

THE APPLICATION OF GEOGRAPHIC INFORMATION SYSTEMS (GIS)
TECHNOLOGIES TO MONITOR AND SUPPORT SUSTAINABLE TOURISM IN THE
THOMPSON-OKANAGAN REGION

by

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ABSTRACT

This study explores the status of sustainable tourism in the Thompson Okanagan Region of British Columbia, Canada, by integrating Geographic Information Systems (GIS), Multi-Criteria Assessment (MCA), and stakeholder perceptions. Guided by the UNWTO Statistical Framework for Measuring the Sustainability of Tourism (SF-MST), the research identifies, collects, and harmonizes a set of environmental, socio-cultural, and economic indicators at the Dissemination Area (DA) level to build a localized sustainability assessment framework. A top-down spatial analysis was conducted using secondary geographic and statistical data, while a bottom-up approach incorporated perceptions from georeferenced stakeholder survey responses across the region. The indicators were normalized, weighted based on stakeholder inputs, and integrated through MCA to generate sustainability scores for each DA. The findings reveal spatial disparities in sustainability performance across the region, with high environmental scores contrasting with limited socio-cultural data availability. A comparison between stakeholder perceptions and computed MCA scores further highlights perception gaps, underscoring the importance of participatory and context-sensitive approaches in sustainability assessment. Despite challenges such as small survey size, uneven data availability, and the need for downscaling, this research demonstrates the feasibility and value of integrating spatial data and stakeholder insights into fine-resolution tourism sustainability evaluations, offering practical implications for policy-making, regional planning, and refining global measurement frameworks for local implementation, such as the development of place-based sustainability monitoring systems, the integration of GIS tools into tourism and land-use planning for evidence-based decision-making, and the stakeholder engagement to ensure inclusivity and relevance in the monitoring process.

Keywords: tourism, tourism destination, Geographic Information Systems, GIS, sustainable development, sustainable tourism, sustainability monitoring, regional sustainability assessment, Multiple Criteria Analysis, Spatial Analysis, Thompson-Okanagan Region, Canada, UN Statistical Framework for Measuring Sustainability of Tourism.

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DEDICATION

To my immediate and extended family. To my parents and siblings, for your constant love, for the nostalgia and concern felt across the distance, and for the pride and excitement you have expressed as I complete this journey.

To my husband for your unconditional love and endless patience. May the completion of this chapter bring you joy, peace, and renewed faith in the goodness that still exists in the world.

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Chapter 1 - Introduction

The tourism industry is recognized as one of the most important industries in the world, contributing a significant 7.6% of global GDP (approximately \$ 7.71 trillion) to the global economy (Statista, 2023), while generating around 10% of global employment (Liu et al., 2022). The hotel industry alone has a significant environmental impact, contributing about 8% to global greenhouse gas emissions, 9% of the world's waste, and consuming 5% of the world's available water (Voukkali et al., 2023). It is also significantly impacted by the effects of over-tourism and climate change (Baloch et al., 2023; Hewer & Gough, 2018). Some researchers argue that this trend will continue; the United Nations, for example, forecasts that "transport-related CO2 emissions of the tourism sector will increase by 103% from 2005 to 2030 due to the growing demand" (UNWTO, 2019a, p. 49).

In 2022, Canada recorded 17.92 million arrivals, including 12.80 million tourists. That same year, there were 21.40 million outbound departures for tourism purposes (UNWTO, 2022). This indicates an incremental growth of four to five times compared to the previous year, reflecting the industry's strong recovery following the significant impact of the COVID-19 pandemic between 2019 and 2021. The contribution to the national economy is notable, bringing nearly \$37.7 billion to Canada's GDP and supporting approximately 1.87 million jobs across the country. Tourism, on the other hand, is one of the industries that contributes the most to developing small and medium-sized local enterprises (Government of Canada, 2022).

The Canadian tourism industry has shown a rapid recovery from the COVID-19 pandemic, reaching 93% of its 2019 tourism business levels and 90% of its 2019 sector jobs by the end of December 2022 (Government of Canada, 2022). In response, the government's strategies for the industry propose two objectives: 1) to become a Top 7 global tourism destination; and 2) to grow tourism GDP by 40%, from \$43.6 billion in 2019 to \$61 billion by 2030 (Government of Canada, 2022).

These trends underscore the urgent need for continued monitoring of tourism's sustainability performance. As growth continues, tourism destinations and local communities will face mounting pressure, making sustainability assessment and governance more crucial

than ever. Achieving the balance between the different dimensions of sustainability requires robust tools and reliable evidence to support well-informed, integrated decision-making. In this context, Geographic Information Systems (GIS), a powerful form of Information and Communication Technology (ICT), can play a significant role in sustainability assessments.

Sustainable Development Conceptualization

The basic concept of sustainable development and its measurement are highlighted as a global concern. Sustainability is defined in the Brundtland Report as “*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*” (UN, 1987, p. 37). This has led to the challenge of measuring the thresholds of population and economic growth that environmental limits can support.

This need for measurement has evolved and become more complex over time (Pan et al., 2018). One of the most widespread milestones is the global agreement on the three dimensions of sustainable development (environmental, economic, and social) and the need for consistent and limited growth to achieve a balance among them (UN, 1987). Furthermore, the importance of adopting new approaches centered on nature conservation, valuation of ecosystem services and management of natural capital is recognized (Costanza et al., 2014).

Sustainable tourism aims to strike a balance between economic growth, socio-cultural equity, and environmental protection, particularly in destinations prone to degradation or overuse. The United Nations' definition of sustainable tourism embraces the need to take “full account of its current and future economic, social and environmental impacts whilst addressing the needs of visitors, the industry, the environment and host communities” (UNWTO, 2024b, p. 6). In this sense, it is essential to have tools to identify, measure, and assess whether the balance between the three pillars of sustainability is at risk, enabling timely corrective action and achieving the goals of sustainable tourism.

One of the most important stakeholders in these efforts is the Destination Management Organizations (DMOs). DMOs have been recognized at the global level as key organizations that can form strong links between different stakeholders and help build a coherent vision that

bridges the needs of promotion and marketing with those of conservation and protection of tourism destinations (UNWTO, 2019). Some DMOs worldwide are part of the International Network of Sustainable Tourism Observatories (INSTO), a United Nations World Tourism Organization (UNWTO) initiative aimed at establishing a cluster of organizations dedicated to monitoring the economic, environmental, and social impacts of tourism at the destination level (UNWTO, 2024a).

However, the information and tools that a country develops to monitor and evaluate its progress or gaps in pursuing sustainability goals are usually available at the national level. Regional and local levels of government are currently challenged to have access to data and tools that enable them to monitor and adjust their strategies locally. In this context, UNWTO recognizes the potential for synergies in using "geospatial information systems and related data sets" (UNWTO, 2024b, p. 151).

On this basis, the present research explores how Geographic Information Systems (GIS) can support the spatial visualization of the current state of sustainability in the tourism industry across municipalities in the Thompson-Okanagan Region. The goal is to provide stakeholders with a practical tool to better understand and assess sustainability in their area. Additionally, this experience may serve as a valuable benchmark for other tourism observatories within the international network.

Contextualizing Tourism Management in British Columbia and the Thompson-Okanagan Region

Canadian tourism management contemplates the division of tourism regions throughout the country. The Canadian provincial government administers these regions and embraces several regional and local Destination Management Organizations (DMOs) within their boundaries. These levels of governance have been demonstrated to be crucial in pursuing a sustainable industry. Federal, provincial, and regional strategies recognize the importance of consistency between the propositions and strategies defined at each level of governance. This can play a crucial role in the success of their implementation (Government of British Columbia,

2022; Government of Canada, 2022; Thompson Okanagan Tourism Association, 2017, 2019b).

The Thompson-Okanagan Region is one of British Columbia's six tourism regions. It is characterized as a popular tourist destination that combines thrilling natural attractions with rural settings, complemented by a strong tourist infrastructure provided by local and big-chain businesses, which dynamize the economy on both a broad and local scale (Government of British Columbia, 2024; Thompson Okanagan Tourism Association, 2019b). These characteristics make it an ideal geographic and strategic zone for the development of the present research.



Figure 1.1: Tourism Regions in British Columbia

The Thompson-Okanagan Region, situated in the southern interior of British Columbia, is home to approximately 653,300 residents (approximately 11.5% of the provincial population) and encompasses more than 120 communities, including 33 First Nations. Major cities such as Kelowna, Kamloops, Vernon, and Merritt anchor a region deeply rooted in Indigenous history, with longstanding cultural connections to the Secwépemc, Syilx,

Nlaka'pamux, and St'át'imc Nations. The landscape, characterized by lakes, valleys, grasslands, and mountain ranges, supports key industries, including tourism, agriculture, forestry, and mining, while also experiencing growing interest in renewable energy and increasing pressures on the urban–rural interface.

Tourism plays a vital economic role, with 2,100 businesses in 2022 representing 12.6% of BC's tourism sector, and generating \$2.6 billion in revenue, \$1.3 billion in regional GDP, and supporting 22,900 jobs. The region also hosts 77 Indigenous businesses listed with ITBC and 913 HelloBC listings that feature accessibility options. While tourism peaks in summer (36% of visitor nights), stable domestic visitation throughout other seasons signals potential for year-round tourism development. Government and private investments in BC tourism totalled nearly \$3 billion in 2022, reinforcing the sector's strategic importance for the region and the province as a whole (Destination BC, 2023).

The region hosts the Thompson-Okanagan Tourism Association, an “industry-led, not-for-profit organization that represents and supports business and community tourism interests throughout the area” (Thompson Okanagan Tourism Association, 2024). This DMO is a member of the United Nations Tourism International Network of Sustainable Tourism Observatories mentioned above, providing an opportunity for a worldwide impact on the results of the present research.

Research problem and questions

In recognition of the prevailing gap in the ability to monitor and evaluate sustainable tourism at sub-national levels in a way that is both data-informed and sensitive to local conditions. Existing frameworks are often not operationalized at fine spatial scales (such as Dissemination Areas), and they rarely integrate spatial data with the perceptions of stakeholders on the ground. In this context, this research aims to provide a conceptual framework for applying Geographic Information Systems (GIS) to assess sustainability in the tourism industry. This effort aligns with the UNWTO's broader goal of empowering regional and local governments with data and tools to monitor and adapt their strategies effectively.

The literature highlights the need for more effective tools to support decision-making and assessment, enabling industry stakeholders to identify the thresholds and priorities necessary to balance the components of sustainability. In this context, the present study seeks to demonstrate how the integration of Multi-Criteria Assessment with Geographic Information Systems (GIS) can enhance the evaluation and monitoring of tourism sustainability. This approach has been explored in other industries; however, there is limited knowledge about it in the tourism industry context. By enabling the geospatial analysis of relationships, patterns, and spatial distributions of social, environmental, and economic factors, GIS can help identify areas that require targeted support to advance sustainability goals.

Therefore, it is expected that the results of the present research will enable stakeholders to benefit from a tool that enhances their understanding of the sustainability status in their region. On the other hand, the experience can potentially be a benchmark for other observatories in the international network worldwide.

Research Questions

In line with the thesis statement of the research proposed above, below are the specific research questions to be addressed in this study based on specific research objectives related to the status of sustainable tourism, the value of GIS, and the perception and attitudes of stakeholders:

- **Status of Sustainable Tourism in the Thompson-Okanagan Region**
 - Research Question 1: What is the status of Sustainable Tourism in the municipalities of the Thompson Okanagan Region?
 - Research Question 2: What is the difference and geographic distribution in the status of sustainable tourism in rural communities versus small towns in the Thompson Okanagan Region?
- **The value of Geographic Information Systems to measure sustainability in the Tourism Industry**

- Research Question 3: What value does GIS technology offer to potentially measure gaps in sustainable tourism components?
- **The perception and attitudes of stakeholders through the use of GIS to monitor sustainability in the tourism industry**
 - Research Question 4: What are the perceptions of stakeholders on the extent of sustainable tourism in the Thompson Okanagan Region, with a focus on their familiarity and implementation of sustainable practices in the use of natural resources?
 - Research Question 5: What are the tourism business stakeholders' attitudes towards providing information that allows GIS to monitor sustainability in the Thompson Okanagan Region?

Thesis overview

This thesis is organized into five chapters. Following the present introductory chapter, which outlines the background, problem statement, research questions, and objectives, the remainder of the thesis presents the theoretical foundation, methodology, results, and final reflections of the study.

Chapter Two provides a comprehensive review of the relevant literature. It begins by exploring key frameworks and debates around the measurement of sustainable development, particularly in the tourism sector. The chapter then examines the role of Geographic Information Systems (GIS) in tourism planning and analysis, highlighting their growing importance in sustainability assessment. Finally, it discusses the integration of Multi-Criteria Assessment (MCA) with GIS tools and the increasing recognition of the need to incorporate stakeholder perceptions into sustainability evaluations.

Chapter Three presents the methodological framework and research design. It begins with the identification and selection of sustainability indicators, guided by the UNWTO Statistical Framework for Measuring the Sustainability of Tourism. The chapter then describes the top-down GIS-based approach used to analyze these indicators spatially across the

Thompson-Okanagan Region. This is followed by a description of the bottom-up approach, which consists of a stakeholder survey designed to capture local perspectives and practices related to sustainability in tourism, as well as their attitudes about using geographic tools in this effort. The final section details the integration of both approaches through a multi-Criteria Assessment, which combines spatial data and stakeholder input to evaluate overall sustainability at the Dissemination Area (DA) level.

Chapter Four presents the study's results, structured in parallel with the methodological components described in Chapter Three. The first section outlines the findings of the top-down GIS analysis, showing spatial patterns of sustainability based on the selected indicators. The second section presents insights from the stakeholder survey, highlighting perceptions of sustainability and the degree to which tourism businesses implement sustainable practices. The third section reports on the outcomes of the MCA, including the effects of stakeholder-derived weighting. The chapter concludes with a description of a GIS-based web application developed to disseminate the results and support decision-making in the region.

Chapter Five provides a discussion of the results in relation to the research questions and the wider academic and policy context. It reflects on the strengths and limitations of the methodological approach, particularly in terms of integrating spatial data with stakeholder perspectives. The chapter also considers the implications of the findings for tourism sustainability planning in the Thompson-Okanagan Region. The thesis concludes by identifying directions for future research, highlighting the gaps identified during data collection, and emphasizing the potential for more participatory, data-driven approaches to monitoring and managing sustainable tourism.

Chapter 2 - Literature Review

Academic interest in sustainability within the tourism industry has grown significantly since the 1990s, reflecting both the expanding global relevance of tourism and its complex socio-environmental impacts. This surge in research has highlighted not only the economic value of tourism but also its consequences for ecosystems and local communities. Simultaneously, it has contributed to the emergence of global discussions and policy shifts aimed at promoting a more sustainable tourism industry (Bramwell et al., 2017; Mauleon Mendez et al., 2018; Merigó et al., 2019).

Over the past three decades, the volume of tourism and sustainability-related publications has increased steadily. For example, the number of articles in the *Journal of Sustainable Tourism* increased from 13 in 1993 to 96 in 2017 (Mauleon Mendez et al., 2018), while *Tourism Geographies* saw a rise from 40 to 80 publications annually between 1999 and 2018 (Merigó et al., 2019). This academic growth has paralleled efforts by international organizations, particularly the United Nations and the UNWTO, to establish high-level frameworks and recommendations for sustainable tourism (UNEP & UNWTO, 2005; UNWTO, 2019, 2024b).

While institutional documents often focus on global strategies and policy guidelines, academic literature has explored diverse conceptual and methodological approaches to sustainability in tourism. These include theoretical analyses, destination-level assessments, and the application of emerging technologies such as GIS and big data (Bramwell et al., 2017; Fan & Cheng, 2023; Kirilenko et al., 2021; Li et al., 2023; Liu et al., 2022; Pan et al., 2018; Peeters et al., 2024).

Several recurring themes emerge from this body of research. Studies emphasize the global nature of sustainable tourism, the centrality of higher education institutions in advancing the field, and the prominent roles of researchers from countries such as the United States, the United Kingdom, Australia, and Spain (Mauleon Mendez et al., 2018; Merigó et al., 2019). Key topics include sustainability planning, poverty reduction, destination development, and governance, alongside critical perspectives on the impacts of tourism and visitor behaviour

(Bramwell et al., 2017; Mauleon Mendez et al., 2018). Climate change, while increasingly recognized as a significant challenge, is often viewed as a contested and technically complex issue that requires specialized expertise (Bramwell et al., 2017; Peeters et al., 2024).

2.1 The Paradigm of Sustainability in the Tourism Industry

The concept of sustainable development, along with its continuous monitoring, has become a major global concern. As defined in the Brundtland Report, sustainability refers to “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (UN, 1987, p. 37). This foundational definition underpins the theoretical framework of sustainable development, which aims to strike a balance between economic growth, the responsible use of natural resources within ecological limits, and the preservation of local communities' socio-cultural identity (Shi et al., 2019).

In the context of tourism, the United Nations defines Sustainable Tourism as “tourism that takes full account of its current and future economic, social and environmental impacts whilst addressing the needs of visitors, the industry, the environment and host communities” (UNWTO, 2024b). This definition, articulated by the United Nations World Tourism Organization (UNWTO), reflects the multidimensional nature of sustainability and aligns with the Brundtland Report’s emphasis on the interdependence of the environmental, socio-cultural, and economic pillars of development.

Despite its widespread adoption, the concept of sustainability has been subject to critical debate. Several researchers argue that the term suffers from a lack of conceptual clarity and consensus, leading to its inconsistent application and, at times, misuse (Boluk et al., 2019; Bramwell et al., 2017; Butler, 1999). This ambiguity has contributed to vague communication about what sustainable practices entail, particularly within the business sector, where issues such as greenwashing and green hushing are increasingly prevalent. These researchers further argue that the failure to implement sustainability principles effectively is rooted in dominant neoliberal economic ideologies, which often prioritize growth over environmental and social responsibility. They highlight the shortcomings in achieving the Millennium Development Goals (MDGs) as an important lesson, suggesting that similar limitations may jeopardize the

current Sustainable Development Goals (SDGs) unless these systemic issues are addressed (Boluk et al., 2019; Butler, 1999; Font et al., 2017; McCloskey, 2015; Sharpley, 2000).

Nevertheless, there is broad consensus on the urgency of improving how sustainability is conceptualized, measured, and implemented. Among the key challenges identified is the need for more effective tools to monitor sustainable practices (Boluk et al., 2019; Butler, 1999). Within the field of tourism, a critical debate has emerged regarding the distinction between sustainable tourism and tourism developed in accordance with sustainable development principles. Butler (1999) emphasized this distinction, arguing that the two concepts should not be conflated. Similarly, Sharpley (2000) identified substantial differences between the theoretical underpinnings of sustainable tourism and broader frameworks of sustainable development. More recently, Mauleon Mendez et al. (2018, p. 2) reaffirmed that the concept of sustainability in tourism remains a subject of debate and requires more critical and comprehensive analysis.

Despite these conceptual complexities, the operational definition of Sustainable Tourism continues to rely on the UNWTO's formulation. This definition emphasizes a holistic approach to sustainability, rooted in the three pillars outlined in the Brundtland Report. Specifically, it includes:

“(i) making optimal use of environmental resources helping to conserve natural resources and biodiversity; (ii) respecting of socio-cultural authenticity of host communities; and (iii) ensuring viable, long-term economic operations that provide socio-economic benefits to all stakeholders that are fairly distributed” (UNWTO, 2024b, p. 14)

In line with this understanding, Butler (1999, p. 9) calls for the development of practical tools and metrics to help “operationalize the concept and evaluate it in operation.” Responding to this need, various researchers have proposed methodological innovations to support the monitoring and assessment of sustainable tourism. These include the use of field experiments, big data analytics, and resource monitoring tools (Bramwell et al., 2017), as well as interdisciplinary approaches to policy evaluation and investment analysis (Pan et al., 2018). In particular, the integration of emerging technologies, such as Geographic Information Systems

(GIS), Big Data, Virtual Reality, and Artificial Intelligence, has been recognized as essential for advancing research in this field. Among these, GIS stands out as a tool that is attracting growing scientific interest for its ability to spatially integrate, analyze, and visualize diverse sustainability indicators (El Archi et al., 2023; Oliveira et al., 2022).

The UNWTO Statistical Framework for Measuring the Sustainability of Tourism (SF-MST)

The growing consensus about the need to measure and monitor sustainability has been institutionalized through the adoption of the Sustainable Development Goals (SDGs), which form the core of the 2030 Agenda for Sustainable Development. The agenda comprises 17 goals and 169 targets, alongside ongoing discussions on how to effectively measure progress (UN, 2015). Within the tourism sector, the most recent and comprehensive global initiative to address these challenges is the development of the Statistical Framework for Measuring the Sustainability of Tourism (SF-MST) by the UNWTO (2024b). This framework provides a conceptual foundation for the systematic collection, organization, and dissemination of data to assess the sustainability of tourism.

The global efforts have sparked extensive discussion on how best to identify, prioritize, and integrate the most relevant aspects of sustainability from among the vast array of available indicators (Butler, 1999; Pan et al., 2018). The challenge lies not only in indicator selection but also in accounting for spatial scale, stakeholder involvement, and the degree to which those involved understand how their actions contribute to sustainability (UNWTO, 2024b). These factors underscore the importance of equipping tourism stakeholders, local decision-makers, and communities with appropriate tools to assess the long-term consequences of their choices and move toward a more balanced and sustainable tourism model (Costanza et al., 2014; UNWTO, 2024b).

The SF-MST proposes a system of more than 105 indicators, organized around the three key dimensions of sustainability: economic, environmental, and social. It offers guidelines on measurement, data disaggregation, and recommended sources of information. While the framework is primarily designed for implementation at the national level, it also offers guidance for sub-national application, allowing for local adaptations. Importantly, the

framework does not prescribe specific thresholds for indicators. As noted by the UNWTO (2024b, p. 24), “thresholds and preferences are not an appropriate statistical task.” Instead, it recommends that “decision-makers and other stakeholders at different locations and with different scales can make their own assessments of the sustainability of tourism,” depending on local priorities and conditions.

The SF-MST outlines several characteristics of indicators under each sustainability dimension (UNWTO, 2024b):

In the environmental dimension, indicators should reflect both the natural assets that support tourism and the environmental pressures that tourism activities may generate. Additionally, the framework recommends capturing sustainability practices adopted by visitors and tourism establishments aimed at mitigating environmental impacts.

Regarding the socio-cultural dimension, the framework emphasizes the importance of understanding the social dynamics influenced by tourism. The SF-MST suggests structuring this dimension around four perspectives: those of visitors, host communities, tourism suppliers, and governance institutions. Each perspective contributes unique insights into how tourism affects cultural integrity, heritage, quality of life, and social cohesion.

For the economic dimension, the framework focuses on the benefits tourism brings to local communities. It recommends measuring variables such as income generated by tourism establishments, wages and salaries paid to tourism sector employees, and indirect benefits accruing to businesses that supply tourism-related goods and services. These indicators should not be analyzed in isolation, but rather in relation to social and environmental trends, recognizing the systemic interconnections that influence and are influenced by tourism.

Achieving sustainable tourism at any geographic scale, therefore, requires decision-making tools that enable assessments to be carried out in an integrated and evidence-based manner. As the UNWTO (2024b, p. 16) states, sustainability assessments depend on “thresholds and preferences that decision-makers and stakeholders establish about the balance between sustainability components.” In this context, the role of new technologies becomes increasingly important. Tools such as GIS, big data analytics, and integrated monitoring

platforms are crucial for supporting sustainability assessments and decision-making processes in complex and dynamic tourism systems (Boluk et al., 2019; Butler, 1999; Pan et al., 2018).

2.2 Geographic Information Systems (GIS), a particular Information and Communication Technologies (ICTs) in support of sustainable tourism

Information and Communication Technologies (ICTs) and their role in the sustainability of the tourism industry

ICTs are defined by the Organization for Economic Cooperation and Development (OECD) as “a combination of manufacturing and service industries that capture, transmit, and display data and information electronically” (OECD, 2002, p. 78), which has grown considerably and contributed exponentially to the economies of the countries since the 1990s.

The broad discourse on ICTs in the tourism industry and different stages of implementation has been studied according to the specific technologies implemented (Buhalis, 2019; Buhalis et al., 2019; Buhalis & Sinarta, 2019), the general impact of the technology on sustainability (Fennell, 2021; Miltchev & Neykova, 2015) and the tourism business, and its implementation and effects in different places around the world (Gosjen et al., 2022; Smerecnik & Andersen, 2011; Um & Chung, 2021).

El Archi et al. (2023, p. 6) identify three main stages in the research about digital technology adoption in tourism:

1st: Early Stage (2003-2012): The most popular technologies used in tourism destinations included online travel agencies (OTAs), destination websites, search engines, email marketing, online booking systems, and virtual tours.

2nd: Growth Stage (2013-2018): where mobile apps, social media platforms, online review sites, location-based services, big data analytics, and cloud computing are the predominant technologies in the literature.

3rd: Hype Stage (2019-2022): focused on Artificial intelligence (AI), augmented reality (AR), virtual reality (VR), internet of things (IoTs), blockchain technology, chatbots, and virtual assistants.

The authors highlighted GIS, Big Data, VR, and AI as emerging topics that warrant attention and further investigation.

The adoption of digital technologies supports sustainability by improving operational efficiency, reducing waste and emissions, enhancing destination marketing, and promoting a circular economy (El Archi et al., 2023; Pan et al., 2018; Pencarelli, 2020). In addition, the adoption of digital technologies has been demonstrated to impact tourist behaviour. This is generally a positive effect on smart tourism satisfaction, with a worldwide emergence of digital tourists inspired by the principle of sustainability (Pan et al., 2018; Pencarelli, 2020).

Another important role of ICTs in the tourism industry is the education that they offer to their stakeholders. However, McCloskey (2015) warns of the need for critical analysis and action to achieve the SDGs, and also suggests that education is the means to provide the critical awareness necessary for their implementation. Gössling (2020) highlights the importance of ICTs in supporting learning, and this topic warrants further critical exploration and detailed examination.

Therefore, critical thinking is essential for utilizing ICTs as tools to achieve sustainability, not only as a means to optimize and educate visitors, but also in all the roles that ICTs can play in contributing to sustainability. As several authors warn, using the Jevons paradox, technological efficiency alone will not produce sustainability (Alcott, 2005). Nonetheless, among the many benefits that the tourism industry can derive from the use of innovation and technology, one of the particular interests of this study is the role that ICTs can play to measure and assess sustainability and the exploration of Geographic Information Systems as a particular ICT that can make a wide contribution to this purpose.

The Geographic Information Systems on sustainability monitoring implementation

Geographic Information Systems (GIS) are a class of ICT that “analyze and display geographically referenced information. They use data attached to a unique location” (USGS, 2023, p. 1). GIS handle both attribute and spatial data, enabling the combination, analysis, and visualization of multiple layers of geographically situated information. Beyond their technological capacity, GIS are also recognized as a scientific discipline with its own set of research questions (Goodchild, 1992).

In recent years, Geographic Information Systems (GIS) have gained increasing recognition within academic and policy circles for their capacity to support sustainable development initiatives (Oliveira et al., 2022). Given that sustainability is an ongoing and dynamic process (UNWTO, 2024b), GIS provides essential capabilities for continuous monitoring and adaptive management, particularly within the domains of tourism and land use. At the destination level, GIS has been extensively applied to assess tourism carrying capacity, map tourism-related impacts and infrastructure, support planning processes and resource inventories, and facilitate informed decision-making within sustainability governance frameworks.

Key studies have applied GIS to support tourism industry management (Bahaire & Elliott-White, 1999; Boers & Cottrell, 2007; Du et al., 2023; Hasse & Milne, 2005; Ma et al., 2022; van der Knaap, 1999), resource identification (Chhetri & Arrowsmith, 2008; Kaptan Ayhan et al., 2020; Li, 2023; Minasi et al., 2020), and impact evaluation (Costanza et al., 2017; Fan & Cheng, 2023; Kirilenko et al., 2021; Liu et al., 2022). GIS-based tools have also been explored in the hotel sector (Brown & Weber, 2013; Fudo et al., 2014; McKercher et al., 2012).

While GIS has been extensively applied in fields like agriculture, environmental planning, and public health, its use in tourism sustainability assessment remains relatively underexplored, particularly in Canada. Promising examples include recent studies that used GIS to create integrated sustainability indices (Haloui et al., 2024) or to assess ecotourism development in Iraq (Mohammed et al., 2023) and India (Chandel & Kanga, 2021).

On the other hand, GIS is also emerging as a tool for integrating stakeholder perceptions into spatial planning. Research has shown that subjective perceptions influence

behaviour, highlighting the need for participatory tools in sustainability assessment actions (UNWTO, 2024b). For example, Kirilenko et al. (2021) utilized GIS to integrate census and industry data with resident perceptions, detecting early signs of over-tourism. Hasse and Milne (2005) emphasized the use of participatory GIS for involving stakeholders in tourism planning, while Baloch et al. (2023) and McKercher et al. (2012) explored participatory and GPS-based mapping of visitor patterns.

Beyond mapping functions, Geographic Information Systems (GIS) offer a range of advanced analytical tools, including spatial regression, spatial analysis, and multi-criteria decision support systems, that are highly relevant for evaluating sustainability within the tourism sector (Alshuwaikhat et al., 2017; Graymore et al., 2009; Li et al., 2023; Liu et al., 2022; Minasi et al., 2020).

Consequently, there is a growing need to examine how GIS can enhance sustainability assessment and monitoring by identifying geographic areas requiring targeted intervention, analyzing the complex interactions among social, environmental, and economic factors, and providing detailed insights at fine spatial scales through the use of disaggregated data. Achieving these objectives involves several critical tasks, including the selection and integration of indicators derived from openly accessible geographic and statistical datasets, the mapping of stakeholder perceptions related to sustainability, and the application of spatial multi-criteria analysis to combine both technical and participatory sources of information.

2.3 Multi-Criteria Assessment (MCA) and Its Integration with GIS in Sustainability Analysis

Multi-Criteria Assessment (MCA), also known as Multi-Criteria Decision Making (MCDM) or Multi-Criteria Decision Analysis (MCDA), is a methodological framework that supports decision-making in contexts where multiple, and often conflicting, criteria must be considered simultaneously. As Zionts (1979, p. 94) noted, MCA enables “problem-solving with multiple conflicting objectives,” making it particularly relevant for sustainability assessments where trade-offs between environmental, economic, and socio-cultural goals are common.

One of the key strengths of MCA lies in its flexibility to incorporate both qualitative and quantitative data. According to Graymore et al. (2009, p. 455), MCA has “the ability to consider many criteria at once, even a mixture of qualitative and quantitative criteria”. This feature makes it especially suitable for sustainability planning, natural resource management, and integrated land-use decision-making. It allows practitioners to structure complex decision problems, assign weights to indicators based on expert judgment or stakeholder input, and generate rankings or classifications that support transparent and defensible outcomes (Graymore et al., 2009; Richards et al., 2007).

The integration of MCA with Geographic Information Systems (GIS) further enhances its potential through what is often referred to as Spatial Multi-Criteria Decision Analysis (SMCDA) (Malczewski, 2006). This hybrid approach enables the spatial representation of sustainability indicators, supporting location-based decision-making. The combination of GIS and MCA allows analysts to visualize spatial variations in sustainability performance, identify priority areas for intervention, and map trade-offs between competing objectives (Graymore et al., 2009; Malczewski, 2006). By producing decision maps that highlight areas of concern or opportunity, SMCDA not only improves analytical rigour but also enhances the communicative value of results for stakeholders and policy-makers.

A critical dimension of effective MCA lies in the incorporation of stakeholder perspectives. Stakeholder-informed weighting of criteria is widely recommended in sustainability planning, as it increases the legitimacy and relevance of the assessment (Richards et al., 2007). Engaging stakeholders in defining priorities and assigning weights ensures that the evaluation reflects real-world values and local context. It also enables comparisons between stakeholder groups and facilitates an understanding of how perceptions align with or diverge from quantitative indicators. Moreover, it supports the analysis of perceptual gaps, highlighting where stakeholders may overestimate or underestimate specific sustainability dimensions compared to data-driven assessments.

Some studies have demonstrated the effectiveness of combining MCA with GIS for tourism planning and sustainability assessments. For instance, Mendoza and Martins (2006) applied an MCA-GIS approach to define ecotourism development zones in the Philippines, integrating both environmental and community-based criteria. Similarly, Haloui et al. (2024)

developed a spatial model for assessing ecotourism suitability in Medina of Tangier-India, which combines economic, environmental, and social indicators. In Australia, the Index of Regional Sustainability (Graymore et al., 2009; Richards et al., 2007) used a GIS-based MCA to support regional planning by integrating land use, biodiversity, and socio-economic indicators. These examples demonstrate how SMCDA can help policymakers and stakeholders visualize sustainability trade-offs and establish spatial priorities based on diverse criteria. This approach remains relatively unexplored in the Canadian tourism context.

While Canada has seen a variety of applications of Multi-Criteria Assessment in environmental management, land-use planning, and urban sustainability, its use specifically within the tourism sector remains limited. Notable examples include GIS-based MCA approaches in land use suitability assessment (Chen, 2014), land-use planning in British Columbia (Dale et al., 2008), and urban sustainability frameworks in Canadian cities (Rauf et al., 2023). However, few studies have applied MCA in combination with GIS to directly assess tourism sustainability at the regional or local level, particularly in contexts that integrate both quantitative indicators and stakeholder perspectives.

This gap underscores the significance of the present research, which employs a spatially explicit MCA approach to assess the sustainability of tourism across the Thompson-Okanagan Region. By combining geospatial analysis with community-informed weighting and perception data, this study contributes to filling a methodological and practical void in the Canadian tourism and sustainability literature.

Chapter 3 Methodology and Methods

3.1 Research Philosophy

The development of this research project, including the methodological approaches adopted and the methods applied, is grounded in a combination of philosophical assumptions and personal and professional experience. These foundations collectively inform the way knowledge is constructed and how solutions to the stated problems are proposed.

I was born and raised in Quito, Ecuador, in a middle-class mestiza family. Now in my forties, I am a proud wife and mother of two children. My academic background includes a Bachelor of Science degree in Geography and Environmental Studies and a Master's Degree in Geographic Information Systems. These studies enabled me to participate in a wide range of projects early in my career, from producing tourism maps to leading land cadastre and urban planning initiatives. Later, I served for over a decade as a public servant at Ecuador's National Statistics Office, contributing to the development of geographic frameworks and geospatial tools for national censuses and household surveys.

In the most recent stage of my professional journey, I have worked as an international consultant with the United Nations Population Fund (UNFPA), specializing in census cartography and geographic infrastructure for national statistical systems. This work involved providing technical assistance to statistical offices around the Latin American Region, particularly at the early stages of census planning. Throughout this process, I began to question how geographic information could be used beyond logistical and operational planning. I recognized a significant gap in the analytical use of spatial and statistical data, a gap that, if bridged, could generate powerful insights and practical solutions for complex challenges, including those related to sustainability.

This growing awareness motivated me to return to academic studies. I pursued academic research to refresh my knowledge and reframe the environmental questions that had shaped my thinking, with the aim of contributing more effectively to sustainable development challenges. In this context, I began exploring how my expertise in human geography and my

professional experience could be applied to the tourism sector: an area where environmental, economic, and socio-cultural dynamics intersect.

Human geography, as an interdisciplinary field that bridges natural and social sciences, provides a valuable lens for studying the interactions between people, places, and environments. Its strength lies in its ability to connect ecological processes with social and cultural dimensions, making it well-suited to examine sustainability in tourism (Paul & Jha, 2021). Consequently, the present research adopts both geographic and social science perspectives to assess sustainability at a local level, drawing on methods that integrate quantitative indicators with qualitative insights.

