POOYAN SEDARATI

SYSTEM DYNAMICS MODELING OF SUSTAINABLE SMART TOURISM ECOSYSTEMS CASE OF PORTUGAL

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Thesis submitted for obtaining the
PhD in Tourism

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AUTHORSHIP DECLARATION

SYSTEM DYNAMICS MODELING OF SUSTAINABLE SMART ECOSYSTEMS CASE OF PORTUGAL

Statement of Work Authorship

I declare to be the author of this work, which is unique and unprecedented. Authors and works consulted are properly cited in the text and are included in the listing of references included.

Pooyan Sedarati

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SUMMARY

The tourism industry is inherently complex and is considered a significant contributor to economic growth and an indispensable constituent in sustainable development. Many destinations thrived into mature touristic spots by introducing a right and adaptive management plan and suitable infrastructure. In order to maintain the high quality of a destination, it is necessary to observe and control the activities and elements of the place. However, this can be a difficult task, as tourism destinations are complex systems, with numerous interactions between the sectors operating within the destinations, and there are multiple stakeholders with varied and at times conflicting interests. The complexity of the problems that emerge in tourism systems, due to the diversity of interests of the different stakeholders and the dynamic and non-linear nature of the interactions between the different components of the systems, has discouraged the use of linear thinking. As a relatively small tourism destination, Portugal offers a wide diversity of attractions providing accessible and unique experiences. Thus, making tourism foci in strategic planning for promoting regional planning, foreign investment, creating employment, and boosting Portugal's external image. Therefore, this thesis intends to outline the concept of smart tourism ecosystems by scrutinizing the tourism industry, smart tourism, complex systems, system dynamics, consequently conducting research to identify gaps and complementarities between research and practice. Hence, to elucidate this issue, this thesis first utilizes system dynamics to discuss and analyze the dynamics of causal relationships among smart tourism ecosystems' components. Second, the proposed methodology enables simulations based on proposed scenarios in which the causality among variables over time can be tested. Third, the employed method simplifies the complex topic of smart tourism ecosystems, thus facilitating understanding the system and furnishing decision-makers with a better perspective. The proposed dynamic model stimulates the creation of economic resilience and a more sustainable economy by promoting smart solutions for the empowerment of the local economy.

Resumo

A indústria do turismo é inerentemente complexa e é considerada como tendo uma contribuição significativa para o crescimento económico sendo um componente indispensável para o desenvolvimento sustentável dos país e regiões. Muitos destinos prosperaram enquanto pontos turísticos maduros, introduzindo um plano de gestão adequado e adaptável, assim como infraestruturas adequadas. Para manter a alta qualidade de um destino turístico, é necessário observar e controlar as atividades e os elementos desse destinos. No entanto, esta pode ser uma tarefa difícil, considerando que os destinos turísticos são sistemas complexos, com inúmeras interações entre os setores que operam entre si, existindo também múltiplos stakeholders com interesses variados e, por vezes, discordantes. A complexidade dos problemas que surgem nos sistemas turísticos, devido à diversidade dos diferentes intervenientes e aos interesses dinâmicos e não lineares das interacções entre os diferentes componentes dos sistemas, tem desencorajado a utilização do pensamento linear. Sendo um destino turístico relativamente pequeno, Portugal oferece uma grande diversidade de atrações que proporcionam experiências acessíveis e únicas. Assim, o objetivo e tornar o turismo centrado no planeamento estratégico para a promoção do planeamento regional, investimento estrangeiro, criação de emprego e dinamização da imagem externa de Portugal. Como efeito, esta tese pretende delinear o conceito de ecossistemas de turismo inteligente através do escrutínio da indústria do turismo, turismo inteligente, sistemas complexos, dinâmica de sistemas, consequentemente realizando pesquisas para identificar lacunas e complementaridades entre pesquisa e prática. De formar a elucidar esta questão, esta tese utiliza em primeiro lugar a dinâmica de sistemas para discutir e analisar a dinâmica das relações causais entre os componentes dos ecossistemas de turismo inteligente. Em segundo lugar, a metodologia proposta permite simulações baseadas em cenários propostos nos quais a causalidade entre variáveis ao longo do tempo pode ser testada. Em terceiro lugar, o método empregado simplifica o tema complex dos ecossistemas de turismo, facilitando assim a compreensão do sistema e providenciando a tomada de decisões baseadas numa melhor perspectiva. O modelo dinâmico proposto estimula a criação de resiliência econômica e uma economia mais sustentável, promovendo soluções inteligentes para o empoderamento da economia local.

GENERAL INDEX

LIST OF ABBREVIATIONS

SD	System Dynamics
STE	Smart Tourism Ecosystems
IT	Information Technology
ICT	Information and Communications Technology
AI	Artificial Intelligence
IoT	Internet of Things
GDP	Gross Domestic Product
GFCF	Gross Fixed Capital Formation
DA	Destination Attractiveness
E-Governance	Electronic-Governance
CF	Crowding Factors
SLR	Systematic Literature Review

Chapter 1.

GENERAL INTRODUCTION

1. Introduction

Tourism has become one of the biggest industries in the world and can be deemed as an economic sector (R. Baggio, 2013). Moreover, it is an industry that is proliferating internationally and regionally and directly impacts economic, environmental, and social aspects (Sinclair-Maragh & Gursoy, 2016). Also, tourism has become a driving force in sustainable development, encouraging many developing countries to promote tourism policies (UNWTO, 2013).

Over the past decades, the issue of sustainability has become the prominent director in forming the economic and political structures of the tourism system, the industry, and their development (Bramwell & Lane, 1993; Saarinen, 2006). The transference of sustainability to tourism started after the Brundtland Commission's report "Our Common Future" in 1987 (Brundtland et al., 1987), which asserts meeting the needs of present generations without endangering the ability of future ones to meet their own needs. With its rapid growth, the tourism industry has become one of the biggest industries in the world, cutting across all industries and directly impacting economic, environmental, and social aspects. In addition, the tourism industry is recognized as one of the major economic driving forces contributing to creating jobs and generating income (Saarinen, 2006; Unwto, 2013).

According to Sharpley (2000a), sustainable development must consider all global factors and consider all socioeconomic, environmental, and political elements. Undoubtedly, also sustainable tourism development encapsulates the holistic approach toward development. According to Liu (2003), the mutual relationship between supply and demand in tourism development creates a constant change representing growth, stagnation, or decline. Consequently, this change creates a dynamic process of matching tourism resources to demand. Moreover, he entails the importance of contributing to the economy and society while sustainably using environmental resources in sustainable tourism. Furthermore, Saarinen (2006) draws a bigger picture of the overall system of the tourism industry in which the movement among elements of the system, both regionally and globally, are socially interrelated. According to Saarinen (2006), the inseparable role of tourism as part of the global economy and culture should not be neglected, but sustainability has been mostly on the destinations level rather than holistic approaches.

Tourism offers a multitude of activities spread across different sectors in order to meet tourists' preferences. Goeldner and Ritchie (2003) proposed a model of the tourism industry components, which acknowledges that tourists use different services such as transportation, food services, accommodation, travel trade, cultural activities, sports and recreation, attractions, retail trade, and other tourism services.

Changes in the tourism system depend on various forces that impact each other (Boukas & Ziakas, 2014). Tourism is known for having various positive influences on economic growth which can contribute to the creation of job opportunities, generate income for local people and motivate them to increase their production (Brouder, 2012). In addition, the financial flow resulting from tourism activities is fundamental to support investment in infrastructures, fostering competitiveness, economic growth, and development (Balaguer & Cantavella-Jordá, 2002).

The interdependence of the socioeconomic and the natural environmental systems and their impacts on sustainability should not, however, be neglected (Burger et al., 2012). Although tourism is considered a major driving force in development, it can also generate negative impacts. For example, it is well known that tourism plays a significant role in CO2 emissions by using transportation, accommodation, and other facilities, making tourism one of the important contributors to climate change (Egilmez & Tatari, 2012; Law et al., 2012). The presence of tourists in a destination leads to higher production of solid and liquid waste, which can cause severe problems for destinations that lack a suitable infrastructure.

This proposal presents some theoretical foundations and empirical findings supported by existing research from multiple fields such as tourism, smart tourism, complex systems, and System Dynamics (SD). Consequently, some important gaps and complementarities between research and practice are identified and used to propose an integrative and comprehensive conceptualization of the proposed topic.

The proposal is organized into seven sections, including the initial introduction. The following section presents background research on the proposed topic by presenting some of the existing definitions already include several essential aspects starting with the importance of focusing on interrelation and feedback structure in the tourism system, contribution of information communication technologies (ICT) in general, and tourism, smart tourism and smart ecosystem. The second section ends with a comprehensive literature review already undertaken in this journey on the application of SD in the

tourism industry. Section three describes the problem and research objectives. It also briefly describes new perspectives of looking at sustainable tourism and Information Technology (IT) and core elements of smart cities which have been given practical tools for ranking, evaluating, or guiding smart city efforts. Based on a comprehensive review of existing literature, section four proposes the goals of the proposed idea. Section five delimits the understudied topic and points out the important reason for choosing Portugal. Section 6 gives an overview of how the proposal will be structured. Finally, Section 7 thoroughly presents the chosen methodology and the reasons for selecting SD.

2. Literature Review

Saarinen (2006) raises this question on the conditions necessary to develop tourism locally and globally sustainably. He believes that to move towards truly sustainable tourism based on the idea of sustainable development, and there is a necessity in re-evaluation and re-location of the current development discourses and actions. Saarinen (2006) finally concludes by emphasizing the importance of iterative and interrelated characteristics of sustainability. Through globalization, sustainable tourism development has also been through changes that urge the tourism industry to define and introduce different political and economic approaches by focusing on human relations and ethics on a global scale (Saarinen, 2006).

Therefore, the iteration and interrelationships can be demonstrated by using a system thinking approach. The adoption of systems thinking and holistic approach to promote understanding of tourism problems and tourism systems are justified on the grounds that the components of the tourism industry interact with each other and offer the same final product, which is an attraction and experience for tourists (Sánchez et al., 2006). Therefore, a holistic, well-managed and systematic plan is necessary to develop and promote the destination as a whole and to ensure its sustainability. The duty of sustainable tourism is not only environmental protection but also includes the livelihood, social and economic dimensions of stakeholders in a touristic area (Angelevska-Najdeska & Rakicevik, 2012). In order to capture and analyze the dynamic and complex nature of systems, multiple approaches have been proposed over the last three decades. The SD approach is one of the best-known examples.

The idea of smartness is devised by a complex technological infrastructure that exists within urban areas to foster economic, social, and environmental prosperity. The ICT

provides the foundation for realizing interconnected systems to tackle the economic, social, and environmental challenges in big cities (Dirks & Keeling, 2009). The potential of smartness and understanding the need to adapt to this rapid change in technology should not be neglected, and how they can contribute to sustainable development and economic growth (Nam & Pardo, 2011). The constant flow of information and data has provided us with an important foundation that proved hard to understand or translate into more straightforward and more understandable language. The emergence of modern technologies facilitates transforming and interpreting complex data into a more readable and understandable form.

The ICT has provided tourists with ubiquitous access to information in which using the internet to acquire information regarding weather forecasts, reservations, entrance fees, tours, services, transportation, and navigation has been facilitated (Buhalis & Law, 2008; Gretzel, Sigala, et al., 2015; Gretzel, Werthner, et al., 2015; Leung et al., 2013; Schoefer, 2003). Furthermore, the implications of IT and sustainability are intertwined, and pillars of sustainability require a proper maintenance system to constantly educate, monitor, and collaborate, which through ICT adoption can be achievable (Benckendorff et al., 2014). This foundation encourages businesses to move their management and marketing strategy in tourism more towards an ICT-dependent strategy to facilitate communication with consumers (Hays et al., 2013).

In a review on the interrelations of IT and sustainability, Gössling (2017) defines these interrelations as very complex. In this review, he draws attention to the necessity of using an in-depth and interdisciplinary approach to illustrate the contribution of IT to sustainability. The constant changes in IT are potentially complex, and its implications on social, environmental, and economic sustainability would be multifaceted. According to Gössling (2017), the advent of sharing websites such as Couchsurfing, on the one hand, can contribute to social sustainability by facilitating the communication between local communities and visitors, on the other hand, can diminish social and economic sustainability due to the lack bilateral relation.

Up until now, several studies have considered determinants of technology acceptance in tourism destinations. Gretzel, Werthner, Koo, and Lamsfus (2015) give a holistic look to smart tourism by considering it a complex and dynamic ecosystem and emphasizing the interconnectivity of the whole system. In this vein, with the emergent context of travel,

the focal concern for smart destinations is to determine tourism experience throughout mobile surroundings (Lamsfus et al., 2015).

Ecosystems are intricate networks of businesses, socio-economic and environmental subsystems. Moreover, tourism destinations consist of various sectors and subsectors which are interrelated and working simultaneously. Therefore, tourism destinations resemble the complexity and interconnectedness of an ecosystem (Perfetto & Vargas-Sánchez, 2018). Ecosystems mainly emphasize the holistic view rather than focusing on elements of systems by recognizing how small changes can have substantial effects, encourages a focus on complex relationships, emphasizes dynamic change (Gretzel, Werthner, et al., 2015). Moreover, this paper draws attention to the technical definition by Boley & Chang (2007) using the term digital ecosystem by pointing out the characteristics of these ecosystems such as flexibility, openness, demand-driven, interactivity. Digital ecosystems focus on the interconnectedness among technological agents (devices, databases, programs, etc.) to enhance the dynamic information exchange within the system. Consequently, a smart tourism ecosystem is defined as follows: A smart tourism ecosystem can be defined as a tourism system that uses smart technology to create, manage and deliver intelligent touristic services/experiences and is characterized by intensive information sharing and value co-creation. Collecting, processing and exchanging tourism-relevant data is a core function within the smart tourism ecosystems (Gretzel, Werthner, et al., 2015, p. 560).

Since the tourism industry is highly dependent on ICT, smart tourism can be a pivotal change from traditional tourism to a more innovative and technology-centered tourism industry, which pushes the businesses towards adopting ICT in their systems (Gretzel, Sigala, et al., 2015). Smart tourism destinations mainly focus on visitors and tourists in destinations and the extent to which they are involved in interacting with contemporary and cognitive tourism services or just become familiar with such products (Lamsfus et al., 2015). They also assert that ICT infrastructure in smart destinations has been developed two-fold: a) Allocating modern mobile technology in the intelligent mobile surroundings; b) Fortifying the cooperation between technology enterprises and tourism stakeholders to foster the foundation of the innovation ecosystem. The dynamicity of Smart Businesses in the intelligent tourism ecosystems could enhance tourism stakeholders to manage the resources in the automated methods (Gretzel et al., 2015). In Smart Tourism Destination, the portion of real-time information trend produces a notable

amount of data sets called Big Data (Buhalis & Amaranggana, 2015). Therefore, it is essential for ICT infrastructure in smart tourism destinations to be concentrated on both technological and touristic aspect simultaneously.

