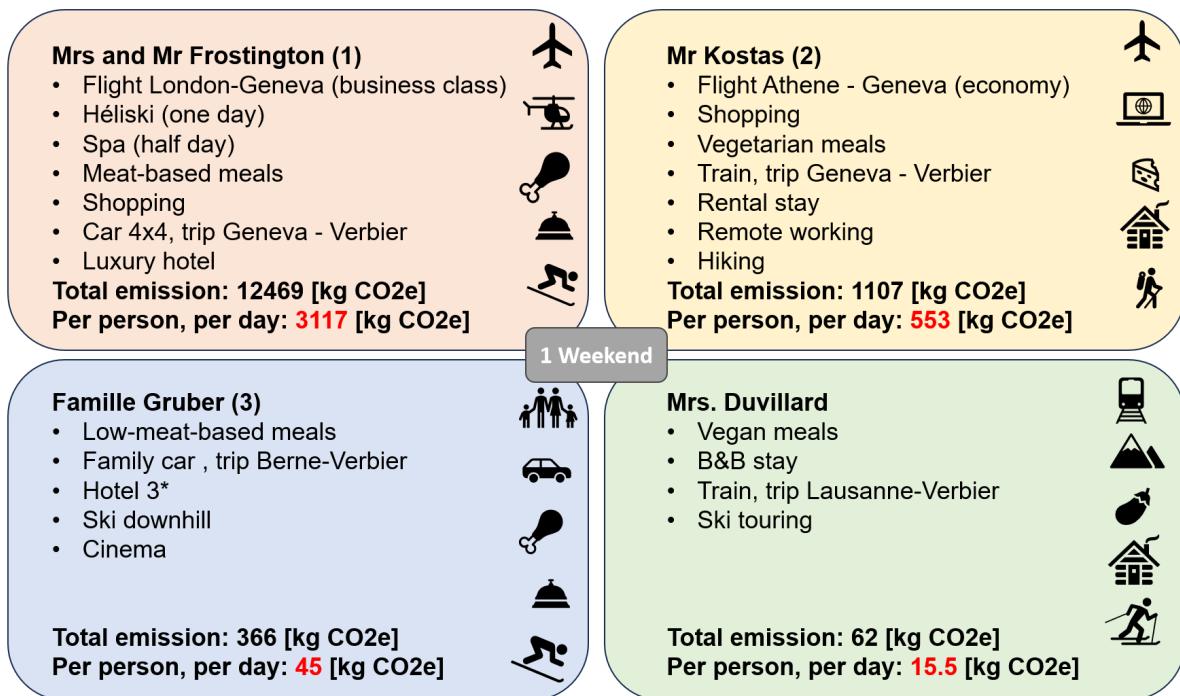


Figure 17: Tourist Carbon Profile Tool output visualisation for four Personas with predetermined holidays in Val des Bagnes with a fixed time duration of one weekend (two nights).