From a philosophical perspective, this study is grounded in pragmatism, a research paradigm that recognizes the coexistence of objectivist and subjectivist epistemologies. In human geography, research is often shaped by multiple epistemological positions, and pragmatism offers a suitable framework for addressing complex and dynamic phenomena (Wood & Smith, 2008). From one perspective, a positivist orientation is reflected in the quantitative component of the study, which involves spatial and statistical analysis of measurable sustainability indicators. From other perspective, the study also embraces constructivist elements, as it incorporates stakeholders' subjective perceptions and values. As the United Nations World Tourism Organization (UNWTO) notes, "people tend to act on perceptions, even when they do not correspond to reality" (UNWTO, 2024b, p. 112).

Pragmatism allows these perspectives to coexist by focusing on the practical application of knowledge and the consequences of research in real-world contexts (Moon & Blackman, 2014). It values both empirical observation and deductive reasoning and emphasizes the role of research in addressing tangible problems. In human geography, pragmatism has encouraged a shift toward problem-solving, community engagement, and participatory inquiry (Wood & Smith, 2008). In this research, a pragmatic lens has informed the selection of theories, such as the sustainable development paradigm, spatial analysis theory, and the diffusion of innovations, as well as the design of methods and tools to support decision-making in tourism planning.

Finally, my personal and professional background has informed the interpretation of results, particularly in recognizing the interdependence between people and their environments. This approach aligns with current movements in human geography that advocate for research that is action-oriented, inclusive, and responsive to local realities. By integrating measurable indicators with stakeholder perceptions and ensuring that findings are accessible to decision-makers and communities, this research seeks to make a meaningful contribution to sustainable tourism planning.

This philosophy is applied to the mixed-methods design that integrates spatial analysis, official statistics, and stakeholder survey data to assess sustainable tourism at a fine geographic scale. The methodology combined top-down and bottom-up approaches to capture both quantitative indicators and qualitative perceptions. The following sections detail the design, data sources, and analytical procedures used throughout the research.

3.1 Conceptual Model

The conceptual model guiding this research builds on the need to adapt the global UNWTO framework for sustainable tourism to a regional context. It emphasizes the selection of relevant, accessible, and spatially disaggregated indicators that reflect the realities of the Thompson-Okanagan Region. In this context, GIS plays a central role by enabling the spatial analysis of sustainability indicators, revealing geographic patterns and interactions between environmental, socio-cultural, and economic dimensions (Alshuwaikhat et al., 2017; Graymore et al., 2009; Muhsin et al., 2022).

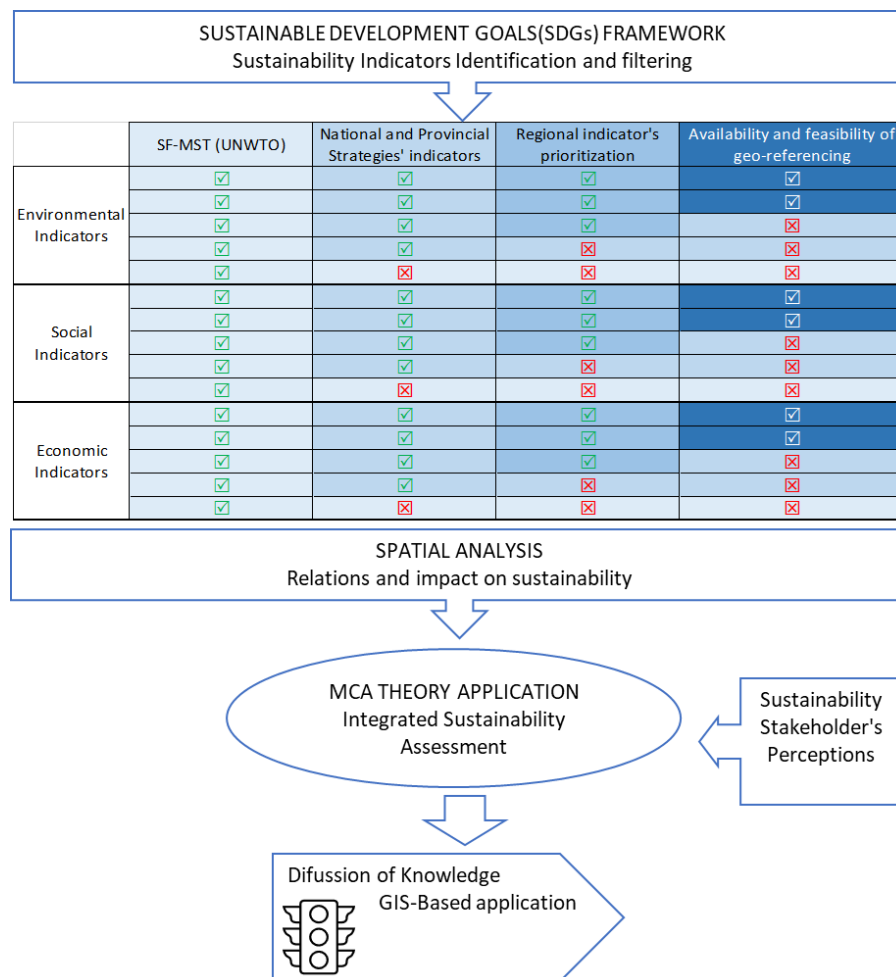


Figure 3.1: Conceptual model for the assessment and monitoring of the sustainable tourism industry

The model also integrates stakeholder perspectives to complement quantitative analysis with qualitative insights. This enables comparisons between measured conditions and community perceptions, promoting more inclusive and locally grounded sustainability assessments (UNWTO, 2024b). Multi-Criteria Assessment (MCA) is used to combine diverse indicators and stakeholder weights, supporting the identification of spatial trade-offs and priority areas (Graymore et al., 2009; Zionts, 1979).

Finally, the model acknowledges the importance of communicating results in a clear and accessible manner. By proposing the development of a GIS-based tool, the model supports

the dissemination of findings to local stakeholders and decision-makers, promoting engagement, transparency, and more informed planning (Smerecnik & Andersen, 2011).

3.1 Study design

To operationalize and validate the conceptual model, the research adopted a mixed-methods design, combining quantitative and qualitative techniques to evaluate the sustainability of tourism in the Thompson-Okanagan Region. This design draws on the methodological frameworks proposed by Boers and Cottrell (2007), Brown and Weber (2013), Kirilenko et al. (2021), and Graymore et al. (2009), who emphasize the value of integrating spatial data with stakeholder input to capture the multidimensional nature of tourism sustainability.

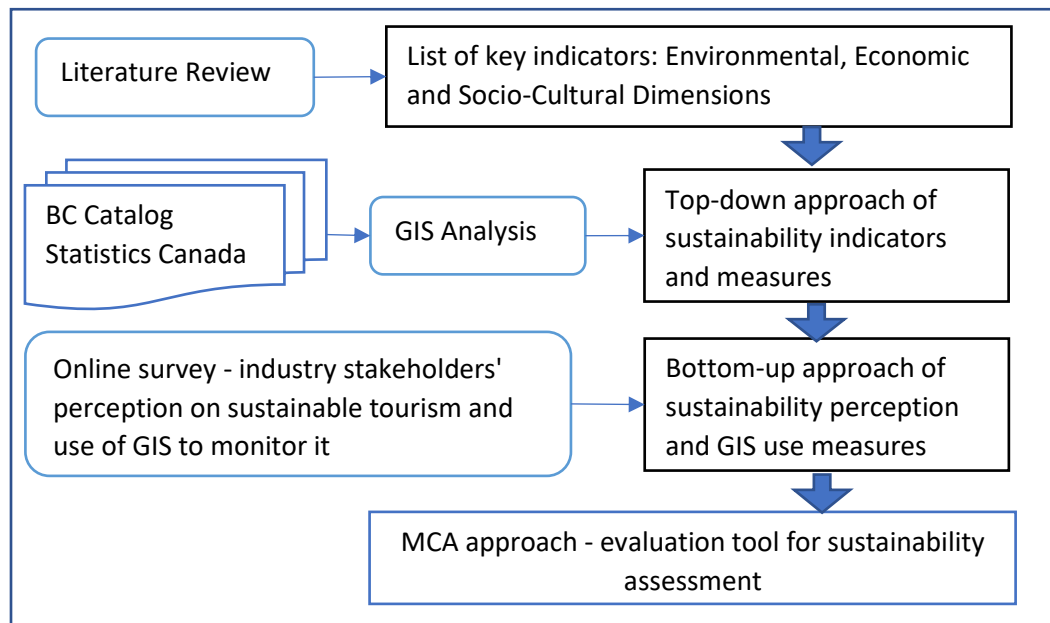


Figure 3.2: Study design

The study was conducted in three stages. The first stage consisted of an extensive review of the literature and an inventory of available data sources. This preparatory phase supported the selection of indicators and helped identify key information gaps that informed the design of the stakeholder survey.

The second stage, employing a top-down approach, involved identifying and analyzing sustainability indicators using spatial data from secondary sources. These indicators were processed using GIS to assess the environmental, socio-cultural, and economic dimensions of tourism sustainability at the Dissemination Area (DA) level.

The third stage, employing a bottom-up approach, involved administering an online survey to tourism business stakeholders across the region. The survey was designed to collect perceptions regarding the extent and implementation of sustainable practices, as well as views on the importance of sustainability dimensions. Stakeholder input was subsequently used to assign weights to MCA components and to explore alignment (or divergence) between perceived and measured sustainability.

During the development of this study, close collaboration was established with the Thompson Okanagan Tourism Association (TOTA), the regional Destination Management Organization. TOTA's participation was instrumental in multiple stages of the research process. In particular, previously conducted sustainability planning exercises and indicator frameworks developed by the organization were reviewed and considered in the selection and contextualization of indicators. These local insights helped ensure that the chosen variables were not only aligned with international frameworks but also relevant to the regional tourism context. In addition, TOTA provided valuable support during the design and distribution of the stakeholder survey, helping to ensure the participation of tourism-related businesses across the study area.

The following sections provide a detailed description of the methods applied at each stage of the study.

3.1 Methodological Approach for the Identification and Selection of Sustainability Indicators

The selection of indicators for this research was guided by the UNWTO's Statistical Framework for Measuring the Sustainability of Tourism (SF-MST), which proposes over 105

measurement points across the economic, environmental, and socio-cultural dimensions of tourism. Many of these indicators include multiple levels of disaggregation, such as by sex, age, income, or mode of transportation. While this increases the number of available data points, the underlying number of core indicators is more limited.

To operationalize this framework, a comprehensive inventory of potential indicators and their disaggregated forms was compiled. Each indicator was assessed using a structured matrix that included the following criteria: sustainability dimension, data source, georeferencing availability (yes/no), level of disaggregation (e.g., national, regional, provincial, municipal, Census Subdivision, Census Dissemination Area), last year available, update frequency, and additional notes. A final column was used to flag selected indicators. This process resulted in the selection of 20 indicators judged to be both methodologically sound and practically applicable to the Thompson-Okanagan Region. The selected indicators can be observed in Table 3.1: Identification and selection of indicators:

Table 3.1: Identification and selection of indicators: Guided by the Framework for Measuring the Sustainability of Tourism (SF-MST)

Sust. Dimension	Measurement Theme	Indicator	Disaggregation	Core	Diss.	Source of data	SEL
General Indicators	Tourism concentration	Number of visitors	Inbound	x		International Travel Survey Visitor Travel Survey Microdata File	x
Economic	Visitor expenditure	Average internal tourism expenditure per visitor	Inbound	x		International Travel Survey Visitor Travel Survey Microdata File	x
	Tourism economic structure	Number of establishments	Other consumption products	x		Open Database of Business	x
	Employment in tourism	Total employment in tourism industries	Number of employed persons	x		Census of population	x
	Employment in tourism	Total employment in tourism industries	Sex		x	Census of population	x
	Employment in tourism	Total employment in tourism industries	Age		x	Census of population	x
	Tourism investment - Produced assets - Tourism-specific fixed assets	Accommodation		x		HelloBC Official Lists	x
Environmental	GHG emissions	GHG emissions: Tourism GHG emissions account ('000 tonnes)	Total	x		Consolidated Community Energy and Emissions Inventory Reports	x
	Solid waste flows	Solid waste: Tourism solid waste account (tonnes)	(emissions-related)	x		Consolidated Community Energy and Emissions Inventory Reports	x
	Energy flows	Energy: Tourism energy flow account (joules)	(emissions-related)	x		Consolidated Community Energy and Emissions Inventory Reports	x

Sust. Dimension	Measurement Theme	Indicator	Disaggregation	Core	Diss.	Source of data	SEL
Environmental	Ecosystem extent (for tourism areas)	Changes in ecosystems due to tourism activity result in a loss of natural ecosystems		x		Land Use time Series	x
	Ecosystem extent (for tourism areas)	Regional ecosystem extent account ('000 hectares) - using the national ecosystem classifications		x		Biogeoclimatic Ecosystem Classification (BEC)	x
	Ecosystem extent (for tourism areas)	Percentage of protected areas (marine and terrestrial) to total tourism area		x		BC Parks, Ecological Reserves, and Protected Areas	x
	Ecosystem services flows for tourism areas	Total recreation-related services in a tourism area		x		Landscape Units of British Columbia - Current	x
Social	Visitor satisfaction	Visitor flow and engagement by local tourism destination (total visitors)	Inbound	x	x		x
	Host community perception	Overall perception of host communities of visitors		x			x
	Host community perception	Need to safeguard communities' cultural heritage		x		First Nation Community Locations	x
	Host community perception					Important Fossil Areas	x

Sust. Dimension	Measurement Theme	Indicator	Disaggregation	Core	Diss.	Source of data	SEL
Social	Host community perception					Historic Places Spatial Layer (Public View)	x
	Host community perception					Historic Trails of British Columbia	x
	Host community perception					Recreational Features Inventory - Polygons	x
	Host community perception					Recreation Lines	x
	Host community perception					Visual Landscape Inventory - Viewing Points	x
	Decent work	Employed persons in tourism industries by key characteristics for the social dimension	Total	x		Census of population	x
	Decent work		Sex		x	Census of population	x
	Decent work		Age		x	Census of population	x

In parallel, the selected indicators were compared against those used in national and regional sustainable tourism strategies, including indicator sets developed by federal agencies, provincial programs, and the Thompson Okanagan Tourism Association (TOTA). This comparison served two purposes: first, to validate the alignment of the selected indicators with existing policy frameworks, and second, to facilitate the future integration of results into ongoing strategy development and evaluation processes.

The complete matrix of indicators is presented in **Appendix 1 – Matrix of Sustainability Indicators**. A digital version of the matrix is available, including details on the selection of indicators and comparisons with national and regional strategies.

3.2 Methodological Approach for the Top-Down approach: use of Geographic Information Analysis

This section describes the geospatial analysis methods applied to evaluate sustainability in the tourism industry across the Thompson-Okanagan Region. The objective of this stage is to collect and analyze relevant sustainability indicators from a spatial perspective, mapping the distribution of environmental, socio-cultural, and economic dimensions at a consistent level of geographic disaggregation.

Building on the indicator selection process outlined in the previous section, this analysis draws exclusively on secondary data sources, including geographic and statistical datasets. These data were extracted for the study area and aggregated to a standard geographic unit (Census Dissemination Area – DA) to facilitate integration, comparison, and mapping across variables.

This part of the study addresses two of the central research questions: RQ1) What is the difference and geographic distribution in the status of sustainable tourism in rural communities versus small towns in the Thompson-Okanagan Region?, and RQ2) What value does GIS technology offer to potentially measure gaps in sustainable tourism components?

The methods described in the following subsections detail how geospatial processing techniques were employed to prepare, normalize, and integrate indicator data, enabling the

spatial representation of sustainability conditions and patterns across the region. The goal is for this information to be subsequently incorporated into a comprehensive assessment of sustainability indicators using the integration of MCA and GIS to identify interactions and patterns among various indicators used to evaluate the status of sustainable tourism.

The spatial analysis and data processing for this research were carried out using a combination of ArcGIS Pro (version 3.4) and the R programming language (version 4.3). R (supported by key packages including terra, sf, tidyverse, bcmaps, cancensus, among others) was used for statistical computation, raster analysis, and reproducible data workflows. In contrast, ArcGIS Pro was primarily used for data preparation and basic analysis tasks, such as clipping, intersection, verification of area calculation, and building a final geodatabase to be integrated into the final GIS-based web application. This dual-platform approach enabled both precision in geoprocessing and flexibility in modelling and data transformation, ensuring consistency and transparency across all analytical steps. The description of the R Scripts code is shown in **Appendix 2 – R Code Scripts Description**.

Data Sources for the Thompson Okanagan Region

Canada benefits from a robust ecosystem of public data platforms that facilitate access to free geographic and statistical information, enabling researchers and decision-makers to conduct evidence-based spatial analysis. Among these, the BC Data Catalogue and Statistics Canada stand out as key sources of information. The BC Data Catalogue offers open access to hundreds of geospatial datasets maintained by provincial ministries, including land-use inventories, environmental classifications, administrative boundaries, and tourism infrastructure layers (Government of British Columbia, 2025a). Statistics Canada, through its Census and Open Data portals, offers a comprehensive array of socio-economic and demographic data at multiple levels of geographic aggregation, from national to Dissemination Area (DA) levels, often accompanied by geospatial boundary files for integration into GIS platforms (Government of Canada, 2025).

Definition of the Geographic Aggregation Unit of Analysis

In this study, all spatial data were harmonized to a common geographic boundary using Dissemination Areas (DAs) as the unit of analysis. DAs are the smallest standard geographic unit for which Statistics Canada releases comprehensive census data, each typically containing between 400 and 700 residents (Statistics Canada, 2022). This level of spatial resolution is particularly suitable for detailed geographic analysis and was selected to enable fine-scale integration of socio-economic, environmental, and tourism-related datasets.

The use of geographically disaggregated data offers significant advantages for spatial analysis. Research has shown that finer geographic scales enhance the detection of local patterns and clusters that may be masked at higher levels of aggregation (Best et al., 2005; Choi & Lawson, 2018). They also reduce the impact of the Modifiable Areal Unit Problem (MAUP), where statistical outcomes can vary depending on the spatial units used for analysis (Jelinski & Wu, 1996). Studies in public health, environmental exposure, and urban planning have demonstrated that fine-scale units, such as DAs, enhance the accuracy and policy relevance of spatial analyses, particularly for identifying localized inequities and guiding targeted interventions (Parsons et al., 2024; Tomal, 2020).

In addition to their utility for analyzing demographic and socio-economic variables, Dissemination Areas (DAs) also serve as an effective spatial framework for aggregating diverse non-social datasets. In this research, DAs served as the standard framework for aligning census data, emissions inventories, land use change, intersections with protected areas, tourism offer and travel survey microdata, allowing for a more nuanced and spatially robust analysis. This enabled the integration of ecological variables with human-centred data at a consistent spatial resolution. Similarly, economic data such as the count and density of registered businesses, derived from business directories or geocoded administrative sources, were aggregated to the DA level to explore spatial patterns of economic development.

The use of DAs in this context facilitates comparability across datasets with different spatial origins and resolutions (e.g., raster-based land cover vs. vector-based administrative boundaries), allowing for multi-dimensional spatial analysis. By serving as a common

denominator across diverse data types, DAs enhance the coherence, precision, and policy relevance of spatial analysis in both urban and regional planning contexts.

Environmental indicators – data collection and harmonization of geographic Information

Based on the sources of secondary information and the **Appendix 1 – Matrix of Sustainability Indicators** with the list of selected indicators, the datasets observed in Table 3.2: GIS layers for sustainability assessment - Environmental Dimension, were obtained and analyzed:

Table 3.2: GIS layers for sustainability assessment - Environmental Dimension

Layer name / Dataframe name	Description	Last Year or period available	Period of update	Publisher	Web access
Land Use time Series	Semi-decadal land use	2000 - 2020	Semi-decadal	Agriculture and Agri-Food Canada (AAFC)	https://agriculture.canada.ca/atlas/apps/aef/main/index_en.html?AGRIAPP=21
BEC Map	Biogeoclimatic Ecosystem Classification (BEC) Zone/Subzone/Variant/Phase map	2021	Varies	Forest Analysis and Inventory Branch	https://catalogue.data.gov.bc.ca/dataset/bec-map
BEC Map - Historic Versions	Biogeoclimatic Ecosystem Classification (BEC) Zone/Subzone/Variant/Phase map - Historic Versions	1995 - 2018	Varies. Available versions: 1995, 2001, 2003, 2006, 2008, 2010, 2014, 2016, 2018	Forest Analysis and Inventory Branch	https://catalogue.data.gov.bc.ca/dataset/bec-map-historic-versions
BC Parks, Ecological Reserves, and Protected Areas	Parks and protected areas managed for important conservation values and are dedicated for preservation	2008-2025	Irregularly based on legislative changes. The last version is provided	BC Parks	https://catalogue.data.gov.bc.ca/dataset/7fcb21f7-e51c-4342-a5e1-445a6c42128e
Landscape Units of British Columbia - Current	Landscape Units are spatially identified areas of land and/or water used for long-term planning of resource management activities.	2008-2025	Irregularly - as needed. The last version is provided	Collaborative Stewardship and Cumulative Effects Management	https://catalogue.data.gov.bc.ca/dataset/11277e35-d8be-47e4-bb1f-c38e393179c6
Current Community Energy and Emissions Inventory data	Greenhouse gas emissions quantified according to the B.C. Best Practices Methodology.	2007-2022	Every two years. Data available by year.	Climate Partnerships and Engagement Branch	https://www2.gov.bc.ca/gov/content/environment/climate-change/data/ceei/current-data

A description on each dataset and the process to harmonize the information is shown below. All spatial layers were reprojected to the BC Albers projection (EPSG:3005) to have a common spatial reference for all the analysis:

Land Use Time Series – To detect change between 2000-2020

To assess land use transitions over time, two reference years were selected: 2000 and 2020, providing a 20-year window to evaluate spatial changes in land cover. The analysis focused specifically on natural-to-developed land transformations, a key indicator of environmental change related to tourism sustainability. Land cover classifications followed the IPCC land use categories, as defined by Agriculture and Agri-Food Canada, to ensure consistency with national climate and sustainability reporting frameworks. This classification divides land into six main categories: Forest Land, Cropland, Grassland, Wetlands, Settlements, and Other Land.

Spatial Clipping and Preparation in ArcGIS Pro

National raster datasets for the years 2000 and 2020 were first clipped using ArcGIS Pro v3.4 to restrict the analysis extent to the Thompson-Okanagan Region, as defined by a selected set of 2021 Census Dissemination Areas (DAs). This clipping step ensured both computational efficiency and geographic relevance. The output consisted of two clipped raster files: LU2000_clip.tif and LU2020_clip.tif, corresponding to the two time periods. These raster files were then prepared for further analysis in R.

Land Use Change Analysis in R

Using the terra, sf, and tidyverse packages in R, a reproducible workflow was developed to quantify and compare the proportion of land use types within each DA across the two reference years. The raster datasets were loaded and aligned with the spatial reference of the DA shapefile.

A custom function was implemented to: extract raster values within each DA polygon, count the frequency of each land use class (by pixel), then convert pixel counts to percentage cover values for each IPCC land use class per DA. This function was applied to both 2000 and 2020 data, resulting in a panel dataset of land cover percentages by class and year. These data were merged and reshaped to facilitate change detection. For each DA and land use class, the change in percent cover between 2000 and 2020 was calculated. Land use classes were then grouped into broader thematic categories to highlight meaningful transformations.

Key Transitions of Interest

Three specific land use transitions were analyzed: i) Forest to Settlement, ii) Forest to Cropland, and iii) Natural to Settlement. These were estimated by calculating the minimum overlap between forest loss and gain in settlement or cropland areas, assuming that new development or agriculture often replaces former forested land. For the third aggregated transition, Forest, Grassland, and Wetland classes were combined into a single "Natural" category. Total losses in natural land from 2000 to 2020 were compared to gains in settlement, producing an estimate of the natural-to-settlement transition, expressed in both percentage of DA area and hectares.

The resulting dataset provides a DA-level view of land use changes over two decades, with each DA characterized by the proportion of its area that underwent transition. These results were joined with the corresponding spatial geometries, enabling visualization and spatial analysis of land use transformation patterns across the Thompson-Okanagan Region.

Bio-geoclimatic Ecosystem Classification (BEC) Zones and Subzones

The Bio-geoclimatic Ecosystem Classification (BEC) system is a foundational ecological framework used in British Columbia for land management, environmental analysis, and resource planning. The BC Ministry of Forests developed the system and has been in use since the 1970s. It has several updates to reflect improved knowledge and mapping accuracy. The system organizes British Columbia's landscape into hierarchical ecological units based on

climatic, vegetation, and soil characteristics. At broad scales, it defines BEC Zones, which represent areas with relatively uniform macroclimate, and within each zone, more specific Subzones that reflect variation in moisture and temperature regimes (B.C. Ministry of Forests, 2021).

The zones and subzones are used extensively in conservation, forestry, and biodiversity studies. For this research, spatial layers representing the BEC Zones and Subzones were obtained from the BC Data Catalogue and BC Maps Online. Versions corresponding to 2016, 2018, and 2021 were used to facilitate a temporal comparison of changes or reclassifications that may impact ecological characterization over time.

To integrate the BEC system into a socio-ecological GIS framework, I intersected the BEC maps with 2021 Census Dissemination Areas (DAs) within the Thompson-Okanagan Region of British Columbia. Spatial geoprocessing was conducted using ArcGIS Pro 3.4. Each BEC map (2016, 2018, 2021) was overlaid with the DA boundaries. Using the “Intersect” geoprocessing tool, the area of each BEC Zone and Subzone within every DA polygon was calculated. This allowed for a consistent measurement of the ecological composition of each Dissemination Area. The results were three distinct datasets, each representing the BEC–DA spatial relationship for one of the three time points (2016, 2018, and 2021). The resulting attribute tables include DA identifiers, BEC zone and subzone labels, and the area of each intersection. These datasets form the foundation for subsequent comparison of ecological zones over time and their integration into socio-economic and environmental analysis at the DA level.

To identify changes in ecological classification over time, ArcGIS software was used to compare the spatial overlap of BEC subzones across three time points: 2016, 2018, and 2021. Using the 2021 dataset as a spatial template for comparison, spatial joins were used to attach the 2016 and 2018 subzone codes information based on spatial intersection. In this way, each polygon in the 2021 base layer contains the subzone codes from all three years.

Logical comparisons were used to create change indicators between 2016-2018 and 2018-2021, as well as to identify any changes that occurred between 2016 and 2021. These comparisons enabled the identification and mapping of areas where subzone classifications

changed over time, whether due to ecological shifts, land use transformations, or updates in BEC mapping methodology.

In the map below (Figure 3.3: BEC Classification comparison between 2018 and 2021 for a specific Dissemination Area), the map shows where changes occurred between the 2018 and 2021 classifications, and the example shows the change for a particular area, the classification for 2018 and for 2021.

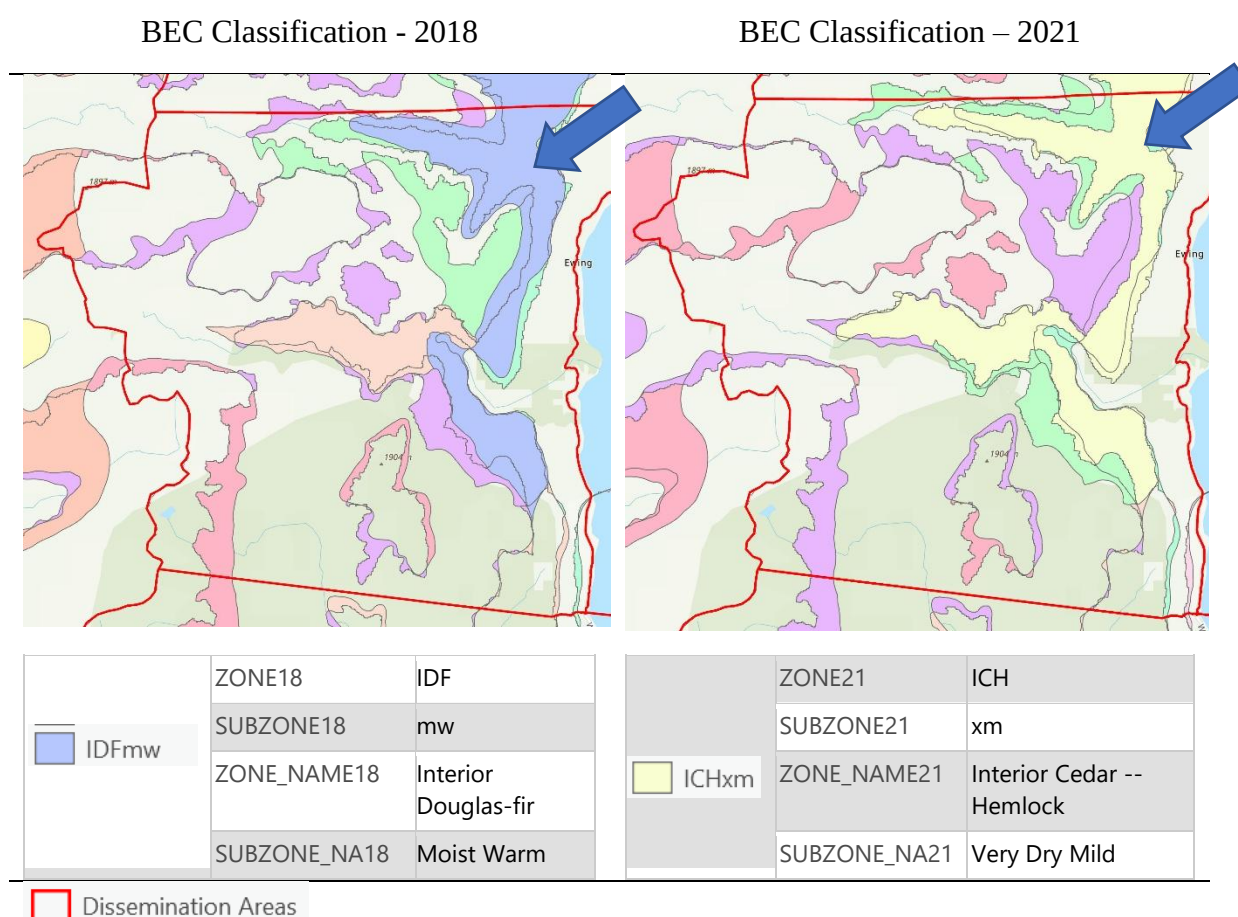
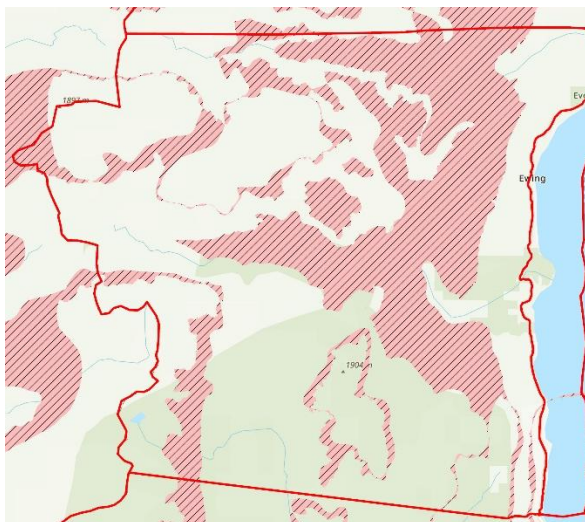


Figure 3.3: BEC Classification comparison between 2018 and 2021 for a specific Dissemination Area

To summarize the change patterns at the dissemination area (DA) level, the unique identifier for each DA was used to group the modified dataset and compute the percentage of the DA area that changed.



Example calculation for one DA:

Area with BEC Changes	13.73 Km ²
Total Area	414.80 Km ²
% of area with changes	33.10%

BC Parks, Ecological Reserves, and Protected Areas

To incorporate ecological conservation into the sustainability assessment, spatial data on BC Parks, Ecological Reserves, and Protected Areas were obtained from the BC Data Catalogue (Government of British Columbia, 2025a). This dataset contains the official boundaries and classifications of all provincially designated parks, conservancies, ecological reserves, and protected areas in British Columbia. Each polygon feature includes metadata on its legal designation, management type, and protection status.

The dataset was clipped using ArcGIS Pro v3.4 to match the extent of the Thompson-Okanagan Region, as defined by the 2021 Census Dissemination Areas (DAs). A spatial intersection was then performed between the protected areas and the DA boundaries to isolate the portion of protected land within each DA. These intersected features were reconnected to the geometries of the whole DA layer, and the protected land area was calculated in square kilometers. The proportion of each DA covered by protected land was computed by dividing this area by the total area of the DA.

The result was a new spatial dataset containing the percentage of land under legal protection for each DA. This variable serves as an ecological indicator within the sustainability

framework, supporting spatial analysis of conservation coverage and its relationship to tourism activities, land-use change, and socio-economic characteristics.

Landscape Units and Biodiversity Emphasis Options

To further assess ecological protection and landscape-level biodiversity planning, data on Landscape Units were incorporated from the BC Data Catalogue (Government of British Columbia, 2025a). Landscape Units are administrative areas used in provincial forest and biodiversity planning, often aligned with ecologically significant areas or watersheds. Each unit is classified by a Biodiversity Emphasis Option (BEO), which defines the level of emphasis placed on biodiversity conservation during land-use planning (B.C. Ministry of Forests, 1995).

The BEO classification includes three categories: i) High: Prioritized for biodiversity conservation, with minimal allowable disturbance; ii) Intermediate: Balancing conservation with economic or recreational land uses; iii) Low: Where conservation plays a lesser role in planning decisions.

For this study, only High and Intermediate BEO areas were considered, as they reflect a more active conservation intent. The dataset was filtered to retain only these classifications and then clipped to the extent of the Thompson-Okanagan Region. A spatial intersection was performed with the DA boundaries, isolating the portion of each DA that overlaps with these conservation-prioritized zones. The area of overlap was calculated and expressed as a percentage of the total DA area.

This indicator captures localized biodiversity planning priorities and contributes to the environmental dimension of the sustainability framework, enabling comparisons across DAs and assessing their overlap with tourism pressures or development.

Greenhouse Gas Emissions Indicators

To estimate environmental pressure associated with energy consumption, waste generation, and vehicle transportation, greenhouse gas (GHG) emissions data were obtained from the Community Energy and Emissions Inventory (CEEI) published by the Government of British Columbia (2025b). These data provide estimates of GHG emissions at the Census Subdivision (CSD) level and are available annually from 2007 to 2022.

Three emissions categories were included in the analysis: i) Energy use in buildings, covering stationary fuel use in the residential, commercial, and institutional sectors; ii) On-road transportation, estimating vehicle emissions within and between communities; and iii) Municipal solid waste, including landfilled waste and diverted waste streams.

Each dataset was downloaded in CSV format and imported into R for processing. Using the `cancensus` and `sf` packages, spatial boundary data for 2021 Census Subdivisions were retrieved, and emissions were joined with geographic identifiers.

Since emissions are reported at the CSD level and not disaggregated by sector, an attribution factor was applied to estimate emissions related to tourism. According to the BC Tourism Climate Resilience Initiative, approximately 3.5% of the province's total emissions can be attributed to tourism-related activities (Destination BC, 2025). This percentage, derived using the Ministry of Environment's methodology, was applied uniformly across all three emission types (energy, waste, and transportation). While this approach is an approximation, it provides a baseline estimate of tourism-related environmental pressure in the absence of more detailed sector-specific data.

Downscaling to the Dissemination Area Level

Because the sustainability analysis was conducted at the Dissemination Area (DA) level, emissions data were downscaled from the CSD level using a proportional allocation method. Population and dwelling counts for each DA were retrieved using the `cancensus` package. The proportion that each DA contributes to its parent CSD was calculated, and this share was used to weight and allocate the CSD-level emissions to the DA level.

Each emissions dataset (energy, waste, and transport) was processed separately and spatially joined to the DA boundaries of the Thompson-Okanagan Region. The resulting emissions were attributed to each DA for each available year and merged into a single spatial layer with variables representing the type of emissions and the year.

The completed emissions dataset was exported to a GeoPackage for further spatial modelling and mapping. These indicators provide a critical measure of environmental pressure associated with tourism-related activities, supporting spatial comparisons across the region over time.