According to Porter and Heppelmann (2015), the evolution of products into intelligent, connected devices which are increasingly embedded in broader systems is radically reshaping companies and competition. Mobility of visitors and tourism experience in a mobile environment is part of the contemporary perspective of the smart destination (Lamsfus et al., 2015). AR wearable technologies, like smart glasses with various sensors comprising GPS, microphone, and built-in camera, provide immersive information in front of the user's eyes. Depending on the smart glass model, the various features can be controlled with several techniques such as gesture, speech, or other methods (Hein & Rauschnabel, 2016). These potentials, according to Tussyadiah (2013); in the tourism context, enable tourists to capture and share travel experiences with peer groups with smart glass built-in cameras. In addition to navigating with immersive functions in front of your eyes, contrary to other mobile devices, the user has to look down and link a virtual map in a device with the perceived reality. Hein and Rauschnabel (2016) argue that the competitiveness of smart glasses refers to the potential of these devices to retain in the industry competitions. Although accessibility and affordability do not guarantee the user's intention to accept a new technology (Gretzel, Sigala, et al., 2015), the development of the relevant information via the application (apps) in the particular context (Hein & Rauschnabel, 2016) could fortify the user's perception of the functionality for technological innovation.

Hein and Rauschnabel (2016) assert that social influences play significant roles in the circumstances in which individuals employ an innovation visibly in front of others. For instance, using ICT advancement varies according to the cultural value for masculine societies, focusing on self-confidence. On the other hand, the value of work in a person's life compares to feminine societies mainly considered modesty and spending more time on leisure activities (Hofstede et al., 2010). The other influential attribute in the hospitality and tourism industry is word-of-mouth (Litvin et al., 2008).

Technological innovation also has limitations that could act as an obstacle in the individual's acceptance behavior. For example, in the survey conducted by Morpace Inc. and the University of Michigan-Dearborn, over 1000 U.S. consumers, almost 30% of respondents argued that utilizing smart glasses intimidated others' privacy (Rauschnabel

et al., 2015). Likewise, respondents declared the anxiety with data privacy in smart tourism research as a negative aspect that could thrive in the development of smart tourism destinations (Buhalis & Amaranggana, 2015).

3. Problem Description and Research Objectives

Many destinations thrived into mature touristic spots by introducing a right and adaptive management plan and suitable infrastructure. In order to maintain the high quality of a destination, it is necessary to observe and control the activities and elements of the place. However, this can be a difficult task, as tourism destinations are complex systems, with numerous interactions between the sectors operating within the destinations, and there are multiple stakeholders with varied and, at times conflicting interests. The complexity of the problems that emerge in tourism systems, due to the diversity of interests of the different stakeholders and the dynamic and non-linear nature of the interactions between the different components of the systems, has discouraged the use of linear thinking. Consequently, the attention of researchers has been drawn to a different interdisciplinary approach for managing tourism destinations. Regarding managing and governing a complex system, Baggio and Del Chiappa (2016) believe that gaining a precise knowledge of the structural and dynamic characteristics of the system is a necessity.

According to Gössling (2017), while there has been significant attention to the technological changes globally regarding the tourism system, which has changed the consumer behavior and raised the importance of new approaches in the management of tourism systems, still the numbers of studies on the interrelation of IT and sustainability is very limited. The review conducted by Gössling (2017) proposed 12 categories that emerged from a deep exploratory review in which IT can be seen as relevant for broader aspects of sustainability-related to three pillars of sustainability. This paper shows that there is a consensus among studies that IT can contribute to tourism sustainability. An interesting conclusion has been drawn by Gössling (2017) regarding the difficulty of discussing the adoption of outcomes of IT in tourism which contrasts the finding and expectations. This arises from the complexity of the interrelationships between IT and sustainability, which calls for more in-depth interdisciplinary approaches. The figure below is a conceptual model of 12 categories in relationship with the three pillars of sustainability.

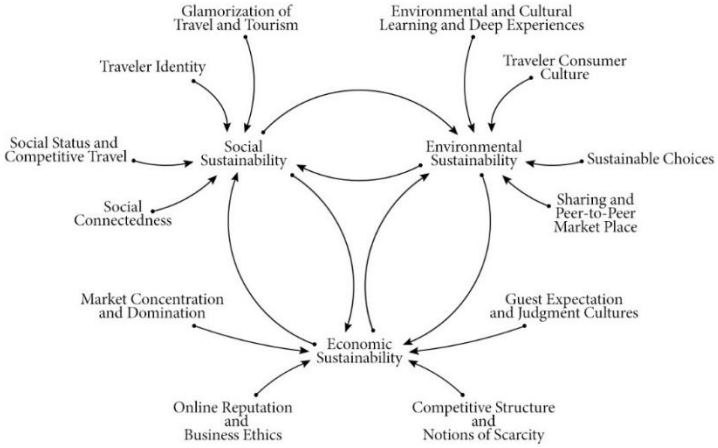

Figure 1. Conceptual model inspired from 12 categories proposed by Gössling (2017)

Moreover, the buzzword of smart is being used everywhere. Smart cities provide a foundation to use this global movement to create a more sustainable and livable community. Also, smart cities can help promote smart tourism due to the cross-cutting nature of travel and tourism. Smart cities collect and use all information possible, from water to buildings and traffic, to help decision-makers analyze and make better decisions. Using the latest technology in the cities will lead to greener, more sustainable, and higher quality for residents, visitors, and businesses (Wayne, 2016). In a report from IBM on a vision of smarter cities (Dirks & Keeling, 2009), it has been tried to draw attention to the necessity of holistically addressing the challenges that threaten cities' sustainability and emphasizes the importance and need to move towards smarter cities. The figure below is a sample that represents the interrelationships among the six core elements.

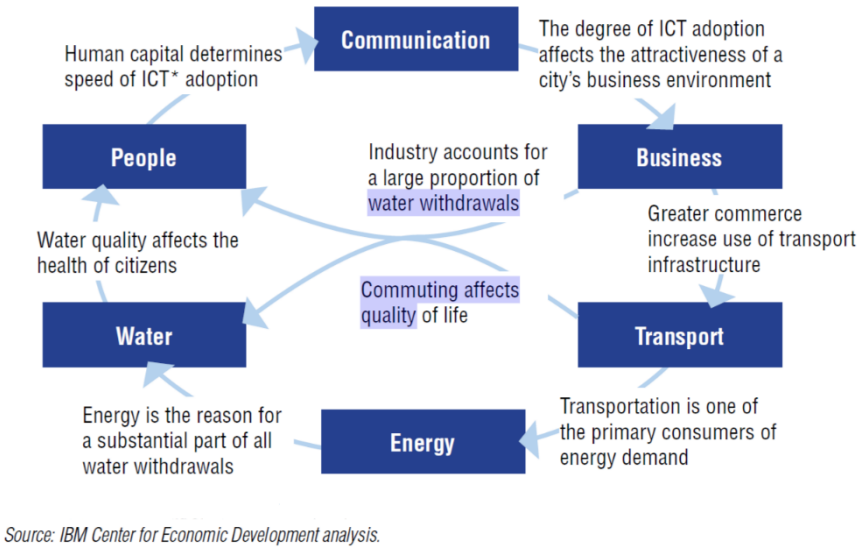

Figure 2 . Interrelationships among the six core elements of smart cities

As a consequence of this problem description, the objective of this proposal is to develop and realize a dynamic model for illustrating and measuring the mutual impact of smart

ecosystems and sustainable tourism development. In order to capture and analyze the dynamic and complex nature of systems, multiple approaches have been proposed over the last three decades. The SD approach is one of the best-known examples. We are trying to investigate the contributions of systems thinking and feedback control, which SD can offer, in analyzing the complex interrelationships among IT, sustainability and tourism to illustrate the impact of ICT on sustainable tourism development. This research scrutinizes the role of ICT in sustainability in general and how sustainable tourism and applications of ICT in sustainable tourism are intertwined. A range of tourism planning technologies (including SD) that help understand complex systems' behavior will be discussed.

4. Research Goals

Bearing the literature review, problem description, and research objective in mind, the primary research questions have been proposed, which are the following:

Research Goal 1: *What is the application of system dynamics in the tourism industry?*

Due to this technique's interdisciplinary approach of this technique, it is necessary to scrutinize the application of SD in the tourism industry. This question was a preliminary question which, by carrying a systematic literature review, we tried to understand and learn from the undertaken studies until now to be able to formulate our further questions.

Research Goal 2: *Demonstrating how a dynamic modeling approach is helpful in conceptualizing the problems and challenges arising in different stages of sustainable smart tourism ecosystems*

By using complex system theory and interdisciplinary approaches, we first need to determine what factors constitute the dynamics of smart ecosystems and sustainable tourism. The initial step is to understand the origin of our under-study problem, which would be scrutinizing the importance of using the IBM model for smarter cities. Afterward, by densifying the IBM model, the systems' indicators will be identified to understand the interrelations between each factor. The indicators will be selected using the literature and will be modified according to our system. Finally, to build a cognitive model and to test it for further simulation, a set of Indicators regarding IT, sustainability, and tourism, measurable (quantitative) or descriptive (qualitative) variables will be developed to characterize the cause and effects in the system to understand better what is

happening in the system. They can also be used to observe trends as criterion changes over time; to identify information needs for long-term policy analysis and potential problems of the current tourism statistics system; to investigate how to effectively employ sustainable tourism development indicators to support scenario-based trade-off analysis.

Research Goal 3: *To develop a model and methodologies for Portugal by using system dynamics and complex system theory for policy planning.*

By using the computational approaches, we want to demonstrate how theoretical and practical solutions to these challenges can be realized in a complex region like Portugal. Furthermore, through empirical analysis and simulation, the result can be beneficial for designing effective policies for sustainable smart tourism destinations.

4.1. Delimitation

The presented proposal's ultimate goal is to implement and examine the idea of this topic in Portugal. As a relatively small tourism destination, Portugal offers a wide diversity of attractions ranging from landscapes, natural parks, historical, architectural, tangible and intangible cultural, and religious heritages, gastronomy, and much more, providing accessible and unique experiences. Thus, making tourism foci in strategic planning for promoting regional planning, foreign investment, creating employment, and boosting Portugal's external image. Portugal has invested significantly in external and internal promotional campaigns since branding a destination is as important as managing and promoting the brand (Moreira, 2018; Parreira et al., 2021). Portugal has envisioned different plans and frameworks, namely "Tourism Strategy 2027" (Portugal, 2017), and "+ Sustainable Tourism Plan 20-23" (Portugal, 2021), to develop an open, dynamic, and collaborative strategy. Promoting Portugal, fostering economic growth, enhancing knowledge, and improving connectivity are some of the envisaged axes of the plan. Looking at Portugal as a destination can be a possibility to see how smart tourism or, in more general terms, creating a smart ecosystem (region) can contribute to the sustainability of this region.

Expectedly, the amount of data collected would be considered due to the variety of indicators and destinations. The indicators and variables will be identified through the study and using the existing literature and current projects in the region, which would be a tremendous help to build a robust model of the region. System dynamics will be a

valuable tool to build a proper model according to our research objective, and results will be presented accordingly. The outcome of this research would be a framework that can be used for designing a dynamic, sustainable smart destination and optimizing the policy planning process.

4.2. Research Structure

This Ph.D. consists of 3 phases, as mentioned below as research goals. Each of these phases will be prepared to be submitted in journals. The work plan below is the outline of this Ph.D.:

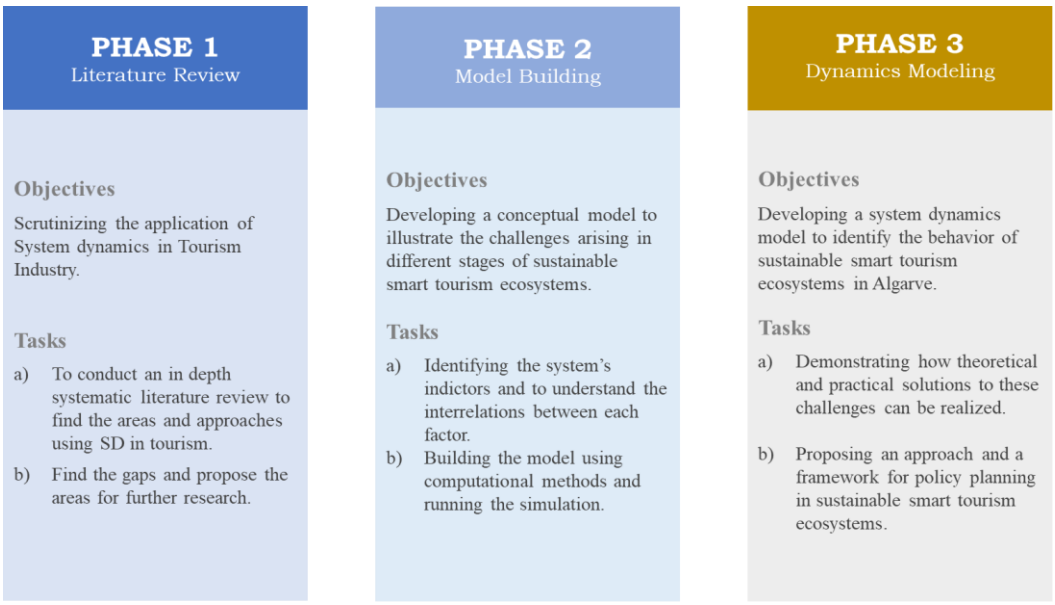

Figure 3. Three Phases of the Thesis

5. Methodology

In this research, the mixed-method approach has been chosen, more specifically an exploratory sequential mixed-methods approach, due to the interdisciplinary nature of this study in which a model will be conceptualized and afterward will be quantified by using SD and ultimately design a new model for improving the existing or proposed system.

5.1. System Dynamics as a Method

System Dynamics is a computer-based approach to understand and analyze a system's behavior over time. The SD approach is capable of breaking a system into pieces and examining each element of the system to find the impacts and outcome of changes on these elements at a macro-level. System Dynamics has been applied in different contexts such as learning organizations (Senge, 1997), transportation (Egilmez & Tatari, 2012),

ecological modeling (Semeniuk et al., 2010), and other different fields of study. Maani & Cavana (2000) explain in their book that SD can be applied to a variety of fields and purposes. For instance, it can be used in designing a new system or restructuring and improving an existing system. System Dynamics can also be used to predict the behavior of complex systems and analyze how each element and segment of a system interact with other components.

The concept of SD comes from the idea of "industrial dynamics" which arose from the work of Forrester (1961) at the Massachusetts Institute of Technology, and at first, it was used in engineering and management. The SD approach is based on internal interaction, information feedback, and cause and effect. It is an underlying premise of the SD method that the behavior of a system arises from its causal structure. Therefore, the ultimate goal in SD modeling is to improve understanding regarding the links between structure and behavior to seek endogenous explanations for the problematic dynamics and design policies that can bring about the desired changes in behavior.

System Dynamics is known as a powerful and practical method that can model complex systems to study how they behave over time. To understand the problems and behavior of a system, it is necessary to look into the cause and effect among its elements. It is well known that some effects are caused simultaneously by different elements. By breaking down the whole system's structure into smaller segments and increasing the possibility of studying dynamic relationships among system elements, SD can be considered one of the best tools for a modeler to have a holistic approach in analyzing the system as a whole.

According to Richardson & Pugh (1981), the use of SD should be focused on a system's problem, not the system itself. Dynamic problems have two main features which make them complex and difficult to analyze. The first one is that dynamic problems contain quantities that will change over time. The second one is that they include feedback structures.