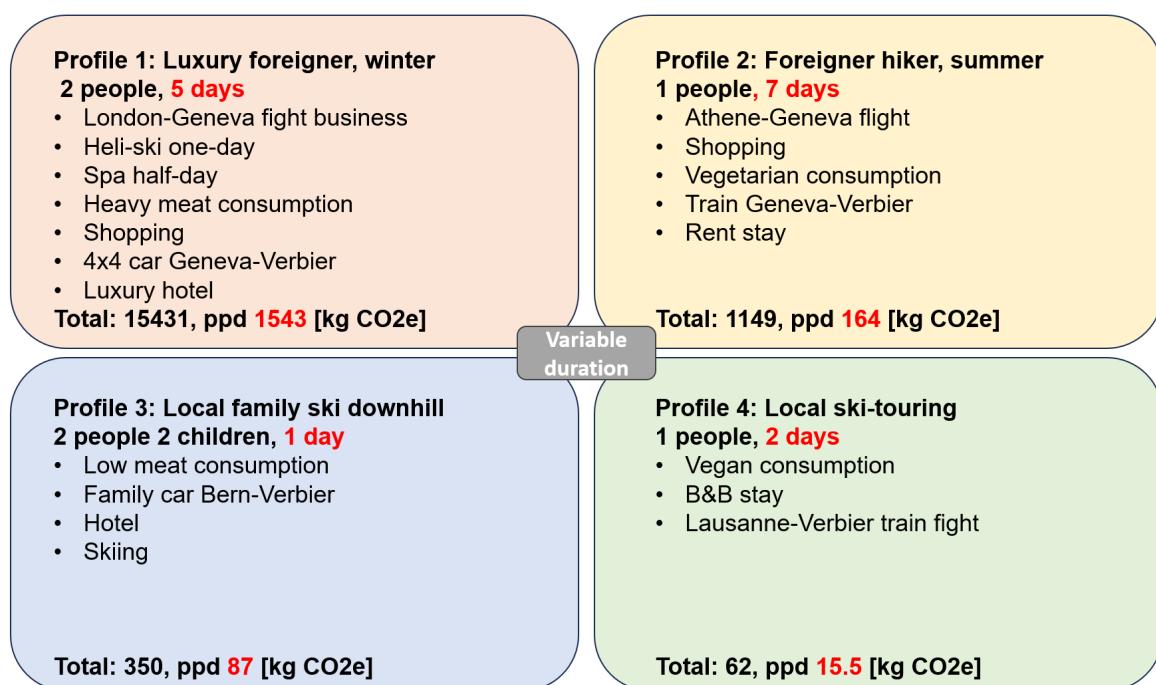


Figure 18: Tourist Carbon Profile Tool output visualisation for four Personas with predetermined holidays in Val des Bagnes with a variable duration across Personas.

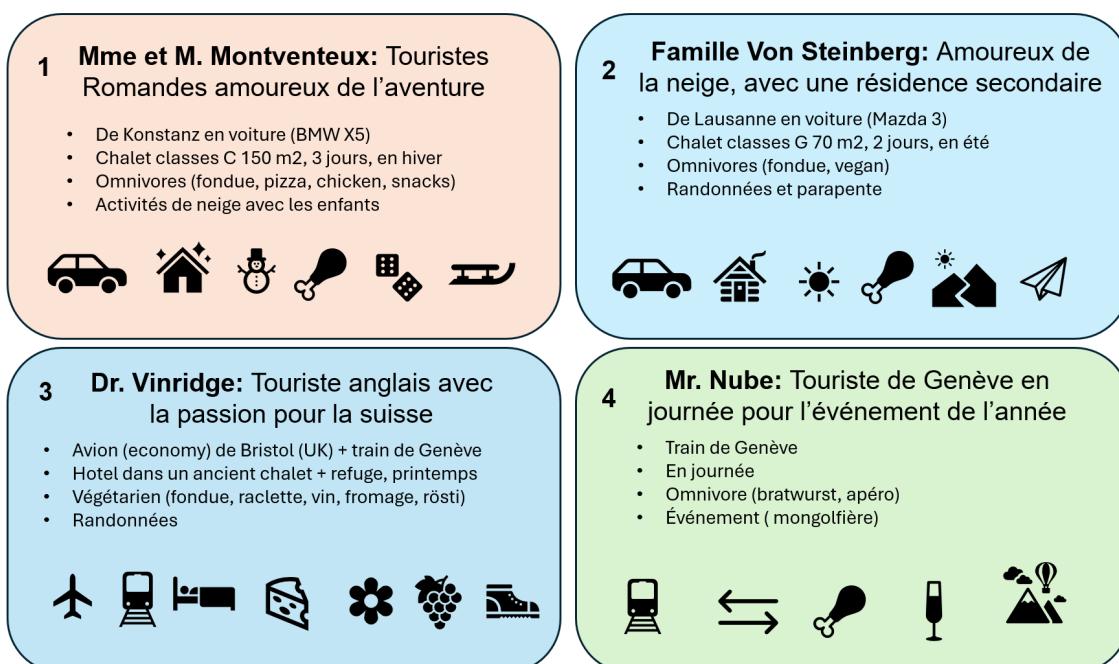


Figure 19: Four Personas brief descriptions with predetermined holidays in Chateaux d'Oex with a variable duration across Personas.