Socio-cultural indicators – collection and harmonization of geographic Information

To represent the socio-cultural dimension of sustainability, a set of spatial indicators was compiled to reflect cultural heritage, Indigenous presence, protected archaeological and historic sites, and recreation-related features (see Table 3.3: GIS layers for sustainability assessment - Socio-cultural Dimension). These indicators offer insight into the cultural identity and historical richness of the Thompson-Okanagan Region, contributing to a more holistic sustainability assessment by enabling comparisons across Dissemination Areas (DAs). Together, they support the evaluation of how sustainability planning intersects with cultural preservation, Indigenous inclusion, and heritage protection.

Table 3.3: GIS layers for sustainability assessment - Socio-cultural Dimension

Layer name / Dataframe name	Description	Last Year or period available	Period of update	Publisher	Web access
First Nation Community Locations	Approximate locations of First Nations in British Columbia. Locations are based on the location of the main community	2015-2024	Daily	Deputy Minister's Office	https://catalogue.data.gov.bc.ca/dataset/first-nation-community-locations
Important Fossil Areas	Locations of important fossil areas in the area. The data is intended to highlight areas where fossil resources are important and where fossil impact assessments should be done before conducting extractive activities	2016-2025	As needed and as new information becomes available, irregularly.	Heritage Branch	https://catalogue.data.gov.bc.ca/dataset/ad97ddb-c-954e-4d30-99ea-31425c7a8a31
Historic Places Spatial Layer (Public View)	Officially recognized historic sites in British Columbia that are post-1846 heritage sites registered on the BC Register of Historic Places	2024	Irregularly - as needed. Continually added and updated based on notifications from local governments and other government agencies.	Heritage Branch	https://catalogue.data.gov.bc.ca/dataset/fc2b29ff-89a4-490b-bf7c-8d3e2f2af5d4
Historic Trails of British Columbia	Spatial and tabular data on non-archaeological historic trails in B.C.	2017	Irregularly. Updated periodically to include new information as it becomes available	Heritage Branch	https://catalogue.data.gov.bc.ca/dataset/98c097cf-32bc-40a6-8061-bfe97a295e37

First Nations Community Locations

The First Nations Community Locations dataset was obtained from the BC Data Catalogue (Government of British Columbia, 2025a). This point-based dataset identifies the geographic location of First Nations communities, typically aligned with administrative or residential centers such as band offices or primary settlements. Each feature is attributed with the name of the Nation, community, and associated governance structure.

To incorporate this information, a spatial intersection was performed between the community point layer and the 2021 Census Dissemination Areas (DAs) for the Thompson-Okanagan Region. A count of First Nations community points per DA was calculated, resulting in a binary or count-based indicator of Indigenous presence. This indicator highlights areas where Indigenous communities are present and where inclusive sustainability planning should be prioritized.

Important Fossil Areas

The Important Fossil Areas (IFA) dataset, provided through the BC Fossil Management Framework (Government of British Columbia, 2025a), delineates zones of significant paleontological value. These areas are identified based on fossil richness, scientific importance, preservation quality, and rarity, and are supported by expert evaluations and recommendations.

To assess their spatial presence at the DA level, IFA polygons were intersected with the Thompson-Okanagan DA boundaries. The surface area of each overlap was calculated and normalized by the total DA area, yielding the percentage of DA land covered by designated fossil areas. This metric represents a non-renewable scientific and cultural conservation indicator.

Historic Places

The Historic Places dataset, also accessed via the BC Data Catalogue (Government of British Columbia, 2025a), includes locations and polygons for sites recognized as culturally or historically significant at local, provincial, or national levels. These features include buildings, landscapes, and districts listed in registries such as the Canadian Register of Historic Places and local inventories.

Historic place polygons were intersected with the DA boundaries, and the overlapping area (in square meters) was calculated for each DA. The results were normalized to compute the percentage of DA land designated as a historic place, serving as an indicator of cultural heritage presence.

Historic Trails

Data on Historic Trails were retrieved from the same source and represent historically significant routes, including Indigenous pathways, fur trade corridors, and settler trails. These linear features are based on archival records, maps, and field verification (Government of British Columbia, 2025a).

To integrate this dataset, trail lines were intersected with DA boundaries, and the total length of trails (in meters) per DA was calculated. This indicator captures historic mobility corridors and contributes to the understanding of the region's cultural landscapes.

Recreational Features and Viewing Points

To evaluate the recreational potential as part of the socio-cultural dimension, three complementary datasets were utilized: i) the Recreational Features Inventory (polygons), ii) the Recreational Features Inventory (lines); and iii) the Visual Landscape Inventory – Viewing Points (Government of British Columbia, 2025a).

The polygon dataset includes spatial features associated with recreational use (e.g., parks, lakeshores, trail networks), each attributed with a Significance Classification. Following

the B.C. Ministry of Forests (1997) guidelines, polygons classified as “High” or “Very High” were selected, as they denote: i) High recreational value or visual importance, ii) Frequent visitation or visibility (e.g., scenic highways or popular trails), and iii) Strategic relevance in regional planning.

Selected polygons were clipped to the study area and intersected with DA boundaries. For each DA, the area of overlap and the percentage of total land area falling within high-significance recreational zones were calculated. This metric captures land-based recreation potential.

The line dataset includes linear recreational infrastructure, such as trails and access routes. These features were intersected with DA boundaries, and the total length of recreational lines per DA was computed, representing a second measure of infrastructure-based recreation potential.

Lastly, viewing points from the Visual Landscape Inventory were spatially joined to DAs. The count of scenic viewing points per DA was calculated, reflecting the presence of geolocated vantage points used for landscape appreciation, including trail lookouts, roadside pullouts, and park viewpoints.

Economic indicators – collection and harmonization of geographic Information

To represent the economic dimension of tourism sustainability, a series of spatial indicators was compiled, capturing the distribution of tourism infrastructure, business activity, employment, and visitor flows (view Table 3.4: GIS layers for sustainability assessment - Economic Dimension).

These indicators enable spatially disaggregated assessments of tourism’s economic pathway across the region.

Table 3.4: GIS layers for sustainability assessment - Economic Dimension

Layer name / Dataframe name	Description	Last Year or period available	Period of update	Publisher	Web access
HelloBC Accommodati ons Listing	List of the locations of B.C. accommodations that are registered with the HelloBC Listings Program.	2015- 2025	Ongoing	Destination BC	https://catalogue.data.gov.bc.ca/dataset/hellobc-accommodations-listing
HelloBC Visitor Centres Listing	List of B.C.'s Visitor Centres that are registered with the HelloBC Listings Program	2015- 2025	Ongoing	Destination BC	https://catalogue.data.gov.bc.ca/dataset/hellobc-visitor-centres-listing
HelloBC Activities and Attractions Listing	List of products that are registered with the HelloBC Listings Program.	2015- 2025	Ongoing	Destination BC	https://catalogue.data.gov.bc.ca/dataset/hellobc-activities-and-attractions-listing
Golf Courses	Point dataset identifying the location of golf courses in British Columbia.	2018- 2025	Updated at the beginning of each month	GeoBC Branch	https://catalogue.data.gov.bc.ca/dataset/90cacd92-f30b-414d-a118-812073b3ec66
Ski Resorts	Point dataset identifying the location of ski resorts in British Columbia.	2018- 2025	Updated at the beginning of each month	GeoBC Branch	https://catalogue.data.gov.bc.ca/dataset/db1489d4-4304-4203-99bf-11b2b23179eb
Open Database of Businesses	Collection of open data containing the names, addresses, and industry information of a selection of businesses across Canada.	2023	Not detailed	Statistics Canada - Data Exploration and Integration Lab (DEIL)	https://www150.statcan.gc.ca/n1/pub/21-26-0003/212600032023001-eng.htm

Census of Population	The most important statistical survey of a country. Counts all the members of a population, including individuals and households, to collect data on their characteristics.	2016, 2011, 2006, 2001	Quinquennial	Statistics Canada	https://www12.statcan.gc.ca/census-recensement/index-eng.cfm
International Travel Survey	Records relate to the activities of Canadians travelling outside the country and visitors to Canada	2013-2017	Annual	Statistics Canada	https://www150.statcan.gc.ca/n1/en/catalogue/24250002
Visitor Travel Survey	The Visitor Travel Survey was introduced in January 2018 to replace the component of the International Travel Survey that tracked U.S. and overseas visitors to Canada.	2018-2019	Annual	Statistics Canada	https://www150.statcan.gc.ca/n1/en/catalogue/66M0001X

Tourism Infrastructure: HelloBC Listings

To characterize tourism-related infrastructure, five-point datasets were retrieved from the BC Data Catalogue (Government of British Columbia, 2025a), including official listings maintained by Destination British Columbia's HelloBC program: i) Activities and Attractions: Locations of cultural, recreational, and nature-based experiences; ii) Visitor Centres: Official tourism information centres, iii) Accommodations: Hotels, motels, B&Bs, and other lodging services; iv) Golf Courses: Geolocated recreational golf facilities; and v) Ski Resorts: Alpine and Nordic ski area locations.

The first three datasets pertain to the official listings of the HelloBC Program, a marketing initiative by Destination BC in partnership with Tripadvisor. Through this program, eligible tourism businesses in British Columbia can appear on HelloBC.com by claiming and optimizing their Tripadvisor listing and linking it to Destination BC's Tourism Business Portal. This integration ensures up-to-date and consistent information across both platforms, improves online visibility, and streamlines listing management. Eligible businesses include accommodation providers (such as hotels, motels, B&Bs, campgrounds, RV parks, and wilderness lodges), activity providers (e.g., ziplining, river rafting, sightseeing tours), and attractions (like museums, art galleries, and gardens). Ineligible businesses include restaurants and dining establishments (which are better suited for platforms like Yelp and OpenTable), associations, Destination Marketing Organizations (DMOs), travel agencies and tour operators, event organizers, and community-focused facilities such as recreation centers and libraries.

Each dataset was spatially joined to 2021 Census Dissemination Area (DA) boundaries using ArcGIS Pro v3.4. The number of features within each DA was counted and stored in an attribute table.

Business Units: Open Database of Businesses (ODBUS)

To complement the infrastructure data, records from the Open Database of Business Units (ODBUS), published by (Statistics Canada, 2023) Statistics Canada (2023), were

processed using R software. The dataset includes business names, sectors, licenses, and location attributes. Records were filtered to retain only businesses located in British Columbia.

Businesses with valid latitude and longitude were directly converted into spatial features. Records lacking coordinates were geocoded in R using the tidygeocoder package and OpenStreetMap's Nominatim API, prioritizing postal codes and full addresses. Incomplete or out-of-region entries were excluded.

Tourism-related businesses were identified using sector codes and keyword filters (e.g., hotels, restaurants, wineries, cultural attractions). After geolocation, all points were spatially intersected with the TOR boundary and 2021 DA geometries. Duplicate entries (such as businesses with multiple licenses) were removed. The final dataset was summarized to generate business unit counts per DA, capturing localized economic activity tied to the tourism sector.

The whole process can be observed on the 04_ODBUS_Goreferencing.R script, available on the digital version of the thesis.

Tourism Employment: Canadian Census (2011, 2016, 2021)

Tourism employment trends were evaluated using the Canadian Census from 2011, 2016, and 2021, accessed via the cancensus R package (von Bergmann J, 2021). The focus was on Dissemination Area-level data for the following NAICS sectors: i) NAICS 72: Accommodation and Food Services; and ii) NAICS 71: Arts, Entertainment, and Recreation.

For each census year, the following variables were retrieved: i) Total labour force (aged 15+) by industry, ii) Employment in NAICS 71 & 72 (disaggregated by sex).

All datasets were retrieved in spatial format and filtered for the TOR. Indicators derived include: i) Absolute employment in tourism-related sectors; ii) Percentage of total employment in tourism-related sectors. These indicators enable longitudinal economic analysis and integration with environmental and socio-cultural variables.

The whole process can be observed on the 05_Census Data.R script, available on the digital version of the thesis.

Visitor Flows and Spending: ITS and VTS Microdata

To capture visitor flow and spending patterns, anonymized microdata from two national surveys were used: i) International Travel Survey (ITS) (2013–2017) (Statistics Canada, 2024); and ii) Visitor Travel Survey (VTS) (2018–2019) (Statistics Canada, 2019).

These datasets provide detailed records of international and domestic trips to Canada, including information on trip origins, purposes, durations, expenditures, and destinations. Although the data are geographically disaggregated only to the Census Metropolitan Area (CMA) level, they offer the most comprehensive sub-provincial source of visitor behaviour and tourism-related spending in Canada.

The microdata was processed in R using the haven package. For each year, records were filtered to include only trips that involved at least one location within British Columbia. CMA-specific trips were isolated by referencing province codes, ensuring that only travel segments associated with CMAs located within British Columbia were retained. The datasets were cleaned by removing entries with missing or placeholder values in the expenditure variables. The survey-provided weight variable was then applied to each record to obtain representative, population-level estimates.

From these cleaned and weighted records, several indicators were computed for each year and quarter, including the total number of visits and average and total expenditures on major spending categories such as accommodation, food and beverage, recreation, transportation, and other expenses. The data from the ITS and VTS were combined into a single aggregated dataset across the years 2013 to 2019.

To enable spatial analysis, CMA boundary geometries were retrieved from the 2021 Canadian Census using the cancensus package, and a geographic identifier (GeoUID) was constructed to align the aggregated travel data with the corresponding spatial units. The

aggregated statistics were then merged with the CMA geometries to produce a spatial dataset containing visit and spending metrics by CMA, quarter, and year.

Downscaling Visitor Data Using Spatial Regression (Kriging)

Since the original survey data are not available at the Dissemination Area (DA) level, a spatial disaggregation method was needed to align these data with the rest of the DA-level indicators. Therefore, a regression kriging approach was applied to estimate tourism activity at a finer spatial resolution. Socioeconomic and demographic predictors at the DA level were retrieved from the Canadian Census using censensus, including total population, employment in accommodation and food services, and average after-tax income. Although income data were considered, they were ultimately excluded from the regression models due to coverage gaps in some DAs.

A linear regression model was constructed for each tourism metric (total visitor spending, number of visits, and average spending per visitor) using log-transformed dependent variables to stabilize variance. The models were trained using only DAs that spatially intersected the CMA boundaries, where both dependent and independent variables were known. Predictions were then generated for all DAs in the Thompson-Okanagan Region using the fitted models. The log-transformed results were back-transformed to the original scale to yield estimates of: i) visitor spending, ii) total visits, and iii) average spending per visit at the DA level.

The final dataset was exported as a GeoPackage and prepared for integration into the broader multi-Criteria Assessment. This disaggregation approach allowed for the spatial integration of tourism demand indicators, overcoming the limitations of CMA-level aggregation and providing detailed estimates of tourism intensity across the region.

This suite of economic indicators enables a robust evaluation of tourism's economic role across the region. By integrating infrastructure, business activity, employment, and visitor demand into a spatial framework, the analysis supports both temporal and cross-sectional comparisons essential to assessing tourism sustainability.

The whole process can be observed on the 06_Visitor Flows.R script, available on the digital version of the thesis.

The final outputs of the bottom-up approach were compiled into a geodatabase, enabling efficient visualization and spatial analysis within ArcGIS version 3.4. This structure facilitates the integration, querying, and mapping of sustainability indicators, supporting further exploration and interpretation of results at multiple geographic scales.

3.3 Methodological Approach for the Bottom-Up approach: Stakeholders Survey

The stakeholder survey was designed to complement the top-down spatial analysis by capturing bottom-up perspectives on sustainability from actors within the tourism sector. Two core objectives guided its development: (1) to explore stakeholder perceptions of the extent of sustainable tourism practices in the Thompson-Okanagan Region, and (2) to assess their attitudes towards using geographic information systems (GIS) to visualize and contribute to sustainability monitoring efforts.

The survey focused on tourism-related business stakeholders, particularly operators in accommodations, food services, and wineries, based on their significant roles in employment generation, service provision, and regional economic activity (Destination BC & NRG Research Group, 2012; Thompson Okanagan Tourism Association, 2017, 2019a). While these sectors were prioritized, responses from other types of businesses were also welcomed and subsequently reclassified during data processing.

The questionnaire aimed to elicit information in two thematic areas. First, it investigated stakeholder familiarity with and implementation of sustainability practices, including water and energy use, waste and recycling management, carbon reduction efforts, sourcing from local suppliers, and educational practices targeted at visitors and employees. Questions also addressed perceptions of tourism seasonality and whether respondents believed

tourism levels were appropriately distributed throughout the year. Second, the survey examined the use of GIS tools and attitudes toward sharing spatial data. Questions examined familiarity with web-based geographic platforms (e.g., Google Maps), perceived value in visualizing tourism-related data on maps, and respondents' willingness to contribute information to digital mapping systems that support sustainability monitoring.

Ethical Considerations

The study received approval from the university's Research Ethics Board. Participation in the survey was entirely voluntary. Respondents were informed of their rights, including the option to withdraw at any time without consequence. Personally identifying information was collected only when voluntarily provided for follow-up or participation in result dissemination.

No monetary compensation was offered; however, participation contributed to a project aimed at improving sustainability planning and tourism policy. The survey was administered via SurveyMonkey's enterprise version, with all responses stored securely on an encrypted, password-protected computer. Data will be destroyed five years after the project completion. Research findings will be shared through academic presentations (e.g., TOTA, TTRA Canada), published articles, and regional stakeholder briefings. An executive summary and consent form were made available to participants who requested them.

Sample Design and Data Collection

A non-probabilistic, purposive sampling strategy was employed to reach tourism businesses across the Thompson-Okanagan Region. Outreach was conducted in partnership with the Thompson Okanagan Tourism Association (TOTA), which promoted the survey through its communication channels. To incentivize participation, two gift cards to well-known regional restaurants were offered. Survey distribution was timed to avoid peak tourism periods and holiday interruptions, running from February 14 to May 5. In parallel, phone outreach was conducted to recover partially completed responses.

Despite some barriers (such as survey fatigue due to similar surveys running, lack of managerial availability, or staff reluctance without employer approval), a total of 122 responses were initiated, and 47 completed surveys were retained for analysis. Of these, 45 could be successfully georeferenced.

Questionnaire Structure and Survey Instrument

The final survey instrument included 30 questions across three sections:

- A section assessing perceptions of sustainable tourism in the community (17 questions)
- A section evaluating GIS familiarity and attitudes towards mapping tools in sustainability contexts (7 questions)
- A demographic and contextual information section (6 questions)

Questions were primarily closed-ended and used five-point Likert scales, multiple-choice responses, or numerical entries. The questionnaire was reviewed by the academic committee and tested prior to distribution.

Data Processing and Statistical Analysis

Survey data were cleaned and analyzed using IBM SPSS Statistics following best practices outlined by Pallant (2020) and Bryman and Cramer (2011). Reliability analysis was conducted using Cronbach's alpha to assess internal consistency (DeVellis, 2016; Gliem & Gliem, 2003), and multi-item indices were constructed and reclassified into ordinal categories for further analysis.

Cronbach's Alpha reliability test

Cronbach's Alpha reliability testing shows a consistent measure of the constructs on the Likert scale questions, with values above 0.6 - 0.7 in all of them.

Table 3.5: Cronbach's Alpha reliability test results

Perceptions on the stakeholders' familiarity with sustainable practices in the use of natural resources	Reliability Statistics	
	Cronbach's Alpha	N of Items
Q09. Familiarity with practices in the management of natural resources	0.89	5
Q10. Frequency of Implementation of Water Management Practices	0.85	8
Q11. Frequency of Implementation of Energy Management Practices	0.76	6
Q12. Frequency of Implementation of Waste Management Practices	0.67	4
Q13. Frequency of Implementation of Food Waste Management Practices	0.91	4
Q14. Frequency of Implementation of Carbon Reduction Practices	0.69	6

Attitudes towards providing information that allows GIS to monitor sustainability	Reliability Statistics	
	Cronbach's Alpha	N of Items
Q27. Frequency of using mapping applications	0.81	6
Q28. Frequency of helping visitors to use mapping applications	0.87	5
Q29. Frequency of helping visitors to use mapping applications	0.90	4

Incomplete responses were excluded. Non-numeric and identifier variables were removed, except for Respondent ID, which was retained for georeferencing. Variables representing Likert-scale N/A questions were recoded to treat "999" values as missing. The internal consistency of the multi-item indices was evaluated using Cronbach's alpha, with an acceptable value of $\alpha \geq 0.70$.

Index scores were computed for constructs such as familiarity with sustainability practices, using the "Compute Variable" function. These scores were classified into three levels (low, medium, and high) using equal-interval reclassification. Questions 22–24, which assessed the perceived importance of environmental, socio-cultural, and economic dimensions of sustainability, were recoded into four ordinal categories and later used to inform the weighting process in the MCA model.

Multiple response sets were defined using SPSS's multiple response analysis tools to process questions with "select all that apply" formats.

Georeferencing of Survey Responses

Responses were georeferenced using business names, addresses, or postal codes. Where exact locations were not provided, reasonable approximations were made by referencing business type and the registered address. The georeferencing process utilized Google Maps and MyMaps, as they facilitated the identification of businesses by company name. This approach was feasible since the addresses or postal codes registered corresponded to the respondent, but not to the businesses themselves. Ultimately, 45 of the 47 valid responses were successfully georeferenced. All geographic data were anonymized, and no personally identifiable information was included in the final spatial dataset. Spatial outputs were used only in aggregate form, with no individual point-level disclosure, in accordance with the ethics protocol.

3.4 Multi-Criteria Assessment and the Integration with GIS

For the evaluation and integration of information, a Multiple Criteria Analysis (MCA) approach has been employed, as observed in Graymore et al. (2009), considering it a supportive tool that provides a systematic framework for evaluating different options.

Multiple Criteria Analysis (MCA) or MCDM (Multi-Criteria Decision Making) is a method that enables problem-solving with multiple conflicting objectives (Zionts, 1979). MCA has the “ability to consider many criteria at once, even a mixture of qualitative and quantitative criteria” (Graymore et al., 2009, p. 455), and has been used effectively in areas such as planning, natural resources management, and sustainable agricultural systems. The use of GIS in combination with MCA, has proven to enhance the decision-making process; they produce maps that show the ranking of options, show where the decision options are located, and enhance the stakeholder’s experience by producing maps of decision options (Graymore et al., 2009).

To integrate the environmental, socio-cultural, and economic indicators into a unified sustainability assessment framework, a Multi-Criteria Assessment (MCA) approach was

applied. The MCA followed a structured pipeline involving data normalization, weighting, aggregation, and mapping, with all analyses performed at the Dissemination Area (DA) level.

Normalization of Indicators

As the selected indicators were expressed in different units and ranges, a min-max normalization procedure was applied to rescale each indicator to a standard range between 0 and 1. This method preserved the relative distribution of each variable while ensuring compatibility across metrics. Indicators representing negative impacts (e.g., GHG emissions, land use conversion from natural to settlement) were inverted during normalization to maintain interpretative consistency, so that higher values uniformly represented more favourable. The normalized values were then grouped by sustainability dimension: environmental, socio-cultural, and economic, and stored in a unified geospatial dataset.

Weighting of Sustainability Dimensions

Weights were assigned to each dimension using values derived from three stakeholder survey questions (Q22–Q24), which asked respondents to rate the importance of each sustainability pillar. The average scores from 45 valid responses were scaled to create a proportional weight distribution across the three dimensions. These weights reflected stakeholder priorities, allowing the MCA to integrate local perceptions into the analytical process.

The resulting dimension-level weights were as follows:

- Environmental: 0.301
- Socio-cultural: 0.356
- Economic: 0.342

These weights were applied during the aggregation phase to influence the contribution of each dimension to the overall sustainability score.

Composite Score Calculation

For each DA, the normalized indicators within each dimension were averaged to produce a dimension score. These three-dimensional scores were then combined into a final composite sustainability index using the weighted sum method. The resulting score ranged between 0 and 1, where higher values indicated stronger sustainability performance based on the integrated set of indicators and stakeholder-informed weights.

In addition to the weighted composite score, a non-weighted version was also calculated by applying equal weights to each dimension. This provided a baseline for comparison and helped evaluate the influence of the weighting process on the final assessment (OECD, 2008).

Comparison of Stakeholder Perceptions and MCA Scores

To explore potential alignment or divergence between stakeholder perceptions and the MCA-based sustainability scores, a spatial comparison was conducted between the survey responses and the composite MCA results. The goal was to assess whether the views of tourism business stakeholders on the importance of sustainability dimensions were reflected in the spatial outcomes of the MCA model.

Each georeferenced survey response was spatially joined to its corresponding Dissemination Area (DA), allowing for direct comparison between the self-reported importance scores (for environmental, socio-cultural, and economic sustainability) and the dimension scores calculated via the MCA model. For this purpose, survey responses to Questions 22, 23, and 24 (indicating perceived importance of each dimension) were rescaled to the same 0–1 scale used in the normalized MCA data. This permitted a standardized, side-by-side assessment.

Descriptive and graphical analyses were performed to examine patterns. In particular, the absolute difference between stakeholder perceptions and MCA scores was calculated for each dimension and response. This allowed for the identification of DAs or subregions where stakeholder expectations and MCA outcomes were either in alignment or in contrast. This comparison offered valuable insights into perception gaps (places where stakeholders perceive a dimension to be more or less important than is reflected in the indicator-based analysis). These gaps are important for two reasons: (1) they may highlight local knowledge or concerns not captured by secondary data, and (2) they help inform future efforts to enhance data availability or participatory monitoring systems. By integrating perceptions with analytical outputs, this approach reinforces the framework's participatory and policy-relevant focus on sustainability assessment.

Mapping and Spatial Analysis

The final results were stored as a spatial dataset and exported in GeoPackage format for visualization in QGIS or ArcGIS Pro. The sustainability scores were mapped to reveal geographic disparities across the region, highlighting areas of strength and vulnerability in each sustainability dimension. The results support spatially targeted policy recommendations and inform regional planning efforts toward sustainable tourism development.

The whole process can be observed on the 07_MCA Analysis.R script, available on the digital version of the thesis.

The methodological framework outlined in this chapter establishes a comprehensive approach to assessing tourism sustainability across the Thompson-Okanagan Region. By integrating geospatial analysis, stakeholder-informed weighting, and a multi-criteria assessment model, the study generated a robust dataset that supports spatial comparisons and provides policy-relevant insights. The following chapter presents the key findings derived from

this analysis, organized according to the sustainability dimensions and research questions introduced earlier.

3.5 Limitations of the proposed methodology

Like any research, this study faces methodological and data-related limitations that should be acknowledged when interpreting its results. One important challenge relates to the integration of stakeholder survey results into the MCA weighting scheme. While the survey offered valuable insights into business perceptions, the relatively small sample size and the potential response fatigue among stakeholders limit the representativeness of these findings. This suggests the need to explore complementary approaches in future work, such as the use of administrative records, big data, or social media sources to capture broader and more dynamic stakeholder perspectives.

Survey Limitations

The survey returned 47 valid responses, which is below the original target of 5% of the business population in the region (approximately 2,500 enterprises). While this number does not provide a statistically representative sample for the entire tourism sector, the responses were geographically well distributed across the study area and included businesses from key tourism-related sectors. This distribution supports the validity of the analysis as an exploratory and indicative tool, rather than as a basis for generalizing findings to the whole population.

The relatively small sample size reflects broader challenges of survey-based research in the tourism industry. Survey fatigue among stakeholders is evident, with several respondents indicating reluctance to participate due to the frequency of survey requests from different organizations. Additionally, some businesses included in the original sampling frame may no longer be in operation, which further complicates achieving higher response rates.

Despite these constraints, the survey remains a valuable complement to the GIS-based analysis, offering unique insights into stakeholder perceptions of sustainability that cannot be captured by secondary data alone. While interviews could have provided richer qualitative detail, they would not have allowed for the same spatial coverage or georeferenced analysis of stakeholder perspectives. Similarly, while big data and social media analytics offer promising

alternatives for the future, such sources are not always accessible or standardized for regional applications.

Although the sample size was modest, the 47 responses are sufficient to identify trends, highlight key perceptions, and demonstrate the feasibility of integrating stakeholder insights into a GIS-based sustainability assessment. The geographic spread of respondents across the region ensured that diverse contexts were captured, reducing the risk of bias from any single location. Thus, while the results should not be interpreted as statistically representative of all tourism businesses, they provide a robust and illustrative basis for exploring the gaps between objective indicators and stakeholder perceptions, which was the central aim of this study.

Ultimately, the survey highlights the importance of developing systematic and coordinated approaches for collecting stakeholder perspectives on sustainability. Integrating such mechanisms into existing monitoring systems, such as those led by tourism organizations, could reduce respondent fatigue while still ensuring that the social dimension of sustainability is adequately represented.

Limitations about data sources

Another limitation stems from the temporal inconsistencies across data sources. Indicators used in the environmental, socio-cultural, and economic dimensions were not always available for the same reference years or at the same frequency. For example, land use data changes slowly over decades, whereas emissions or tourism activity can vary annually or even seasonally. Although the methodology sought to harmonize these differences to highlight overall trends, there is an inherent limitation in comparing datasets with different temporal resolutions. The objective was not to achieve perfect temporal alignment but rather to capture broad patterns and trajectories of change, acknowledging that some finer dynamics may have been masked.

At the spatial level, the use of Dissemination Areas (DAs) as the unit of analysis brings both strengths and weaknesses. DAs provide the most detailed scale of official census geography in Canada, enabling fine-grained analysis of tourism sustainability. However,

aligning certain datasets to this level required downscaling or estimation procedures (e.g., distributing CSD-level emissions data to DAs). While population and dwelling-based weighting ensured consistency, these procedures inevitably introduce uncertainty and may not fully capture local variations in tourism-related activity.

The socio-cultural dimension also faced particular limitations. Many cultural assets and Indigenous knowledge systems are not systematically documented or available through official sources. As a result, the study was unable to capture the full extent of cultural and heritage values in the region. This gap highlights the need for better integration of cultural mapping into official data systems to strengthen the representation of socio-cultural sustainability.

Finally, some indicators, such as transportation emissions, were only partially available or aggregated in ways that did not allow differentiation between freight and passenger traffic. This reduced the ability to isolate the specific contribution of tourism-related mobility. Similarly, while visitor flows and spending estimates were successfully downscaled, they remain approximations, and further refinement is possible with more detailed survey or administrative data.

Despite these limitations, the methodology demonstrated the feasibility of integrating diverse datasets and perspectives into a coherent sustainability assessment. Importantly, the study shows that even with imperfect data, geographic analysis can reveal meaningful patterns and trends, offering a valuable basis for decision-making and pointing toward areas where improved data collection and integration are most urgently needed.

Chapter 4 Results

4.1 Top-Down Approach: Geographic Information Analysis Results

This section presents the results of the top-down geospatial analysis conducted to evaluate the sustainability of tourism across the Thompson-Okanagan Region. The analysis was based on the integration of selected spatial indicators, which represent the environmental, socio-cultural, and economic dimensions of sustainability. All data were harmonized and aggregated to the 2021 Census Dissemination Area (DA) level, enabling a consistent geographic basis for comparison.

The top-down analysis allowed the researcher to answer research questions 2 and 3 by evaluating the geographic distribution of the selected indicators. The questions are as follows:

- RQ2: What is the difference and geographic distribution in the status of sustainable tourism in rural communities versus small towns in the Thompson Okanagan Region?
- RQ3: What value does GIS technology offer to potentially measure gaps in sustainable tourism components?

The geospatial analysis focused on identifying patterns, disparities, and areas of concentration for key sustainability indicators across the region. The following subsections summarize the main findings for each sustainability dimension.

Environmental Dimension - conservation strengths and environmental pressures

Protected areas and high biodiversity emphasis zones showed spatial clustering in mountainous and forested DAs, especially those in proximity to provincial parks and ecological reserves.

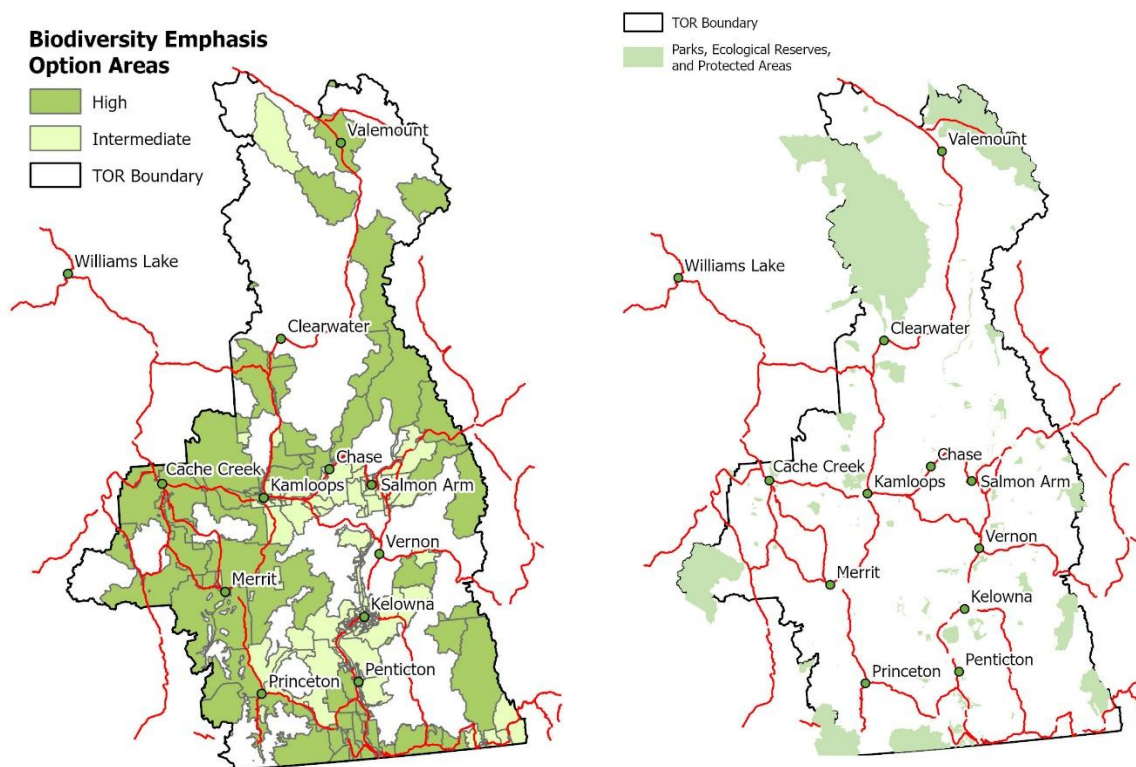


Figure 4.1: Areas with conservation strengths

This information allows the researcher to determine the percentage of areas with conservation strengths at the DA level. These zones received high scores for conservation-oriented indicators, such as protected area coverage and Biodiversity Emphasis Option (BEO) classifications.