Causal loop and stock and flow diagrams are the most important parts of SD modeling. The ability to find out the relations of feedback processes, stock and flow diagrams, time delays, and nonlinearities in the system is considered as an art in SD modeling (J. Sterman, 2000). The relations among elements of the system and all the causes and effects are shown in causal loop diagrams. Causal loop diagrams are very helpful in structuring a mental model of the system and forming the relations among elements. Coyle (2000) discusses the ability of causal loop diagrams to show the interactions of a system and gain

a better understanding of its dynamics. These diagrams help the modeler to convert qualitative dynamic models into quantitative ones easily. Furthermore, causal loop diagrams are frequently used to study dynamic problems and give insight into the problem rather than at its quantification. When the objective is to analyze the system by developing quantitative simulation models, it is common to precede the development of these models with stock and flow diagrams. In these diagrams, the stocks represent the state of the system, which changes by increases or decreases in the flow rates. Also, stock and flow models provide a useful view over the status of the system's performance due to the implementation of different decisions and policies. After using causal loop and/or stock and flow diagrams to represent the system's main components, it is common to use computer simulation to validate the nature of the relationships between the different components of the system by representing the behavior of past data. Then the outputs of this simulation are compared with the real behavior of the system to determine whether the SD model is valid or not. Once a model has satisfied basic validity tests and has been considered satisfactory for its purpose, it can be used for policy analysis (Forrester, 1961), exploring what-if scenarios (Morecroft, 1988), optimizing key decisions (Coyle, 1985), and investigating organizational redesign (Wolstenholme, 1999). In either case, the model is aimed at improving problematic behavior.

6. Thesis Organization

Overall research objective

The main objective of this thesis is to outline the concept of smart tourism ecosystems by scrutinizing the tourism industry, smart tourism, complex systems, SD, consequently conducting research to identify gaps and complementarities between research and practice. Furthermore, SD enables us to understand better smart tourism ecosystems, all the cause and effect relationships among the components, and studying their dynamic behaviors. Thereupon, proposing alternative strategies for policy makers and practitioners.

Research Structure

This thesis is organized through five chapters. Chapter one, the general introduction, begins with the general idea of the research and the most significant concepts and approaches in the field, providing a brief background to communicate the recent theoretical achievements. The following four chapters are partially dependent pieces

acting as a narrative of this research with their independent topics, purposes, literature reviews, and methodological approach while theoretically interrelated.

Chapter two, System Dynamic in Tourism Planning and Development, provides a comprehensive literature review of using systematic literature review to examine the application of SD in the tourism industry. This chapter dives deep into the existing literature to explore the extent to which the SD approach has been implemented in the tourism industry. In particular, we intend to use a systematic literature review to scrutinize what has been done in this field and present possible future research areas.

Chapter three provides a debate on how we can conceptualize the concept of smart tourism ecosystems. This chapter uses the systems thinking approach as a powerful tool to develop a conceptual model (causal loops diagram) of smart tourism ecosystems by illustrating the most influential interconnections among such systems' components. The intention is to create a new perspective for looking at the complexity of smart tourism ecosystems and to call out the necessity of using the human-centered approach in the smart destination, which could provide a more robust backbone for providing sustainability in the long run.

Chapter four serves as an empirical study to pursues the SD approach to provide different tools and methods for attentively monitoring and analyzing the complex interrelationships, underlying values, and stakeholders' perspectives of smart tourism ecosystems, ultimately ensuring the prevalence of sustainable tourism development. Therefore, to elucidate this issue, this paper first utilizes SD to discuss and analyze the dynamics of causal relationships among smart tourism ecosystems' components.

Chapter five corresponds to the general conclusion of the thesis based on the results of the previous chapters. The chapter highlights the most important implications and recommendations for applying the findings. The limitations of this research, together with avenues for further research, are included in this concluding chapter.

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Chapter 2.

SYSTEM DYNAMICS IN TOURISM PLANNING AND DEVELOPMENT

Abstract

System Dynamics (SD) is a method that has the ability to capture the dynamic behavior of a complex system over time. The tourism industry, due to the myriad of interactions among its sectors, can be considered as a complex system. Therefore, SD has drawn the attention of tourism researchers over the last two decades. The goal of this study is to assess the application of the SD method in planning and development of the tourism industry. For this purpose, a systematic literature review (SLR) was performed and a set of 27 papers was selected. The analysis of the papers shows the applicability of the SD method to address a multitude of different problems. Overall, however, it can be concluded that whilst the SD method has shown considerable potential to provide tourism decision makers and regulators with tools for strategic and operational policy development at many different levels of analysis, the number of applications in this sector is still limited. Therefore, it is recommended that the use of SD modelling in the tourism industry be extended in order to promote a holistic understanding of the complex issues faced by this industry and to assist in the development of more effective policies.

Keywords: System Dynamics, Tourism, Systematic Literature Review, Planning and Development.

1. Introduction

Tourism has become one of the biggest industries in the world and can be deemed as an economic sector (R. Baggio, 2013). It is an industry that is growing rapidly internationally and regionally and has a direct impact on economic, environmental, and social aspects(Sinclair-Maragh & Gursoy, 2016). Also, tourism has become a driving force in sustainable development, encouraging many developing countries to promote tourism policies (UNWTO, 2013).

Tourism offers a multitude of activities spread across different sectors in order to meet tourists' preferences. Goeldner and Ritchie (2003) proposed a model of the tourism industry components, which acknowledges that tourists use different services such as transportation, food services, accommodation, travel trade, cultural activities, sports and recreation, attractions, retail trade, and other tourism services. Among these, the attractions sector plays a fundamental role in tourism since every industry and service provider depends on it.

Changes in the tourism system depend on a variety of forces that have impacts on each other (Boukas & Ziakas, 2014). Tourism is known for having various positive influences on economic growth, which can contribute to the creation of job opportunities, generate income for local people and motivate them to increase their production (Brouder, 2012). The financial flow resulting from tourism activities is fundamental to support investment on infrastructures, fostering competitiveness, economic growth, and development (Balaguer & Cantavella-Jordá, 2002).

The interdependence of the socioeconomic and the natural environmental systems and their impacts on sustainability should not, however, be neglected (Burger et al., 2012). Although tourism is considered a major driving force in development, it can also generate negative impacts. For example, it is well known that tourism plays a significant role in CO2 emissions by using transportation, accommodation and other facilities which make tourism one of the important contributors to climate change (Egilmez & Tatari, 2012; Law et al., 2012). The presence of tourists in a destination leads to higher production of solid and liquid waste, which can cause severe problems for destinations that lack a suitable infrastructure.

Many destinations thrived into mature touristic spots by introducing a correct and adaptive management plan and suitable infrastructure. In order to maintain the high

quality of a destination, it is necessary to observe and control the activities and elements of the place. However, this can be a difficult task, as tourism destinations are complex systems, with numerous interactions between the sectors operating within the destinations, and there are multiple stakeholders with varied and, at times conflicting interests. The complexity of the problems that emerge in tourism systems, due to the diversity of interests of the different stakeholders and the dynamic and non-linear nature of the interactions between the different components of the systems, has discouraged the use of linear thinking. Consequently, the attention of researchers has been drawn to a different interdisciplinary approach for managing tourism destinations.

The adoption of systems thinking and holistic approach to promote understanding of tourism problems and tourism systems are justified on the grounds that the components of the tourism industry interact with each other and offer the same final product, which is an attraction and experience for tourists (Sánchez et al., 2006). A holistic, well-managed and systematic plan is, therefore, necessary to develop and promote the destination as a whole and to ensure its sustainability. The duty of sustainable tourism is not only environmental protection but also includes the livelihood, social and economic dimensions of stakeholders in a touristic area (Angelevska-Najdeska & Rakicevik, 2012).

In order to capture and analyze the dynamic and complex nature of systems, multiple approaches have been proposed over the last three decades. The SD approach is one of the best-known examples. The purpose of this study is to explore the extent to which the SD approach has been implemented in the planning and development of the tourism industry. In particular, we intend to use a systematic literature review to scrutinize what has been done in this field and present possible future areas of research.

2. What is System Dynamics?

System Dynamics is a computer-based approach to understand and analyze a system's behavior over time. The SD approach can break a system into pieces and examine each element of the system to find the impacts and outcome of changes on these elements at a macro-level. System Dynamics has been applied in different contexts such as learning organizations (Senge, 1997), transportation (Egilmez & Tatari, 2012), ecological modeling (Semeniuk et al., 2010), and other different fields of study. Maani & Cavana (2000) explain, in their book, that SD can be applied to a variety of fields and purposes. For instance, it can be used in designing a new system or restructuring and improving an

existing system. System Dynamics can also be used to predict the behavior of complex systems and analyze how each element and segment of a system interact with other components.

The concept of SD comes from the idea of "industrial dynamics" which arose from the work of Forrester (1961) at the Massachusetts Institute of Technology. Originally was first used in engineering and management. The SD approach is based on internal interaction, information feedback, and cause and effect.

It is an underlying premise of the SD method that the behavior of a system arises from its causal structure. The ultimate goal in SD modeling is, therefore, to improve understanding regarding the links between structure and behavior in order to seek endogenous explanations for the problematic dynamics. It also intends to design policies that can demonstrate the desired changes in behavior.

System Dynamics is known as a powerful and practical method which has the ability to model complex systems in order to study how they behave over a period of time. To understand the problems and behavior of a system, it is necessary to look into the cause and effect among its elements. It is well known that some effects are caused simultaneously by different elements. By breaking down the whole system's structure into smaller segments and increasing the possibility of studying dynamic relationships among system elements, SD can be considered one of the best tools for a modeler to have a holistic approach in analyzing the system as a whole.

According to Richardson & Pugh (1981), the use of SD should be focused on a system's problem, not the system itself. Dynamic problems have two main features which make them complex and difficult to analyze. The first one is that dynamic problems contain quantities that will change over time. The second one is that they include feedback structures.

Causal loop and stock and flow diagrams are the most important parts of SD modeling. The ability to find out the relations of feedback processes, stock and flow diagrams, time delays, and nonlinearities in the system is considered as an art in SD modeling (J. Sterman, 2000). The relations among elements of the system and all the causes and effects are shown in causal loop diagrams. Causal loop diagrams are very helpful in structuring a mental model of the system and forming the relations among elements. Coyle (2000) discusses the ability of causal loop diagrams to show the interactions of a system and gain

a better understanding of its dynamics. These diagrams help the modeler to easily convert qualitative dynamic models into quantitative ones. Furthermore, causal loop diagrams are frequently used to study dynamic problems and are aimed at giving an insight towards the problem rather than at its quantification. When the objective is to analyze the system by developing quantitative simulation models, it is common to precede the development of these models with stock and flow diagrams. In these diagrams, the stocks represent the state of the system, which changes by increases or decreases in the flow rates. Also, stock and flow models provide a useful view over the status of the system's performance due to the implementation of different decisions and policies. After using causal loop and/or stock and flow diagrams to represent the main components of the system, it is common to use computer simulation in order to validate the nature of the relationships between the different components of the system by representing the behavior of past data. Then the outputs of this simulation are compared with the real behavior of the system to determine whether the SD model is valid or not. Once a model has satisfied basic validity tests and has been considered satisfactory for its purpose, it can be used for policy analysis (Forrester, 1961), exploring what-if scenarios (Morecroft, 1988), optimizing key decisions (Coyle, 1985), and investigating organizational redesign (Wolstenholme, 1999). In either case, the model is aimed at improving a problematic behavior.

Due to its characteristics, the SD approach has been applied to many fields and industries and with many different purposes. The tourism industry has been no exception as it has also been targeted by this approach with the purpose of assisting the implementation of sustainable tourism policies, identifying the strengths and the weaknesses of tourism systems, assisting the management and planning of tourism destinations, managing the value chain in the hotel industry, among many other purposes. The application of the SD model in the tourism industry is discussed in detail in the subsequent sections. In particular, by carrying out our literature review, we aim to assess the extent to which SD has been used in the planning and development of the tourism industry.

The following section discusses the methodology employed to identify the relevant papers and is composed of two parts. The first part explains what a systematic literature review (SLR) is, as well as the basic concepts and the main advantages of this method. Then, the second part describes each of the steps necessary to conduct a SLR.

3. Methodology

In order to scrutinize the application of the SD method in tourism, a systematic approach was used to analyze and explore the literature regarding this subject. The Systematic Literature Review (SLR) is a method to summarize a large amount of information and has proved valuable to identify and evaluate the relevant studies regarding a specific subject. This method pays close attention to a set of scientific methods in order to decrease systematic errors (Beelmann et al., 2006).

The SLR method initially arose in the field of medical science and health care (Higgins & Green, 2008) and has not yet been extensively applied to tourism research (Carter et al., 2015). One of the first definitions of this technique was proposed by Sweet and Moynihan (2007), who describes it as a good tool for gathering and assessing the studies on a specific topic while minimizing the bias compared to non-systematic reviews. In comparison with the traditional literature review methods, the SLR aims at specific research objectives or questions. Similar to other methods, the SLR presents advantages and disadvantages. One of its main disadvantages is that it is very time-consuming while demanding considerable effort on the researcher's part. On the other hand, one of its main advantages is that it provides a replicable and a broader/structured perspective towards a problem. In what follows we discuss the main steps taken to systematically review the relevant literature to our research.

3.1. Defining the Review Objective

In order to conduct a SLR, a review objective was defined: Assessment of the application of the SD method to the tourism industry. For the successful achievement of this objective, all the relevant publications had to be identified.

3.2. Searching for the Relevant Papers

In order to identify the relevant papers to address our review objective, a search was conducted on the “Scopus”, “Web of Science” and “EBSCO” bibliographic databases. To this effect, a set of terms was defined and searched in the titles, abstracts and keywords of all the papers indexed in these databases. The Boolean operators “OR” and “AND” were also used in our search to ensure that only the relevant papers would be retrieved. The search string used was:

("System* Dynamic*" OR "System* Thinking" OR "System* Approach" OR "Causal loop*" OR "Stock and Flow*" OR "Feedback Loop*" OR "Causal Mapping" OR "System* Archetype*") *AND* (*Touris*).

For the purpose of this study, we focused on the papers published in peer reviewed journals from 1961 to 2015. Our search was undertaken on the 11th of June 2015, therefore does not include the papers published afterwards. Only "articles" were selected in the document type tab in the bibliographic databases. In order to exclude the irrelevant papers from our analysis, it was necessary to define the exclusion criteria. All the selected papers that met the criteria below were excluded from further analysis.

Table 1. Exclusion Criteria in the SLR

	CRITERIA
1	*Non-peer review journals, books and book chapters, master and PhD theses*
2	*Other languages than English*
3	*Conference papers*
4	*Different subjects than the tourism industry and its related sectors*
5	*Papers referring to dynamic systems but not using the System Dynamics method*
6	*Review articles on related topics*
7	*Papers published in predatory publications* (Beall, 2014)

3.3. Checking the Titles and Abstracts

By using the above search string, and restricting our analysis to "articles", our search resulted in the identification of 369 papers. After checking all the three databases for duplicates, 144 papers were excluded, and thus the number of papers found potentially relevant was reduced to 225. Then, the titles and abstracts of these papers were read and all the papers that were not related to the research objective (i.e. applying SD to tourism) were excluded from further analysis.

3.4. Obtaining Full Texts and Data Extraction

Once the title and abstract of each paper were screened, the full version of the papers considered potentially relevant was downloaded. After assessing and extracting the details of each paper, while applying the exclusion criteria, a final sample of 27 papers was obtained for further analysis. In order to summarize the information retrieved, and to compare different publications, a table was elaborated (Table A1 in appendix) with the following sections: authors, journal where the study was published, general objective of the paper, location of the problem analyzed, stakeholders involved, type of modelling implemented (i.e. quantitative vs qualitative), objective of using SD, and sector where the analysis took place. Figure 1 presents a flowchart showing the process we have followed to obtain the final sample of papers.