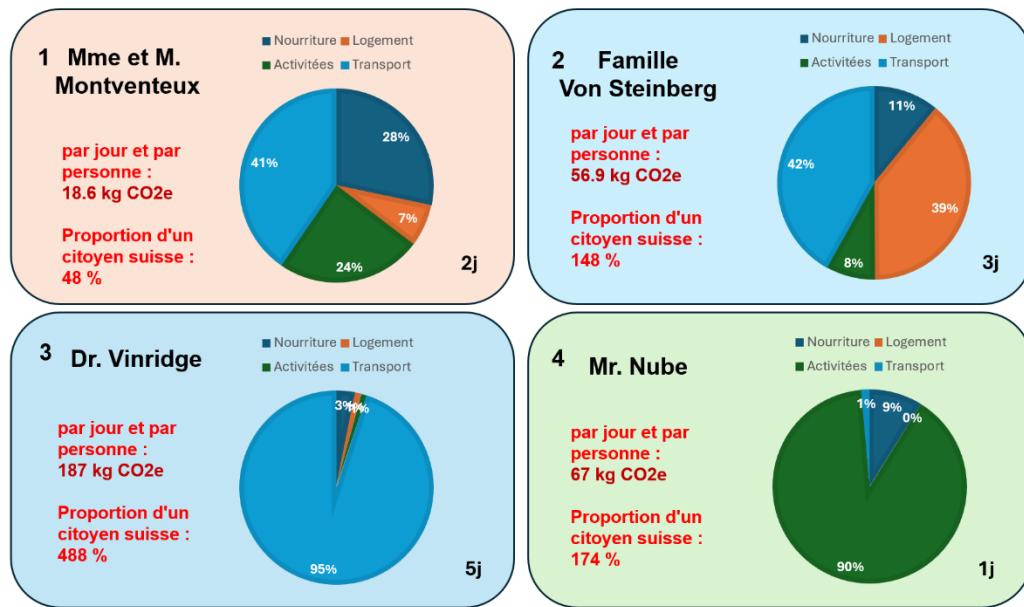


Figure 20: Tourist Carbon Profile Tool output visualisation per sector for four Personas with predetermined holidays in Chateaux d'Oex with a variable duration across Personas.

Activity	Field	amount	unit	emission	scope		Instructions & Results
Transport	city car Lausanne - Château-d'Oex	1	round-trip	30	1		
Leisure	paraglide equipment / 50 uses	2	day	10	1		
Leisure	hiking equipment 100d	2	day	2	1		
Food	breakfast generic	4	breakfast	4	1		
Food	Fondue	2	meal	8.4	1		
Food	vegetarian egg sandwich	2	meal	1.4	1		
Food	hiking snacks	2	snack	1.4	1		
Food	generic vegan meal	2	meal	2	1		
Leisure	uphill transport to destination per person	2	trip	6	1		
Stay	chalet summer70m2 class G	2.5	day	5.25	1		
Food	Rosti egg and lardons	2	meal	3.8	1		
0		0	0	0	0		
0		0	0	0	0		
0		0	0	0	0		
0		0	0	0	0		
0		0	0	0	0		
Persona				Emissions kgCO2e		Characteristics	
PeH1	Total			per person, per day	% of a swiss citizen	People	Days
	74.25			18.563	48.40%	2	2
						Meals	Breakfast
						8	4
				Emissions across fields kgCO2e			
Transport	Stay	Food	Leisure	Shopping			
30	5.25	21	18	6	emission		
40.49	7.07	28.26	24.24	0.08	percentage		

Activity	Field	amount	unit	emission	scope	P2	Instructions & Results
Transport	car Konstanz-Château-d'Oex BMW x5	1	round-trip	286	1		Instructions-> (1) Choose the persona in the black case; (2) In the left table, choose a field, then the specific activity; (3) Specify the amount for each activity, for example, "two vegetarian meals"; (4) numbers of days, people and respective meals are shown in the green table on the right; (4) Results are shown on the right in red and in the pie chart. (5) If you want to calculate emission for another persons, duplicate this sheet, clear the content in the left table, and follow the exact instructions. Average emission of a Swiss citizen : 14t CO2e per year.
Stay	chalet winter 150m2 class C	2	day	266	1		
Food	fondué	6.8	meal	28.56	1		
Food	bratwurst and mashed potates, coleslaw	6.8	meal	24.48	1		
Food	wood oven pizza	3.4	meal	14.96	1		
Food	vegetarian egg sandwich	3.4	meal	2.38	1		
Food	hiking snacks	6	snack	4.2	1		
Leisure	Ski equipment	8	day	56	2		
Leisure	Streaming	3	hour	0.3	3		
0		0	0	0	0		
0		0	0	0	0		
0		0	0	0	0		
0		0	0	0	0		
0		0	0	0	0		
0		0	0	0	0		
Persona	Emissions kgCO2e			Characteristics			
	Total	per person, per day	% of a Swiss citizen	People	Days	Meals	Breakfast
PeH2	682.88	56.907	148.39%	4	3	24	12
Emissions across fields kgCO2e							
Transport	Stay	Food	Leisure	Shopping	emission	percentage	
286	266	74.58	56.3	0			
41.68	38.95	10.92	8.24	0.06			