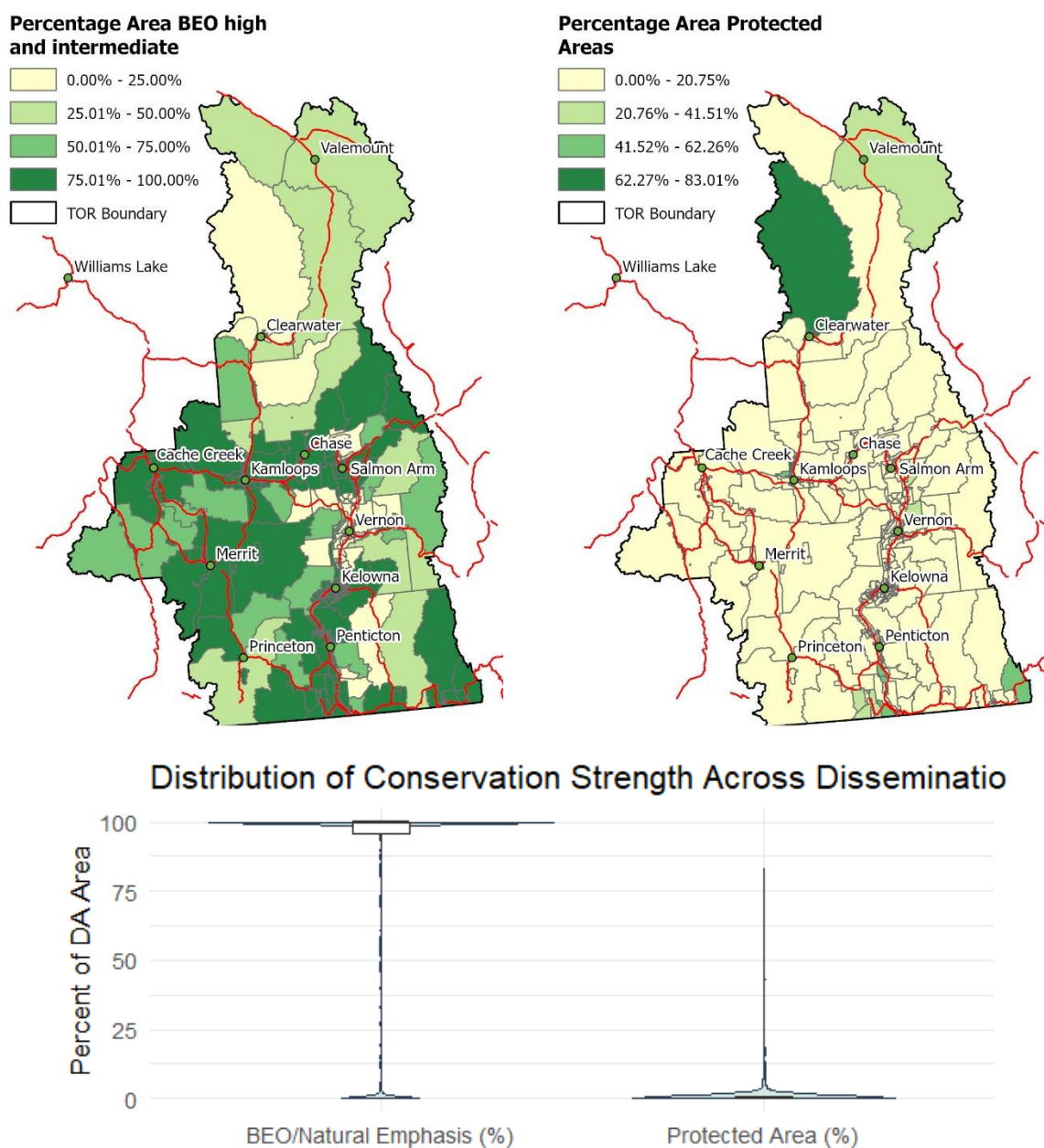


Figure 4.2: Distribution of Areas with Concentration Strength across Census Dissemination Areas

Conversely, areas with intensive land use change, particularly transitions from forest, wetland, or grassland to settlement, were concentrated around urbanizing corridors, including the Kelowna and Kamloops metropolitan areas. The Natural to Settlement transition indicator revealed significant development pressure in peri-urban DAs and tourism-heavy lakefront

communities. The map below illustrates the spatial distribution of these changes, highlighting areas where land conversion occurred at higher rates.

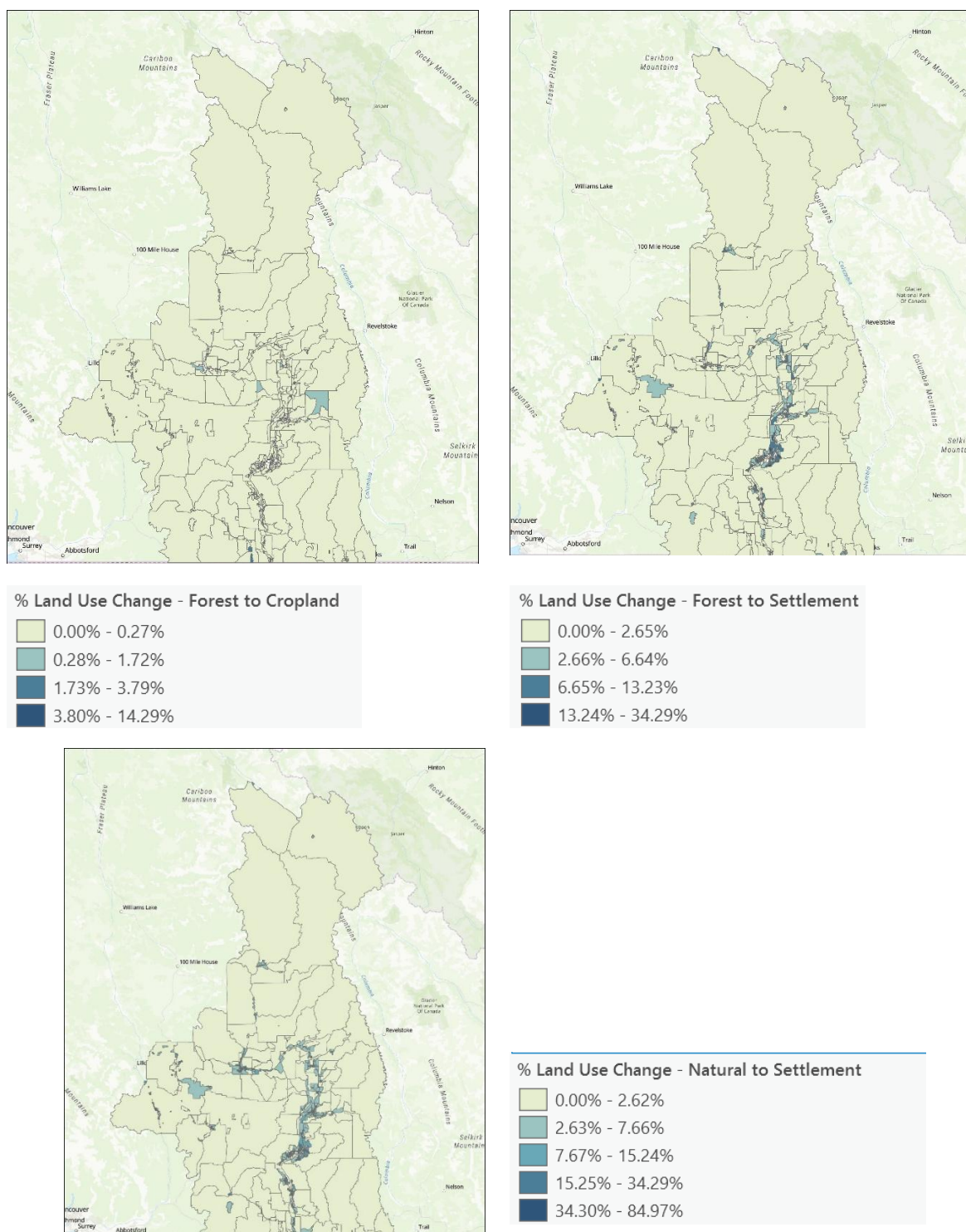


Figure 4.3: Land Use change between 2000 – 2020 by Dissemination Area

In addition, the identification of areas where Bio-geoclimatic Ecosystem Classification (BEC) classifications changes, provides a DA-level dataset indicating where ecological classification updates have occurred, incorporating the percentage of the area that has changed over this period of time (2016-2018-2021), allowing for the exploration of the spatial distribution of ecological boundary changes and the assessment of potential correlations with land use or anthropogenic activities. The map below shows where these changes occurred in a higher percentage.

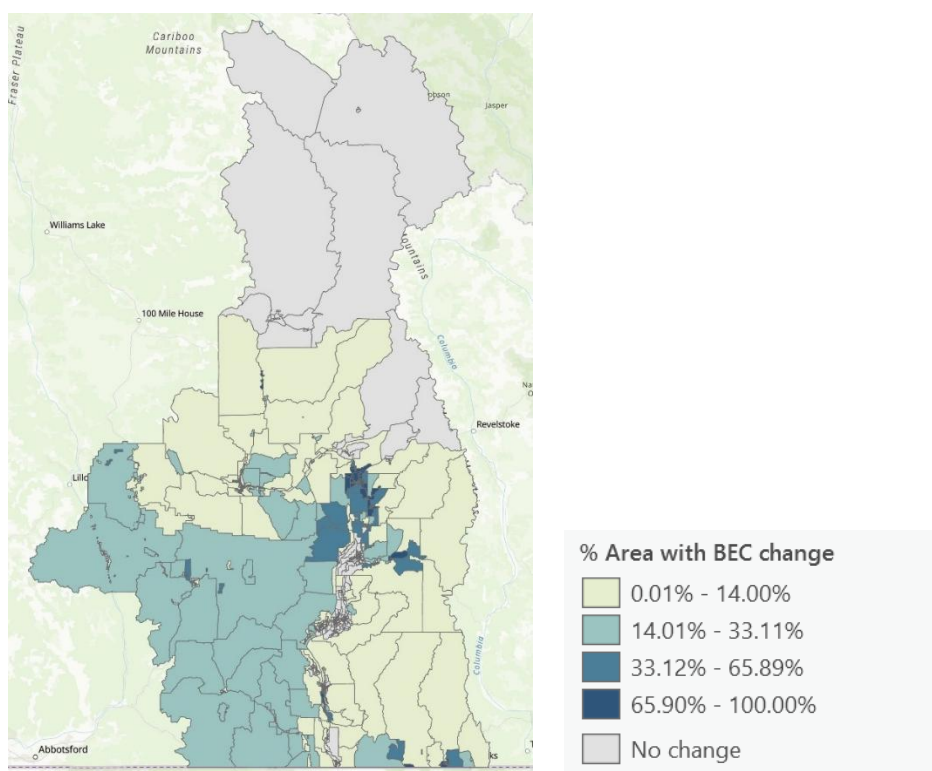
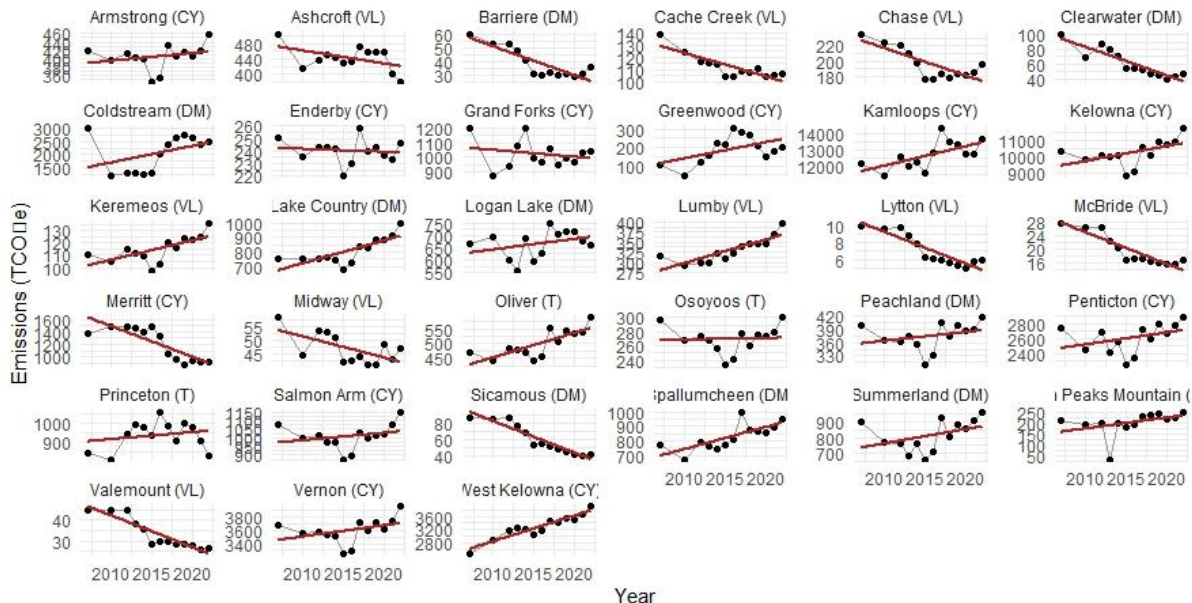


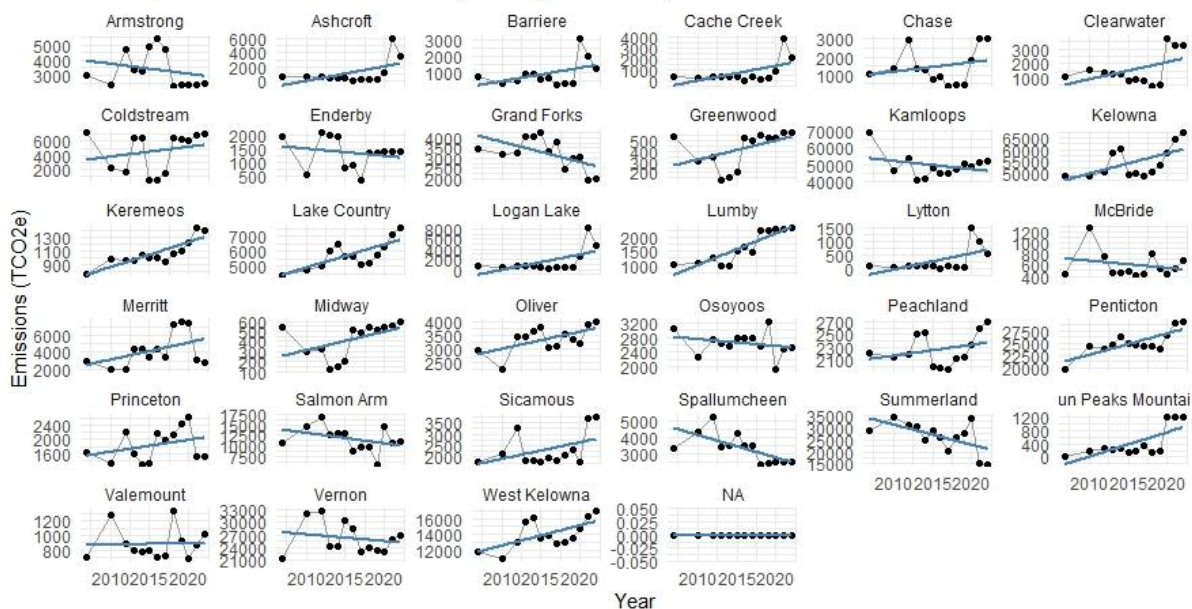
Figure 4.4: Areas where Bio-geoclimatic Ecosystem Classification (BEC) classifications changes

Tourism-related GHG emissions, estimated from the Community Energy and Emissions Inventory (CEEI), allowed the researcher to observe the trends in the emissions between 2007-2022 by Municipality or Census Sub-Division.

Energy-Related Tourism Emissions by CSD (2007–2022)



Municipal Solid Waste Emissions by CSD (2007–2022)



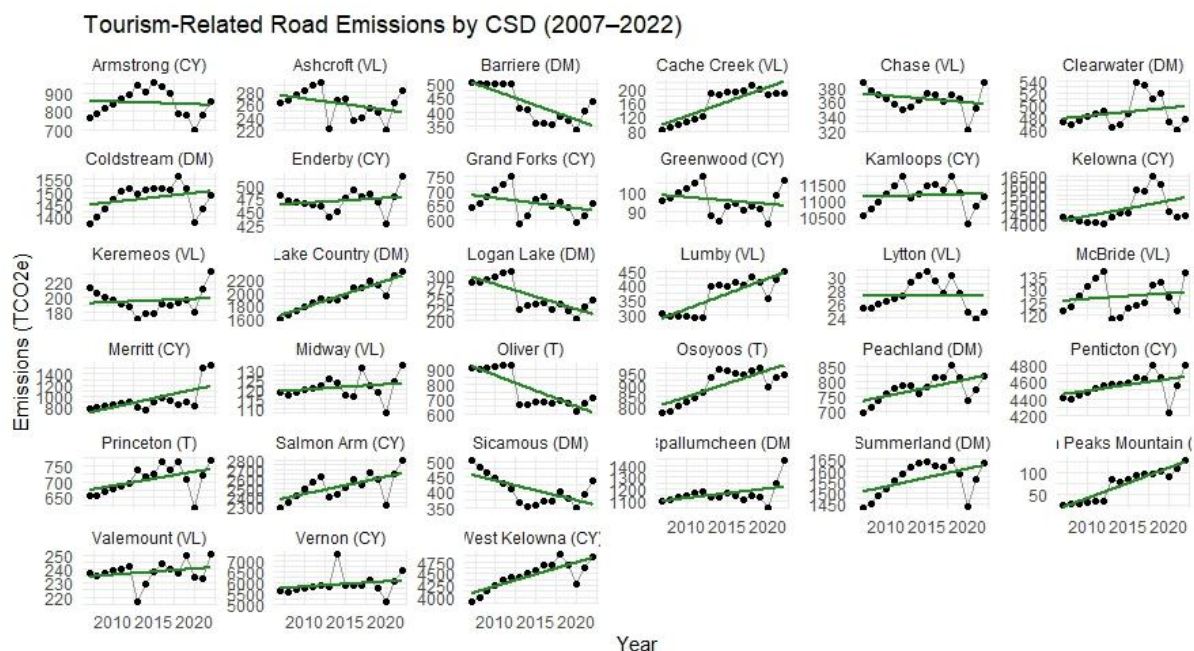


Figure 4.5: Energy buildings related, Municipal Solid Waste and Transportation Road Related GHG Emissions

This information, downscaled to the DA level, indicated higher levels in areas with greater business density and population. The spatial distribution of emissions from transportation, energy, and waste showed clear alignment with road networks, service corridors, and major tourism destinations.

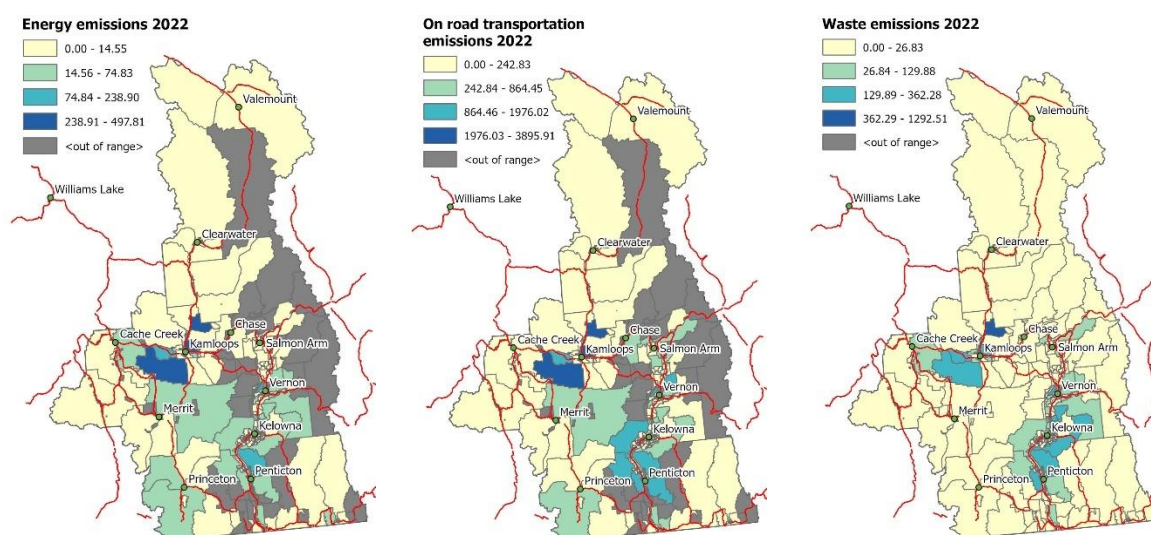


Figure 4.6: Spatial distribution of emissions from transportation, energy, and waste

Environmental Indicators Summary

The top-down spatial analysis revealed substantial variation in environmental conditions and pressures across the Thompson-Okanagan Region, as captured through a suite of geospatial sustainability indicators. These indicators represent both conservation coverage and environmental stressors associated with land use change and tourism-related emissions.

Table 4.1: Environmental Indicators Summary

	Protected Area (%)	Natural Emphasis (%)	BEC Change (%)	Forest to Cropland (%)	Forest to Settlement (%)	Natural to Settlement (%)	GHG Energy (ton/year)	GHG Transport(tonn/y)	GHG Waste(tonn/year)
Mean	0.83	79.02	10.58	0.08	4.13	3.98	8.09	78.34	15.75
Median	0.00	100.00	0.00	0.00	2.57	1.34	1.20	24.52	6.43
Standard Deviation	5.38	39.05	25.82	0.70	4.69	6.48	38.46	270.91	51.34
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	83.01	100.00	100.00	14.29	34.29	84.97	642.30	3834.03	1117.82

Conservation Indicators

Across all 1,001 Dissemination Areas (DAs), the average coverage of formally designated Protected Areas was relatively low, at just 0.83%, with a median value of 0%. This suggests that the majority of DAs contain no legally protected land, although a few DAs (maximum: 83%) are largely or entirely encompassed by parks or ecological reserves. The high standard deviation (5.38%) further reflects this skewed distribution.

In contrast, areas designated under Natural Emphasis Conservation, which includes protected areas as well as land categorized with High or Intermediate Biodiversity Emphasis (BEO), were more widespread. The average coverage was 79.0%, with a median of 100%, indicating that many DAs fall entirely within conservation-prioritized zones. However, the substantial standard deviation (39.1%) reveals a split between areas with full conservation emphasis and others with none at all.

Land Use Change Indicators

Land use change indicators present a more heterogeneous pattern. The BEC zone change metric, which captures ecological transitions in biogeoclimatic classifications between historical and current maps, had a mean of 10.6%, with extreme variation across DAs (SD: 25.8%). While the median was 0%, some DAs experienced near-complete (100%) shifts, suggesting concentrated zones of ecological transformation.

Indicators capturing the conversion of natural land to developed uses provide insight into landscape pressures. The Forest to Settlement transition averaged 4.13%, while Natural to Settlement (combining forest, grassland, and wetland loss) averaged 3.98%. Both measures had skewed distributions, with medians well below the mean, and a small number of DAs experiencing transitions exceeding 30% of their area. Forest to Cropland conversions were less common (mean: 0.08%, max: 14.3%), concentrated in agricultural valleys and rural expansion zones.

Tourism-Attributed GHG Emissions

Tourism-related greenhouse gas (GHG) emissions, estimated using sectoral attribution factors and downscaled to the DA level, revealed distinct patterns by sector. On average, transportation emissions were the highest, at 78.3 tonnes CO₂e/year, followed by waste (15.7 tonnes/year) and energy (8.1 tonnes/year). However, these averages mask sharp contrasts: for example, GHG from transport ranged from 0 to over 3,800 tonnes/year per DA, reflecting the spatial concentration of traffic and tourism intensity. Similar dispersion was noted in the waste and energy sectors, with large differences between low-density rural areas and high-activity tourism nodes.

Socio-Cultural Indicators – heritage presence and recreation potential

Socio-cultural indicators revealed the presence of Indigenous communities in central and northern portions of the region, with several DAs intersecting with First Nations administrative centers. DAs with recognized cultural or historical heritage, such as designated

historic places, fossil zones, and historic trails, were more evenly distributed but showed concentration in older settlement areas and those along legacy transportation routes.

Recreation-related indicators (e.g., scenic viewpoints, recreational infrastructure) showed elevated values in mountainous and lakeside areas, particularly in DAs associated with provincial parks or scenic corridors. This distribution reflected both natural features and tourism development patterns, indicating a spatial link between natural amenities and cultural heritage value.

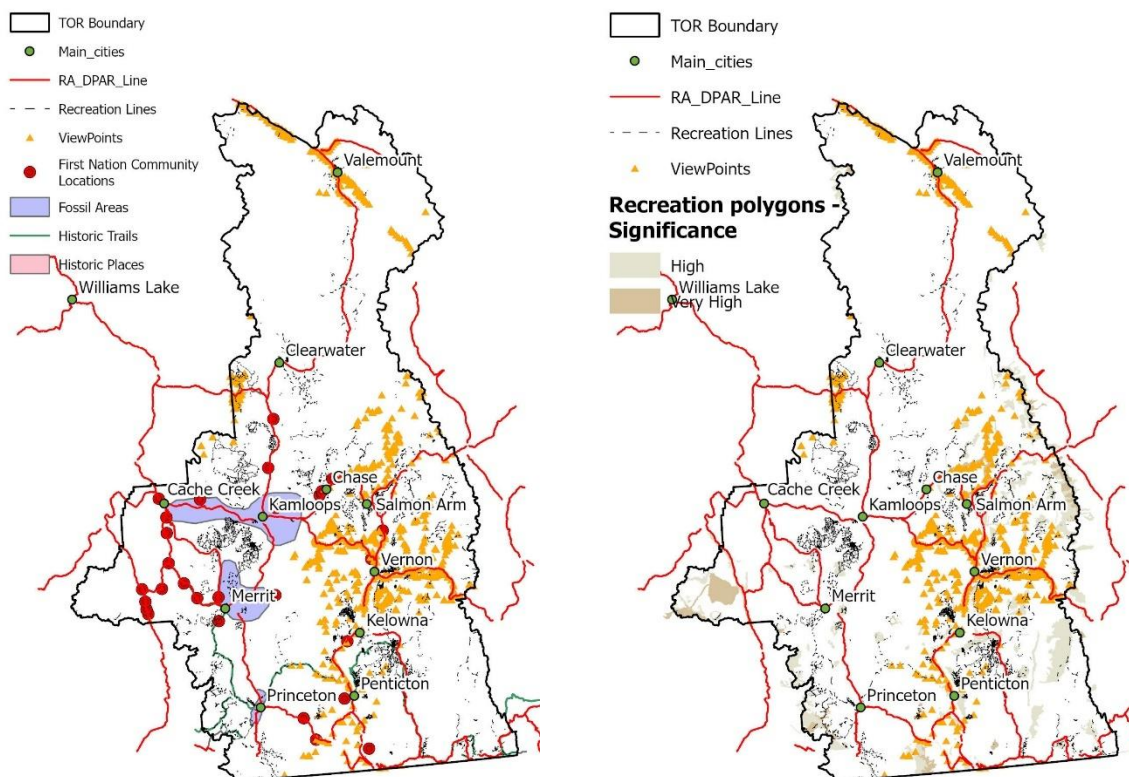


Figure 4.7: Socio-cultural and Recreation-related indicators distribution

Socio-Cultural Indicators Summary

The socio-cultural indicators assessed in this study reflect the presence of Indigenous communities, cultural heritage assets, and recreation-related infrastructure across the Thompson-Okanagan Region. All data were aggregated to the Dissemination Area (DA) level,

enabling spatially disaggregated insights into how cultural and community features are distributed throughout the territory.

Table 4.2: Socio-cultural indicators summary

	First Nations Communities Location (Count)	Fossil areas (%)	Historic places (%)	Historic trails (length)	Recreation lines (length)	Recreation polygons (%)	Viewpoints (count)
Mean	0.03	17.93	0.58	0.63	12.58	8.98	0.80
Median	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Standard Deviation	0.16	37.79	3.78	5.00	74.97	25.23	4.75
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	1.00	100.00	96.24	80.95	1495.83	100.00	88.00

Indigenous Presence

The presence of First Nations communities was represented through a binary or count-based indicator derived from point locations of administrative and residential First Nations centers. While most DAs did not include a community location (mean: 0.03, median: 0), a small subset of DAs did intersect with official First Nations community points. The maximum recorded value was 1, confirming that in all cases, at most one recognized First Nations location was situated per DA. This spatial sparseness highlights both the low number of officially mapped community points and the concentration of Indigenous administrative areas in specific zones of the region.

Cultural Heritage Sites

Fossil area coverage had a mean of 17.93%, but a highly skewed distribution (SD: 37.79%, median: 0%), with many DAs containing no fossil areas, and others reaching 100% coverage. This suggests that paleontological significance is concentrated in a few key zones.

Historic places coverage was similarly sparse in most DAs (mean: 0.58%, median: 0%), with a few DAs having high concentrations of officially recognized cultural sites (up to 96.2% of the DA area), mainly in urban centers.

Historic trail length also demonstrated high variability, with most DAs showing no measurable trail length (median: 0), but some containing trail networks exceeding 80 km within a single DA.

These results suggest that officially designated cultural heritage assets are geographically concentrated, and many communities may lack visible or documented recognition of their cultural history within these official datasets.

Recreational and Scenic Infrastructure

Recreation lines (e.g., trails, access routes) showed considerable variability, with a mean length of 12.6 km per DA and a maximum of nearly 1,500 km. This indicates a highly uneven distribution, with key corridors and parks containing dense networks of trails.

Recreation polygons (areas of high or very high recreation potential) had an average coverage of 8.98% per DA, with some DAs reaching full coverage (100%). The large standard deviation (25.2%) again underscores the spatial heterogeneity of recreation opportunities.

Scenic viewpoints ranged from 0 to 88 per DA, with a mean of 0.8 and a high standard deviation (4.75). This reflects the clustering of visual amenities along key tourism corridors, highways, and protected landscapes.

These indicators collectively highlight the selective and clustered nature of cultural and recreational assets across the region. While some DAs, particularly those near parks, trails, or heritage towns, have high scores across several indicators, many DAs, particularly those with urban or agricultural character, contain none of these socio-cultural features.

Economic Indicators – employment, visitor flows and tourism infrastructure

Employment in tourism-related sectors (NAICS 71 and 72), retrieved from the 2011, 2016, and 2021 censuses, revealed growth over time in most DAs, with higher values in major urban areas and tourism hubs.

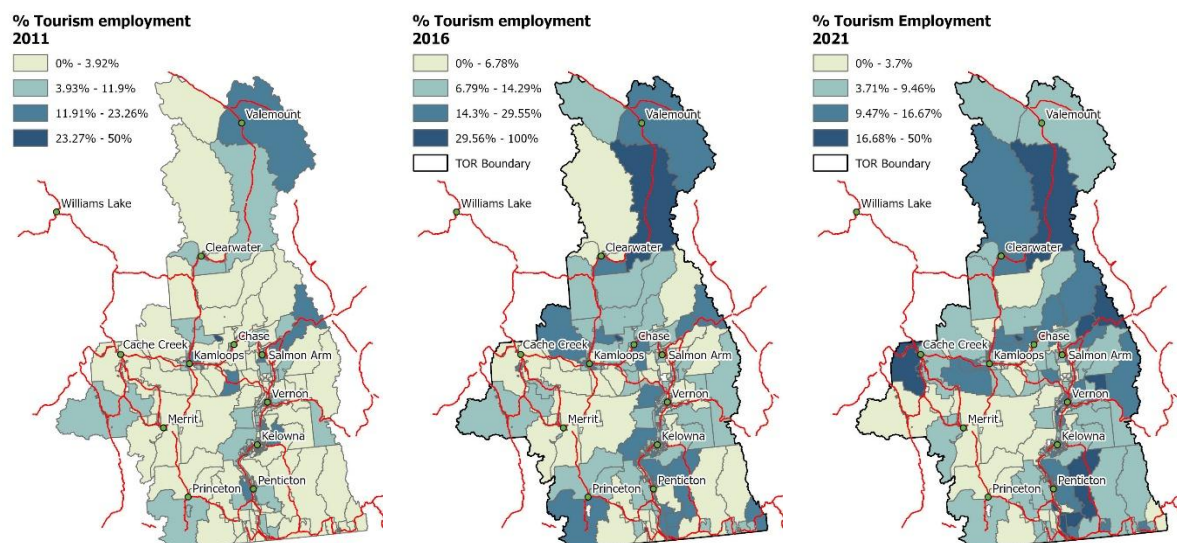


Figure 4.8: Employment in tourism-related sectors. 2011, 2016 and 2021 censuses

Tourism infrastructure was densest in urban and resort-oriented DAs, particularly around Kelowna, Penticton, Vernon, and Kamloops. The concentration of accommodations, visitor services, and attraction listings (from HelloBC and the Open Database of Business Units) confirmed the economic specialization of these areas in tourism services. Rural DAs exhibited more sparse infrastructure but, in some cases, had high relevance due to the presence of key tourism assets (e.g., wineries, golf courses, ski resorts).

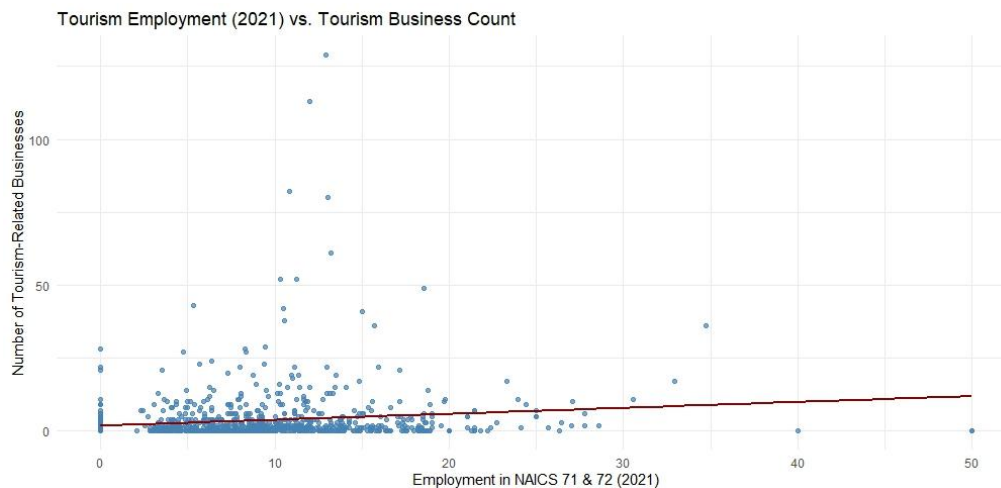


Figure 4.9: Tourism employment (2021) vs. Tourism Business Count

Modelled estimates of visitor flows and spending, produced via spatial regression kriging of travel survey data, showed similar spatial patterns, confirming the tourism intensity of central corridors and lake-adjacent DAs.

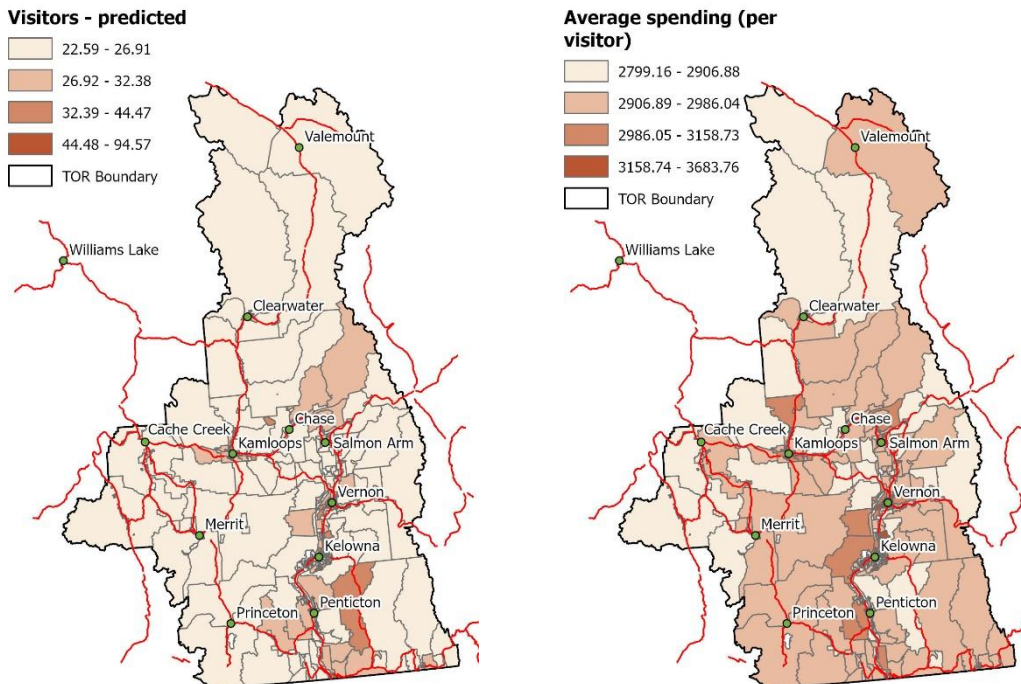


Figure 4.10: Modelled estimates of visitor flows and average spending per visitor

Economic Indicators Summary

To explore the economic dimension of tourism sustainability across the Thompson Okanagan Region, a series of indicators were analyzed at the Dissemination Area (DA) level. These indicators include average spending per visitor, estimated number of visits, percentage of the labour force employed in tourism-related sectors for the years 2011, 2016, and 2021, and the number of tourism-related businesses.