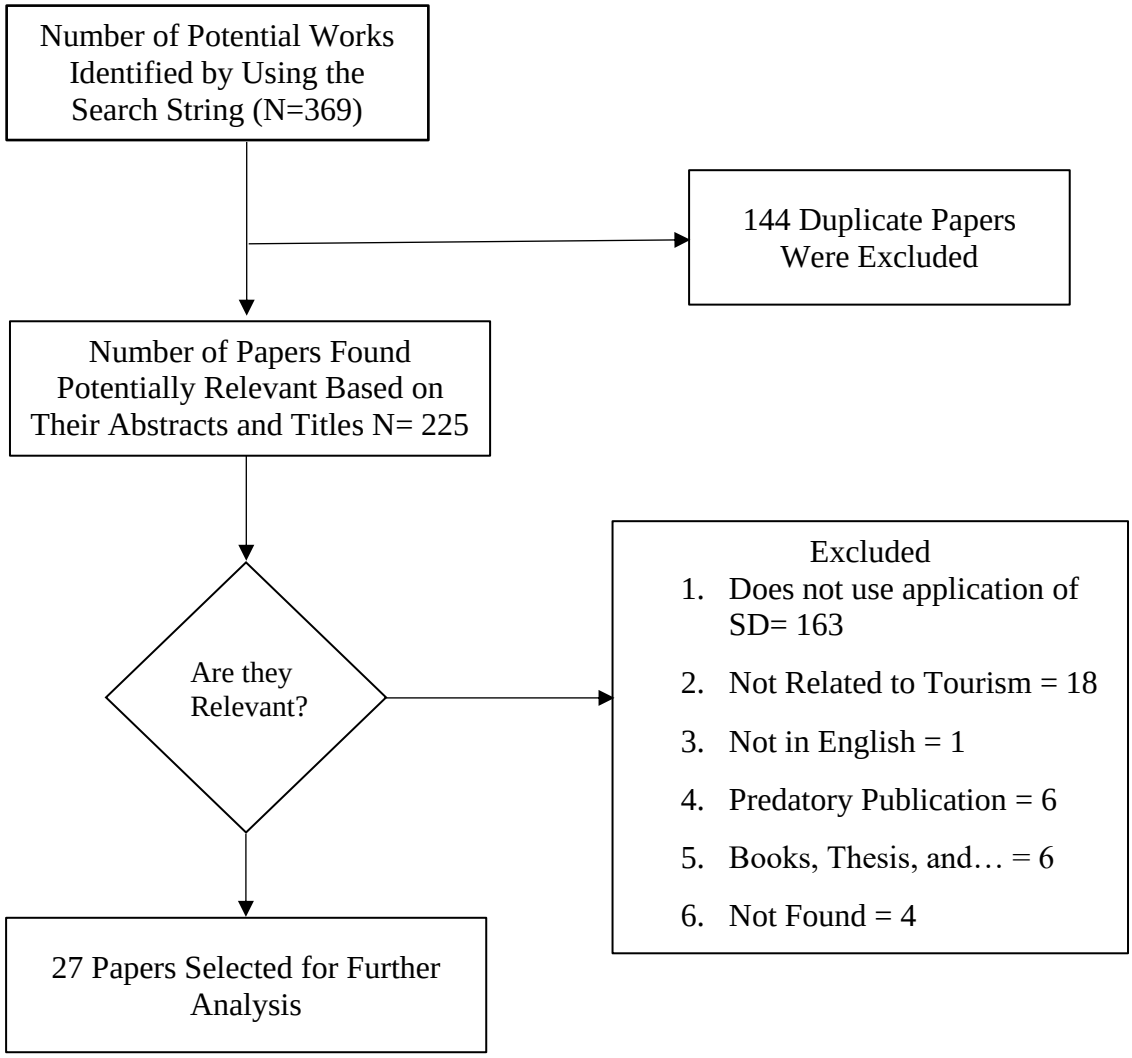

Figure 1. Flowchart of Paper Selection Process

3.5. Limitations of the Methodology

While the SLR offers many advantages and is a well-established methodology, it also has some limitations. In particular, the search and selection criteria used can lead to some relevant papers being excluded from the analysis. For example, although we covered the publications indexed in some of the best known bibliographic databases, it is important to bear in mind that articles not indexed in "Scopus", "Web of Science" or "EBSCO" were excluded. Studies discussing the application of SD in tourism that used a language other than English, were also missed from our analysis. In the same way, articles that did not use the terms tourist or tourism in the title, abstract or keywords or publications other than articles, such as books, book chapters, conference proceedings and dissertations, were also not covered. In spite of this, the criteria used and the bibliographic databases searched allow us to offer a robust assessment of the state of the art in which regards the application of SD in the tourism industry.

4. Results

The data extraction table (Table A1 in appendix) of the SLR provided us with a useful overview about the selected papers which enables us to analyze aspects such as publication trends, geographical location and type of stakeholders involved in the modelling process. After assessing the papers in detail, the results show that only 27 of the papers, published in international journals and indexed in the bibliographic databases selected, use the SD method in the field of tourism. Moreover, we found that only eight out of the selected papers were published in tourism journals. Likewise, only one paper was published in the "System Dynamics Review", the most well-known journal in the area of SD. Kybernetes, in the field of information and knowledge management, with three publications is the journal with the largest number of papers in our sample. The remainder 15 papers were published in three main scientific fields: environmental & ecological modelling, computer science and operations research.

Regarding the modelling method, 37% of the selected papers used exclusively qualitative modelling, 3.7% exclusively a quantitative approach, and 59.3% used both qualitative and quantitative modelling. In what follows we present some results regarding the number of publications by year, the geographic location of the tourism system analyzed, the distribution of publications by sector and the stakeholders involved.

4.1. Publication by Year

Figure 2 shows the publishing frequency of the selected articles from 1994 to 2015. It indicates that while the total number of publications is not very expressive, there is an upward trend in the use of SD in tourism, over the past two decades.

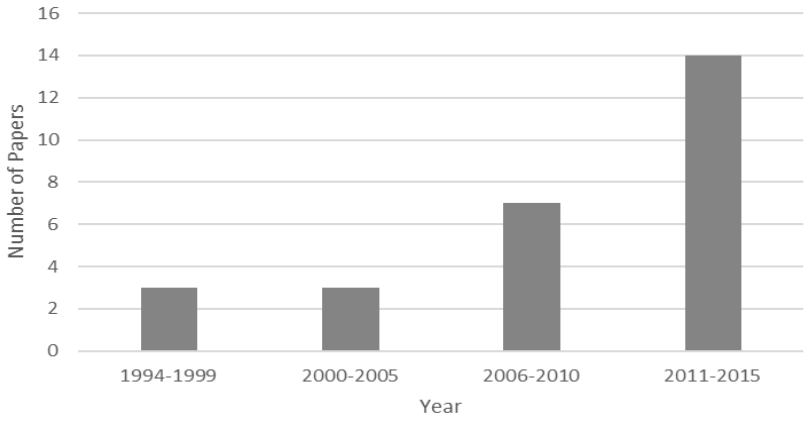

Figure 2. Publication by Year

4.2. Geographic Location of the Tourism Systems Analyzed

Figure 3 shows the geographic location of the tourism systems analyzed by means of the SD approach. China with five papers and Slovenia with three papers are the countries that have received most attention, thus far. They are followed by Australia, Croatia, Taiwan and USA, with two papers each. It should be noted that three papers, instead of analyzing a tourism system in a specific location, focused on a general model. Two papers addressed multiple countries (North Mediterranean countries; and Southern European Islands).

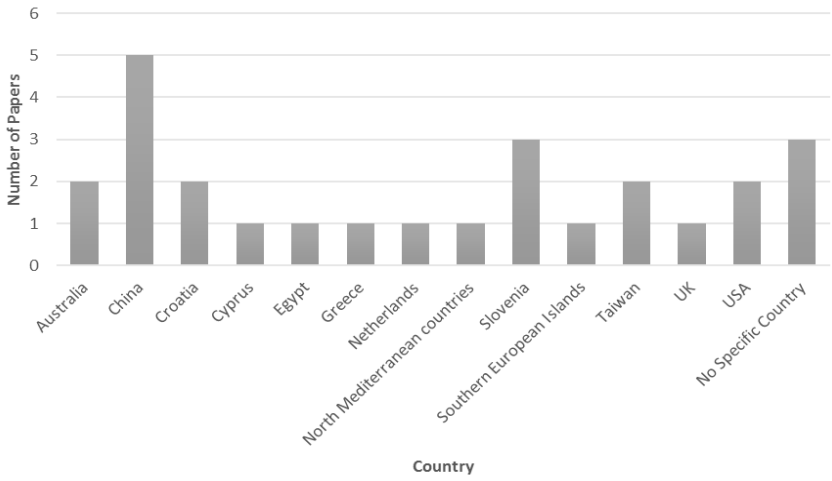

Figure 3. Geographic Location of the Tourism System Analyzed

4.3. Distribution of Publications by Sector

When we analyze the distribution of the publications by sector, as shown in Figure 4, the attractions sector, with 14 papers, is the tourism sector that has been most frequently studied by means of the SD modelling approach. This sector is composed of various sub-sectors, such as cultural, and natural attractions which offer a wide range of activities to tourists (Honggang, 2003; G. Liu & Chen, 2014; Xu & Dai, 2012). The accommodation sector was addressed in three papers (Georgantzas, 2003; Law et al., 2012; Stipanovic & Rudan, 2014). Authors have also addressed other sectors, for instance, Woodside (2009) focused on sustainable golf tourism in the Adventure and Outdoor sector, Golob and Jere Jakulin (2014) in the Event sector, and Li, Zhang, Xu, and Jiang (2015) in the Transportation sector. In which regards the sectoral application of SD, the studies selected show that there is also a significant number of multisector applications (7 papers).

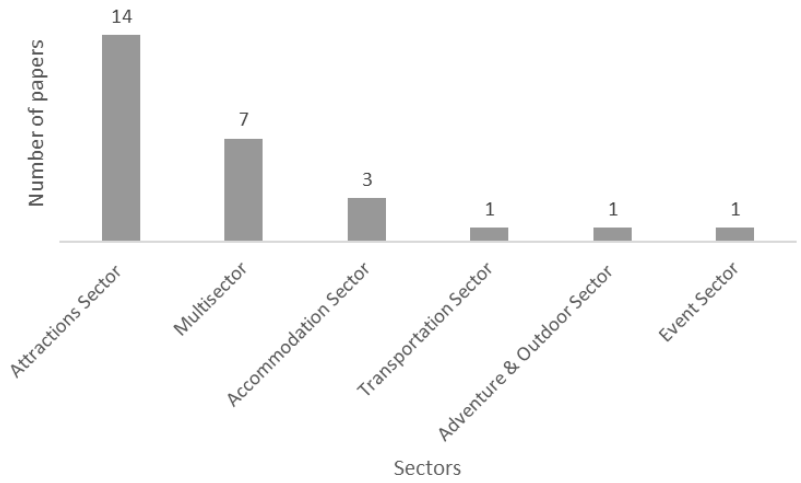

Figure 4. Distribution of Publications by Sector

4.4. Stakeholders Involvement

Involving stakeholders in the modelling process plays an important role in gaining a better understanding of a complex problem and in ensuring implementation of the solutions proposed. Despite the importance of stakeholder involvement, our review indicates that only 11 papers involved stakeholders in the modelling process. This involvement took place mainly during the mental modelling phase. Stakeholders were involved in the studies directly and indirectly. The direct involvement happened through workshops and collaboration in the modelling process. In some studies, however, stakeholders were indirectly involved through questionnaires which helped modelers to gain a better perspective of stakeholders' opinions. The fact that the majority of the studies (16 out of

27) does not explicitly acknowledge the involvement of key stakeholders raises some concerns regarding the acceptability and, consequently, the likely impact of these studies.

5. Discussion

The main objective of the selected publications is the use of SD to analyze and discuss tourism and its related systems. However, due to the variety of the tourism industry's sectors and sub-sectors, the focus of the papers has varied from specific subjects to broader ones. As mentioned above, tourism is a complex system which makes it hard to describe concisely. Therefore, the model proposed by Goeldner and Ritchie (2003, p. 14) was used in our review to structure the discussion regarding the implementation of SD in the tourism industry. This model shows the processes, activities and outcomes of tourism by focusing on different components such as natural resources, built environment and operating sectors of the tourism industry.

After analyzing the selected articles and considering the operating sectors of the tourism industry in Goeldner & Ritchie's (2003) model, the papers were organized into six different categories, which are as follows: 1. Multisector, 2. Attractions, 3. Adventure & Outdoor Recreation, 4. Transportation, 5. Accommodation, 6. Events. The following discussion reports on what has been done regarding the application of SD in tourism with an emphasis on the components of the tourism management model proposed by Goeldner & Ritchie (2003). This discussion is structured to scrutinize different aspects of the SD application in tourism planning and development. In this way we aim to understand how complex problems are defined in tourism and what kind of dynamic characteristics have been identified to conceptualize the tourism system.

5.1. Multisector Applications

Some authors use SD to explain the dynamic characteristics of destinations and present a more holistic approach regarding their feedback structures. According to Lazanski and Kljajić (2006), the tourism industry is composed of a large number of sectors with different economic, social and environmental dimensions. Each of these sectors can be a complex system by itself and, therefore, they should be managed simultaneously. In addition, Chen (K. C. Chen, 2004) used SD to build a decision support system for natural resources-based tourism to analyze different environmental and investment scenarios. In his study, SD was used to create a generic model for regions where environmental conservation is necessary due to tourism activities. The result of three scenarios reveals

the importance of exploring resource development policies for regional tourism development. In order to successfully implement sustainable policies, Farsari (2012) emphasizes the necessity of well-defined sustainable tourism policies. Therefore, in order to develop a conceptual holistic model of a sustainable tourism policy, the author uses SD to demonstrate the interrelations between policy issues. The conceptual model presented in this study is a practical tool for helping policy planners to gain a holistic perspective regarding sustainable tourism development. System Dynamics was also used for analyzing tourism sustainability in Tibet (Zhang et al., 2015). Selected sustainability indicators were found closely interrelated in the model. Thus, to maintain sustainability in the region, it was found necessary to change the employment concept, and form a new approach towards environmental protection. Schianetz et al. (2007), in turn, emphasize the role of stakeholders' collaboration at an organizational level for achieving sustainable tourism development. After reviewing six case studies, the authors describe the ability of SD modelling in promoting stakeholders' collaboration and encouraging a learning process. The learning tourism destination framework presented in this study is a provisional concept, which was used to review the case studies.

Lazanski and Kljajić (2006) draw a bigger picture of the tourism's complex system by explaining the complexity of interactions among elements of a system. The authors emphasize the benefits of learning through decision-making processes, which contributes to the development of a system. In this study, viewpoints of different methods about complex systems were discussed, and afterwards a dynamic model of Slovene tourism was presented to indicate the potential of SD in solving complex problems.