Figure 21: Tourist Carbon Profile Tool output for four Personas with predetermined holidays in Chateaux d'Oex with variable duration across Personas (first two profiles)



Activity	Field	amount	unit	emission	scope
Transport	flight economy Bristol - Geneva	1	round-trip	884	1
Stay	average hostel stay	2	bed - night	5.2	1
Stay	hotel swiss old style summer	3	day	4.5	1
Transport	train Geneva- Château-d'Oex	1	round-trip	1.8	1
Food	bottle of wine	3	bottle	3	1
Food	Breakfast generic	5	breakfast	5	1
Food	hiking snacks	10	snack	7	1
Leisure	hiking equipment 100d	8	day	8	1
Food	Bastette	1	meal	5.2	1
Food	Basti egg and lardons	1	meal	1.9	1
Food	vegetarian egg sandwich	4	meal	2.8	1
Food	Apero cheese, cured meat, wine	2	portion	3.8	1
Food	wood oven pizza	1	meal	4.4	1
0				0	0
0				0	0
0				0	0

P3

Instructions & Results

Instructions>> (1) Choose the persona in the black case; (2) In the left table, choose a field, then the specific activity; (3) Specify the amount for each activity, for example, "two vegetarian meals"; the number of days, people and respective meals are shown in the green table on the right. (4) Results are shown on the right in red and in the pie chart. (5) If you want to calculate emission for another persona, duplicate this sheet, clear the content in the left table, and follow the exact instructions. Average emission of a Swiss citizen : 14t CO2e per year.

Persons	Emissions kgCO2e			Characteristics			
	Total per person, per day	% of a swiss citizen	People	Days	Meals	Breakfast	
PeH3	936.2	187.328	488.45%	1	5	10	5

Emissions across fields KgCO2e				
Transport	Stay	Food	Leisure	Shopping
885.8	9.7	28.7	8	0
94.58	1.04	3.06	0.85	0.00
				percentage

Activity	Field	amount	unit	emission	scope
2	Transport	train Geneva- Château-d'Oex	1	round-trip	1.8
3	Leisure	Mongolpier 1.5h, per person	2	flight	120
4	Food	Apero cheese, cured meat, wine	2	portion	3.8
5	Food	bratwurst and mashed potatoes, coleslaw	2	meal	7.2
6	Food	hiking snacks	1	snack	0.7
7	0			0	0
8	0			0	0
9	0			0	0
10	0			0	0
11	0			0	0
12	0			0	0
13	0			0	0
14	0			0	0
15	0			0	0
16	0			0	0
17	0			0	0

P4

Instructions & Results

Instructions>> (1) Choose the persona in the black case; (2) In the left table, choose a field, then the specific activity; (3) Specify the amount for each activity, for example, "two vegetarian meals"; the number of days, people and respective meals are shown in the green table on the right. (4) Results are shown on the right in red and in the pie chart. (5) If you want to calculate emission for another persona, duplicate this sheet, clear the content in the left table, and follow the exact instructions. Average emission of a Swiss citizen : 14t CO2e per year.

Persons	Emissions kgCO2e			Characteristics			
	Total per person, per day	% of a swiss citizen	People	Days	Meals	Breakfast	
PeH4	133.5	66.750	174.05%	2	1	4	2

Emissions across fields KgCO2e				
Transport	Stay	Food	Leisure	Shopping
1.8	0	11.7	128	0
1.35	0.00	8.76	93.85	0.00
				percentage

Figure 22: Tourist Carbon Profile Tool output for four Personas with predetermined holidays in Chateaux d'Oex with variable duration across Personas (second two profiles)

8.4 Mountain Tourism Fresk Deck of Cards

See attached file

8.5 Mountain Tourism Fresk Participants Survey

See attached file



Appendix