Table 4.3: Economic Indicators Summary

	Avg spending per visitors	Estimated visits	% Employees Tourism 2011	% Employees Tourism 2016	% Employees Tourism 2016	Business count
Mean	2672.20	24.41	5.63	10.36	8.01	3.42
Median	2914.53	25.69	0.00	10.14	7.69	1.00
Standard Deviation	838.18	8.51	7.44	7.50	6.51	8.82
Minimum	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	3683.76	94.57	50.00	100.00	50.00	129.00

The average spending per visitor across all DAs was approximately \$2,672, with a median of \$2,914. This relatively high median value, exceeding the mean, suggests a slightly left-skewed distribution, where a small number of DAs reported considerably lower spending levels. The minimum value of \$0 highlights the existence of DAs with no recorded or modelled visitor spending, which may indicate non-touristic zones or modelling limitations due to low visitation or business presence. In contrast, the maximum recorded value of \$3,684 corresponds to high-value tourism nodes, likely characterized by premium services such as resorts, wineries, or ski destinations. The relatively large standard deviation (\$838) underscores the spatial disparities in tourism spending across the region.

The estimated number of visits per DA follows a relatively symmetrical distribution, with a mean of 24.4 and a median of 25.7 visits. The presence of DAs with zero estimated visits again reflects areas with little to no tourism activity, while others recorded up to 95 visits,

positioning them as key tourism hubs. These high-visit areas are of particular interest for sustainability planning, as they likely bear the highest tourism pressures.

Tourism employment, measured as the percentage of the labour force working in sectors defined by NAICS codes 71 (Arts, Entertainment, and Recreation) and 72 (Accommodation and Food Services), was evaluated for the years 2011, 2016, and 2021. In 2011, the mean percentage of tourism employment was 5.63%, with a median of 0%, indicating that many DAs had no reported employment in these sectors. By 2016, the mean had increased substantially to 10.36%, and the median rose to 10.14%, reflecting a regional expansion of the tourism sector prior to the COVID-19 pandemic.

However, in 2021, the mean declined to 8.01%, and the median dropped slightly to 7.69%. This reduction likely reflects the pandemic's impact on the tourism industry, which experienced significant contractions in employment and operations during this period. The variability in the data is considerable across all years, with standard deviations exceeding 6 percentage points, suggesting significant heterogeneity in tourism employment between DAs. Notably, the maximum values reached 50% in 2011 and 2021, and 100% in 2016, the latter likely corresponding to small DAs where the tourism sector accounted for the entirety of recorded employment.

The number of tourism-related businesses per DA exhibited high variation. While the mean was 3.42 businesses per DA, the median was only 1, and the maximum reached 129. These figures suggest that most DAs have a very limited tourism-related business presence, whereas a small number of urban or commercial nodes concentrate a substantial share of the regional tourism infrastructure. The standard deviation (8.82) further highlights the disparity in business distribution, with tourism-related economic activity highly concentrated in a few key areas.

Based on the data analysis, it was found that there is a difference in the geographic distribution in the status of sustainable tourism in rural communities versus small towns in the Thompson Okanagan Region, as queried by research question 2. Together, these indicators confirm that the tourism economy in the Thompson Okanagan Region is spatially uneven. A

limited number of DAs concentrate the majority of visitor activity, employment, and business infrastructure, while others remain largely disengaged from the tourism sector.

These findings underscore the importance of place-based planning approaches that recognize this heterogeneity and support both the management of tourism pressure in high-activity areas and the development of underrepresented areas with tourism potential, as research question 3 wanted to demonstrate, observing the value in the use of GIS technology to highlight these differences.

4.2 Bottom-Up approach: Stakeholders' Georeferenced Survey Results

As part of the bottom-up approach to assessing tourism sustainability, an online survey was conducted targeting stakeholders in the tourism sector across the Thompson Okanagan Region. The objective was to gather insights into stakeholder perceptions regarding sustainable tourism practices and to evaluate their familiarity with, and attitudes toward, the use of Geographic Information Systems (GIS) as a tool to support sustainability planning and monitoring.

The bottom-up analysis allowed the researcher to answer research questions 4 and 5 by evaluating the perceptions and attitudes of stakeholders. The questions are as follows:

- RQ4: What are the perceptions of stakeholders on the extent of sustainable tourism in the Thompson Okanagan Region, with a focus on their familiarity and implementation of sustainable practices in the use of natural resources?
- RQ5: What are the tourism business stakeholders' attitudes towards providing information that allows GIS to monitor sustainability in the Thompson Okanagan Region?

The data were analyzed using SPSS, with procedures including data cleaning, reliability testing (Cronbach's Alpha) for Likert scale questions, index construction, and

recoding into categorical variables to facilitate interpretation. Multiple-response questions were aggregated to identify the most frequently reported practices or attitudes.

Demographics

The respondents represented a range of tourism-related businesses, including accommodations, restaurants, wineries, attractions, and tour services. Most were small to medium-sized enterprises, consistent with the region's business landscape. Most of the responses were concentrated in the more populated and touristic DAs, though the sample also included businesses located in more rural areas.

Table 4.4: Stakeholder Survey – Demographics of Survey Respondents and Company Information

Type of company	Frequency	Percent	Valid Percent	Cumulative Percent
Hotel	7	14.89	14.89	14.89
Restaurant	3	6.38	6.38	21.28
Winery	9	19.15	19.15	40.43
Other	28	59.57	59.57	100.00
Total	47	100.00	100.00	
Type of position	Frequency	Percent	Valid Percent	Cumulative Percent
Owner	15	31.91	31.91	31.91
Supervisor	22	46.81	46.81	78.72
Representative	4	8.51	8.51	87.23
Service support	2	4.26	4.26	91.49
Prefer not to answer	4	8.51	8.51	100.00
Total	47	100.00	100.00	
Employment status	Frequency	Percent	Valid Percent	Cumulative Percent
Other (please specify)	7	14.89	14.89	14.89
Part-time position	3	6.38	6.38	21.28
Full-time position	35	74.47	74.47	95.74
Various positions at various periods of time	1	2.13	2.13	97.87
Prefer not to answer	1	2.13	2.13	100.00

Total	47	100.00	100.00	
Respondent identification as	Frequency	Percent	Valid Percent	Cumulative Percent
Female	21	44.68	47.73	47.73
Male	23	48.94	52.27	100.00
Total	44	93.62	100.00	
Missing	3	6.38		
Total	47	100		
Level of education	Frequency	Percent	Valid Percent	Cumulative Percent
High school or less	1	2.13	2.27	2.27
Post-secondary school (university/college)	27	57.45	61.36	63.64
Registered Apprenticeship or another Certificate or Diploma	7	14.89	15.91	79.55
Graduate school (Master's/Doctorate) or Professional Advance Degree	9	19.15	20.45	100.00
Total	44	93.62	100.00	
Missing	3	6.38		
Total	47	100		
Age group	Frequency	Percent	Valid Percent	Cumulative Percent
18-24	2	4.26	4.55	4.55
25-34	3	6.38	6.82	11.36
35-44	10	21.28	22.73	34.09
45-54	12	25.53	27.27	61.36
55-64	10	21.28	22.73	84.09
65 and over	7	14.89	15.91	100.00
Total	44	93.62	100.00	
Missing	3	6.38		
Total	47	100		
Time of residence in the area	Frequency	Percent	Valid Percent	Cumulative Percent
5 years or less	7	14.89	15.91	15.91
6-9 years	11	23.40	25.00	40.91
10-14 years	5	10.64	11.36	52.27

15-19 years	6	12.77	13.64	65.91
20-24 years	1	2.13	2.27	68.18
25 or more years	14	29.79	31.82	100.00
Total	44	93.62	100.00	
Missing	3	6.38		
Total	47	100.00		

Stakeholders' Perceptions on Sustainability, Familiarity, and Implementation of Sustainable Practices

Descriptive analysis of the responses revealed different perceptions about sustainability and varied levels of engagement with sustainable practices. For example, many businesses reported implementing initiatives related to water conservation, energy efficiency, waste management, and carbon reduction. However, the level of adoption varied significantly across respondents. Notably, practices such as sourcing from local suppliers and engaging in visitor education about sustainability were less consistently implemented.

In general, stakeholders report feeling well-informed about sustainable practices, with 80.85% of respondents indicating a positive level of awareness, compared to 17.02% who stated that they do not feel adequately informed. However, when asked to assess their familiarity with specific practices related to the management of natural resources, the responses reveal a more nuanced pattern, suggesting variability in knowledge depending on the type of practice considered.

Familiarity with Sustainable Practices

A majority of respondents reported medium (39.1%) or high (37.0%) familiarity with sustainable practices, while approximately 24% reported low familiarity.

This distribution indicates a relatively positive level of awareness across the tourism industry in the region, though nearly one-quarter of respondents still lack basic familiarity, highlighting a potential target group for capacity-building or training initiatives.

Implementation of Water, Energy, and Waste Practices

Water management practices were moderately implemented, with 38.6% reporting high implementation and 45.5% indicating medium. Only 15.9% reported low implementation. Energy management exhibits a similar pattern, albeit slightly lower on the high end: 51.1% medium, 40.4% high, and only 8.5% low, indicating that it is among the more consistently implemented categories. Waste management practices, particularly general waste management and food waste reduction, show divergent patterns. While 59.6% of respondents reported high implementation of general waste management, food waste practices had the lowest rate of high implementation (28.3%) and the highest percentage of low implementation (28.3%), indicating a significant implementation gap.

Carbon Reduction Practices

Responses regarding carbon reduction efforts were more balanced, with 56.7% at the medium level, 31.2% at the high level, and 12% at the low level. This may reflect both an intermediate level of awareness and challenges in translating intentions into concrete carbon-reducing actions, which often require more specialized knowledge or resources (e.g., tracking emissions, retrofitting buildings, or shifting transportation modes).

The responses regarding distances to local suppliers and workplaces reveal distinct patterns in spatial accessibility for tourism stakeholders. When asked about the distance to local farms, markets, or suppliers, a majority of respondents (77.8%) reported living within 20 kilometers, with 28.9% located within 5 kilometers and an additional 48.9% within the 6–20 km range. A smaller proportion (15.6%) indicated traveling between 21 and 50 kilometers, while no respondents reported distances greater than 50 kilometers. Only 2.2% were unsure.

For other types of local product markets or suppliers, a similar distribution is observed, with 66.7% reporting access within 20 kilometers. However, a notable 13.3% reported distances exceeding 51 kilometers, suggesting that some specialized products may require travel beyond the immediate region. Again, 6.7% were unsure of the distance.

In terms of commuting from home to the workplace, accessibility appears slightly more concentrated. A combined 57.8% of respondents reported commuting less than 10 kilometers (28.9% within 5 km and 28.9% between 6–10 km), while 15.6% commute between 11 and 20 kilometers. Interestingly, 17.8% selected “Other,” which may indicate flexible work arrangements (e.g., remote work or mobile operations typical of tourism roles). No respondents reported being unsure of their commuting distance. These patterns could indicate that access to the workplace is predominantly within short commuting distances, suggesting localized employment patterns.

Table 4.5: Distances expressed by respondents regarding local consumption and commuting distances

Distances	How far away are the local farms/markets/suppliers on average		How far away are the other type of products local markets/suppliers on average		What is the distance or how long does it take you to get from your home to your place of work?	
	Responses		Responses		Responses	
Not sure / don't know	2.2%	1	6.7%	3	0.0%	0
Within 5 kilometers (less than 10 minutes by car, approximately)	28.9%	13	24.4%	11	28.9%	13
6 – 10 kilometers (11 – 15 minutes by car, approximately)	20.0%	9	24.4%	11	13.3%	6
11 – 20 kilometers (16 – 20 minutes by car, approximately)	28.9%	13	17.8%	8	15.6%	7
21 - 50 kilometers (21 - 60 minutes by car, approximately)	15.6%	7	8.9%	4	15.6%	7
More than 51 kilometres (more than 1 hour by car, approximately)	0.0%	0	13.3%	6	8.9%	4
Other (please specify)	4.4%	2	4.4%	2	17.8%	8
	Answered	45	Answered	45	Answered	45

Waste and energy management appear to be the most widely implemented practices, with a majority of respondents indicating medium or high levels of adoption. Conversely, food waste and carbon reduction show greater variance and lower overall implementation, which

may suggest either a lack of practical solutions tailored to the tourism industry or lower prioritization by stakeholders.

The pattern of results suggests a general “middle-ground” engagement: most businesses are aware of sustainability concepts and have adopted some measures, but a relatively small proportion are leaders in advanced or systemic implementation.

The gap between familiarity and high implementation (e.g., ~37% high familiarity vs. only 31% high in carbon reduction, or 28% for food waste) suggests that even familiar stakeholders may face barriers in consistently applying practices. This confirms what the stakeholders indicate about financial constraints with a 71.11% of respondents attributing as a barrier, lack of technical knowledge, or organizational constraints.

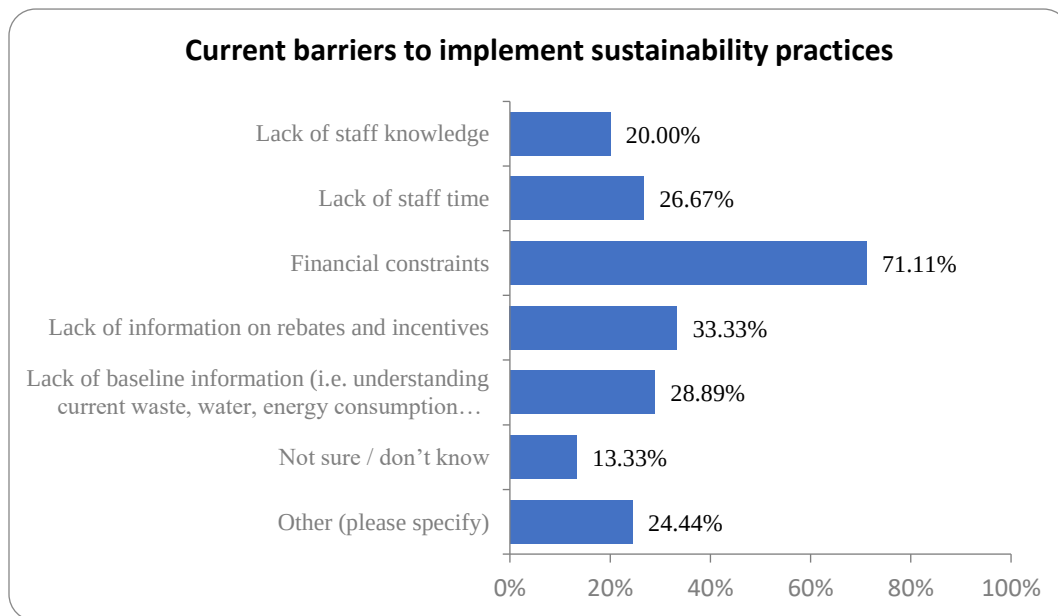


Figure 4.11: Current barriers to implementing sustainability practices expressed by the respondents

Conversely, the data reflect stakeholder perceptions regarding the number of tourists across the four seasons, revealing distinct seasonal patterns in the perceived volume of tourism.

In winter (December to February), a clear majority of respondents (68.89%) felt that too few tourists visit the region during this period, with only 6.67% perceiving the number as excessive and 20.00% indicating it was just right. A small portion (4.44%) were unsure. This

suggests a general consensus that winter tourism in the region is underdeveloped or underutilized.

Spring (March to May) shows a similar trend, with 70.45% of respondents also perceiving too few tourists. Only 2.27% believed there were too many, and 25.00% considered the volume appropriate. This pattern reinforces the idea that the spring season, like winter, is seen as having untapped tourism potential.

In contrast, summer (June to August) received more mixed responses. While nearly half of respondents (48.89%) felt the number of tourists was just right, a significant share (31.11%) still thought there were too few, and 17.78% believed there were too many. These findings suggest summer is the most balanced in terms of perceived tourism volume, though some stakeholders may be concerned about crowding or saturation in peak months.

For fall (September to November), responses once again leaned toward identifying an underutilized season, with 68.18% perceiving too few tourists. Only 4.55% indicated an excess of visitors, and 25.00% considered the volume adequate.

Even with the small sample in relation to tourism businesses in the region, these findings suggest an opportunity to enhance capacity-building programs, particularly in areas such as food waste management and carbon reduction, where implementation remains limited. Tailored technical assistance, incentives for infrastructure upgrades, and targeted education campaigns may be needed to move medium-level implementers into the high category. The relatively strong performance in energy and general waste practices suggests a base of successful strategies that could be scaled or replicated in less advanced areas.

Detailed data and responses graphics can be found in the **Appendix 4 – Survey responses and detailed graphics**.

Attitudes towards using Geographic Information Systems

Regarding the use of GIS and digital mapping platforms, the results indicated moderate levels of familiarity. While many respondents reported using tools such as Google Maps for basic navigation and promotional purposes, fewer reported using GIS platforms for operational or strategic purposes. Despite this, the majority recognized the potential value of using spatial tools to better understand visitor flows, environmental impacts, and tourism asset distribution.

Stakeholder Familiarity and Perceived Value of GIS Tools in Tourism Sustainability

To assess the role of Geographic Information Systems (GIS) in tourism management, the stakeholder survey included a series of questions related to the frequency of GIS use, the extent to which stakeholders use GIS to assist visitors, and the perceived value of GIS in supporting sustainability monitoring. Table 4.6: Stakeholder Familiarity and Perceived Value of GIS Tools in Tourism Sustainability summarizes the responses categorized into low, medium, and high levels, with an additional category capturing non-responses.

Table 4.6: Stakeholder Familiarity and Perceived Value of GIS Tools in Tourism Sustainability

	Frequency GIS Use	Frequency GIS Help visitors	Value on using GIS to map sustainability
Low	14.90%	23.40%	19.10%
Medium	48.90%	51.10%	34.00%
High	29.80%	19.10%	40.40%
Missing	6.40%	6.40%	6.40%

Frequency of GIS Use

Approximately 48.9% of respondents reported medium-level use of GIS tools in their business operations, while 29.8% indicated high usage, and 14.9% reported low usage. This suggests that while GIS is moderately integrated into the day-to-day operations of many tourism businesses, a significant portion still uses it infrequently or not at all. The relatively high proportion of medium and high responses reflects the growing accessibility of mapping tools such as Google Maps or booking platforms that incorporate geolocation.

GIS for Supporting Visitor Orientation

When asked whether they use GIS tools to assist visitors, such as offering digital maps, directions, or spatially organized information about attractions, 51.1% of respondents reported medium engagement, and 23.4% indicated low engagement, while only 19.1% reported high use. This distribution reveals that the role of GIS in enhancing visitor experience remains limited among most businesses, particularly in smaller or less technologically advanced operations. There may be untapped potential for enhancing visitor services and interpretation by utilizing spatial tools more effectively.

Perceived Value of GIS for Mapping Sustainability

The perceived value of GIS in contributing to sustainability efforts was notably higher than current levels of use. 40.4% of respondents considered GIS to have high value in visualizing sustainability indicators and monitoring practices. A further 34.0% assigned it a medium value, while only 19.1% considered its value low. This contrast between perceived importance and actual usage suggests that many stakeholders recognize the potential of GIS but may lack the resources, training, or integration strategies to implement it effectively.

There is a clear gap between the perceived importance of GIS for sustainability and its actual use in practice, particularly in supporting visitor experiences.

Most businesses are situated at a medium level of engagement, suggesting a good baseline from which to promote more advanced GIS applications. Targeted support programs, training sessions, or demonstration platforms may help convert positive perceptions into tangible adoption, especially for small businesses with limited capacity. Enhancing GIS usage for sustainability mapping, visitor support, and operational planning aligns with stakeholder values and could improve monitoring, transparency, and public engagement at the local level.

Towards the MCA Analysis

Three questions (Q22, Q23, and Q24) asked respondents to assess the relative importance of environmental, socio-cultural, and economic sustainability dimensions. These were rated on a scale from 0 to 100, with results indicating strong support for the relevance of all three dimensions. The average scores were as follows:

Environmental dimension: 58.5%

Socio-cultural dimension: 66.5%

Economic dimension: 69.2%

These responses were later used to inform the weighting scheme in the Multi-Criteria Assessment (MCA), providing a participatory basis for integrating stakeholder values into the sustainability scoring process.

In addition to informing the MCA model, the georeferenced survey results allow for spatial analysis of sustainability perceptions. Although the sample size is limited in relation to the total number of tourism businesses in the region, this bottom-up component adds valuable qualitative depth and local knowledge to the otherwise top-down sustainability assessment framework. Moreover, the data demonstrate the potential of combining stakeholder input with spatial modelling to improve evidence-based decision-making in tourism planning.

4.3 Multi-Criteria Assessment – Sustainability Assessment

This section presents the results of the Multi-Criteria Assessment (MCA) used to evaluate the sustainability of tourism at the Dissemination Area (DA) level across the Thompson Okanagan Region. The MCA integrates a series of environmental, socio-cultural, and economic indicators derived from spatial and statistical sources, processed through a structured normalization, weighting, and aggregation procedure.

The multi-criteria assessment allowed the researcher answer research questions 1 and 2 by integrating the geographic analysis and the survey's selected questions to score sustainability dimensions and build an index for sustainability assessment. The questions are as follows:

- RQ1: What is the status of Sustainable Tourism in the municipalities of the Thompson Okanagan Region?
- RQ2: What is the difference and geographic distribution in the status of sustainable tourism in rural communities versus small towns in the Thompson Okanagan Region?

The main objective of the MCA is to synthesize complex and multidimensional data into composite sustainability scores that can support evidence-based decision-making, identify spatial disparities, and reveal potential trade-offs between sustainability dimensions.

Dimension Scores and Composite Index

For each DA, three sub-indices were calculated:

- Environmental Sustainability Score: Aggregated from seven environmental indicators.
- Socio-Cultural Sustainability Score: Based on six cultural and heritage-related indicators.
- Economic Sustainability Score: Derived from seven indicators of tourism employment, infrastructure, and modelled visitor flows.

Each sub-score was initially calculated as an unweighted average of its component indicators, and subsequently as a weighted average, incorporating the scores derived from the survey responses. These dimension-specific scores were then combined into a Composite Sustainability Index, reflecting the overall sustainability performance of each DA.

The results of the MCA were mapped to visualize the spatial distribution of sustainability scores. These maps reveal clear geographic patterns: higher environmental

scores are often associated with DAs that overlap protected areas, biodiversity emphasis zones, or that have low emissions and minimal land use change; socio-cultural scores tend to be higher in areas with significant heritage resources, Indigenous community presence, and visible recreation infrastructure; economic sustainability scores are highest in areas with dense tourism infrastructure, high visitor spending, and substantial employment in the sector. Very few differences were found in the weighted and unweighted results.

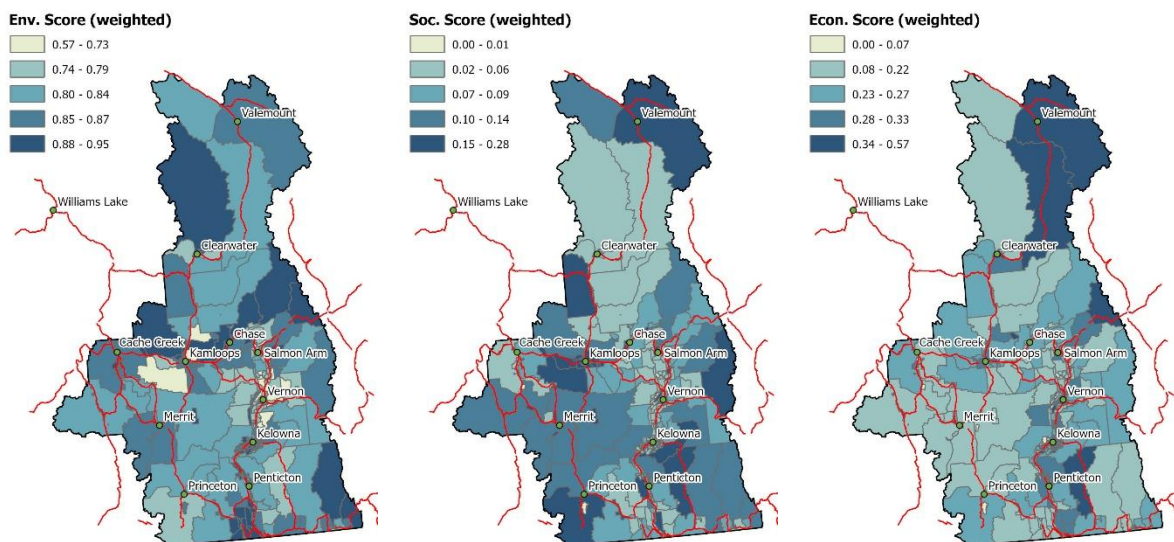


Figure 4.12: Spatial distribution of MCA scores for each sustainability dimension

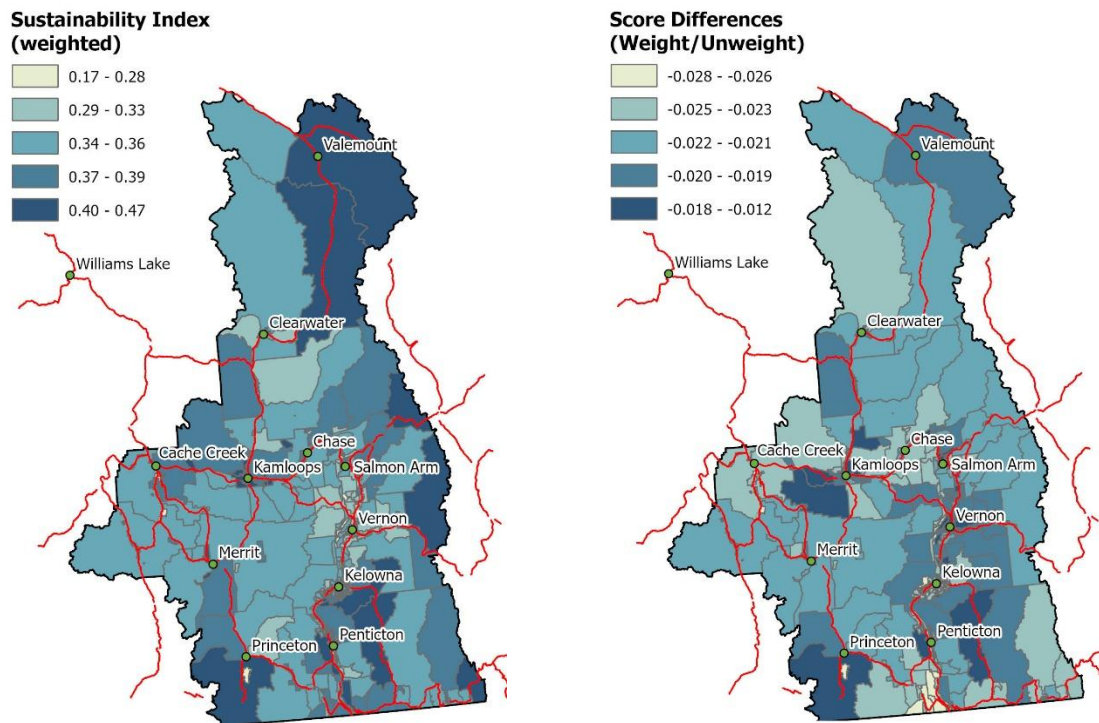


Figure 4.13: MCA Sustainability index, weighted vs unweighted

Descriptive statistics for each sustainability score show a wide range of values across the study area. Some DAs consistently performed well across all dimensions. In contrast, others exhibited high performance in one or two areas and lower scores in others, highlighting potential spatial trade-offs or imbalances between environmental, cultural, and economic components.

Table 4.7: MCA Scores Descriptive Statistics

Dimension	mean	median	sd	min	max
Economic Score	0.23	0.24	0.08	0.00	0.57
Environmental Score	0.82	0.85	0.06	0.57	0.95
Socio-cultural Score	0.07	0.04	0.06	0.00	0.28
Sustainability Index	0.35	0.35	0.04	0.17	0.47

Some insights about these scores are presented below:

Environmental Sustainability

The environmental score presents the highest average value among the three dimensions, with a mean of 0.82 and a median of 0.85. The relatively low standard deviation (0.06) indicates that most DAs perform consistently well in environmental terms, with scores ranging from 0.57 to 0.95. This suggests that many areas benefit from the presence of protected lands, lower emissions, and limited land use conversion, all of which positively contribute to environmental performance. The strong environmental performance across the region reflects regional conservation strategies and low development pressures in some zones.

Economic Sustainability

The economic dimension shows moderate performance, with a mean score of 0.23 and a median of 0.24. The wider standard deviation (0.08) compared to the environmental dimension reflects greater variation in tourism-related employment, infrastructure, and spending across the region. The maximum value (0.57) indicates that a few DAs are highly concentrated with tourism activity, while several areas (minimum = 0.00) remain economically marginal with limited tourism infrastructure or services. This uneven economic distribution reflects a tourism geography centred on a few hubs.

Socio-Cultural Sustainability

The socio-cultural score presents the lowest average across the three dimensions, with a mean of 0.07 and a median of only 0.04. The relatively high coefficient of variation (standard deviation = 0.056) in proportion to the mean indicates that socio-cultural assets are very unevenly distributed, or that there is not enough information for the assessment. Most DAs score close to zero, suggesting that they lack significant cultural heritage features, Indigenous presence, or recreational infrastructure. The maximum value of 0.28 suggests that only a handful of DAs register as strong cultural nodes. This low and skewed distribution highlights the need to map, recognize, preserve, and promote socio-cultural features more effectively in tourism planning.

Composite Sustainability Index

The overall sustainability index, a stakeholder-weighted combination of the three dimensions, has a mean of 0.35 and a median of 0.35, with values ranging from 0.17 to 0.47. The relatively narrow spread ($SD = 0.04$) and the moderate average value suggest that, while environmental sustainability positively impacts the composite score in most DAs, the low socio-cultural and moderate economic scores limit the overall sustainability potential in the region.

Dimension-to-Dimension Correlations

To understand the correlation between dimensions, a Pearson correlation test was used. Table 4.8 presents the Pearson correlation coefficients among the three sustainability dimensions: environmental (env_score), socio-cultural (soc_score), and economic (eco_score), as well as the overall sustainability index. These coefficients measure the degree of linear association between pairs of variables, with values ranging from -1 (perfect negative correlation) to +1 (perfect positive correlation).

The correlation between environmental and socio-cultural scores is low but positive ($r = 0.15$), indicating a slight tendency for areas with higher environmental performance also to have stronger socio-cultural features. However, the weak magnitude suggests that these dimensions are largely independent, and high performance in one does not guarantee performance in the other.

Table 4.8: Pearson's correlation between sustainability scores by dimension

	env_score	soc_score	eco_score	sustainability_index
env_score	1	0.15	0.10	0.57
soc_score	0.15	1	0.02	0.55
eco_score	0.10	0.02	1	0.73
sustainability_index	0.57	0.55	0.73	1

The environmental and economic scores show a similarly weak positive correlation ($r = 0.10$), suggesting that while a few areas may perform well in both dimensions, there is no strong association between economic vitality and environmental protection across the study region. This may indicate spatial trade-offs or distinct underlying geographies for economic versus ecological functions.

The socio-cultural and economic scores exhibit the lowest correlation ($r = 0.02$), indicating virtually no linear relationship between these two dimensions. This suggests that socio-cultural richness (e.g., historic or Indigenous presence) and tourism-related economic development tend to occur in different places, or that these aspects are not jointly prioritized in planning and investment.

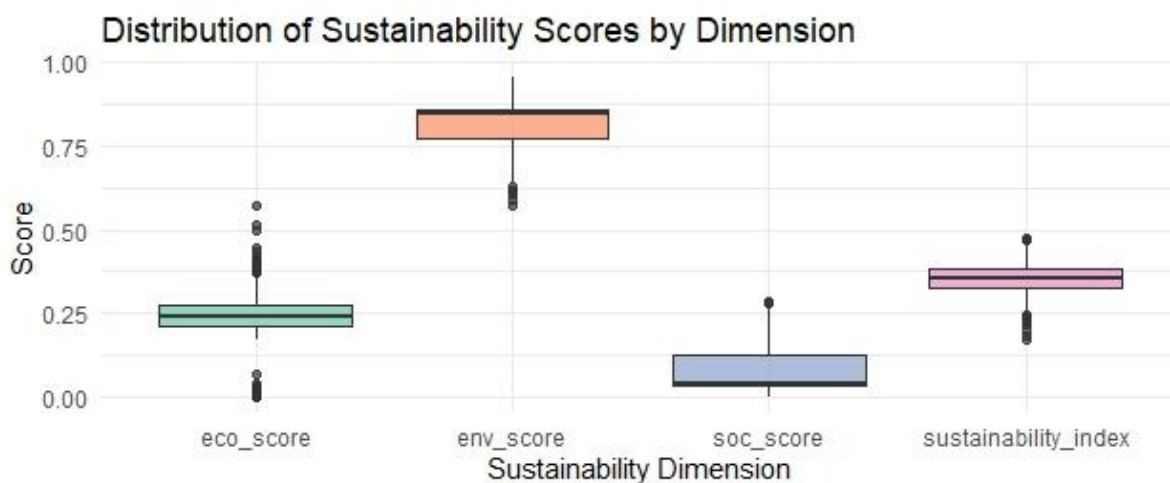


Figure 4.14: Distribution of sustainability scores by dimension

All three-dimension scores are positively correlated with the sustainability index, which is expected given that the index is derived as a weighted combination of them. The economic score shows the strongest correlation with the overall sustainability index ($r = 0.73$), indicating that economic performance is the most influential dimension in determining composite sustainability scores under the current weighting scheme. This is consistent with the survey-based weights, which gave the economic dimension the highest relative importance.

The socio-cultural score is also moderately correlated ($r = 0.55$) with the sustainability index, indicating that it makes a meaningful contribution to the overall composite score, particularly in areas where cultural or recreational features are present.

The environmental score exhibits a moderate correlation ($r = 0.57$) with the sustainability index, indicating its relatively high values across most DAs, but a lower weight in the MCA framework. This suggests that while environmental conditions are strong, they may have less influence on the final score compared to the more variable and heavily weighted economic and socio-cultural dimensions.

Comparison with Stakeholder Perceptions

A comparison was conducted between MCA scores and stakeholder responses to explore potential alignment or dissonance between top-down sustainability outcomes and perceived realities. Results indicate that in many areas, stakeholder perceptions of sustainability correlate well with the composite scores, especially in high-performing DAs. However, notable mismatches were also identified in some areas, particularly where environmental performance was low but economic activity was high.