Peric and Djurkin (2014) use system thinking to provide a new perspective within destination management and social responsibility. The authors also emphasize the importance of paying attention to stakeholders' interests for tourism development. In this study, a deeper look was given to the community-based tourism with an organizational approach at the destination level. According to the authors, the use of the system thinking approach in Croatia turned out to be a successful tool for achieving economic and social sustainability. In a similar vein of research, Ropret et al. (2014) used a systems approach to analyze the Slovenian tourism policy plan. In their work, a qualitative approach was implemented to identify the strengths and weaknesses of the current system. The study demonstrated the inability of the current policy plan in achieving an optimal tourism development.

5.2. Attractions Sector

The attractions sector consists of multiple sub-sectors which vary from cultural attractions to nature-based and recreational activities. This sector plays a vital role in the tourism industry by offering different activities and experiences. Different elements are involved in the perception of tourists regarding destination attractions. These differences show the importance of destination management in order to promote attributes that correspond to everyone's interests (Kozak, 2002; Richards, 2002). Pull and push factors have impact on travelers' choice, the former concerns the destination attractions and the latter the socio-psychological needs of the traveler (Klenosky, 2002). In the following sections, the attractions sector is divided into four sub-categories according to the papers' focus.

5.2.1. Cultural attractions

Three papers focused on cultural attractions and a consensus can be found among them that sustainable cultural tourism can be reached in the long run. China was the geographic location analyzed in the three papers. A generic model by Liu and Chen (2014) and a case study by Honggang (2003)featured SD to assess cultural tourism development. The third article (Xu & Dai, 2012) focuses on community development in heritage sites. It shows the interaction among components of such system and tests different policies. Overall, SD proved to be an effective and useful technique in capturing the complexities and nonlinearities of cultural tourism. Moreover, the results showed the necessity of evaluating the vulnerability of cultural resources and the ability to transform them into cultural attractions.

In managing cultural tourism, Liu and Chen (2014) assert on the necessity of using a holistic approach rather than focusing on a specific objective in order to establish an effective and inclusive management system. In this study, SD was used to investigate the conflicts among different interest groups in cultural tourism. It was also used to find the components which lead to dynamic changes in the system. From the outcome of the simulation, we can conclude that there are four main aspects that can contribute to a sustainable development of cultural tourism: value assessment of cultural heritage, investment protection, locals' participation, and implementation of a crowding ratio.

In the case of the Zhouzhuang region (Honggang, 2003), SD was used to find radical solutions for improving cultural tourism development in the long run by analyzing the complexities and feedbacks of a tourism destination. Improving operators' performance,

stakeholders' participation, carrying capacity, and protecting the physical environment were the implemented scenarios for tourism development. The results show that all the scenarios worked temporarily and failed to find a radical solution in the long run.

In heritage sites, Xu and Dai (2012) used SD to gain a new perspective regarding the interrelation between community development and tourism at heritage sites. They investigated the implementation of four different scenarios, having concluded that controlling the use of residential houses for tourism and using the generated income to restore the monuments leads to a sustainable preservation and to a change in residents' attitudes.

5.3. Natural Attractions

5.3.1. Concentration on Islands Tourism

Islands destinations, due to the numerous interactions among their components, can be considered as complex systems and they have drawn researchers' attention (van den Bergh & Nijkamp, 1994). In order to reach sustainable development in such destinations, tourism is being used to enhance the economies by improving the islands' supply chain system (Georgantzas, 2003; van den Bergh & Nijkamp, 1994; Xing & Dangerfield, 2010).

Three papers in our selected sample focused on the application of SD to the management of islands destinations. In the case of the Sporades islands (van den Bergh & Nijkamp, 1994), the study was conducted to explore conflicts between economic development and environmental conservation and to model the dynamic interaction between land and marine environments. The purpose of the study was to reach an environmentally sustainable development. Van den Bergh and Nijkamp (1994) used two constraints for designing scenarios. The first constraint was the high dependency of the Sporades islands' economy on tourism. The second one was the sensitive condition of environmental conservation of Monk seals which is influenced by the economy and human activities. Afterwards, scenarios were formed based on social, economic and environmental patterns. The outcome of this study showed the ability of SD to provide insight over the long run. Moreover, the different scenarios indicate that tourism growth would reduce unemployment and enhance the economy but in order to realize such an outcome, it was necessary to implement some restrictive policies to reduce the negative impacts on the environment.

Carlsen (1999) argues that tourism is an open system and constantly growing towards a more complex state. The open system of tourism is responsive to social, economic and environmental changes. In the work of Carlsen (1999), a soft system methodology (SSM) was used in order to provide a systematic approach towards small island destinations with population of less than one million. The results show the applicability of SSM for the management and planning of island tourism destinations. This technique is particularly useful for small islands where the interrelation among elements of the system can be captured in an easier way.

Following the dynamic modelling for tourism development in island destinations, carried out by several authors, Xing and Dangerfield (2010) used SD to demonstrate the ability of this technique in modelling the sustainability of mass tourism in island tourism economies. In this study, instead of developing a forecasting model, the authors provide a model to test different scenarios for policy planning and stakeholders' engagement. The result of the tested scenarios showed that imposing sustainable policies would be hard, therefore, it is necessary to make stakeholders aware of the importance of these policies.

5.3.2. Concentration on landscapes and land use

Mao et al. (2014) explain the complexity and dynamics of land use and assert on the contribution of tourism development to generate positive economic impacts, as well as the negative impacts on the environment. The Lijiang River was used as a case study to explore the environmental effects of tourism on land use and show the interrelations between land use systems and tourism. The river provides tourism with many natural resources which make the management of sustainable tourism development and environmental conservation necessary. After running five scenarios, the results of simulation show that in order to reach sustainable land use development, imposing a strict construction policy combined with a normal environmental conservation is necessary. Morris et al. (2006) used, in turn, SD to identify the factors of sustainable land use management in Herefordshire by using a local learning approach. System Dynamics helped stakeholders to see Herefordshire as an endangered cultural landscape. This contributed to a sense of local identity and encouraged local residents to develop the destination in a sustainable manner.

5.3.3. Concentration on Coastal areas

Coastal regions are dealing with a multitude of activities and industries which causes a negative impact on the ecological system of these areas. System Dynamics is being used for different purposes such as integrated coastal zone management, social-ecological modelling, and learning tourism destinations. “Tourism Future Simulator”, developed by Walker et al. (1998), is one of the primary works on the application of SD to the management of coastal areas. This simulator proved to be a powerful tool for capturing nonlinearities of the tourism industry. Walker et al. (1998) used SD to manage tourism development in the Great Barrier Reef in a sustainable manner and asserted on the necessity of understanding the forces which shape the future of tourism in a holistic approach. According to these authors, tourism was considered as a complex system with a multitude of activities which should be managed simultaneously. In order to do so, a framework including all the factors that affect the tourism system was created.

According to Chang et al. (2008), coastal areas are considered complex regions which are in interaction with multiple complex systems. Coastal zones are being used for tourism, agriculture, fisheries, and industrial activities which increases the necessity of conserving these areas. Coral reefs have an important role as ecosystems and also provide humans with different opportunities for tourism activities. In the work of Chang et al. (2008), a decision support system was used in order to provide stakeholders and policy planners with a tool to analyze sustainable coral reef management. Seven scenarios were implemented and tested on the model and the results showed that imposing an entrance fee to access the coastal zone would be the best policy. The use of SD contributed to the enhancement of management efficiency and coral reef sustainability.

In the process of investigating the interactions between humans and the environment, Mavrommati et al. (2014) built a framework for the sustainability of lake systems. Four scenarios with different environmental impacts on lake system were defined. The purpose of using SD in this study was to build a framework for identifying the components which have impacts on the socioeconomic and natural systems of St. Clair Lake. The proposed scenarios in this study show that a holistic approach in the management of the lake’s system is necessary.

In developing a social-ecological system (SES) in the coastal area of Dutch Wadden Sea, a group model building was used to understand the dynamic characteristics of the SES

(Vugteveen et al., 2015). Sustainable mussel fisheries and tourism development were the analyzed scenarios. The result of the simulation showed a strong relation between three variables: “Natural Value”, “Experience Value”, and “Number of Tourists”. The experience from natural environment turned out to be the best motivation for tourism activities in the region. Since group model building is an effective approach that facilitates SD modelling by capturing the stakeholders’ views, it has also been used to systematically manage the sustainability of wetland in Jiading, Taiwan (H. Chen et al., 2014). System Dynamics was used to analyze complexities of the wetland system by considering the impact of the yacht industry on the Jiading wetland. The results of simulation showed that the development of a system for wetland management was necessary. In addition, Schianetz et al. (2009) examined the concept of learning tourism destination (LTD) in the Ningaloo Coast (Australia). In this study, stakeholders had the opportunity to participate in decision making through a learning process. System Dynamics modelling in this study proved to be a strong tool for creating a shared vision and understanding of the tourism system.

5.4. Adventure and Outdoor Recreation Sector

The Adventure & Outdoor Recreation sector is characterized by complex mutual relationships between the ecological systems and human factors. Tourism, natural resources, climate change, local communities, and recreational activities are all interdependent (K. C. Chen, 2004; Schianetz et al., 2009; Woodside, 2009). Only one article was found in this sector: Woodside (2009) applies system thinking to golf tourism. The author uses causal mapping to demonstrate the relationships among golf, tourism, and the environment as a motive for regional development. Since criticism to the golf industry is growing rapidly, due to its environmental impacts, the lack of an effective control and management system can be felt (Woodside, 2009). Due to the existence of contradictions regarding golf, tourism, and the environment, the application of SD can be helpful to gain a better perspective in order to reach an agreeable decision by all the stakeholders. The results of simulation show that the government regulations can play an important role in sustainable development of golf courses.

5.5. Transportation Sector

The transportation sector deals with a huge amount of interactions at the same time. Moreover, as all industries and services depend on transportation, this sector plays a significant role in the supply chain (Egilmez & Tatari, 2012). Many authors argue that

accessibility and transport infrastructure can have a strong influence on a destination's attraction (Dickinson et al., 2009; Kozak & Rimmington, 2000; Odoki et al., 2001). As pointed out by Crompton & Ankomah (1993), Crouch, (1994)and Prideaux (2000), tourist choice of a destination is affected by the time and cost of the travel, showing the importance of transport infrastructure in tourism destinations. Tourists are constantly using different means of transportation and consequently they have direct and indirect impact on traffic, delays, construction and maintenance. Meanwhile, climate change has drawn a serious attention to CO2 emissions associated to tourism (Egilmez & Tatari, 2012; Guzman et al., 2013; Trappey et al., 2012).

In our selected sample only the article by Li et al. (2015) featured SD to model and demonstrate the complexities and interdependencies of transportation infrastructure on tourism development. Their paper focuses on destinations which share the same tourism market and explores how infrastructure can influence tourist choice. Competition and cooperation scenarios were used to assess the role of the transportation infrastructure of Xidi and Hongcun heritage sites in tourist's choice behavior. The results of simulation show that both scenarios can increase the attractiveness of the destinations. Furthermore, cooperation on investment can increase the chance of merging two destinations into one.

5.6. Accommodation Sector

Sharpley (2000b) discusses how accommodation contributes to economic gains within a destination and plays an important role in creating a tourism experience. The accommodation sector provides a multitude of choices for tourists with different preferences from five star hotels to campsites, each of which, due to their scales and attributes, offers a particular range of services (Benítez et al., 2007).

Three papers used the SD approach to address the accommodation sector. The first focuses on the value chain management in the hotel industry in Cyprus (Georgantzas, 2003). The second addresses the links between greenhouse gas emissions of the hotel industry and tourists' choice in Egypt (Law et al., 2012). The third explores innovation in the hospitality logistics in Croatia (Stipanovic & Rudan, 2014). Georgantzas (2003) uses SD in order to investigate the hotel value chain structure in Cyprus' tourism and what would happen to Cyprus' tourism in the future. He suggests four scenarios for the hotel value chain in Cyprus. These scenarios aim to assess changes in bed capacity, value chain parameters, tourism growth, and price seasonality. The bed capacity and value

chain scenarios indicate that the impact of the bullwhip effect on the tourism market can be seen more on suppliers than hotels. The tourism growth scenario suggests that building hotels in Cyprus is prone to market changes and any fluctuation can lead to significant negative impacts. The last scenario, the one exploring price seasonality, indicated that reducing seasonality can contribute to increasing hotels' profit. The results showed that Cyprus' hotel value chain is unstable due to its specific structure. Building several scenarios proved helpful for hotel managers to prepare themselves for any further changes.

Stipanovic & Rudan (2014) explain the influence of the providers of hospitality services and their value system characteristics on the logistic process. In this study, they explore the ways to innovate the logistic process in the hospitality industry. The importance of environmental, social and economic aspects of responsible logistics was considered. Causal loop diagrams are used to demonstrate the significance of a new strategic orientation in a dynamic environment. The study shows the role of knowledge and information in sustainable development of the companies in the hospitality industry. It also demonstrates the necessity of constant innovation to cope with the dynamics of the tourism industry. In the process of reaching a green economy, Law et al. (2012) used different environmental, social and economic scenarios to demonstrate the impact of pollution on the opinion of tourists. These scenarios showed the ability of SD in assessing the impacts of tourism indicators such as destination revenue, hotel occupancy level and greenhouse gases emissions.

5.7. Event Sector

The event sector has been recognized as one of the important players in the development of tourism destinations as it brings competitive advantages (Getz, 2008; Golob & Jere Jakulin, 2014). The only study we found in this sector is the one by Golob & Jere Jakulin (2014), which focuses on categorizing the event sector based on the quality of different factors in Slovenia. A qualitative SD approach was used to explain the event tourism system in a more understandable and rational way. The outcome of the modelling process showed the necessity of a holistic approach in the management of operation and information systems. Simultaneously, it also showed that changing the legislative system of events into a more standardized system is necessary.

6. Conclusions

In the previous sections, the application of SD in the tourism industry was explored. This helped us to gain a better perspective about the use of this method in the tourism industry. The SLR performed disclosed useful information about the concentration of publications on each sector, and opened a new outlook about the possible applications of SD to tourism development.

A set of 27 papers was selected and reviewed. All the assessed papers showed the relevance of using the SD method in the tourism industry and its contribution to planning and development of related sectors. This study aimed to identify the tourism complex problems in different sectors. Furthermore, it investigated the ways in which a system was structured, and what kind of behaviors it would generate as a result of different scenarios and policies.

Several other approaches exist to model the complex structure of industries such as geographic information systems (GIS), and agent-based models (ABM). Nevertheless, the evidence and results of this study show that the SD ability to integrate qualitative and quantitative information can be an important advantage for capturing the complex interactions of the different systems in the tourism industry.

The results of the SLR show that only 27 papers have applied the SD method to the tourism industry, despite its wide use in other fields. This indicates that the application of this method to tourism is still in an early development phase. As SD is a computer-based method, the majority of the papers were published in journals in the domains of information & computer science and environmental & ecological modelling. The number of publications in tourism related journals is still limited. A considerable number of papers applied the SD method to case studies. This shows that SD is a practical tool to address real world problems.

Regarding the location of the systems analyzed in the selected papers, our review shows that many geographical locations are underrepresented; such as Africa, Middle East, and South America. The review also shows that the majority of the selected papers stakeholders are not strongly involved in the modelling process. This is significant limitation, as stakeholders' knowledge is fundamental to designing a reliable model. Moreover, in a tourism destination, using a group model building approach involving modelers and key stakeholders can be very helpful for improving mutual understanding

of a complex problem. Overall, the idea of sustainable tourism development prevails in the selected papers, allowing us to conclude that SD provides researchers with a powerful tool to look at complex problems in a holistic way.