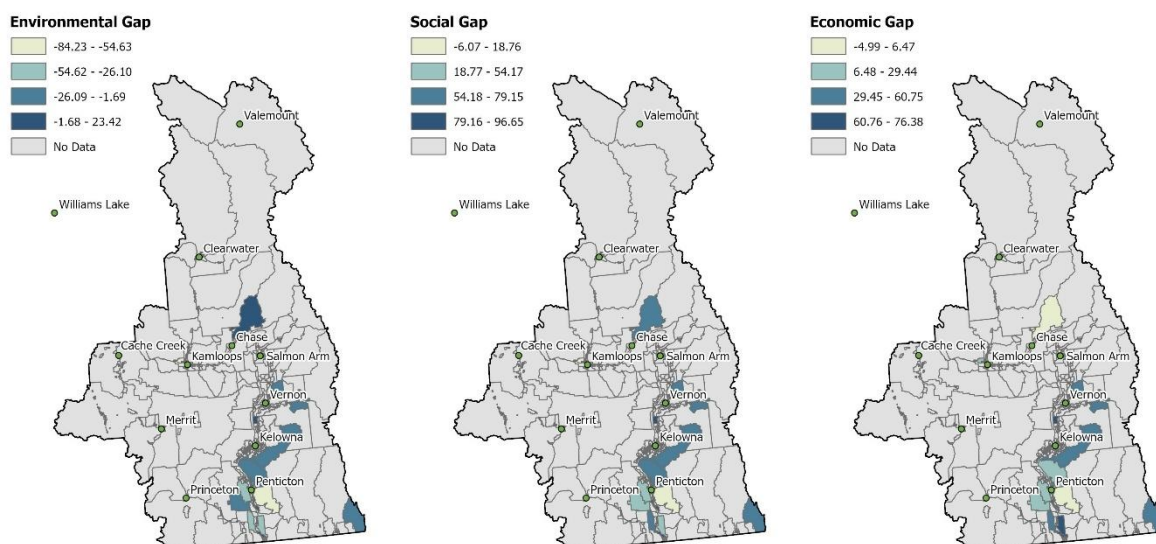


Figure 4.15: Gaps identified between the MCA assessment and the stakeholders' perceptions on sustainability

The analysis of the perception gap compares stakeholders' subjective evaluations of sustainability with the objective scores derived from the Multi-Criteria Assessment (MCA). The values are expressed as percentages, indicating the relative difference between perceived and computed sustainability at the Dissemination Area (DA) level. A positive gap suggests that stakeholders perceive sustainability to be higher than what the indicators objectively reflect, potentially indicating optimism, familiarity bias, or limited awareness of underlying challenges. Conversely, a negative gap implies that stakeholders perceive sustainability to be lower than the measured conditions, which may highlight unmet expectations, lack of communication regarding initiatives, or distrust in local performance. These gaps offer critical insights into areas where perceptions align with or diverge from empirical evidence, informing strategies for stakeholder engagement, communication, and policy refinement.

These discrepancies highlight the value of integrating bottom-up perspectives into regional assessments, as they provide qualitative insights that complement quantitative models and help inform more inclusive and context-sensitive planning strategies.

Chapter 5 Discussion and Conclusions

This chapter presents an analysis of the key findings of the research, including the research questions, theoretical framework, and existing literature on sustainable tourism and geographic information analysis. Drawing on the results from the top-down and bottom-up approaches, including the integration of spatial indicators and stakeholder perceptions through Multi-Criteria Assessment (MCA), the discussion explores the implications of observed patterns, correlations, and gaps. The aim is to critically interpret the outcomes, highlight the strengths and limitations of the methodology, and reflect on the broader significance of using GIS-based tools for sustainability assessment in tourism regions. Through this lens, the discussion contributes to a deeper understanding of the dynamics shaping sustainable tourism in the Thompson Okanagan Region.

This study successfully addressed all five research questions, while also recognizing the limitations discussed earlier, by delivering a comprehensive, fine-scale assessment of sustainable tourism in the Thompson Okanagan Region.

In response to the first research question: “RQ1: What is the status of Sustainable Tourism in the municipalities of the Thompson Okanagan Region?”, the analysis revealed clear variation in sustainability across census dissemination areas (DAs), as measured through dimension-specific scores and a composite index. The composite index ranged from approximately 0.20 to 0.50, reflecting significant disparities in how sustainability is manifested across the region. Areas with higher indices tended to combine environmental strengths, such as conservation coverage and lower emissions, with economic activity that generated tourism-related employment for local residents. By contrast, areas with lower indices were often characterized by limited tourism investment and employment, substantial land-use change, or influences from industries other than tourism, such as construction. In some cases, low scores were also a result of missing or incomplete data, particularly in small or predominantly residential DAs that lacked direct connections to tourism activity. These findings highlight both the uneven distribution of sustainable tourism and the importance of integrating diverse indicators to capture local realities.

In relation to the second research question: “RQ2: What is the difference and geographic distribution in the status of sustainable tourism in rural communities versus small towns in the Thompson Okanagan Region?”, the analysis revealed notable differences in sustainability index performance between rural and urban settings, though these differences are shaped by multiple sectors beyond tourism alone. Rural areas with significant tourism activity often demonstrate higher sustainability indices, as investments in these territories tended to exert less pressure on environmental conditions or cultural assets, while simultaneously attracting higher-spending visitors and generating employment opportunities for local residents. By contrast, some urban and peri-urban areas, despite possessing established tourism infrastructure, exhibited lower or medium sustainability scores due to limited evidence of corresponding visitor spending or local employment benefits. From a policy perspective, this finding is particularly relevant: the region holds a wealth of underutilized tourism resources in dispersed rural areas, suggesting that targeted investment in such locations could enhance sustainability outcomes while reducing the risks of overconcentration and industry saturation in already developed hubs.

In addressing the third research question: “RQ3: What value does GIS technology offer to potentially measure gaps in sustainable tourism components?”, the study demonstrated the considerable utility of Geographic Information Systems (GIS) in identifying, mapping, and analyzing the components of tourism sustainability. By integrating economic, environmental, and socio-cultural information at a consistent level of spatial disaggregation, such as the Dissemination Area (DA), GIS enabled a complex evaluation of territorial conditions that would otherwise remain uneasy. A further contribution lies in the capacity of GIS to incorporate stakeholder perceptions at the same geographic scale, allowing for a meaningful comparison between objective indicators and the subjective insights of those directly engaged in the tourism sector. This dual perspective provides a more holistic understanding of sustainability, reinforcing the role of GIS as a powerful decision-support tool that can highlight gaps, visualize trade-offs, and guide more informed and context-sensitive strategies.

In response to the fourth research question: “RQ4: What are the perceptions of stakeholders on the extent of sustainable tourism in the Thompson Okanagan Region, with a focus on their familiarity and implementation of sustainable practices in the use of natural

resources?”, the survey results provided valuable, if limited, insights. Despite the relatively small number of responses, stakeholders generally reported being well-informed about sustainable practices. However, closer analysis revealed variability in both familiarity and implementation depending on the type of practice. While waste and water management were widely adopted, practices such as carbon reduction and food waste management were less consistently implemented, suggesting uneven capacity or prioritization across the sector. Financial constraints were cited as the most significant barrier to adopting further measures, underscoring the resource limitations faced by many businesses. In terms of seasonality, respondents perceived winter, spring, and fall as underutilized periods for tourism activity, whereas summer received mixed evaluations, with nearly half (48.9%) considering visitor levels to be “just right.” These findings highlight both opportunities and constraints in advancing sustainability, reflecting the importance of aligning strategies with the economic realities and seasonal dynamics of tourism businesses.

Addressing the fifth research question: “RQ5: What are the tourism business stakeholders’ attitudes towards providing information that allows GIS to monitor sustainability in the Thompson Okanagan Region?”, the findings reveal a notable contrast between perceived value and actual usage of GIS tools. Stakeholders demonstrated moderate familiarity with widely accessible platforms such as Google Maps, primarily for navigation and promotional purposes, but far fewer reported using GIS in operational or strategic decision-making. Despite this limited application, respondents consistently acknowledged the high value of GIS for visualizing sustainability indicators and monitoring practices. This gap suggests that, while stakeholders recognize the potential of GIS to enhance sustainability management, barriers such as resource constraints, limited training, or lack of integration into business processes hinder its broader adoption. These results emphasize the need for targeted capacity-building initiatives and institutional support to foster the effective use of GIS in the tourism sector.

The geospatial analysis of sustainability indicators revealed meaningful spatial disparities within the region. Environmental indicators, particularly the proportion of protected and conservation-designated land, showed strong patterns, with certain DAs standing out for their high biodiversity value. In contrast, indicators of environmental pressure, such as GHG

emissions from tourism-related transport and land conversion, highlighted areas undergoing more intense anthropogenic transformation. Such changes mirror patterns observed in coastal and heritage destinations globally, where mass tourism has accelerated land-use and land-cover transitions, as has been highlighted in the work of Baloch et al. (2023) and Kirilenko et al. (2021).

The violin plots and summary statistics further demonstrated that while many DAs registered relatively low levels of emissions or land-use change, a small number of outlier areas contributed disproportionately to overall environmental impact. These findings highlight the need for geographically targeted interventions that reflect the localized dynamics of tourism activity and environmental sensitivity.

It is important to acknowledge that observed land use changes and shifts in Biogeoclimatic Ecosystem Classification (BEC) zones cannot be attributed to the tourism industry exclusively. In several areas, particularly those experiencing rapid urban development, such as Juniper Ridge, land conversion is largely driven by construction and residential expansion. These locations exhibited notably high percentages of change over the past two decades. The dynamics in such areas suggest the presence of overlapping pressures from multiple sectors, highlighting the need for further research into cross-industry interactions and their cumulative impact on sustainability outcomes.

Water management practices were moderately implemented, with 38.6% reporting high implementation and 45.5% indicating medium. Only 15.9% reported low implementation. Energy management exhibits a similar pattern, albeit slightly lower on the high end: 51.1% medium, 40.4% high, and only 8.5% low, indicating that it is among the more consistently implemented categories. Waste management practices, particularly general waste management and food waste reduction, show divergent patterns. While 59.6% of respondents reported high implementation of general waste management, food waste practices had the lowest rate of high implementation (28.3%) and the highest percentage of low implementation (28.3%), indicating a significant implementation gap.

Conversely, the stakeholder survey results offered an important counterbalance to the indicator-based analysis by introducing the voices of those directly involved in the tourism

sector. While most of the respondents reported moderate familiarity with sustainable practices, the actual level of implementation varied across domains. Water and energy management practices showed moderate implementation; waste management practices showed the highest levels of adoption, whereas carbon reduction and food waste initiatives were less consistently implemented. These results are consistent with Obersteiner et al. (2021), who found that hotels and restaurants consistently implemented water-saving measures and waste-recycling practices more frequently than initiatives aimed at reducing carbon emissions; furthermore, Pan et al. (2018) remark on the need to integrate or combine different strategies for the management of renewable energy sources. This suggests a degree of alignment with more visible or cost-saving sustainability actions, but also underscores areas where technical or informational support may be lacking.

Survey results reveal clear seasonal trends in stakeholder perceptions of tourism volume. Winter, spring, and fall are widely regarded as underutilized periods, with more than two-thirds of respondents indicating that the number of tourists during these seasons is too low. In contrast, summer is perceived as more balanced, with nearly half of the participants stating that the number of tourists is appropriate. However, a notable minority expressed concerns about potential overcrowding during the peak season. These findings suggest strong support for initiatives aimed at promoting year-round tourism, particularly by enhancing visitation during shoulder and off-peak seasons. Such strategies may contribute to a more balanced distribution of tourism activity, improved economic resilience, and reduced environmental pressure during peak months.

Regarding the interaction of stakeholders with Geographic Information Systems (GIS), although many respondents acknowledged the potential value of this tool in monitoring tourism sustainability, actual use of GIS tools in daily operations remained limited. The gap between perceived utility and practice highlights the need for enhanced capacity-building and digital literacy in the tourism sector. The identification of participation barriers, ranging from time constraints to organizational gatekeeping, further illustrates the structural and operational challenges that must be addressed to enable broader industry engagement in sustainability monitoring.

The Multi-Criteria Assessment (MCA) revealed important variation in sustainability performance across DAs. Among the three sustainability dimensions, environmental scores were highest on average, reflecting relatively strong conservation coverage and low emissions in many areas. Economic scores were moderate, driven by variation in tourism-related employment, business activity, and visitor spending. In contrast, socio-cultural scores were the lowest, highlighting a lack of cultural infrastructure or heritage recognition in many communities, as pointed by Isgren and Longo (2024) and Richards et al. (2007), who found that social sustainability has some significant conceptual and analytical weaknesses, and as evidenced by stakeholder responses that ranked social indicators as three to four times less important than environmental ones. The composite sustainability index synthesized these differences, revealing substantial differences across the region.

The dimension-level correlations demonstrated that all three components contributed to overall sustainability, but the economic dimension had the strongest relationship with the final index. This underscores the central role of tourism-related economic activity in shaping regional sustainability performance, while also suggesting that parallel improvements in socio-cultural or environmental dimensions may not always accompany gains in economic indicators. The cluster analysis reinforced these observations, identifying typologies of DAs with differing strengths and weaknesses, for instance, areas with strong environmental protection but limited cultural assets, or economically active zones with higher emissions. These spatial patterns support the case for place-based policy strategies tailored to the unique sustainability profile of each locality.

The composite sustainability index masks some of these inequalities; however, a disaggregated view highlights the importance of addressing imbalances between sustainability dimensions to build a more equitable tourism system.

The low intercorrelation among dimensions confirms the need for a multidimensional approach to sustainability assessment; no single dimension can act as a proxy for the others. The strong correlation between the economic dimension and the composite index reflects the stakeholders' prioritization of economic performance in the tourism context, but also underscores a potential bias in composite results toward economically active areas. The weak association between socio-cultural and economic indicators points to a gap that could be

addressed through policies promoting cultural tourism, Indigenous inclusion, and heritage-linked economic development.

Regarding the Socio-Cultural Dimension, a key gap and future directions identified in this study is the relative weakness of the socio-cultural dimension in the sustainability assessment. This weakness is not necessarily a reflection of its importance but rather of the limited availability of data and the challenges in systematically capturing cultural assets, heritage values, and Indigenous knowledge within existing statistical and geographic frameworks. Unlike environmental indicators, which benefit from standardized datasets such as protected areas and land-use classifications, socio-cultural indicators remain fragmented and underrepresented.

The weak association between socio-cultural and economic indicators observed in the analysis suggests that vital aspects of community identity, heritage, and cultural continuity are not sufficiently integrated into tourism development and monitoring systems. In particular, Indigenous knowledge and values, which are highly relevant in the Thompson Okanagan Region, remain largely absent from official sources of information. The absence of these perspectives represents both a limitation of this study and an important research and policy gap.

Future research should therefore prioritize collaborations with Indigenous communities, the development of methods to spatialize cultural assets, and the integration of socio-cultural knowledge into sustainability monitoring frameworks. Strengthening this dimension will not only provide a more balanced view of sustainability but also help to close the conservation gap evident in land-use and protected area management, where cultural values could guide more inclusive and place-based approaches.

A particularly novel element of this research was the comparison between stakeholder perceptions and indicator-based assessments of sustainability. By analyzing differences between the perceived importance of sustainability dimensions and the MCA-derived scores, the study uncovered perceptual gaps. Positive gaps indicated that stakeholders perceived sustainability levels to be higher than suggested by the indicators, whereas negative gaps reflected underestimated sustainability performance. These divergences illuminate the

cognitive dimension of sustainability: while objective data is essential for assessment, it is stakeholder perception that often drives engagement and decision-making, as pointed by McCloskey (2015) and Phillips et al. (2014), and recognized as well by the UNWTO (UNWTO, 2024b, p. 112).

This finding supports the broader argument that both measurement and communication of sustainability must be sensitive to local knowledge, values, and expectations. Bridging the gap between perception and reality, whether through participatory mapping, community workshops, or more transparent data platforms, can improve stakeholder buy-in and support more collaborative approaches to sustainable tourism planning.

In conclusion, the present research enabled an examination of the geographic distribution and variation in the status of sustainable tourism across rural communities and small towns within the Thompson Okanagan Region, as inquired in the research questions stated (RQ1, RQ2). This spatial perspective highlighted local disparities and helped uncover patterns that would not be visible through aggregated data alone. Second, the analysis demonstrated the value of Geographic Information Systems (GIS) as a tool for identifying and visualizing spatial gaps in sustainability components (RQ3), emphasizing its potential to support evidence-based decision-making and targeted regional planning.

The application of geographic analysis enabled the identification of areas of high ecological sensitivity and significant cultural value, where conservation efforts should be prioritized. Simultaneously, it also revealed zones where conservation priorities could be balanced more flexibly with opportunities for tourism infrastructure development and the emergence of new visitor interest areas. In this context, the spatial analysis tool offers stakeholders new perspectives to inform the sustainable development of the tourism industry. These findings reinforce the importance of integrating indicators that capture cultural and heritage values, and demonstrate how their spatial representation serves as a valuable complement to sustainability assessments.

Environmental sustainability is a relative strength of the Thompson Okanagan Region, driven by strong natural protection frameworks and low-impact land use in many DAs.

Economic sustainability is uneven, with well-performing tourism centers surrounded by underdeveloped rural areas. Socio-cultural sustainability is the most critical gap, indicating an opportunity for investment in cultural heritage, Indigenous tourism, and recreational infrastructure, and the collection of information on this area.

This study faced certain limitations, particularly the small survey sample, temporal inconsistencies across data sources, and the need to downscale some indicators to the DA level, which introduced uncertainty. The socio-cultural dimension was especially constrained by limited official data on cultural assets and Indigenous knowledge. Despite these challenges, the integration of diverse datasets demonstrated the feasibility of conducting fine-scale sustainability assessments and highlighted areas where improved data collection could strengthen future applications.

Despite these limitations, by visualizing these results together, priority areas for policy action can be identified, whether to mitigate environmental pressures in economically active zones, to enhance tourism capacity in underdeveloped areas, or to preserve cultural resources in growing destinations.

This study successfully addressed all five research questions, while acknowledging the limitations discussed, by delivering a comprehensive, fine-scale assessment of sustainable tourism in the Thompson-Okanagan Region. First, the analysis of spatial indicators established the status of sustainable tourism across municipalities (RQ1), while the comparison between rural communities and small towns revealed distinct geographic distributions and disparities in sustainability outcomes (RQ2). The application of GIS proved valuable for measuring gaps in sustainability components, demonstrating its potential to integrate diverse datasets and highlight spatial patterns that inform decision-making (RQ3). Complementing this top-down analysis, the stakeholder survey captured perceptions of sustainable practices in resource management, highlighting both strengths and gaps in implementation (RQ4). Finally, the survey also revealed positive yet cautious attitudes among tourism businesses toward contributing information for GIS-based monitoring, emphasizing the importance of trust, engagement, and practical relevance in shaping future participation (RQ5). Together, these findings demonstrate the feasibility of combining spatial analysis with stakeholder

perspectives to strengthen sustainable tourism assessments and planning at regional and local scales.

Areas for future research

While the present study offers important insights into assessing sustainable tourism using spatial analysis and stakeholder perspectives, it also opens several avenues for further investigation. The complexity of sustainability, both conceptually and in practice, demands continued methodological refinement and broader empirical application. As data availability, technology, and stakeholder engagement strategies evolve, future research can build upon the foundation laid here to enhance both the precision and the inclusiveness of sustainability assessments. The following areas are proposed as meaningful directions to advance scholarship and practice in this field.

Given the relatively lower scores in the socio-cultural dimension and the limited availability of standardized, official (government) heritage data, future research may focus on methods better to capture intangible cultural assets and Indigenous knowledge systems. This could involve co-developing indicators in collaboration with First Nations communities, enhancing the visibility of non-material heritage in official secondary data sources, and assessing the impact of such efforts on the spatial equity of sustainability outcomes.

Lastly, future work could explore the trade-offs and synergies that emerged between the sustainability dimensions in this study in greater depth. The clustering and correlation analyses suggest that environmental protection, cultural richness, and economic vitality do not always converge within the same areas. A comparative, multi-temporal, and multi-industry analysis could help uncover how these relationships evolve over time. Scenario-based applications of GIS-MCA can provide a powerful decision-support tool for evaluating the sustainability implications of proposed tourism policies or land-use changes. Such efforts would continue to position GIS-based multi-criteria analysis as a robust, participatory, and evidence-informed approach for advancing sustainability in tourism regions.

Theoretical implications

The conceptual model proposed in this study represents a meaningful advancement in bridging global sustainability frameworks with localized, actionable strategies. By integrating geospatial analysis, multi-criteria assessment, and stakeholder perceptions, the model enables a comprehensive understanding of sustainability across the environmental, socio-cultural, and economic dimensions. Its emphasis on territorialization ensures that global indicators are adapted to the realities of specific communities, enhancing both the relevance and applicability of sustainability monitoring. This approach not only facilitates evidence-based decision-making and targeted policy development but also promotes participatory engagement by aligning technical assessments with local knowledge. As such, the model offers a practical pathway for implementing sustainable tourism planning that is both data-informed and contextually grounded.

The findings and methodological contributions of this research point to several promising directions for future investigation in the field of sustainable tourism assessment using geographic information systems. One clear opportunity lies in the advancement of sub-national sustainability indicator systems. While this study demonstrated the feasibility of applying indicators at the Dissemination Area (DA) level, it also revealed notable limitations related to data availability and geographic disaggregation, particularly within the socio-cultural dimension. Future studies could explore the development of new data frameworks that improve access to fine-resolution indicators, potentially incorporating remote sensing, administrative microdata, or volunteered geographic information (VGI) to enrich spatial and thematic coverage.

A second line of inquiry pertains to refining stakeholder engagement strategies. The observed discrepancies between stakeholder perceptions and the MCA-derived sustainability scores emphasize the importance of understanding how sustainability is subjectively experienced and interpreted by tourism operators. Longitudinal research can provide insights into evolving perceptions over time, while participatory approaches, such as community mapping or deliberative workshops, may yield more grounded knowledge on barriers to the adoption of sustainable practices. Future studies may also compare perception gaps between

different groups, including public administrators, private-sector operators, and community-based tourism actors.

Additionally, this study suggests the potential value of integrating real-time or dynamic data sources into sustainability analysis. While most indicators used here were derived from static secondary data, future research could experiment with mobility datasets, smart infrastructure metrics, or social media traces to capture more responsive indicators of tourism flows, environmental stress, and local engagement. Similarly, further development and testing of GIS-based tools, such as the web application prototype used in this study, could help evaluate their usability and decision-making impact among local stakeholders and policy-makers.

Practical implications

Quality of Input Data and Information for the Research

The construction of a sustainability indicator matrix at the Dissemination Area (DA) level, based on the wide list of indicators of the UNWTO Statistical Framework for Measuring Sustainable Tourism, represents one of the central contributions of this study. By harmonizing a diverse set of indicators across environmental, socio-cultural, and economic dimensions, the matrix facilitated a fine-grained and geographically disaggregated understanding of tourism sustainability in the Thompson Okanagan Region. This spatial resolution provided analytical depth and supported nuanced comparisons across communities. However, the process also revealed challenges, particularly in terms of data disaggregation.

Despite these constraints, the final selection of indicators reflected a balance between methodological rigour and practical feasibility. Furthermore, this process resulted in the establishment of a substantial database, which will serve as a foundation for future research and in-depth analysis. A total of 21 indicators were successfully derived from available geographic and statistical data at the DA level.

Overall, this research highlights the potential of existing geographic and statistical data to inform sustainability assessments at a highly localized scale. More importantly, it

underscores the flexibility of the methodological framework developed here: the indicator matrix and resulting sustainability scores can be readily updated or expanded as new data become available. This adaptability offers an opportunity not only for local monitoring but also for informing broader policy dialogues. Findings from this study may contribute to ongoing discussions within international organizations and national governments regarding how global frameworks can be refined to reflect the realities of data availability and local sustainability priorities.

Within the environmental dimension, some gaps remain. Air emissions or domestic visitor flows, for example, could not be disaggregated to the DA level. Although a proxy estimate could be developed using visitor count data, a more robust measure would require detailed travel distance information. Moreover, the UNWTO framework did not explicitly include environmental risk exposure. Since the framework mentions that it is part of complementary systems, such as risk assessment systems and carrying capacity systems, both could be addressed through enhanced integration of geographic data. These observations point to the potential value of expanding the methodology to complementary systems in future analyses.

Similarly, the socio-cultural dimension exhibited the lowest data availability among the three pillars. While the UNWTO framework emphasizes the importance of measuring perceptions of visitors and host communities, such subjective data are often absent or inconsistently collected at the local level. The present study aimed to address this gap by incorporating spatially referenced cultural heritage indicators and stakeholder perceptions; however, the lack of systematic data on cultural assets, social cohesion, and inclusion remains a challenge. Future efforts could build on the demonstrated utility of geographic information to map and analyze cultural features, including intangible heritage, as part of a more comprehensive approach to cultural heritage management.

Geographic Insights from the Top-Down analysis

Furthermore, the use of official statistical data from Statistics Canada, at the most disaggregated geographic level available, has underscored the significant potential of integrating socio-economic information into sustainability assessments. The combination of

economic and social statistics with spatial environmental indicators revealed meaningful patterns and relationships, offering a more holistic understanding of sustainability dynamics. The methodological pipeline developed in this research includes reproducible and automated R scripts, allowing for the timely updating of results as new datasets become available. In this regard, the forthcoming 2026 Canadian Census presents an opportunity to reassess and refine the analysis with up-to-date information.

One of the limitations encountered during the study was the inability to disaggregate domestic tourism data at the Dissemination Area level, mainly due to the limited geographic detail in the original survey instruments. Applying this methodology at a more aggregated level, such as the Census Subdivision scale, could enable comparative analysis between domestic and international tourism flows. In addition, the study did not address the issue of seasonality in tourism patterns. Future work could explore temporal variations more deeply, leveraging national and international travel surveys to examine seasonal trends and compare them with stakeholder perceptions collected through survey instruments.

Stakeholder Insights from the Bottom-Up Survey

One of the key discussion points related to this component concerns the challenges encountered in collecting data through the proposed survey-based methodology. Despite the use of targeted outreach strategies, institutional partnerships, and the inclusion of incentives, the data collection process revealed significant barriers. While the final dataset achieved acceptable geographic coverage and data quality, the effort required to obtain these responses highlighted a broader issue: the increasing difficulty in engaging participants through traditional survey instruments. Several respondents explicitly expressed fatigue or reluctance when contacted by phone, underscoring a growing sense of exhaustion toward frequent survey requests. Based on these observations, this research recommends that future studies consider alternative approaches to data collection, such as leveraging existing survey data through partnerships with institutions or exploring the use of big data sources to supplement or replace traditional survey techniques. These strategies may help ensure greater efficiency, broader reach, and more sustainable participation in stakeholder-based research.

The integration of geographic analysis into existing surveys regularly conducted by tourism organizations, such as the Resident Sentiment Survey and the Business Sentiment Survey led by Destination Canada, emerges as a potential area for future research. Incorporating spatial components into these instruments could offer a systematic solution to the growing issue of respondent fatigue by maximizing the value of already-collected data. This study has demonstrated that spatially contrasting stakeholder perceptions can yield valuable insights, particularly for targeting interventions and refining sustainability strategies.

Dissemination of the results: GIS-based web application

To effectively disseminate the results of this research, the use of a Story Map application was selected as the most appropriate communication tool. Story Maps offer an engaging and accessible platform that blends narrative with geospatial data, making complex scientific findings more relatable to both specialized and non-specialized audiences. Storytelling has long been a fundamental way for humans to share knowledge; it fosters understanding, evokes curiosity, and bridges the gap between data and real-world meaning. In this context, Story Maps provide a powerful medium to convey research findings conducted with scientific rigor in a format that is both informative and approachable.

Throughout the data collection phase, it became evident that the volume of available information is vast so much so that comprehensively cataloguing all existing data proved to be an unfeasible task. Each day raised new questions about what additional data might be relevant to include. However, it was necessary to define a stopping point and focus on communicating the insights gathered thus far. Here, the researcher's expertise played a critical role in assessing the value and relevance of the information being used.

Recognizing the importance of communication, the study incorporated stakeholder perceptions regarding the use of geographic tools. The growing familiarity with digital mapping platforms such as Google Maps has increased public awareness and understanding of

geospatial technologies. Although this research involved a limited sample, preliminary findings suggest that public perceptions of these tools are more nuanced than previously assumed. Expanding the sample in future studies may help to capture a broader diversity of perspectives. It is also worth noting that many geographic data portals and tools remain underutilized, often because they are designed primarily for specialists, limiting accessibility for the general public.

In response, this project aimed to develop a Story Map application that communicates research findings in a compelling and user-friendly manner. The application is structured to tell a coherent story that highlights key aspects of the tourism landscape in the Thompson Okanagan Region. It begins by showcasing the region's tourism offerings, followed by a discussion of the importance of sustainability in preserving natural beauty, supporting local livelihoods, and promoting cultural integrity. Subsequent sections present thematic maps covering economic, sociocultural, and environmental dimensions, leading to a final section that displays the key results and maps from the Multi-Criteria Assessment (MCA).

The prototype of the tool is attached digitally in the next link: <https://arcg.is/1SfmfO1>.

Value of the Study

The value of this study lies not only in the empirical findings but also in the methodological contribution it makes to the field of tourism sustainability. By developing a GIS-based framework and applying it with open-source tools such as R, the research demonstrates a replicable and adaptable approach that can evolve as new data and indicators become available. The graphics and maps generated through the application serve as practical resources for training, communication, and decision-making, allowing stakeholders to visualize both current conditions and desired future states.

Although barriers remain, the study highlights how these challenges can be addressed by using open, transparent, and reproducible methods. Tourism, as one of the industries most directly connected to sustainability challenges and opportunities, is uniquely positioned to

showcase how spatial analysis can support evidence-based strategies. The framework developed here provides a structured basis for future studies and industry applications, offering a flexible tool that can be adapted to changing contexts, enriched with new data, and scaled across different regions.

Ultimately, this research demonstrates how academic inquiry can be directly translated into actionable insights, guiding both policy-making and industry practice toward more sustainable tourism futures.

References

- Alcott, B. (2005). Jevons' paradox. *Ecological Economics*, 54(1), 9-21.
<https://doi.org/https://doi.org/10.1016/j.ecolecon.2005.03.020>
- Alshuwaikhat, H. M., Abubakar, I. R., Aina, Y. A., Adenle, Y. A., & Umair, M. (2017). The Development of a GIS-Based Model for Campus Environmental Sustainability Assessment. *Sustainability*, 9(3), 439. <https://www.mdpi.com/2071-1050/9/3/439>
- B.C. Ministry of Forests, L. a. N. R. O. (1995). *Biodiversity Guidebook*. Retrieved from <https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/frep/frep-docs/biodiversityguidebook.pdf>
- B.C. Ministry of Forests, L. a. N. R. O. (1997). *VISUAL LANDSCAPE INVENTORY. Procedures & Standards Manual*. British Columbia Retrieved from <https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/visual-resource-management/visual-landscape-inventory>
- B.C. Ministry of Forests, L. a. N. R. O. (2021). *Biogeoclimatic Ecosystem Classification - How BEC Works*. Forest Analysis and Inventory Branch.
<https://www.for.gov.bc.ca/hre/becweb/system/how/index.html>
- Bahaire, T., & Elliott-White, M. (1999). The Application of Geographical Information Systems (GIS) in Sustainable Tourism Planning: A Review. *Journal of Sustainable Tourism*, 7(2), 159-174. <https://doi.org/10.1080/09669589908667333>
- Baloch, Q. B., Shah, S. N., Iqbal, N., Sheeraz, M., Asadullah, M., Mahar, S., & Khan, A. U. (2023). Impact of tourism development upon environmental sustainability: a suggested framework for sustainable ecotourism. *Environmental Science and Pollution Research*, 30(3), 5917-5930. <https://doi.org/10.1007/s11356-022-22496-w>
- Best, N., Richardson, S., & Thomson, A. (2005). A comparison of Bayesian spatial models for disease mapping. *Stat Methods Med Res*, 14(1), 35-59.
<https://doi.org/10.1191/0962280205sm388oa>
- Boers, B., & Cottrell, S. (2007). Sustainable Tourism Infrastructure Planning: A GIS-Supported Approach. *Tourism Geographies*, 9(1), 1-21.
<https://doi.org/10.1080/14616680601092824>
- Boluk, K. A., Cavaliere, C. T., & Higgins-Desbiolles, F. (2019). A critical framework for interrogating the United Nations Sustainable Development Goals 2030 Agenda in tourism. *Journal of Sustainable Tourism*, 27(7), 847-864.
<https://doi.org/10.1080/09669582.2019.1619748>
- Bramwell, B., Higham, J., Lane, B., & Miller, G. (2017). Twenty-five years of sustainable tourism and the Journal of Sustainable Tourism: looking back and moving forward. *Journal of Sustainable Tourism*, 25(1), 1-9.
<https://doi.org/10.1080/09669582.2017.1251689>
- Brown, G., & Weber, D. (2013). Using public participation GIS (PPGIS) on the Geoweb to monitor tourism development preferences. *Journal of Sustainable Tourism*, 21(2), 192-211. <https://doi.org/10.1080/09669582.2012.693501>
- Buhalis, D. (2019). Technology in tourism-from information communication technologies to eTourism and smart tourism towards ambient intelligence tourism: a perspective article. *Tourism Review*, ahead-of-print. <https://doi.org/10.1108/TR-06-2019-0258>

- Buhalis, D., Harwood, T., Bogicevic, V., Viglia, G., Beldona, S., & Hofacker, C. (2019). Technological disruptions in services: lessons from tourism and hospitality. *Journal of Service Management*, 30(4), 484-506. <https://doi.org/10.1108/JOSM-12-2018-0398>
- Buhalis, D., & Sinarta, Y. (2019). Real-time co-creation and nowness service: lessons from tourism and hospitality. *Journal of Travel & Tourism Marketing*, 36(5), 563-582. <https://doi.org/10.1080/10548408.2019.1592059>
- Butler, R. W. (1999). Sustainable tourism: A state-of-the-art review. *Tourism Geographies*, 1(1), 7-25. <https://doi.org/10.1080/14616689908721291>
- Chandel, R., & Kanga, S. (2021). GIS and management planning for sustainable ecotourism development: a case study of Jodhpur, Rajasthan, India. *Sustainability Agri Food and Environmental Research*, 11, 2023. <https://doi.org/10.7770/safer-V11N1-art2505>
- Chen, J. (2014). GIS-based multi-criteria analysis for land use suitability assessment in City of Regina. *Environmental Systems Research*, 3(1), 13. <https://doi.org/10.1186/2193-2697-3-13>
- Chhetri, P., & Arrowsmith, C. (2008). GIS-based Modelling of Recreational Potential of Nature-Based Tourist Destinations. *Tourism Geographies*, 10(2), 233-257. <https://doi.org/10.1080/14616680802000089>
- Choi, J., & Lawson, A. B. (2018). Bayesian spatially dependent variable selection for small area health modeling. *Stat Methods Med Res*, 27(1), 234-249. <https://doi.org/10.1177/0962280215627184>
- Costanza, R., de Groot, R., Braat, L., Kubiszewski, I., Fioramonti, L., Sutton, P., Farber, S., & Grasso, M. (2017). Twenty years of ecosystem services: How far have we come and how far do we still need to go? *Ecosystem Services*, 28, 1-16. <https://doi.org/https://doi.org/10.1016/j.ecoser.2017.09.008>
- Costanza, R., de Groot, R., Sutton, P., van der Ploeg, S., Anderson, S. J., Kubiszewski, I., Farber, S., & Turner, R. K. (2014). Changes in the global value of ecosystem services. *Global Environmental Change*, 26, 152-158. <https://doi.org/https://doi.org/10.1016/j.gloenvcha.2014.04.002>
- Dale, A., Chris, L., & and Newman, L. (2008). Does Place Matter? Sustainable Community Development in Three Canadian Communities. *Ethics, Place & Environment*, 11(3), 267-281. <https://doi.org/10.1080/13668790802559676>
- Destination BC. (2023). *Thompson Okanagan Regional Tourism Profile*. <https://www.destinationbc.ca/research-insights/type/regional-research/regional-profiles/>
- Destination BC. (2025). *How do you measure up? - BC Tourism Climate Resilience Initiative*. Retrieved from https://www.destinationbc.ca/content/uploads/2025/04/Destination-BC-BC-Tourism-Climate-Resiliency-Initiative-How-Do-You-Measure-Up-Toolkit-V7_FINAL.pdf
- Destination BC, & NRG Research Group. (2012). *In-Market Research Report Thompson Okanagan*. https://www.destinationbc.ca/content/uploads/2018/05/In-Market_Regional_Report_TOTA_2012.pdf
- Du, X., Wang, Z., & Wang, Y. (2023). The Spatial Mechanism and Predication of Rural Tourism Development in China: A Random Forest Regression Analysis. *ISPRS International Journal of Geo-Information*, 12(8), 321. <https://doi.org/10.3390/ijgi12080321>

- El Archi, Y., Benbba, B., Kabil, M., & Dávid, L. D. (2023). Digital Technologies for Sustainable Tourism Destinations: State of the Art and Research Agenda. *Administrative Sciences*, 13(8), 184. <https://doi.org/10.3390/admsci13080184>
- Fan, X., & Cheng, Y. (2023). Assessing a Tourism City from an Ecosystem Services Perspective: The Evaluation of Tourism Service in Liyang, China. *Land*, 12(11), 2019. <https://doi.org/10.3390/land12112019>
- Fennell, D. A. (2021). Technology and the sustainable tourist in the new age of disruption. *Journal of Sustainable Tourism*, 29(5), 767-773. <https://doi.org/10.1080/09669582.2020.1769639>
- Font, X., Elgammal, I., & Lamond, I. (2017). Greenhushing: the deliberate under communicating of sustainability practices by tourism businesses. *Journal of Sustainable Tourism*, 25(7), 1007-1023. <https://doi.org/10.1080/09669582.2016.1158829>
- Fudo, Y., Matsumoto, S., Kashima, T., & Akiyoshi, M. (2014, 7-8 Nov. 2014). A study on sightseeing promotion with ICT from the viewpoint of sustainability. 2014 IEEE 7th International Workshop on Computational Intelligence and Applications (IWCIA),
- Goodchild, M. F. (1992). Geographical information science. *International journal of geographical information systems*, 6(1), 31-45. <https://doi.org/10.1080/02693799208901893>
- Gosjen, D., Hizkia Haryadi, K., Nicholas, Santoso, A., Mila, C., & Adiati, M. (2022). Implementation e-concierge in hotel. *ScienceDirect*.
- Gössling, S. (2020). Technology, ICT and tourism: from big data to the big picture. *Journal of Sustainable Tourism*, 29(5), 849-858. <https://doi.org/10.1080/09669582.2020.1865387>
- Government of British Columbia. (2022). *Strategic Framework for Tourism 2022–2024. A Plan for Recovery and Resiliency*. British Columbia Retrieved from <https://www2.gov.bc.ca/gov/content/tourism-immigration/tourism-resources/tourism-framework>
- Government of British Columbia. (2024). *Regions in B.C.* <https://www.welcomebc.ca/Choose-B-C/Explore-British-Columbia/Regions-in-B-C>
- Government of British Columbia. (2025a). *BC Data Catalogue*. https://bcgov.github.io/data-publication/pages/dps_bcdc.html
- Government of British Columbia. (2025b). *Current Community Energy and Emissions Inventory data*. <https://www2.gov.bc.ca/gov/content/environment/climate-change/data/ceei/current-data>
- Government of Canada. (2022). *Canada 365: Welcoming The World. Every Day. The Federal Tourism Growth Strategy* Retrieved from <https://ised-isde.canada.ca/site/canadian-tourism-sector/en/canada-365-welcoming-world-every-day-federal-tourism-growth-strategy>
- Government of Canada. (2025). *Data*. <https://www150.statcan.gc.ca/n1/en/type/data?MM=1>
- Graymore, M. L. M., Wallis, A. M., & Richards, A. J. (2009). An Index of Regional Sustainability: A GIS-based multiple criteria analysis decision support system for progressing sustainability. *Ecological Complexity*, 6(4), 453-462. <https://doi.org/https://doi.org/10.1016/j.ecocom.2009.08.006>

- Haloui, S., EL Mansouri, F., Tayeq, H., & Chao, J. (2024). Integrated Economic, Environmental and Social Index—Case Study: Medina of Tangier. *Tourism and Hospitality*, 5(2), 489-505. <https://www.mdpi.com/2673-5768/5/2/30>
- Hasse, J. C., & Milne, S. (2005). Participatory Approaches and Geographical Information Systems (PAGIS) in Tourism Planning. *Tourism Geographies*, 7(3), 272-289. <https://doi.org/10.1080/14616680500164666>
- Hewer, M. J., & Gough, W. A. (2018). Thirty years of assessing the impacts of climate change on outdoor recreation and tourism in Canada. *Tourism Management Perspectives*, 26, 179-192. <https://doi.org/https://doi.org/10.1016/j.tmp.2017.07.003>
- Isgren, E., & Longo, S. B. (2024). Social sustainability: more confusion than clarity. *Journal of Environmental Studies and Sciences*, 14(4), 820-825. <https://doi.org/10.1007/s13412-024-00978-2>
- Jelinski, D. E., & Wu, J. (1996). The modifiable areal unit problem and implications for landscape ecology. *Landscape Ecology*, 11(3), 129-140. <https://doi.org/10.1007/BF02447512>
- Kaptan Ayhan, Ç., Cengiz Taşlı, T., Özkök, F., & Tatlı, H. (2020). Land use suitability analysis of rural tourism activities: Yenice, Turkey. *Tourism Management*, 76. <https://doi.org/10.1016/j.tourman.2019.07.003>
- Kirilenko, A. P., Ma, S., Stepchenkova, S. O., Su, L., & Waddell, T. F. (2021). Detecting Early Signs of Overtourism: Bringing Together Indicators of Tourism Development With Data Fusion. *Journal of Travel Research*, 62(2), 382-398. <https://doi.org/10.1177/00472875211064635>
- Li, Y. (2023). Relationship between perceived threat of artificial intelligence and turnover intention in luxury hotels. *Heliyon*, 9(8), e18520. <https://doi.org/10.1016/j.heliyon.2023.e18520>
- Li, Z., Yang, M., Zhou, X., Li, Z., Li, H., Zhai, F., Zhang, Y., & Zhang, Y. (2023). Research on the spatial correlation and formation mechanism between traditional villages and rural tourism. *Scientific Reports*, 13(1). <https://doi.org/10.1038/s41598-023-35486-w>
- Liu, J., Yue, M., Liu, Y., Wen, D., & Tong, Y. (2022). The Impact of Tourism on Ecosystem Services Value: A Spatio-Temporal Analysis Based on BRT and GWR Modeling. *Sustainability*, 14(5), 2587. <https://www.mdpi.com/2071-1050/14/5/2587>
- Ma, X., Yang, Z., & Zheng, J. (2022). Analysis of spatial patterns and driving factors of provincial tourism demand in China. *Scientific Reports*, 12(1). <https://doi.org/10.1038/s41598-022-04895-8>
- Malczewski, J. (2006). GIS-based multicriteria decision analysis: a survey of the literature. *International Journal of Geographical Information Science*, 20(7), 703-726. <https://doi.org/10.1080/13658810600661508>
- Mauleon Mendez, E., Genovart-Balaguer, J., Merigo, J. M., & Forteza, C. (2018). Sustainable Tourism Research Towards Twenty-Five Years of the Journal of Sustainable Tourism. *Advances in Hospitality and Tourism Research (AHTR)*, 6. <https://doi.org/10.30519/ahtr.406555>
- McCloskey, S. (2015). From MDGs to SDGs: We Need a Critical Awakening to Succeed. *Policy and Practice: A Development Education Review*, 20, 186-194. <https://www.developmenteducationreview.com/issue/issue-20/mdgs-sdgs-we-need-critical-awakening-succeed>

- McKercher, B., Shoval, N., Ng, E., & Birenboim, A. (2012). First and Repeat Visitor Behaviour: GPS Tracking and GIS Analysis in Hong Kong. *Tourism Geographies*, 14(1), 147-161. <https://doi.org/10.1080/14616688.2011.598542>
- Mendoza, G. A., & Martins, H. (2006). Multi-criteria decision analysis in natural resource management: A critical review of methods and new modelling paradigms. *Forest Ecology and Management*, 230(1), 1-22. <https://doi.org/https://doi.org/10.1016/j.foreco.2006.03.023>
- Merigó, J. M., Mulet-Forteza, C., Valencia, C., & Lew, A. A. (2019). Twenty years of <i>Tourism Geographies</i>: a bibliometric overview. *Tourism Geographies*, 21(5), 881-910. <https://doi.org/10.1080/14616688.2019.1666913>
- Miltchev, R., & Neykova, M. (2015). *THE IMPACT OF TECHNOLOGICAL INNOVATIONS ON THE SUSTAINABILITY OF THE E-BUSINESS SYSTEMS OF ORGANIZATIONS OPERATING IN THE TOURISM SECTOR*.
- Minasi, S. M., Lohmann, G., & Valduga, V. (2020). Geographic Information Systems are critical tools to manage wine tourism regions. *Tourism Geographies*, 25(1), 198-219. <https://doi.org/10.1080/14616688.2020.1861081>
- Mohammed, M. W., Feizizadeh, B., Klug, H., Ghanbari, A., & Blaschke, T. (2023). Ecotourism sustainability assessment using geospatial multiple approach in the Kurdistan region of Iraq. *GeoJournal*, 88(3), 3283-3306. <https://doi.org/10.1007/s10708-022-10807-0>
- Moon, K., & Blackman, D. (2014). A Guide to Understanding Social Science Research for Natural Scientists. *Conservation Biology*, 28(5), 1167-1177. <https://doi.org/10.1111/cobi.12326>
- Muhsin, N., Noguchi, R., & Ahamed, T. (2022). GIS-Based MCA Modeling to Locate Suitable Industrial Sites in Suburb Areas of Bangladesh for Sustainability of Agricultural Lands. In T. Ahamed (Ed.), *Remote Sensing Application: Regional Perspectives in Agriculture and Forestry* (pp. 185-214). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-0213-0_7
- Obersteiner, G., Gollnow, S., & Eriksson, M. (2021). Carbon footprint reduction potential of waste management strategies in tourism. *Environmental Development*, 39, 100617. <https://doi.org/https://doi.org/10.1016/j.envdev.2021.100617>
- OECD. (2002). *Measuring the Information Economy* (O. Publishing, Ed.). OECD Publishing. <https://doi.org/https://doi.org/10.1787/9789264099012-en>
- OECD. (2008). *Handbook on Constructing Composite Indicators*. Retrieved from https://www.oecd.org/en/publications/handbook-on-constructing-composite-indicators-methodology-and-user-guide_9789264043466-en.html
- Oliveira, V. T. d., Teixeira, D., Rocchi, L., & Boggia, A. (2022). Geographic Information System Applied to Sustainability Assessments: Conceptual Structure and Research Trends. *ISPRS International Journal of Geo-Information*, 11(11), 569. <https://www.mdpi.com/2220-9964/11/11/569>
- OpenAI. (2024). ChatGPT (GPT-4 model) [Large language model]. In.
- Pan, S. Y., Gao, M., Kim, H., Shah, K. J., Pei, S. L., & Chiang, P. C. (2018). Advances and challenges in sustainable tourism toward a green economy. *Sci Total Environ*, 635, 452-469. <https://doi.org/10.1016/j.scitotenv.2018.04.134>

- Parsons, M., Asena, Q., Johnson, D., & Nalau, J. (2024). A bibliometric and topic analysis of climate justice: Mapping trends, voices, and the way forward. *Climate Risk Management*, 44, 100593. <https://doi.org/10.1016/j.crm.2024.100593>
- Paul, K., & Jha, V. C. (2021). Paradigm Shifts in Geographical Research and Geospatial Applications. *Sociedade & Natureza*, 33. <https://doi.org/10.14393/SN-v33-2021-59651>
- Peeters, P., Çakmak, E., & Guiver, J. (2024). Current issues in tourism: Mitigating climate change in sustainable tourism research. *Tourism Management*, 100. <https://doi.org/10.1016/j.tourman.2023.104820>
- Pencarelli, T. (2020). The digital revolution in the travel and tourism industry. *Information Technology & Tourism*, 22(3), 455-476. <https://doi.org/10.1007/s40558-019-00160-3>
- Phillips, L. T., Weisbuch, M., & Ambady, N. (2014). People perception: Social vision of groups and consequences for organizing and interacting. *Research in Organizational Behavior*, 34, 101-127. <https://doi.org/10.1016/j.riob.2014.10.001>
- Rauf, M. A., McCordic, C., Sgro, J., Frayne, B., & Wilson, J. (2023). Trading off sustainable development in Canadian cities: theoretical implications of SDG 11 indicator aggregation approaches [Original Research]. *Frontiers in Sustainable Cities*, Volume 5 - 2023. <https://doi.org/10.3389/frsc.2023.1264710>
- Richards, A., Anne, W., & Graymore, M. (2007). An Index of Regional Sustainability (AIRS): Incorporating system processes into sustainability assessment.
- Sharpley, R. (2000). Tourism and Sustainable Development: Exploring the Theoretical Divide. *Journal of Sustainable Tourism*, 8(1), 1-19. <https://doi.org/10.1080/09669580008667346>
- Shi, L., Han, L., Yang, F., & Gao, L. (2019). The Evolution of Sustainable Development Theory: Types, Goals, and Research Prospects. *Sustainability*, 11(24), 7158. <https://www.mdpi.com/2071-1050/11/24/7158>
- Smerecnik, K. R., & Andersen, P. A. (2011). The diffusion of environmental sustainability innovations in North American hotels and ski resorts. *Journal of Sustainable Tourism*, 19(2), 171-196. <https://doi.org/10.1080/09669582.2010.517316>
- Statista. (2023, Dec 18, 2023). *Global tourism industry - statistics & facts*. Statista. Retrieved May 9 from <https://www.statista.com/topics/962/global-tourism/#topicOverview>
- Statistics Canada. (2019). *Visitor Travel Survey, fourth quarter 2019*. Retrieved from <https://www150.statcan.gc.ca/n1/daily-quotidien/200708/dq200708e-eng.htm>
- Statistics Canada. (2022). *Boundary Files, Reference Guide Second edition, Census year 2021*. Retrieved from <https://www150.statcan.gc.ca/n1/en/catalogue/92-160-G2021002>
- Statistics Canada. (2023). *The Open Database of Businesses*. <https://www150.statcan.gc.ca/n1/pub/21-26-0003/212600032023001-eng.htm>
- Statistics Canada. (2024). *International Travel Survey Microdata File*. <https://doi.org/10.25318/66m0001x-eng>
- Thompson Okanagan Tourism Association. (2017). *Thompson-Okanagan Regional Tourism Profile*. https://www.destinationbc.ca/content/uploads/2018/05/Thompson-Okanagan-Regional-Tourism-Profile_2017.pdf

- Thompson Okanagan Tourism Association. (2019a). *Embracing our Potential 2.0 - Thompson Okanagan Tourism Region*. Retrieved from <https://www.totabc.org/regional-strategy>
- Thompson Okanagan Tourism Association. (2019b). *Embracing Our Potential: 10-Year Regional Tourism Strategy for the Thompson Okanagan Region*. Retrieved May 15 from <https://www.totabc.org/regional-strategy>
- Thompson Okanagan Tourism Association. (2024). *About TOTA — Thompson Okanagan Tourism Association (TOTA)*. Retrieved May 13 from <https://www.totabc.org/about>
- Tomal, M. (2020). Modelling Housing Rents Using Spatial Autoregressive Geographically Weighted Regression: A Case Study in Cracow, Poland. *ISPRS International Journal of Geo-Information*, 9(6), 346. <https://doi.org/10.3390/ijgi9060346>
- Um, T., & Chung, N. (2021). Does smart tourism technology matter? Lessons from three smart tourism cities in South Korea. *Asia Pacific Journal of Tourism Research*, 26(4), 396-414. <https://doi.org/10.1080/10941665.2019.1595691>
- UN. (1987). *Our common future - Brundtland Report*. <http://www.un-documents.net/our-common-future.pdf>
- UN. (2015). *Transforming our world: the 2030 Agenda for Sustainable Development* <https://sdgs.un.org/2030agenda>
- UNEP, & UNWTO. (2005). *Making Tourism more Sustainable: A Guide for Policy Makers*
- UNWTO. (2019). *UNWTO Guidelines for Institutional Strengthening of Destination Management Organizations (DMOs) Preparing DMOs for new challenges* [doi:10.18111/9789284420841]. World Tourism Organization. <https://doi.org/doi:10.18111/9789284420841>
- UNWTO. (2024a). *INSTO Observatories*. <https://www.unwto.org/sustainable-development>
- UNWTO. (2024b). *Statistical Framework for Measuring the Sustainability of Tourism (SF-MST): Final Draft*. Statistical Commission Fifty-fifth session, New York.
- USGS. (2023). *What is a geographic information system (GIS)?* [https://www.usgs.gov/faqs/what-geographic-information-system-gis#:~:text=A%20Geographic%20Information%20System%20\(GIS\)%20is%20a%20computer%20system%20that,attached%20to%20a%20unique%20location.](https://www.usgs.gov/faqs/what-geographic-information-system-gis#:~:text=A%20Geographic%20Information%20System%20(GIS)%20is%20a%20computer%20system%20that,attached%20to%20a%20unique%20location.)
- van der Knaap, W. G. M. (1999). Research report: GIS-oriented analysis of tourist time-space patterns to support sustainable tourism development. *Tourism Geographies*, 1(1), 56-69. <https://doi.org/10.1080/14616689908721294>
- von Bergmann J, S. D., Jacobs A. (2021). *cancensus: R package to access, retrieve, and work with Canadian Census data and geography*. <https://mountainmath.github.io/cancensus/>
- Voukkali, I., Papamichael, I., Loizia, P., & Zorpas, A. A. (2023). Urbanization and solid waste production: prospects and challenges. *Environmental Science and Pollution Research*, 31(12), 17678-17689. <https://doi.org/10.1007/s11356-023-27670-2>
- Wood, N., & Smith, S. J. (2008). Pragmatism and geography. *Geoforum*, 39(4), 1527-1529. <https://doi.org/https://doi.org/10.1016/j.geoforum.2008.06.003>
- Zionts, S. (1979). MCDM: If Not a Roman Numeral, then What? *Interfaces*, 9(4), 94-101. <http://www.jstor.org/stable/25059779>

Appendices

Appendix 1 – Matrix of Sustainability Indicators

No	Sust. Dimension	Measurement Theme	Indicator	Dissagregation	Core	Diss.	Source of data	SELECTED
1	General Indicators	Regional boundaries			x			
2		Size of the region			x			
3		Population characteristics			x			
4	General Indicators	Length of stay	Average length of stay of inbound tourist	Total	x		International Travel Survey	
5				Total			Visitor Travel Survey Microdata File	
6				Total			Frontier Counts	
7				Sex of visitors		x		
8				Age of visitors		x		
9				Country of residence		x		
10				Annual Household income		x		
11				Main purpose of the trip		x		
12				Mode of transport of the trip		x		
13			Average length of stay of domestic tourist	Total	x		Travel Survey of Residents of Canada	
14							National Travel Survey	
15				Sex of visitors		x		
16				Age of visitors		x		
17				Country of residence		x		
18				Annual Household income		x		

No	Sust. Dimension	Measurement Theme	Indicator	Dissagregation	Core	Diss.	Source of data	SELECTED
19				Main purpose of the trip		x		
20				Mode of transport of the trip		x		
21		Tourism concentration	Number of visitors	Total	x			
22				Inbound	x		International Travel Survey	x
23							Visitor Travel Survey Microdata File	x
24							Frontier Counts	
25				Domestic	x		Travel Survey of Residents of Canada	
26							National Travel Survey	
27				per 100 residents		x		
28				per hectare of habitable land		x		
29				Sex of visitors		x		
30				Age of visitors		x		
31				Country of residence		x		
32				Annual Household income		x		
33				Main purpose of the trip		x		
34				Mode of transport of the trip		x		
35		Tourism visitor dependency	Number of inbound visitors relative to total internal visitors	Total	x			
36				Tourist	x			

No	Sust. Dimension	Measurement Theme	Indicator	Dissagregation	Core	Diss.	Source of data	SELECTED
37				Same Day	x			
38		Tourism seasonality	Variations in visitor arrivals on a regular time horizon and in regular frequencies.	Total	x			
39				Inbound	x			
40				Tourist	x			
41				Same Day	x			
42	Economic	Visitor expenditure	Average internal tourism expenditure per visitor	Total	x			
43				Inbound	x		ITS, NTS, VTS Microdata Files	X
44				Domestic	x			
45				Tourist	x			
46				Same day	x			
47				Tourism characteristic products (accommodation, food and beverage, transport services, among others)		x	ITS, NTS, VTS Microdata Files	
48				Other consumption products		x	ITS, NTS, VTS Microdata Files	
49		Tourism economic structure	Number of establishments		x		Open Database of Business	X

No	Sust. Dimension	Measurement Theme	Indicator	Dissagregation	Core	Diss.	Source of data	SELECTED
50			Size of establishments (# employees)		x		Canadian Business Counts	X
51			Ownership (# establishments)		x			
52			Legal entity type (# establishments)		x			
53			Share of large tourism establishments (see Key Small Business Statistics 2022)		x			
54			Share of SME (small to medium-sized enterprise)		x			
55			Share of resident ownership		x			
56		Tourism economic performance	Output of Tourism Characteristic products (accommodation, food and beverage, transport services, among others)	Total	x	x	Provincial and territorial tourism supply and expenditure	
57				Other output		x		
58				Total output		x		
59				Total intermediate consumption		x		
60			Gross value added	Total	x			
61				Compensation of employees		x		

No	Sust. Dimension	Measurement Theme	Indicator	Dissagregation	Core	Diss.	Source of data	SELECTED
62				Other taxes less subsidies on production		x		
63			Gross mixed income	Total	x			
64			Gross operating surplus	Total	x			
65			Tourism direct GDP	Total	x			
66			Tourism share of total output for each tourism industry	Total	x			
67		Distribution of economic benefits	Total establishments	Total	x			
68				Number of small and medium (SME) establishments (<100 employees)		x	Key Small Business Statistics 2023	
69				Number of large establishments (>100 employees)		x		
70				Number of resident owned establishments		x		
71				Number of non-resident owned establishments		x		
72			Total Jobs		x			
73				Number of jobs held by women		x		
74				Number of jobs held by men		x		
75				Number of non-management jobs		x		

No	Sust. Dimension	Measurement Theme	Indicator	Dissagregation	Core	Diss.	Source of data	SELECTED
76			Tourism compensation of employees (COE)		x			
77			Tourism gross operating surplus (GOS)		x			
78			Share of Tourism Gross GOS according to SME		x			
79			Share of Tourism GOS according to residents		x			
80			Share of Tourism GOS according to women		x			
81			Share of Tourism GOS according to non-managers		x			
82			Share of compensation of employees relative to tourism direct value added in the tourism industries		x			
83		Employment in tourism	Total employment in tourism industries	Number of jobs	x			
84				Number of employed persons	x		Census of population	X
85				Sex		x	Census of population	X
86				Age		x	Census of population	X
87				Education level (ISCED-2011 Classes)		x	Census of population	

No	Sust. Dimension	Measurement Theme	Indicator	Dissagregation	Core	Diss.	Source of data	SELECTED
88				Occupation (by ISCO-08 major groups)		x	Census of population	
89				Earnings (relative to average earnings)		x	Census of population	
90				Hours of work (per week)		x	Census of population	
91				Nationality		x	Census of population	
92			Share of employed persons in tourism industries relative to total economy		x			
93			Share of women in jobs in the tourism industries		x			
94			Share of women in employed persons in the tourism industries		x			
95			Share of women in employers in the tourism industries		x			
96			Labour productivity of different tourism industries		x			
97		Tourism investment - Produced assets - Tourism specific fixed assets	Accommodation		x		HelloBC Official Lists	X

No	Sust. Dimension	Measurement Theme	Indicator	Dissagregation	Core	Diss.	Source of data	SELECTED
98			Other non-residential buildings and structures proper to tourism industries		x			
99			Passenger transport equipment for tourism		x			
100			Other machinery and equipment specialized for the production of tourism characteristic products		x			
101			Improvements of land used for tourism purpose		x			
102			Non-tourism specific produced assets					
103			Total gross fixed capital formation (GFCF) in tourism specific fixed assets relative to total GFCF of tourism industries		x			
104			Total GFCF by tourism industries and relative to total economy GFCF		x			
105		Government tourism-related transactions	Total tourism related government final consumption expenditure		x		Tourism Investment Module, 2023	

No	Sust. Dimension	Measurement Theme	Indicator	Dissagregation	Core	Diss.	Source of data	SELECTED
106				Roads		x		
107				Ports		x		
108				Airports		x		
109				Tourism promotion services		x		
110				Visitor information services		x		
111				Public administrative services related to the distributive and catering trades, hotels and restaurants		x		
112				Public administrative services related to tourism affairs		x		
113				Market research and public opinion polling services		x		
114				Police and fire protection services		x		
115				Other education and training services, n.e.c.		x		
116				Educational support services		x		
117	Environmental	GHG emissions	GHG emissions: Tourism GHG emissions account ('000 tonnes)	Total	x		Consolidated Community Energy and Emissions Inventory Reports	X
118				Type of substance		x		

No	Sust. Dimension	Measurement Theme	Indicator	Dissagregation	Core	Diss.	Source of data	SELECTED
119				Tourism ratio (%)		x		
120				Visitors direct emissions (residents/non-residents)		x		
121			Internal tourism GHG emissions per visitor		x			
122			Internal tourism GHG emissions per unit of tourism direct GDP		x			X
123		Solid waste flows	Solid waste: Tourism solid waste account (tonnes)		x		Consolidated Community Energy and Emissions Inventory Reports	X
124			Generation of solid waste residuals			x		
125			Collection and disposal of solid waste residuals			x		
126			Tourism Solid waste generated by tourism industries per visitor/tourist		x			
127			Tourism solid waste generated per unit of tourism direct GDP		x			

No	Sust. Dimension	Measurement Theme	Indicator	Dissagregation	Core	Diss.	Source of data	SELECTED
128			Share of Tourism solid waste generated by tourism industries and relative to total solid waste		x			
129		Water flows	Water: tourism water flow account		x		Physical flow account for water use	
130			Sources of abstracted water			x		
131			Water supply			x		
132			Return flows of water generated			x		
133			Tourism water use per visitor/tourist and per visitor overnight		x			
134			Tourism water use per unit of tourism value added		x			
135		Wastewater	Tourism wastewater per visitor overnight		x			
136		Water resources	Annual tourism water use by tourism industries as a proportion of the net change in stock of water resources		x			
137		Energy flows	Energy: Tourism energy flow account (joules)		x		Consolidated Community Energy and	X

No	Sust. Dimension	Measurement Theme	Indicator	Dissagregation	Core	Diss.	Source of data	SELECTED
							Emissions Inventory Reports	
138			Energy from natural inputs			x		
139			Production of energy products			x		
140			Generation of energy residuals and other residual flows			x		
141			Electricity and gas supply		x			
142			Generation of air pollutants		x			
143			Total tourism end-use of energy products by tourism industries		x			
144		Ecosystem extent (for tourism areas)	Changes in ecosystems due to the tourism activity resulting in a loss of natural ecosystems		x		Land Use time Series	X
145			Regional ecosystem extent account ('000 hectares) - using the national ecosystem classifications		x		Biogeoclimatic Ecosystem Classification (BEC)	X

No	Sust. Dimension	Measurement Theme	Indicator	Dissagregation	Core	Diss.	Source of data	SELECTED
146			Share of tourism-related ecosystem assets to the total tourism area		x		-	
147			Percentage of protected areas (marine and terrestrial) to total tourism area		x		BC Parks, Ecological Reserves, and Protected Areas	X
148		Ecosystem services flows for tourism areas	Total recreation related services in a tourism area		x		Landscape Units of British Columbia - Current	X
149			Environmental protection expenditure	Paid to other establishments	x	x		
150				Undertaken on own-account		x		
151				Financing of other restoration activity		x		
152				Total environmental protection expenditure		x		
153				Payment of environmental taxes		x		
154				Energy, transport, pollution and resource taxes		x		
155	Social	Visitor satisfaction	Visitor flow and engagement by local tourism destination (total visitors)	Inbound	x	x		X

No	Sust. Dimension	Measurement Theme	Indicator	Dissagregation	Core	Diss.	Source of data	SELECTED
156				Domestic		x		
157				Average length of stay		x		
158				Country of residence		x		
159				Visitor dependency rate		x		
160			Visitor engagement (participation in cultural events, visitation to museum, attendance and participation in cultural performances)		x			
161			Share of visitors satisfied with overall experience at destination		x			
162			Number of repeat visitors		x			
163			Extent to which visitors would recommend a destination		x			
164		Host community perception	Overall perception of host communities of visitors		x			X
165				Perception of effects on cost of living, including housing affordability, due to tourism.		x	British Columbia Resident Sentiment Research	

No	Sust. Dimension	Measurement Theme	Indicator	Dissagregation	Core	Diss.	Source of data	SELECTED
166				Perceptions of effects of tourism on the local environment including concerning cleanliness, land use (soil sealing), waste management and pollution.		x	British Columbia Resident Sentiment Research	
167				Perceptions of effects of tourism on local social context including crime, safety, and noise.		x	British Columbia Resident Sentiment Research	
168				Perceptions of effects of tourism on local levels of congestion, noise, crowdedness and access to community facilities.		x	British Columbia Resident Sentiment Research	
169				Perceptions on effects of tourism on the prevailing culture identity.		x	British Columbia Resident Sentiment Research	
170				Perceptions of effects of tourism on access to and quality of public services.		x	British Columbia Resident Sentiment Research	
171				Perceptions on effects of tourism on job creation and employment (including seasonal employment).		x	British Columbia Resident Sentiment Research	

No	Sust. Dimension	Measurement Theme	Indicator	Dissagregation	Core	Diss.	Source of data	SELECTED
172				Perceptions on tourism's collaboration with wider local business and community organizations.		x	British Columbia Resident Sentiment Research	
173				Perceptions on the negative and positive contribution of tourism to overall wellbeing.		x	British Columbia Resident Sentiment Research	
174			Need to safeguard communities' cultural heritage		x		First Nation Community Locations	X
175							Important Fossil Areas	X
176							Historic Places Spatial Layer (Public View)	X
177							Historic Trails of British Columbia	X
178							Recreational Features Inventory - Polygons	X
179							Recreation Lines	X
180							Visual Landscape Inventory - Viewing Points	X
181			Tourism carrying capacity		x			

No	Sust. Dimension	Measurement Theme	Indicator	Dissagregation	Core	Diss.	Source of data	SELECTED
182		Decent work	Employed persons in tourism industries by key characteristics for the social dimension	Total	x		Census of population	X
183				Sex		x	Census of population	X
184				Age		x	Census of population	X
185				Education level		x	Census of population	
186				Hours of work (per week)		x		
187				Managerial positions (female, male)		x		
188				Time in job		x		
189				Nationality		x		
190				Work formality		x		
191				Earnings (average hourly earnings)		x		
192				Pension scheme coverage		x		
193			Employed persons in tourism industries as a percentage of working-age population.		x			
194			Percentage of employed persons in tourism industries that work part-time (threshold should be determined).		x			

No	Sust. Dimension	Measurement Theme	Indicator	Dissagregation	Core	Diss.	Source of data	SELECTED
195			Average hourly earnings of employed persons in tourism industries relative to average earnings of employed persons economy wide and for the services sector.		x			
196			Proportion of women in managerial position in tourism industries.		x			
197			Proportion of informal employment in total employment in tourism industries.		x			
198			Percentage of employed persons in tourism industries who are covered by a pension scheme.		x			
199			Share of compensation of employed persons relative to tourism direct value added in the tourism industries		x			
200			Share of employed persons in tourism industries who are informally employed		x			

No	Sust. Dimension	Measurement Theme	Indicator	Dissagregation	Core	Diss.	Source of data	SELECTED
201		Governance	Implementation of standard accounting tools to monitor the economic and environmental aspects of tourism sustainability		x			
202			Non-discrimination and equality	x	x			
203			Participation		x			
204			Openness		x			
205			Access to and quality of justice		x			
206			Responsiveness		x			
207			Absence of corruption		x			
208			Trust		x			
209			Safety and security		x			

Appendix 2 – R Code Scripts Description

01. 01_BEC Map analysis.R

Script to analyze changes on the BEC features

02. 02_Land Use Time Series.R

Script to analyze land use changes

03. 03_CEEI Data.R

Script to analyze the Current Community Energy and Emissions Inventory data for emissions on road, businesses and waste

04. 04_ODBUS Georeferencing.R

Script to georeference the Open Database of Businesses (ODBUS) by Statistics Canada

05. 05_Census Data.R

Script to process the Census data

06. 06_Visitor Flows.R

Script to process the International Visitor Flows Surveys

07. 07_MCA Analysis.R

Script to run the Multi-Criteria Assessment analysis

This research has used OpenAI's ChatGPT (GPT-4) (OpenAI, 2024) as a writing assistant and research support tool throughout this thesis. ChatGPT was utilized to support the coding process and enhance writing. All content generated was critically reviewed, edited, and validated by the author.