System Dynamics helps to capture and understand the behaviors driving the processes in the complex system of tourism. Recently, new publications applying SD to tourism have emerged. Tegegne, Moyle, & Becken (2016) proposed a qualitative SD approach in order to gain a better understanding of the core components of the destination image of Ethiopia in the Japanese market. The feedback structure illustrated a holistic view of the destination image and facilitated the process of identifying the factors affecting the image of Ethiopia as a tourism destination. The application of SD cuts across a variety of fields in tourism studies such as health tourism (Vetitnev et al., 2016) in which SD is being used to forecast health demand in Krasnodar, Russia. System Dynamics proved to be a useful method for decision making in health tourism due to the complexity of this sector and the uncertainty it involves (Vetitnev et al., 2016).

Concurrently, SD is being used as a method to assess and analyze the robustness of long-term strategies in coastal urban tourism. Carlisle et al. (2016) used SD to illustrate the ability of this approach to represent a coastal urban system and help in its strategic planning. Pizzitutti et al. (2017) applied SD, in a participatory context, to the management of tourism in the Galapagos Island, Ecuador. The models presented in the study show the necessity of developing viable and realistic solutions for all direct and indirect threats that affect Galapagos.

There are different applications of SD that can help practitioners in managerial decision making processes. System Dynamics can be used in destination management level, strategic and policy planning, and project management. For instance:

a) Sustainable tourism policies and strategies can be illustrated by using system thinking methods;

b) In heritage sites, SD can be used in stakeholder involvement using group model building which helps to engage stakeholders and modelers to achieve a consensus over the problems;

c) System Dynamics can help to understand the complex behavior of the hotel industry by considering all the endogenous and exogenous factors involving its

value chain This helps the hotel managers in long-term planning and increases the accuracy of their cost benefit analysis;

d) Data driven SD models using “Big data” analysis can facilitate scenario planning and decision support systems for policy makers.

This study contributed to finding the literature on the application of SD to the tourism industry but many issues remain to be analyzed by this technique. The majority of papers have focused on the sectors that independently can be considered as a complex industry. Nonetheless, for future work, it is important to bear in mind that SD has the potential to analyze tourism systems either in particular or in general. The most important and necessary work is to concentrate more on different types of tourism by applying a holistic approach to this industry. For instance, some issues that could be analyzed include the long run impact of mass tourism on tourism hotspots or the balancing role of particular tourism activities, as a complementary tool to promote sustainable tourism development. More specifically, SD can be used for modelling and strategic planning of natural resources in the tourism industry. Another possible application is to model the interactions of tourism destinations with focuses such as tourist behavior and satisfaction level, security issues and the impacts of tourists on a specific environment.

Many other issues remain, however, open to research. For example, in the development of community-based tourism enterprises, a holistic organizational model for social responsibility in tourism can be developed. In cultural studies, there is a need to increase the number of case studies in order to expand the scope of the research about heritage systems. Concurrently, alternative sustainable development approaches have to be found for risk management in heritage sites. In social-ecological systems, further studies are necessary to improve model quantification. In Islands systems, many interactions among population, environment and tourism’s feedback loops are yet to be worked on. In ecosystem services, two challenges remain ahead, first quantifying ecosystem services on human well-being, and second, developing a SD model in order to apply the concept of sustainability at operational level. In order to further scrutinize the hospitality innovation logistic process, it is also deemed necessary to quantify the new strategic approaches for logistic process improvement. To conclude, SD provides a strong tool for addressing complex problems in tourism, and for offering several opportunities for researchers and practitioners alike.

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Chapter 3.

SYSTEMS APPROACH TO MODEL SMART TOURISM ECOSYSTEMS

Abstract

The tourism industry is inherently complex and a key player in sustainable development. This paper intends to discuss the path towards building a sustainable smart tourism ecosystem model by delving deep into the pivotal topics with interesting speculations on smart cities' perspectives that lay a broader foundation of smart tourism destinations. First, it discusses the interconnections and foundation of smart tourism ecosystems by proposing a general conceptual model describing traditional tourism transformation through ICTs. Second, by explicating each building blocks of smart tourism ecosystems and using systems methodology (systems thinking method and qualitative modeling in a frame of system dynamics) to break down the complex system of smart tourism's roles and components. The proposed causal loop diagram considers sustainability as one of the main concerns and trying to shed some light on intricate networks of businesses, socio-economic, and environmental subsystems in smart tourism destinations that are performing distinctively yet interdependent.

Keywords: Smart Tourism Destinations, Smart Ecosystems, Sustainable Tourism, Complex Systems, Systems methodology

1. Introduction

As a highly complex system, the tourism industry has proven itself as a key player in sustainable development. From a systems point of view, sustainable tourism is grounded in the holistic perspective, in which systems thinking can provide a powerful tool for illustrating the world and uncovering the interconnections between the components of the systems. The adoption of systems thinking and a holistic approach to promote understanding of tourism problems and tourism systems is justified on the grounds that the components of the tourism industry interact with each other and offer the same final product, which is an attraction and experience for tourists (J. Baggio & Baggio, 2020; Batat & Prentovic, 2014; Sánchez et al., 2006). The Information Communication Technologies (ICTs) have provided tourists with ubiquitous access to information in which using the internet to acquire information regarding weather forecasts, reservations, entrance fees, tours, services, transportation, and navigation has been facilitated (Buhalis & Law, 2008; Gretzel, Sigala, et al., 2015; Gretzel, Werthner, et al., 2015; Leung et al., 2013; Schoefer, 2003). Furthermore, IT and sustainability implications are intertwined, and sustainability pillars require a proper maintenance system to educate, monitor continually, and collaborate, which, through ICT, can be achievable (Benckendorff et al., 2014; Gössling, 2017). Gretzel, Werthner, et al. (2015) give a holistic look at smart tourism by considering it as a complex and dynamic ecosystem and emphasizing the interconnectivity of the whole system. Ecosystems are intricate networks of businesses, socio-economic, and environmental subsystems. Moreover, tourism destinations consist of various sectors which are interrelated and working simultaneously, subsequently resembling the complexity and interconnectedness of an ecosystem (Neirotti et al., 2014; Perfetto & Vargas-Sánchez, 2018). Ecosystems mainly emphasize the holistic view rather than focusing on elements of systems by recognizing how small changes can have substantial effects, encourages a focus on complex relationships, stresses dynamic changes (Gretzel, Werthner, et al., 2015). Moreover, this paper draws attention to the technical definition by Boley and Chang (2007) using the term digital ecosystem by pointing out on the characteristics of these ecosystems, such as flexibility, openness, demand-driven, interactivity.

The complexity of the problems that emerge in tourism systems, due to the diversity of interests of the different stakeholders and the dynamic and non-linear nature of the interactions between the different components of the systems, has discouraged the use of

linear thinking. According to Gössling (2017), while there has been significant attention to the technological changes globally regarding the tourism system, which has changed consumer behavior and raised the importance of new approaches in the management of tourism systems, still the number of studies on the interrelation of IT and sustainability is limited. Systems approach thus represents an excellent methodology with its methods of systems modeling and simulation (Jere Jakulin, 2017).

Integrating the feedback structures and smart tourism ecosystems help us create a simple conceptual model to illustrate all the leverage points for creating a sustainable system. The collision of population, economic growth, and technology with limited resources on our planet will lead to new challenges for managing sustainability. Concurrently, cities are growing in number and population and desperately seeking a solution to become more efficient and sustainable. Cities are composed of multiple sectors incorporating technologies to provide more efficient service for citizens and tourists. While there is no general guideline to answer such challenges, rapidly growing digital and smart solutions offer an efficient strategical pathway to reach a prosperous society. Therefore, such strategies should be entirely focused on a human-centered approach where people can accept and adopt new technologies to their advantage. This study uses the systems thinking approach as a powerful tool to develop a conceptual model (causal loops diagram) of smart tourism ecosystems by illustrating the most influential interconnections among such systems' components. The intention is to create a new perspective for looking at the complexity of smart tourism ecosystems and to call-out the necessity of using the human-centered approach in the smart destination, which could provide a more robust backbone for providing sustainability in the long run.

Considering the above premises outlined, this paper intends to discuss the path towards building a sustainable smart tourism ecosystem model by delving deep into the pivotal topics with interesting speculations on smart cities' perspectives that lay a broader foundation of smart tourism destinations. Henceforth, the section -On the basis of sustainable tourism- scrutinizes sustainability and tourism's complex characteristics and the shifting towards nonlinear thinking as a sine qua non. Then, the study describes the background and roadmap from smart cities to smart tourism destinations. Next, by diving more in-depth in the concept of ecosystems, this paper portrays the process of utilizing smart technologies to shape the smart tourism ecosystems as an initial conceptual model. The remainder of the paper explains systems thinking as the research methodology and

illustrates the interconnectivity of six building blocks of smart cities. Afterward, key variables of smart tourism ecosystems are identified, and the relationships among the variables are then illustrated as a causal loop diagram (CLD). The final section concludes the contributions, implications, limitations, and future research areas.

2. A Base of Sustainable Tourism

The main properties and driving forces of contemporary local and global tourism institutions within a frame of tourism supersystem are; information processing, decision-making and learning for a development. The success or failure of a tourism development initiative or strategic plan is largely dependent on whether the decision-makers truly understand the interaction and complexity of the system he or she is trying to influence (Jere Jakulin et al 2020). As one of the fastest-growing industries in the world, tourism deemed as an economic sector (R. Baggio, 2013) contributing to job creation, poverty alleviation, and has a direct impact on the economic, environmental, and social sustainability of destinations (Sinclair-Maragh & Gursoy, 2016; UNWTO, 2017). Over the past decades, the idea of sustainability has become the main driving force in forming the economic and political structures of the tourism system (Bramwell & Lane, 1993; Saarinen, 2006). Evolving out of the idea of "The limit to growth" (Meadows et al., 1972), the transference of the idea of sustainability to tourism started after Brundtland Commission's report "Our Common Future" in 1987, which asserts on the process of meeting the needs of present generations without endangering the ability of future ones to meet their own needs (Brundtland et al., 1987). The ultimate goal of sustainability is to take into account all the factors of socio-economic, environmental, and political systems and create equilibrium among them (Boluk et al., 2019). Undoubtedly, the tourism industry encapsulates the holistic approach toward sustainable development (Sharpley, 2000a) and plays a significant role in promoting the Sustainable Development Goals (UN, 2015).

Saarinen (2006) depicts a bigger picture of the tourism system emphasizing the interrelations among the system's elements, both regionally and globally. According to Saarinen (2006), the inseparable role of tourism as part of the global economy and culture should not be neglected, but the focus of sustainability has, however, been mostly on destinations level rather than holistic approaches. Tourism, without a doubt, has an impact on characterizing the Anthropocene and the problems related to sustainability (Cheer et

al., 2019; Fletcher, 2019; Gren & Huijbens, 2014, 2016; Hall & Saarinen, 2010), which demand re-evaluation and re-location of the current development discourses and actions (Saarinen, 2006). Consequently, the emphasis on the importance of iterative and interrelated characteristics of sustainability necessitates critical thinking to scrutinize the dynamic power of tourism, and simultaneously call out for re-examining and re-enacting systems thinking towards solving complex problems (McDonald, 2009; Mowforth & Munt, 1998; Saarinen, 2006; Sterman, 2011).

For decades, many scholars approached tourism from a reductionist approach, which led to neglect the inherent dynamic and complexity of tourism's sub-systems and some of the presented models failed to explain the existing complex interrelations within the tourism system (Baggio, 2008; Feldman, 2012; McDonald, 2009; McKercher, 1999). Nevertheless, many scholars believe that the dynamics of the tourism system is grounded in the constant change created from the trade-off between supply and demand in tourism development. The complex interrelations among elements of tourism systems coupled with numerous external elements, elucidate how tourism function in a nonlinear manner (R. Baggio, 2008; Clarke, 1997; Feldman, 2012; Leiper, 1990; Z. Liu, 2003; McDonald, 2009; McKercher, 1999; Sainaghi & Baggio, 2017; Sedarati et al., 2018). Baggio and Del Chiappa (2016) define the management and governance of complex systems "notoriously daunting", which requires the proper knowledge of the system's dynamic characteristics. Moreover, Liu (2003) entails the importance of contributing to the economy and society while sustainably using environmental resources in sustainable tourism. The path towards developing sustainable tourism can be somehow precarious due to the multisectoral nature of tourism wherein a multitude of stakeholders are involved; thus, moving towards a much more comprehensive view of systems and using a holistic approach would be crucial (Boluk et al., 2019; McDonald, 2009; Van Mai & Maani, 2010). Nevertheless, it is needless to mention that the tourism industry's ramifications have a significant role in undermining sustainable development (Higgins-Desbiolles, 2010; Janusz & Bajdor, 2013; Law et al., 2012).

3. From Smart Cities to Smart Tourism Destination

Cities are growing bigger every day both in numbers and populations by witnessing a gradual shift in the tendency to live in urban areas. Nowadays, more than half of the world's population lives in cities, and this number is expected to grow by 2050 (Dirks &

Keeling, 2009; United Nations, 2019). The urban sprawl has led to the creation of multiple complex socio-economic issues in terms of lifestyle, built environment, gentrification, infrastructures, and many more; subsequently, the manifested complexity entails a specific approach of decision making to contemplate all the prerequisite of city development. Therefore, to solve the unpredictable behavior of cities' ecosystems, complex systems thinking can offer a solution to decision-makers and planners to fathom better how inextricably interrelated all sectors of a city are (Batty, 2007; Innes & Booher, 1999; Lombardi et al., 2012; United Nations, 2019). The extant diversified group of stakeholders within cities' complex systems inevitably tend to become chaotic, wherein challenges such as waste management, resource allocation, pollution, infrastructure deterioration are among emerging issues that affect the quality of life, and consequently, threaten the sustainability of the cities (Chourabi et al., 2012; Dirks & Keeling, 2009). To ensure a better quality of life, a more livable environment, and prosperity of the place, thus, cities are seeking smarter ways to overcome the aforementioned issues (Chourabi et al., 2012; Giffinger & Pichler-Milanović, 2007).

The idea of smartness is devised by a complex technological infrastructure that exists within urban areas to foster economic, social, and environmental prosperity (Lara et al., 2016). Information and communication technologies provide the foundation for realizing an interconnected system to tackle the economic, social, and environmental challenges in big cities (Dirks & Keeling, 2009; Sharifi, 2020). The potential of smartness and understanding the need to adapt to this rapid change in technology should not be neglected, and how they can contribute to sustainable development and economic growth (Nam & Pardo, 2011; Stratigea et al., 2015). The constant flow of information and data has provided us with an essential foundation that proved to be hard to understand or translate into simpler and more understandable language. The emergence of modern technologies facilitates the transformation and interpretation of complex data into a more readable and understandable form.

While cities are grappling with emerging issues, Dirks & Keeling, and Dirks, Keeling, and Dencik (2009; 2009), in reports from IBM, emphasize technology's power as an empowering tool for better understanding and controlling cities' operations systems and development processes. Several scholars have acknowledged the significant role of smart technologies and smart solutions for cities' authorities as an innovative approach to control the unprecedented challenges city systems are dealing with on a daily basis and

becoming a smart city (Albino et al., 2015; Caragliu et al., 2011; Giffinger & Pichler-Milanović, 2007; Gil-Garcia et al., 2015; Govada et al., 2017; C. Harrison et al., 2010; Henzelmann, 2019; Nam & Pardo, 2011; Woetzel et al., 2018).

A report from Mckinsey Global Institute (2018) explains how the idea of smart cities initially started in the early 2000s with a technology-centric view for development (Smart City 1.0), however, soon after years of trial and error, the second era of smart cities (Smart City 2.0) with a multisectoral and human-centered approach wherein a smart city is not only a highly technological place but on the contrary, the focus is on the quality of life the citizens (De Guimarães et al., 2020; Giffinger & Pichler-Milanović, 2007; C. Harrison et al., 2010; Pencarelli, 2019; Woetzel & Kuznetsova, 2018; Yeongbae et al., 2017). Additionally, IBM corporation's reports denote three fundamentals characteristics of a smart city; "instrumented, interconnected, and intelligent." Instrumented is the ability to capture real-time data through the presence of multiple sensors, meters, and other similar "data-acquisition systems". Interconnected can be defined as a bridge between the physical and virtual world, in which the captured information through instrumentation allows different sectors to communicate much efficiently. Ultimately, the interconnected information coupled with the complex analytical power furnishes decision-makers with a much more intelligent and optimal solutions (Dirks et al., 2009; Dirks & Keeling, 2009; C. Harrison et al., 2010). Moreover, they have devised cities' operational systems into six core interrelated sub-systems of people, business, transport, communication, water, and energy. Capitalizing on instrumentation, interconnectedness, and intelligence, therefore, forms an interrelated "system of systems," which independently deal with the challenges of their own (Dirks & Keeling, 2009). Furthermore, it is needless to mention that the framework of smart cities was initially developed by Giffinger et al. (2007) where they identified six core elements of a smart city: Smart People; Smart Economy; Smart Environment; Smart Governance; Smart Living; and Smart Mobility, which later on was further developed by Boyd Cohen (2013) with a much more holistic view of the smart cities.

The advancements of ICT in the tourism industry have been manifold, hence, created a new concept or a buzzword called *smart tourism*, that nurtures on highly advanced intelligent systems and technologies, such as sensors, big data, Internet of Things (IoT), and more recently 5G (Gretzel, Sigala, et al., 2015; Matos et al., 2019). Smart tourism's emergence can be described as a fuzzy concept due to the rapid transition of traditional

tourism through the extensive adoption of new technologies to smart tourism. Moreover, the ubiquitous access and infrastructures formed by multidimensional technological development have been transforming tourists' experiences through offering customized, personalized, or smart experiences per se (Buhalis & Law, 2008; Gretzel, Sigala, et al., 2015; Gretzel, Werthner, et al., 2015; Leung et al., 2013; Schoefer, 2003). Consequently, the below definition by Gretzel, Sigala, et al. (2015) distinguishes smart tourism from e-tourism:

> "Tourism supported by integrated efforts at a destination to collect and aggregate/harness data derived from physical infrastructure, social connections, government/organizational sources and human bodies/minds in combination with the use of advanced technologies to transform that data into on-site experiences and business value-propositions with a clear focus on efficiency, sustainability and experience enrichment (Gretzel, Sigala, et al., 2015, p. 181)."

The tourism industry, as one of the sub-systems of smart cities, utilizes ICT in tourism destinations to foster several aspects such as improving infrastructures, monitoring and managing tourism hotspots, and enhancing tourism experiences (Gretzel, Sigala, et al., 2015; Tripathy et al., 2018; Wayne, 2016). Similarly, the concept of smart tourism destinations has been emerged and perceived as a place wherein technology is seen as a tool and enabler for value co-creation, experience enhancement, improving supply and demand (Boes et al., 2015; Buhalis & Amaranggana, 2013; Lamsfus et al., 2015; Neuhofer et al., 2012).

Smart tourism destinations, due to their complexities and interrelations among the component of the destinations, represent a new way of understanding destinations and therefore substantiate the necessity of using a systematic approach for better understanding the complex issues (Femenia-Serra et al., 2019; Ivars-Baidal et al., 2017; Jovicic, 2017; Saraniemi & Kylänen, 2011). The advent of the digital revolution has provided all stakeholders of tourism destinations with accessible information and facilitated the innovation process. Hence, to gain a competitive advantage, collaboration of digital business ecosystems with stakeholders, complemented with technological infrastructure, would be indispensable (R. Baggio & Del Chiappa, 2014; Jovicic, 2016; Pencarelli, 2019).

While there is no consensus over the definition of smart tourism destinations (Del Chiappa & Baggio, 2015), many scholars have suggested several definitions for smart destinations (Ávila, 2015; Boes et al., 2015; Buhalis & Amaranggana, 2013; Lamsfus et al., 2015). Up till now, one of the most frequently used definitions by SEGITTUR organization; therefore, the smart tourism destination is:

> "An innovative space, accessible for all, established on a cutting edge technology infrastructure which guarantees sustainable development of the land, facilitates the interaction and integration of the visitor with the surroundings and increases the quality of their experience in the destination, as well as the quality of life of residents" (Ávila et al., 2015, p. 32).

Several authors have proposed models regarding critical components of smart tourism destinations. For instance, Gretzel, Sigala, et al. (2015), have proposed a model wherein IT has a pivotal role in the majority of tourism-related sub-systems. This model consists of three components; Smart Destination, Smart Experience, and Smart businesses. Wherein, smart destinations are applying the same rules of smart cities while considering tourists as their imperative stakeholders. Afterward, smart experience enhances stakeholders' experiences through "technology-mediated" involvement. Ultimately, smart businesses refer to the intricate web of tourism-related businesses that support the process of co-creation. More importantly, these three abovementioned components are intertwined with three layers of data in the smart tourism system; (1) Smart information layer (data collection); (2) Smart exchange layer (interrelationships); (3) Smart processing layer (data analysis).

Buonincontri and Micera (2016) argue that the smart tourism destination, by leveraging technological components, can contribute to the co-creation of tourists' experiences in a way that effective interaction with service providers, active involvement throughout the experience, and ultimately sharing the experiences through social would ensue. This study emphasizes the significant role of technology that is integrated into tools and applications to develop and improve tourists' experience and co-creation throughout the whole process of tourist experience (Buonincontri & Micera, 2016).

In another view, Ivars-Baidal, et al. (2017) used a systemic approach to evaluating the evolution of ICT in smart tourism destinations. In particular, they proposed three interconnected levels: (1) the strategic-relational level (focusing on destination governance and the public-private collaboration); (2) The instrumental level (based on

technological connectivity and sensors); and, (3) The applied level (based on smart solutions for destination management). Moreover, they suggest that smart solutions represent a considerable enhancement in different parts of tourism management; for instance, in the field of 'experience enhancement', the visitors' experiences could be augmented through different technologies. Nevertheless, the main obstacle towards the development of smarter tourism is the collaboration between destination governance and public-private (strategic-relational level) (Ivars-Baidal et al., 2019).

More recently, Shafiee, Rajabzadeh Ghatari, Hasanzadeh, and Jahanyan (2019) proposed a holistic model for smart tourism destinations by implementing grounded theory methodology. They have decomposed and identified the component of smart tourism destinations to present a process model towards better decision-making and the development of sustainable smart tourism destinations. The produced model through the grounded theory identified different codes of 1) Causal conditions (foundational components); 2) Context conditions (influencing factors); 3) Intervening conditions (government support), 4) Interactions, and 5) Consequences, regarding sustainable smart tourism destinations as a phenomenon. Wherein, the model elucidates the intricate interrelationships among constituent elements of smart tourism destinations. Moreover, they stress the importance of understanding the casual, contextual, and intervening conditions to develop a sustainable smart tourism destination (Shafiee et al., 2019).

Additionally, Cavalheiro, Joia, & Cavalheiro (2020) proposed a conceptualized a holistic framework of smart tourism destination development to enhance competitiveness and promote co-creation within a destination. The presented model as a strategic process tends to encompass approaches of sustainable development, citizen-centric, public-private engagement fo building a smarter tourism destination. Cavalheiro, et al. (2020) devised their model into four layers, wherein 1) ground layer (tourism destination) refers to the competitive advantages gained though the formation of a tourism destination; 2) Layer one (smart ICT infrastructure) denotes the role of ICT as an empowering tool to promote citizen participation, create an interconnected ecosystem within the destination and support the entire tourist experience and all businesses; 3) Layer two (tourism application) illustrate the importance of adoption and usage of ICT in tourism destination where an integrated ICT ecosystem; 4) Layer three (smart tourism destination) as the final step of this process describes how ICT can construct a sustainable and competitive destination and ultimately promote public value creation within the host community.

4. Towards Sustainable Smart Ecosystems in Tourism

Ecosystems are intricate networks of businesses, socio-economic, and environmental subsystems, including all direct and indirect factors as both competitors and collaborators (Moore, 2006). Arguably, the attribute of modularity enables ecosystems to perform distinctively, yet be interdependent. Besides, ecosystems' inherent complexity describes it as a set of multilateral complementarities that links various parties together (Jacobides et al., 2018). Moreover, digital business ecosystems, as an extension of Moore's (2006) idea pivoting around digital technology as the dominant factor (Nachira, 2002; Senyo et al., 2019), referring to a biological community of interacting organisms (R. Baggio & Del Chiappa, 2013). Thus, the digital business ecosystem is a networked system of multilateral players complemented by technology to form a transparent and open environment (R. Baggio & Del Chiappa, 2013; Stanley & Briscoe, 2010). Cities, similarly, are complex ecosystems where a multitude of interests and stakeholders are involved (Lombardi et al., 2012), and are encompassing innovative and creative environment while striving to achieve a sustainable environment and better quality of life through collaboration with each other (Ahvenniemi et al., 2017; Capdevila & Zarlenga, 2015; De Guimarães et al., 2020). Several scholars considered cities in general and smart cities in particular organic systems comprising many subsystems, wherein the amalgam of ICT, ubiquitous access, knowledge networks, and applications coupled the interdependency among this complex components makes the system of systems smarter (Cavalheiro et al., 2020; Chourabi et al., 2012; Dirks et al., 2009).

Likewise, tourism destinations comprise various sectors and subsectors, which are interrelated and working simultaneously, consequently, resembling the complexity and interconnectedness of an ecosystem (R. Baggio, 2008; Femenia-Serra et al., 2019; Perfetto & Vargas-Sánchez, 2018). R. Baggio and Del Chiappa (2014) claim that the topic of digital business ecosystems in the field of tourism has been underrepresented and has mostly been a description of the interrelation between ICT and tourism rather than an approach to examining the complex behavior of tourism systems. Ecosystems mainly emphasize the holistic view rather than focusing on elements of systems by recognizing how small changes can have substantial effects, encourages a focus on complex relationships, underlines dynamic change (Benckendorff et al., 2014; Gretzel, Werthner, et al., 2015). Hence, digital ecosystems are focusing on the interconnectedness among technological agents (devices, databases, programs, etc.) to enhance the dynamic

information exchange within the system. Consequently, a smart tourism ecosystem is defined as follow:

> "A smart tourism ecosystem (STE) consequently can be defined as a tourism system that takes advantage of smart technology in creating, managing and delivering intelligent touristic services/experiences and is characterized by intensive information sharing and value co-creation. Collecting, processing and exchanging tourism-relevant data is a core function within the STE" (Gretzel, Werthner, et al., 2015, p. 560).

Since the tourism industry is highly dependent on ICT, smart tourism can be a pivotal change from traditional tourism to a more innovative and technology-centered tourism industry, which pushes the businesses towards adopting ICT in their systems (Gretzel, Sigala, et al., 2015). All the stakeholders, therefore, through an advanced infostructure provided by innovative technologies, form a dynamic network of interconnected actors within the tourism ecosystem wherein smart users can enhance their smart experiences and co-create with other stakeholders (Buhalis, 2019; Femenia-Serra et al., 2019). According to Porter and Heppelmann (2015); products are evolving into smart, connected devices that are increasingly embedded in broader systems; thus, reconstructing companies and competition. Smart destinations have provided visitors with new ways of mobility and tourism experiences through a mobile environment (Lamsfus et al., 2015). For instance, new digital technologies such as IoT, augmented reality (AR), artificial intelligence (AI), and wearable devices provide tourists with immersive experiences and enable them to capture and share their experiences (Buhalis, 2019; Hein & Rauschnabel, 2016; Pencarelli, 2019; Sedarati & Baktash, 2017; Tussyadiah, 2013). While the accessibility and affordability of technology do not necessarily guarantee the users' acceptance (Gretzel, Sigala, et al., 2015), the relevant application development (Hein & Rauschnabel, 2016) could reinforce the users' perception of the functionality of technology. Nevertheless, it has been argued that to promote co-creation and enhance tourism experiences in a destination, establishing a collaborative ecosystem where a wide range of stakeholders, authorities, tourists, businesses, and government are involved is crucial (Pencarelli, 2019).

Additionally, scholars have proclaimed that digital ecosystems are complex adaptive systems with attributes such as self- organization & scalability and thought to solve complex dynamic problems where can be beneficial in addressing the sustainability of

social, environmental, economic systems (Darking et al., 2006; Senyo et al., 2019; Stanley & Briscoe, 2010). Moreover, to achieve a better quality of life, environmental preservation, economic growth, smart tourism destinations have to move towards the sustainability paradigm (Koo et al., 2016; Pencarelli, 2019). In another view, Höjer and Wangel (2014) propose the “smart sustainable cities” and argue that a city's sustainability is not necessarily dependent on the use of smart technologies; as such, ICT can be implemented for sustainable development purposes. However, they believe that the notion of sustainability is concealed within the definition of smart cities but can often be excluded. Besides, Neirotti et al. (2014) enumerate smart mobility, smart environment, and the smart economy as the prominent domains of smart city initiatives in recent studies. Subsequently, Höjer and Wangel (2014) define a smart sustainable city based on the Brundtland report (1987) as a place supported by ICT, where people's present and future needs are met socially, environmentally, and economically. An attempt to carry a comprehensive review regarding various aspects and building blocks of smart tourism destinations and bearing the shaping factors of smart ecosystems furnished us with a better understanding to proposes a holistic model of smart tourism ecosystems formation in this study. The model, therefore, contributes to defining the process of forming smart tourism ecosystems and helps to better understand the process, which can lay the foundation for developing and designing qualitative and quantitative models. Furthermore, smart technologies' role is encapsulated in the model as a catalyzer to generate interconnected systems of systems where the constant flow of information coupled with the analytical power of new technologies and intelligent systems will shape an iterative process of value co-creation. Figure 1. shows the smart tourism ecosystem model.