Appendix 3 – Geodatabase Structure

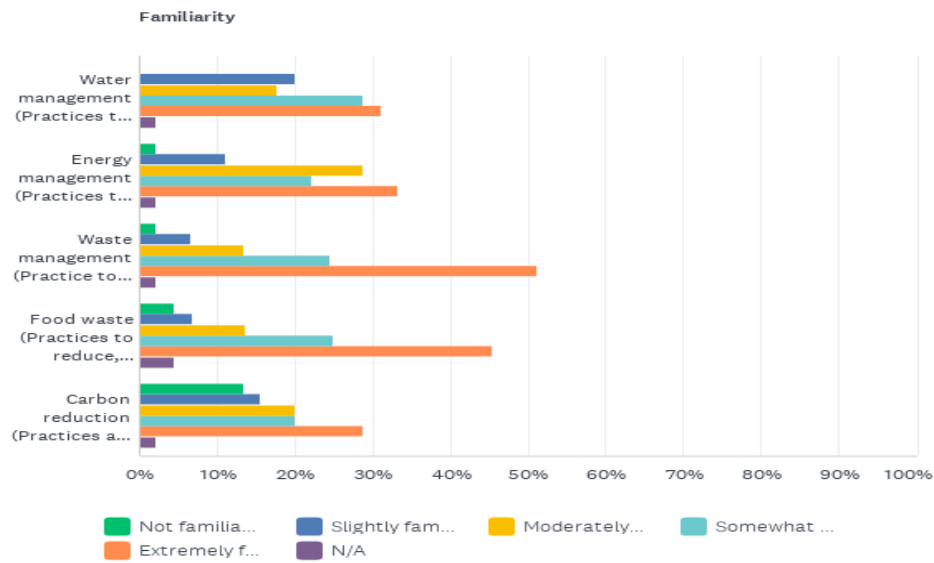
Feature Dataset	Feature layer	Dataset Type	Description
	LU2000_clip	Raster Dataset	Raster dataset. Clip LandUse 2000 into the TOR Boundary
	LU2020_clip	Raster Dataset	Raster dataset. Clip LandUse 2020 into the TOR Boundary
Base_layers		FeatureDataset	BASE LAYERS Feature Dataset
Base_layers	us_boundaries_2018	FeatureClass	US State Boundaries (Reference). US Census Bureau
Base_layers	Main_cities	FeatureClass	Main cities in the Thompson Okanagan Region (TOR)
Base_layers	ADM_TRREG_polygon	FeatureClass	Tourism Administrative Regions in the TOR
Base_layers	tor_boundary_DA	FeatureClass	Thompson Okanagan Region boundary based on the DAs boundaries
Base_layers	RA_DPAR_Line	FeatureClass	Digital Road Atlas (DRA). Retrieved from BC Catalogue
Base_layers	lpr_000b21a_e	FeatureClass	Census Provinces Boundaries 2021. Statistics Canada
Base_layers	tor_disseminat ion_areas	FeatureClass	Census Dissemination Areas for the TOR. Statistics Canada
ENV01_Conserv_str		FeatureDataset	ENVIRONMENTAL DIMENSION INDICATORS: TOR Conservarion Strenght Feature Dataset
ENV01_Conserv_str	tor_RMP_LU_HighInt_Diss	FeatureClass	Landscape Units of British Columbia - High and Intermediate Dissolve
ENV01_Conserv_str	tor_RMP_LU_HighInt	FeatureClass	Landscape Units of British Columbia - High and Intermediate
ENV01_Conserv_str	RMP_LU_SVW_TOR_High_Int	FeatureClass	Landscape Units of British Columbia - TOR filtered
ENV01_Conserv_str	tor_natural_emphasis_byDA	FeatureClass	Resulting Areas with Conservation Strenght
ENV01_Conserv_str	tor_DA_TA_PEP_SVW	FeatureClass	Clipped BC Parks, Ecological Reserves, and Protected Areas, selected for the TOR
ENV01_Conserv_str	TA_PEP_SVW_tor	FeatureClass	BC Parks, Ecological Reserves, and Protected Areas, selected for the TOR
ENV02_Consv_press		FeatureDataset	ENVIRONMENTAL DIMENSION INDICATORS: TOR Conservarion Pressures Feature Dataset
ENV02_Consv_press	tor_timechange_LU0020_byDA	FeatureClass	Resulting Areas with changes in Land Use between 2000 and 2020
ENV02_Consv_press	BEC_2016_DA_TOR	FeatureClass	Bio-geoclimatic Ecosystem Classification 2016 for the TOR
ENV02_Consv_press	BEC_2021_DA_TOR	FeatureClass	Bio-geoclimatic Ecosystem Classification 2021 for the TOR
ENV02_Consv_press	BEC_2018_DA_TOR	FeatureClass	Bio-geoclimatic Ecosystem Classification 2018 for the TOR

Feature Dataset	Feature layer	Dataset Type	Description
ENV02_Consv_press	BEC_21int18int_16_C_Dissolve	FeatureClass	BEC processing temporal result layer
ENV02_Consv_press	BEC_21int18int_16	FeatureClass	BEC processing temporal result layer
ENV02_Consv_press	BEC_21int18	FeatureClass	BEC processing temporal result layer
ENV02_Consv_press	BEC_21int18int_16_Change	FeatureClass	BEC processing temporal result layer
ENV02_Consv_press	BEC_21int18int_16_C_Dissolve1	FeatureClass	BEC processing temporal result layer
ENV02_Consv_press	tor_timechange_BEC161821_byDA	FeatureClass	Resulting Areas with changes in BEC between 2016, 2018 and 2021
ENV02_Consv_press	tor_community_emissions	FeatureClass	Community emissions at DA level in the TOR
SOC_Heritage_and_Recreation		FeatureDataset	SOCIAL DIMENSION INDICATORS: Heritage and Recreation Feature Dataset
SOC_Heritage_and_Recreation	FTN_REC_LN_DAs	FeatureClass	Recreation Lines Clipped by DA
SOC_Heritage_and_Recreation	FTN_REC_LN_DAs_Dissolve	FeatureClass	Recreation Lines Dissolved by DA
SOC_Heritage_and_Recreation	FN_COM_LOC_point_TOR	FeatureClass	First Nations in British Columbia in the TOR. Location of the main community
SOC_Heritage_and_Recreation	FOSS_IMP_A_polygon_TOR	FeatureClass	Important Fossil Areas in British Columbia in the TOR
SOC_Heritage_and_Recreation	RCVWPNT_TOR	FeatureClass	Recreation View Points in the TOR
SOC_Heritage_and_Recreation	REC_INVTRY_int_DA1_diss	FeatureClass	Recreation Feature Inventory identifies areas of land and water encircling a recreation feature
SOC_Heritage_and_Recreation	REC_INVTRY_polygon_TOR	FeatureClass	RFI processing temporal result layer
SOC_Heritage_and_Recreation	REC_INVTRY_int_DA1	FeatureClass	RFI processing temporal result layer
SOC_Heritage_and_Recreation	REC_INVTRY_int_DA	FeatureClass	RFI processing temporal result layer
SOC_Heritage_and_Recreation	H_TRAILS_line_TOR	FeatureClass	Historic Trails in the TOR
SOC_Heritage_and_Recreation	HISTENVPA_polygon_TOR	FeatureClass	Historic sites in British Columbia in the TOR
SOC_Heritage_and_Recreation	tor_recreation_potential_byDA	FeatureClass	Resulting Areas with recreation potential in the TOR
SOC_Heritage_and_Recreation	tor_sociocult_byDA	FeatureClass	Resulting Areas with socio cultural indicators in the TOR
ECO01_Employment_Visitors		FeatureDataset	ECONOMIC DIMENSION INDICATORS: Employment Feature Dataset

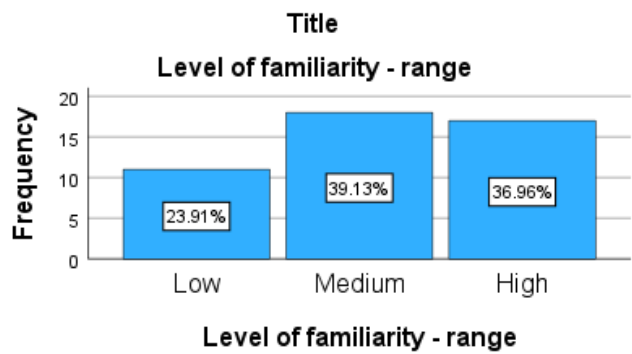
Feature Dataset	Feature layer	Dataset Type	Description
ECO01_Employment_Visitors	tor_cen11_labour	FeatureClass	Census 2011 indicators at DA level
ECO01_Employment_Visitors	tor_cen16_labour	FeatureClass	Census 2016 indicators at DA level
ECO01_Employment_Visitors	tor_cen21_labour	FeatureClass	Census 2021 indicators at DA level
ECO01_Employment_Visitors	tor_cen11_16_21_labour	FeatureClass	Combination of Census 2011, 2016 and 2021 indicators at DA level
ECO01_Employment_Visitors	tor_visflow_estimates	FeatureClass	Visitor Flows estimates at DA level
ECO02_Tourism_Infrastructure		FeatureDataset	ECONOMIC DIMENSION INDICATORS: Tourism Infrastructure Feature Dataset
ECO02_Tourism_Infrastructure	SKI_RESORT_TOR	FeatureClass	Ski resorts in the TOR
ECO02_Tourism_Infrastructure	GOLF_COURS_TOR	FeatureClass	Golf courses in the TOR
ECO02_Tourism_Infrastructure	HLLBC_ATT_TOR	FeatureClass	Hello BC Attractions in the TOR
ECO02_Tourism_Infrastructure	HLLBC_ACC_TOR	FeatureClass	Hello BC Accommodations in the TOR
ECO02_Tourism_Infrastructure	HLLBC_VC_TOR	FeatureClass	Hello BC Visitor Centers in the TOR
ECO02_Tourism_Infrastructure	ODBus_tourism_tor	FeatureClass	ODBUS Database extracted for the TOR
ECO02_Tourism_Infrastructure	tor_tourism_infrastructure_byDA	FeatureClass	Resulting Areas with tourism infrastructure indicators in the TOR
MCA_Analysis		FeatureDataset	MULTI CRITERIA ASSESSMENT Process
MCA_Analysis	tor_das_MCA_no_weight	FeatureClass	MCA not weighted
MCA_Analysis	tor_das_MCA_weight	FeatureClass	MCA weighted
MCA_Analysis	survey_points_25May	FeatureClass	Stakeholders' Survey Georeferenced
MCA_Analysis	tor_das_MCA_INTEGRATED	FeatureClass	MCA integrated

Appendix 4 – Survey responses and detailed graphics

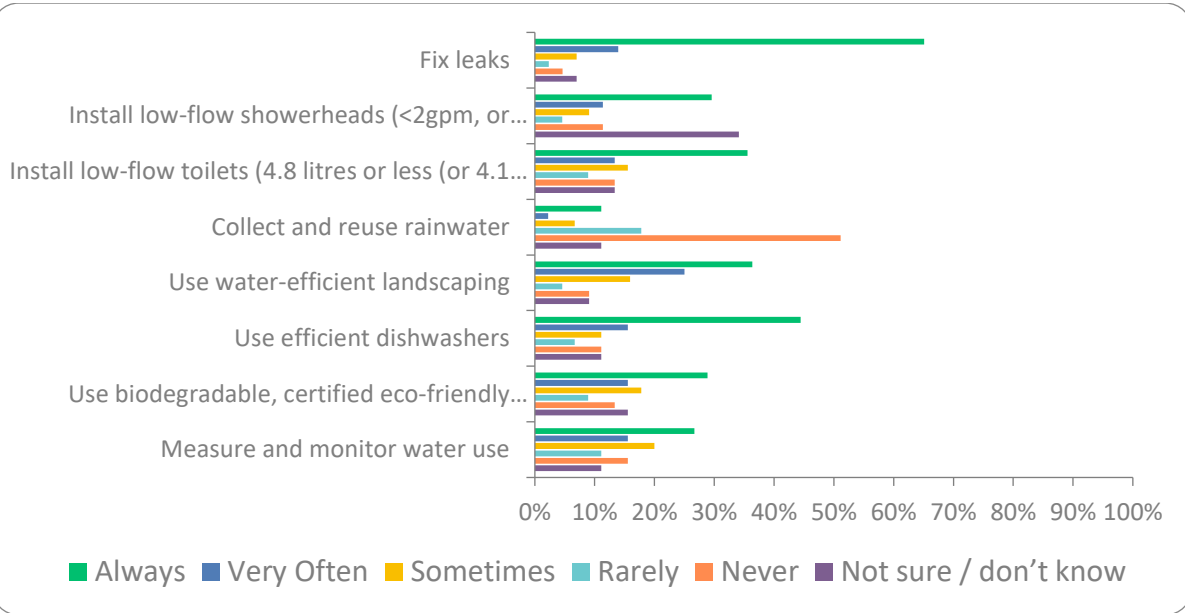
Level of familiarity with some practice in the management of natural resources:



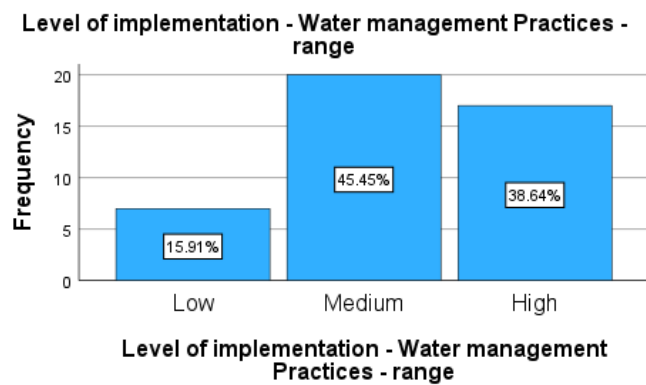
Sum Index for level of familiarity



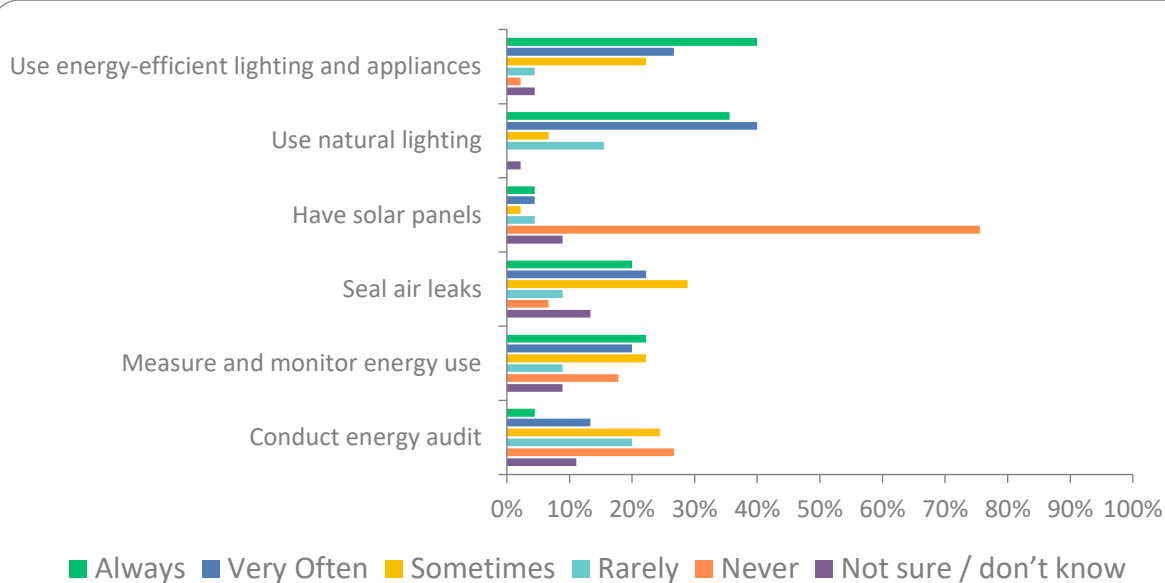
Level of implementation of Water Management practices



Sum Index for level of Water Management practices

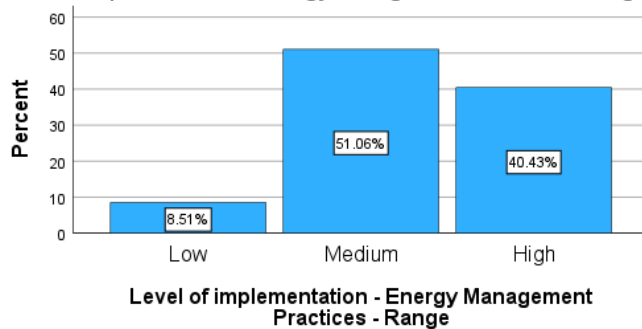


Level of implementation of Energy Management practices

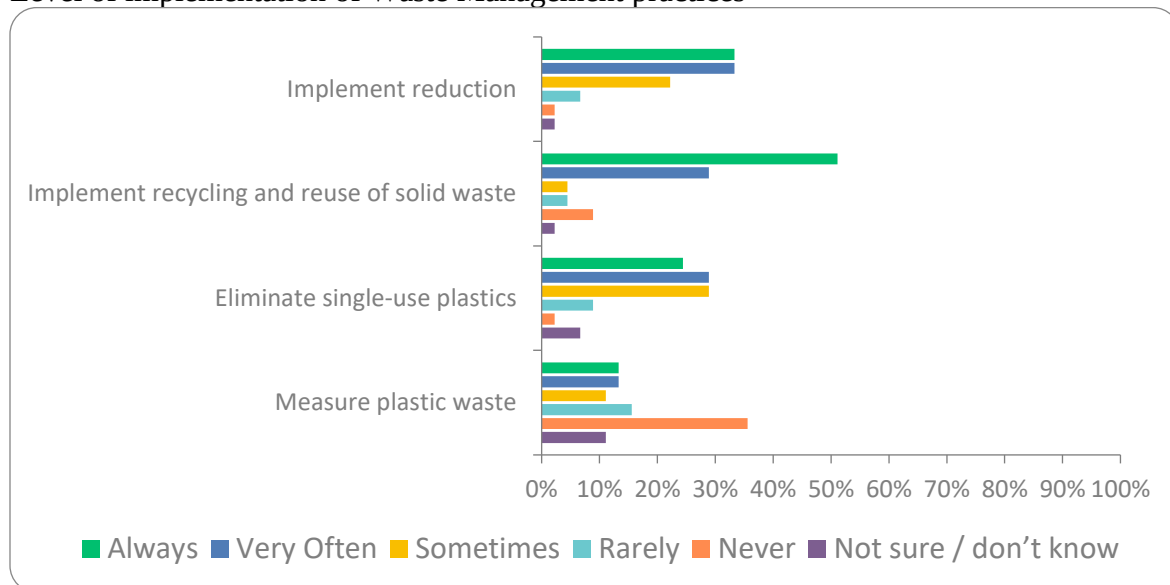


Sum Index for level of Energy Management practices

Level of implementation - Energy Management Practices - Range

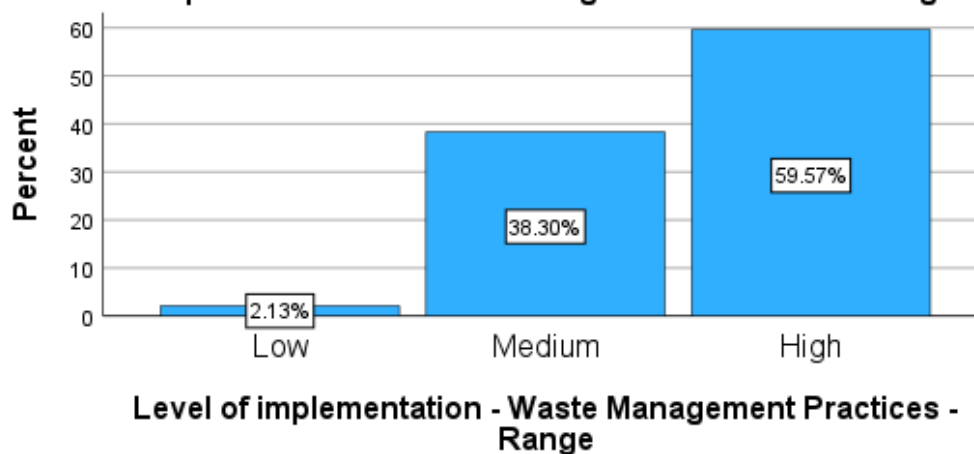


Level of implementation of Waste Management practices

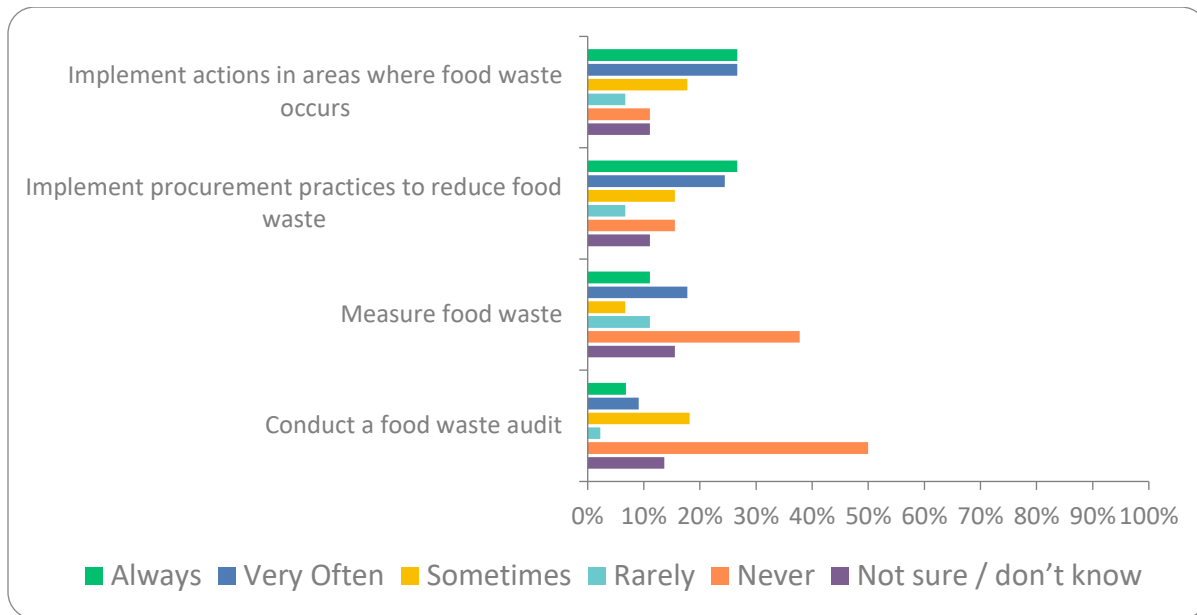


Sum Index for level of Waste Management practices

Level of implementation - Waste Management Practices - Range

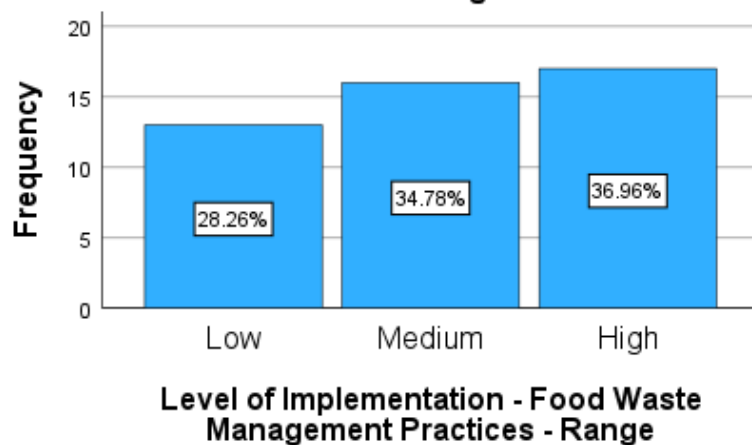


Level of implementation of Food Waste Management practices

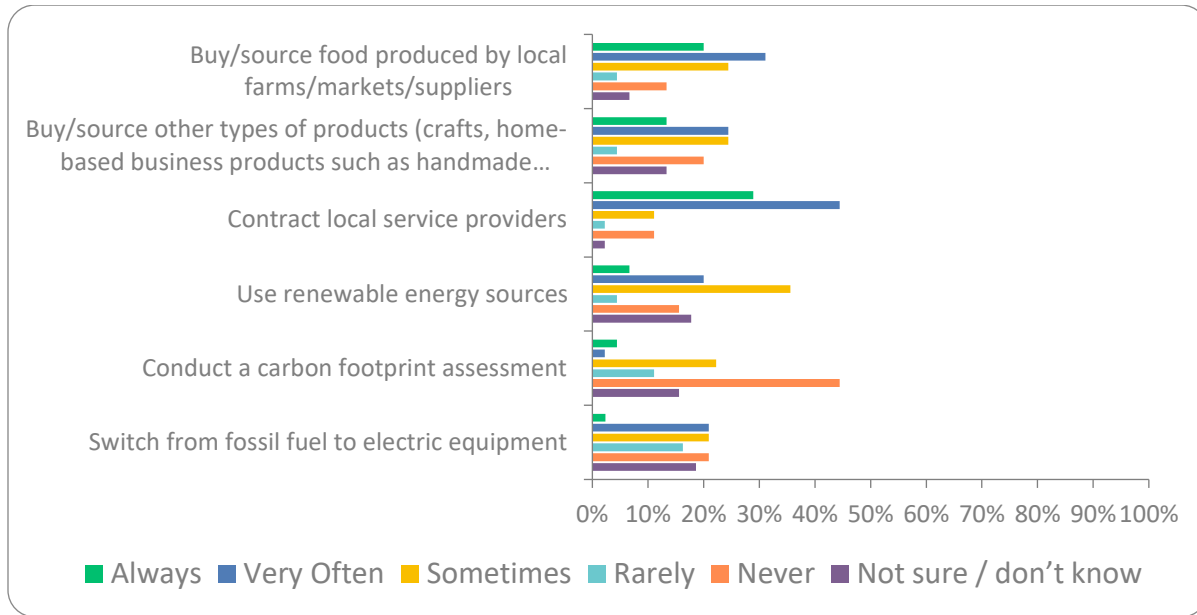


Sum Index for level of Food Waste Management practices

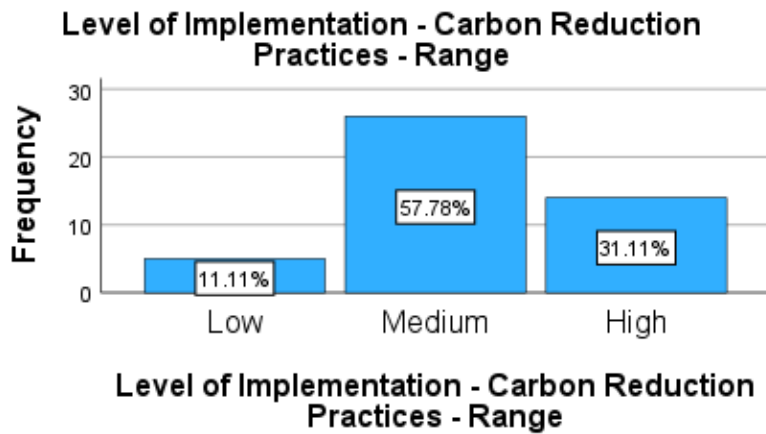
Level of Implementation - Food Waste Management Practices - Range



Level of implementation of Carbon Reduction practices



Sum Index for level of Carbon Reduction practices



Appendix 5 – Survey Questionnaire



THOMPSON RIVERS UNIVERSITY

The Application of GIS (Geographic Information Systems) Technologies to monitor and support Sustainable Tourism in the Thompson-Okanagan Region Municipality

Definitions and Respondent Characteristics (related to the business)

Definitions

Throughout the remaining components of this survey, we will ask for your perspectives on different aspects of sustainability in the tourism industry in your community.

For the purpose of this survey, please refer to the following definitions:

- Your community: refers to the community/town/city where you currently live.
- Tourism businesses: businesses in the tourism industry that include activities like providing information, accommodations, transportation, experiences and other services to visitors. For the purpose of the present research, the study will focus on three types of tourism businesses: hotels, wineries and restaurants in the Thompson-Okanagan Region
- Geographic Information Systems: a computer system that analyzes and displays geographically referenced information. It uses data that is attached to a unique location. (USGS, 2023). Digital mapping applications such as Google Maps, iPhone Maps, ArcGIS and QGIS are considered GIS tools.
- Sustainability: is defined in the Brundtland Report as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (UN, 1987, p. 37).
- Sustainable tourism: the United Nations definition, which defines it as “tourism that takes full account of its current and future economic, social and environmental impacts whilst addressing the needs of visitors, the industry, the environment and host communities” (UNWTO, 2024b).
- Sustainable practices: practices that pursue to achieve sustainable principles, managing resources effectively, reducing operation costs, managing waste or developing recycling practices and practices that pursue carbon reduction.

Respondent characteristics (related to the business)

4. For classification purposes only, please provide your address:

Street address

Zip code

5. Please provide the type and name of your company

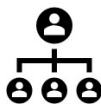
- ☐ Hotel
- ☐ Restaurant ☐

Winery

☐ Other Name

6. How best do you describe the type of position that you have at your company?

☐ Owner

☐


Supervisor: a supervisor position conducts activities as supervises, directs, and coordinates the activities of workers in her/his charge

Supervisor

☐


Representative: a representative position conducts activities for client attention and personal service for customers, like bartenders, maîtres d'hôtel and hosts/hostesses, and food and beverage servers, among others

Representative

☐


Service Support: a service support position conducts activities for support services in the company, like food counter attendants, kitchen helpers, carriers of customers' luggage, cleaners, and janitors, among others

Service support

☐ Prefer not to answer

7. Which of the following categories best describes your employment status?

☐ Part-time position ☐

Full-time position

☐ Various positions at various periods of time ☐

Other (please specify)

Prefer ☐ to answer

* 8. In general terms, do you feel well-informed about sustainable practices in your company?

☐ Yes ☐

No

☐ Other (please specify)

* 9. How familiar are you with some practice in the management of natural resources, as mentioned in the next options?

Familiarity

Water management
(Practices to optimize
water usage, reduce
water consumption or
minimize water
pollution)

Energy management
(Practices to optimize
energy use or reduce
energy consumption)

Waste management
(Practice to minimize waste and its sources, or to use creative ways to recycle or reuse waste)

Food waste (Practices to reduce, repurpose and recover food or have proper disposal methods)

Carbon reduction
(Practices and strategies to reduce carbon footprint and carbon offsets)

10. How often do you or your company implement some of the next practices for Water Management at your place of work?

	Always	Very Often	Sometimes	Rarely	Never	Not sure / do not know
Fix leaks	☐	☐	☐	☐	☐	☐
Install low-flow showerheads (<2gpm, or WaterSense certified)	☐	☐	☐	☐	☐	☐
Install low-flow toilets (4.8 litres or less (or 4.1 litres/6 litres dual flush))	☐	☐	☐	☐	☐	☐
Collect and reuse rainwater	☐	☐	☐	☐	☐	☐
Use water-efficient landscaping	☐	☐	☐	☐	☐	☐
Use efficient dishwashers	☐	☐	☐	☐	☐	☐
Use biodegradable, certified eco-friendly detergents	☐	☐	☐	☐	☐	☐
Measure and monitor water use	☐	☐	☐	☐	☐	☐
Other (please specify)						

11. How often do you or your company implement some of the next practices for Energy Management at your place of work?

Always	Very Often	Sometimes	Rarely	Never	Not sure / don't know
Use energy-efficient lighting and appliances	☐	☐	☐	☐	☐
Use natural lighting	☐	☐	☐	☐	☐
Have solar panels	☐	☐	☐	☐	☐
Seal air leaks	☐	☐	☐	☐	☐
Measure and monitor energy use	☐	☐	☐	☐	☐
Conduct energy audit	☐	☐	☐	☐	☐
Other (please specify)					

12. How often do you or your company implement some of the following practices for Waste Management (except food waste) at your place of work?

Always		Very Often	Sometimes	Rarely	Not sure / don't Never know	
Implement reduction	☐	☐	☐	☐	☐	☐
Implement recycling and reuse of solid waste	☐	☐	☐	☐	☐	☐
Eliminate single-use plastics	☐	☐	☐	☐	☐	☐
Measure plastic waste	☐	☐	☐	☐	☐	☐
Other (please specify)						

13. How often do you or your company implement some of the next practices for Food Waste at your place of work?

Always		Very Often	Sometimes	Rarely	Not sure / don't Never know	
Implement actions in areas where food waste occurs	☐	☐	☐	☐	☐	☐
Implement procurement practices to reduce food waste	☐	☐	☐	☐	☐	☐
Measure food waste	☐	☐	☐	☐	☐	☐
Conduct a food waste audit	☐	☐	☐	☐	☐	☐
Other (please specify)						

Not su○/ don't know

16. If yes, how far away are the other type of products local markets/suppliers on average?

☐ Within 5 kilometers (less than 10 minutes by car, approximately) ☐ 6 –

10 kilometers (11 – 15 minutes by car, approximately)

☐ 11 – 20 kilometers (16 – 20 minutes by car, approximately)

☐ 21 – 50 kilometers (21 – 60 minutes by car, approximately)

☐ More than 51 kilometers (more than 1 hour by car, approximately) ☐

Other (please specify)

☐ Not sure / don't know

17. What is the distance or how long does it take you to get from your home to your place of work?

☐ Within 5 kilometers (less than 10 minutes by car, approximately) ☐ 6 –

10 kilometers (11 – 15 minutes by car, approximately)

☐ 11 – 20 kilometers (16 – 20 minutes by car, approximately)

☐ 21 – 50 kilometers (21 – 60 minutes by car, approximately)

☐ More than 51 kilometers (more than 1 hour by car, approximately) ☐

Other (please specify)

☐ Not sure / don't know

18. What practices do your company employ to educate employees about sustainability? (select all that apply)

☐ Conduct regular training sessions ☐

Provide informational materials ☐ Use sustainable signage

☐ Conduct employee engagement programs ☐

Other (please specify)

None of the above ☐

19. What practices do your company employ to educate visitors about sustainability? (select all that apply)

☐ Provide information pre-visit (e.g. website) ☐

Provide informational materials

☐ Use sustainable signage on the property

☐ Provide information on other ways to promote sustainability ☐

Other (please specify)

None ☐ of the above

20. What are the current barriers to implementing sustainability practices? (select all that apply)

☐ Lack of staff knowledge ☐

Lack of staff time

☐ Financial constraints

☐ Lack of information on rebates and incentives

☐ Lack of baseline information (i.e. understanding current waste, water, energy consumption compared to other similar businesses)

☐ Not sure / don't know Other

(please specify)

21. Do you think your community has too few, too many, or just the right amount of tourism throughout the year? (Please select one response per item)

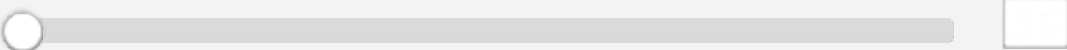
Too many		Just the right amount		Too few		Not sure / don't know
Winter (Dec-Feb)	☐	☐		☐		☐
Spring (Mar-May)	☐	☐		☐		☐
Summer (Jun-Aug)	☐	☐		☐		☐
Fall (Sep-Nov)	☐	☐		☐		☐

22. On a scale of 1-100% what is your business contribution to **Environmental Sustainability**

0	50	100	

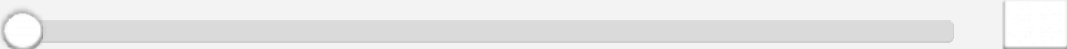
23. On a scale of 1-100% what is your business contribution to **Economic Sustainability**

0 50 100



24. On a scale of 1-100% what is your business contribution to **Social Sustainability**

0 50 100



25. Have you heard about digital mapping applications such as Google Maps, iPhone Maps, or any other type of digital mapping application?

- ☐ Yes
- ☐ No
- ☐ Don't know / Prefer not to respond

26. Do you use digital mapping applications such as Google Maps, iPhone Maps, or any other type of digital mapping application?

- ☐ Yes
- ☐ No
- ☐ Don't know / Prefer not to respond

27. How often do you use mapping applications for the tasks listed in the next options?

Frequency

To find the location of places, attractions or suppliers of products and services	
To find routes and journey times to a specific destination	
To find visitors' preferences and their distribution	
To analyze information about market statistics and develop marketing strategies	
To observe the impact of human activity in the environment close to my community	
To analyze information about natural or man-made hazards	

Other (please specify)

28. How often do you help your visitors to use mapping applications for the tasks listed in the next options?

Frequency

To find the location of places, attractions or suppliers of products and services	
To find routes and journey times to a specific destination	
To find visitors' preferences and their distribution	
To observe the impact of human activity in the environment close to my community	
To analyze information about natural or man-made hazards	
Other (please specify)	

29. Please respond to what degree you agree or disagree with the following statements about the use of GIS technologies.

Strongly Agree	Neither agree Agree nor disagree	Strongly Disagree Disagree	Don't know/ prefer not to respond
----------------	-------------------------------------	-------------------------------	---

Using GIS technologies to map the sustainability status of a business is easy.

☐ ☐ ☐ ☐ ☐ ☐

Using GIS technologies to map the sustainability status of a business is a good idea.

☐ ☐ ☐ ☐ ☐ ☐

Using GIS technologies to map the sustainability status of a business is convenient.

☐ ☐ ☐ ☐ ☐ ☐

Using GIS technologies to map the sustainability status of a business pays off.

☐ ☐ ☐ ☐ ☐ ☐

30. Do you think using these digital mapping tools and applications contributes to improving sustainable tourism development in your community?

☐ Yes, highly contributes

☐ Yes, moderately contributes ☐

Yes, slightly contributes

☐ Neither contributes nor does not contribute ☐

No, it does not contribute

☐ Don't know/prefer not to respond

31. Please respond to what extent you agree or disagree with this statement: I would be willing to provide information to update digital mapping applications that contribute to sustainable tourism development in the region.

☐ Strongly Agree ☐

Agree

☐ Neither agree nor disagree ☐

Disagree

☐ Strongly Disagree

Don't know/prefer not to respond

The next questions are simply to ensure we collect responses from a broad range of persons. Please be assured all your answers will be combined with others to ensure your anonymity

32. Do you identify as:

☐ Female ☐

Male ☐ Other

☐ Prefer not to answer

33. What is the highest level of education that you have completed? (Please select the highest one)

- ☐ High school or less
- ☐ Post-secondary school (university/college)
- ☐ Registered Apprenticeship or another Certificate or Diploma
- ☐ Graduate school (Master's/Doctorate) or Professional Advance Degree ☐

Other

- ☐ Prefer not to answer

34. Which age group do you belong?

- ☐ 18-24
- ☐ 25-34
- ☐ 35-44
- ☐ 45-54
- ☐ 55-64
- ☐ 65 and over

Prefer ☐ to respond

35. How long have you resided in your current area?

- ☐ 5 years or less
- ☐ 6-9 years
- ☐ 10-14 years
- ☐ 15-19 years
- ☐ 20-24 years
- ☐ 25 or more years

36. How would you describe your business location?

- ☐ Urban core of a large city ☐

Suburban

- ☐ Small town or rural

Don't know / Prefer not to answer ☐