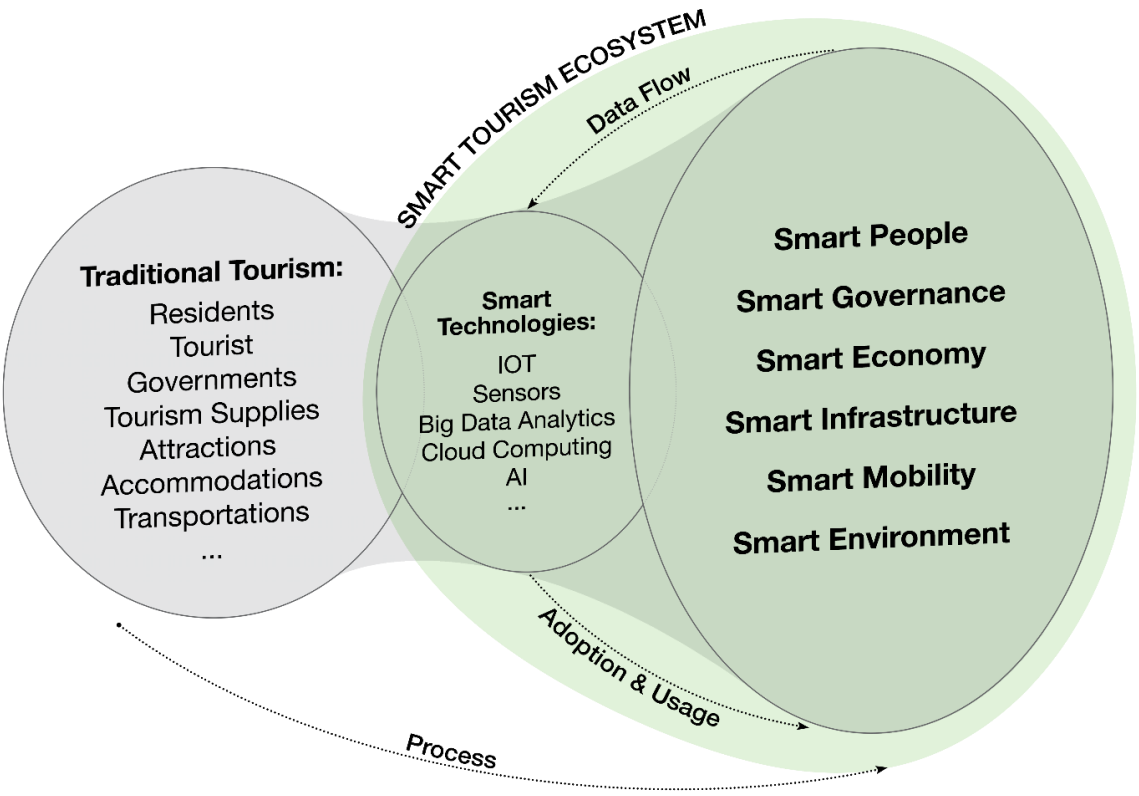

Figure 1. Smart Tourism Ecosystem Model

5. A Systems Thinking Outlook

Constant of change in our modern times is what Sterman (2000) believes drives the transformation of humans, technologies, and economies expeditiously. Nevertheless, such changes' collateral effects cannot be neglected; specifically, challenges traditional systems and organizations face due to lack of comprehension of the repercussions. Therefore, many scholars advocate a fundamental shift towards new ways of thinking wherein world being acknowledged as complex interconnected systems and the holistic view is promoted (J. Baggio & Baggio, 2020; Meadows, 2008; Meadows et al., 1972; Senge, 1997; Sterman, 2000). This view is entrenched in complexity science (Bertuglia & Vaio, 2005; McDonald, 2009; Siegfried, 2014), offering alternative ways of observing the world through a holistic lens as a complex, interconnected system. Complex systems are usually consisting of a large number of interrelated components wherein the interaction among the components explains the systems' behavior (Ackoff, 1971; Boardman & Sauser, 2006). The foci of this study are revolving around the Ackoff's (1971) & Meadows's (2008) ideas of interconnectedness and coherence of a system's components (Meadows, 2008), and "system of systems" wherein each component

represents a complex system interrelated to other elements of the system (Ackoff, 1971). Consequently, to understand such intricate interdependencies, a new approach and way of thinking are required, and systems thinking has the ability to view the system through a holistic lens (Gharajedaghi, 2012; Maani & Cavana, 2000; Sanneh, 2018). Systems thinking as an approach permeates many fields of study ranging from planning & development, sociology, human development, and business to sustainability. Several scholars have attempted to define systems thinking; it could be therefore said that unanimously there is a consensus that such a discipline perceives the world as a complex system and recognize, understand, and synthesize the interconnectedness and interconnectivity (Arnold & Wade, 2015; Cabrera et al., 2008; Checkland, 1999; Kim, 1999; Maani & Cavana, 2000; Meadows, 2008; Schianetz et al., 2007; Schuster, 2018; Senge, 1997; Sterman, 2000).

The terminology of systems thinking does not have a precise application and often applied to soft operation research (OR) or SD methodology depending on the approach (Checkland, 1981; Forrester, 1994) and generally defined as a holistic approach to analyze and understand system's complex interrelations and its behavior over time by breaking down a system into smaller components (Bala et al., 2017; Kim, 1999; Maani & Cavana, 2000). Moreover, Richardson & Pugh (1981) argue that systems dynamics should focuses on the system's problem rather than the system itself. What makes dynamic problems complex and challenging to analyze is containing quantities that change over time and including feedback structures. The general methodological approach of this study mostly pivots around the SD method, which arises from the work of Forrester (1961) at Massachusetts Institute of Technology, which emphasizes the essential foundation underlying effective thinking about systems. Several authors have scrutinized the development of SD and systems thinking such as Coyle (2000; 1997), Senge (1997), Richardson and Pugh (1981), Morecroft (1988), Vennix (1996), Morecroft and Sterman (2000), Wolstenholme (1999), Maani and Cavana (2000), Sterman (2000), along with others.

Systems Thinking grants us the ability to look at the world from another perspective and perceive the interactions and interrelations of a system, thus leading us to contemplate our actions' repercussions in the long run (Schuster, 2018). Maani and Cavana (2000) describe systems thinking as an emerging discipline and identify three dimensions for systems thinking: 1) Paradigm: as a way of thinking and describing the dynamic

interrelationships of the world, emphasizing the nonlinearity and complexity of the systems; 2) Language: as a tool to facilitate the understanding of complexity; 3) Methodology: as a set of computer-based tools such as Causal Loop Diagramming (CLD), Stock and Flow Diagrams, Simulation, and Implementation for understanding, measuring, and predicting the complex behavior of systems. The interconnections among system's elements and causes and effects are shown in causal loop diagrams that help to structure a mental model of the system. Coyle (2000) discusses the ability of causal loop diagrams to show the system's interactions and gain a better understanding of its dynamics. These diagrams help the modeler to convert qualitative dynamic models into quantitative ones easily. Causal loop diagrams are essential parts of the systems thinking modeling process, and Sterman (2000) recognizes the ability to find the feedback structure, stock and flow diagrams, time delays, and nonlinearities in the system an art in the modeling process.

Furthermore, causal loop diagrams are frequently used to study dynamic problems and aim to give an insight into the problem rather than at its quantification. When the objective is to analyze the system by developing quantitative simulation models, it is common to precede the development of these models with stock and flow diagrams. In these diagrams, the stocks represent the state of the system, which changes by increases or decreases in the flow rates. Also, stock and flow models provide a useful view of the status of the system's performance due to the implementation of different decisions and policies. Once the developed model has been considered satisfactory for its purpose, it can be used for policy analysis (Forrester, 1961), exploring what-if scenarios (Morecroft, 1988), optimizing critical decisions (Coyle, 1985), and investigating organizational redesign (Wolstenholme, 1999).

Key findings of the carried out literature on the complexity of smart cities and smart tourism destinations wherein building blocks and shaping factors of smart tourism ecosystems have been scrutinized, enabled us to employ systems thinking methodology to depict the existing interconnections and feedback structures within smart tourism destination ecosystems. Hence, the proposed model of smart destinations (fig.2), by using Vensim Software, serves as the premise for further developing our model on smart tourism ecosystems. The process of CLD development initially starts with structuring the problem wherein the scopes and boundaries of the study are identified. Afterward, key variables are identified, and the relationships among the variables are then illustrated.

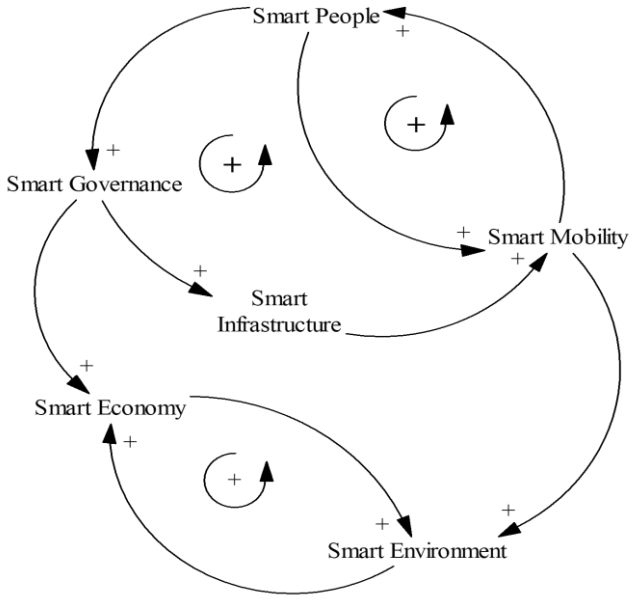

Fig. 2. CLD Model of Smart Destinations' Building Blocks

6. Sustainable Smart Tourism Ecosystems: A Conceptual Model

The imperative shift from a traditional perspective to a novel approach by utilizing a set of artificial, numerical, and computer-based models necessitates a systemic and holistic approach for addressing complex problems. Wherefore, proper knowledge of the dynamic characteristics of the complex systems is essential for their management and governance (J. Baggio & Baggio, 2020; R. Baggio & Del Chiappa, 2016; Jackson, 1990; Sanneh, 2018). Furthermore, Senge (1997) describes the interconnections among elements of the system as "invisible fabrics" where delays define the time of their impacts. He then emphasizes the importance of a holistic view and how systems thinking offers a powerful framework and tool to look into the big picture and its changes rather than the smaller components of the system (Senge, 1997). As discussed earlier, looking into the cause and effect among the elements of the system is a necessary step to understand a system's behavior while considering some effects are caused by the simultaneous consequences of different elements in one system. By breaking down the whole system's structure into smaller segments and increasing the possibility of studying dynamic relationships among elements of the system, systems thinking can be deemed as one of the practical tools for a modeler to have a holistic approach in analyzing models (Jere Jakulin, 2017a; Sedarati et al., 2018).

Moreover, tourism as an industry represents the characteristics of complex systems wherein all the actors and components are interconnected (R. Baggio & Del Chiappa,

2016; Gunn, 1994; Leiper, 1990; Mill & Morrison, 1985; Thanh & Bosch, 2010). Many authors have attempted to delineate a rigorous definition of complex systems in general, and mainly for tourism systems, notwithstanding, a consensus over the nonlinearity of interactions among elements of the systems and their ramifications exists. This view further applies to the tourism industry as a complex system where attentions have been drawn to systems thinking as a viable approach for better understanding the complexities of tourism industries regarding the economy, environment, governance, residents, and others, and interrelationships among several systems in a destination (R. Baggio & Sainaghi, 2011; Jere Jakulin, 2020; McKercher, 1999; Peric & Djurkin, 2014; Sainaghi & Baggio, 2017).

Maani and Cavana (2000) describe the process of developing causal loop diagrams using systems thinking methodology. Initially, the scope and boundaries of the under-study issue will be identified, which is common in most problem-solving approaches. Clarifying the objectives, identifying multiple stakeholders, collecting data, and scrutinizing previous studies are some of the few necessary steps for structuring the problem. Subsequently, the conceptual model (causal loop diagrams) will be created through some steps of 1) identifying key variables; 2) defining a reference mode for the key variables; 3) developing CLD to illustrate the relationships among the elements of the system. By using casual loops diagrams as a tool and considering the factors mentioned previously, this study tries to focus on understanding the cause and effect relationships of each indicator. Delving in the existing literature and extracting key components forming a smart tourism ecosystem allowed us to depict a bigger picture of the system of systems of tourism within a smart destination (Fig. 2) and further explore the key variables. The scrutiny of all building blocks of smart tourism ecosystems presented below and considering the previously mentioned literature, all the key variables have been elicited and illustrated in the CLD model (Fig. 3):

6.1.Smart Economy

Tourism plays an essential role in destinations' economy, which encompasses the indisputable impact on multiple interrelated sectors, while each sector independently is a complex system (Chourabi et al., 2012; Matos et al., 2019). Moreover, the incremental shift towards the circular economy by becoming more innovative, competitive, digital, and sustainable has become increasingly evident. Thus, permeating ICT to all economic activities offers an opportunity and facilitates the process of realizing the smart economy

concept in the complex system of a tourism destination (Perles Ribes & Ivars Baidal, 2018; Vinod Kumar & Dahiya, 2017; WEF, 2018). Through the encouragement of ICT development, smart tourism destinations, improve tourism experiences and increase competitiveness ergo economic, environmental, and social sustainability within a smart tourism ecosystem can be attained. (Gallarza et al., 2002; Gretzel, Sigala, et al., 2015; Ribes & Baidal, 2018; Shafiee et al., 2019).

6.2. Smart infrastructure

Suffice to say that, smart tourism destinations share the same features of smart cities wherein ICTs lay the foundation for a complex interconnected ecosystem trying to tackle the economic, social, and environmental challenges (R. Baggio & Del Chiappa, 2014; Boes et al., 2015; Dirks & Keeling, 2009; Jovicic, 2019; Pencarelli, 2019). The recent trends in the advancement of new technologies impel traditional infrastructures to shift towards smart infrastructures by deploying IoT, AI, and Big data analytics for remotely manage and improve the quality of services and, consequently, the residents' quality of life (Shafiee et al., 2019; Stratigea et al., 2015). Smart infrastructures comprise a multitude of complex domains forming an interconnected network between devices and people to gather data on various sectors such as energy, transportation, public safety, water, and several other endpoints, thus, delivering smart solutions and establishing a backbone for holistic monitoring (C. Harrison et al., 2010; Colin Harrison & Donnelly, 2011; Lea, 2017; Lom & Pribyl, 2020; Woetzel et al., 2018). Smart technologies have shaped an accessible interconnected open platform through the actuation of innumerable embedded sensors in destinations' infrastructure, hence, fundamentally disrupted traditional infrastructures. Moreover, the cost-efficiency and accessibility of IoT technology allow businesses to capture and make use of the sheer volume of data generated by users (residents/visitors) and analyze the real-time data to help people make more optimized and intelligent decisions (Caragliu et al., 2011; Gretzel, Sigala, et al., 2015; Lara et al., 2016; Shafiee et al., 2019; Thaler & Tucker, 2013). Thereupon, it is widely believed that the implications of such advancements offer multiple smart solutions addressing socio-economic, economic, and environmental challenges and paving the way for improving quality of life and achieving a level of sustainability within a destination (Ahvenniemi et al., 2017; Bifulco et al., 2016; Capdevila & Zarlenga, 2015; Gössling, 2017; Gretzel, Werthner, et al., 2015; Matos et al., 2019; Sharifi, 2020; Stratigea et al., 2017).

6.3.Smart Mobility

Mobility, as one of the vital functions of tourism destinations, has a substantial impact on its behavior, whereas transportation produces a series of negative impacts affecting stakeholders' quality of life (Benevolo et al., 2016; Neirotti et al., 2014). Pollution, traffic congestions, a long commute time, parking issues, and highly-priced public transport are some of the reasons cities are moving towards smart mobility as a promising solution. Being ICT-dependent, ubiquitous access, and sustainable makes smart mobility a multifaceted issue that can contribute to environmental footprint reduction, supporting the traffic optimization and collecting citizens' (user) generated contents regarding the quality of transport, livability of the cities, and ultimately improving the quality of life and reducing costs for all stakeholders. Correspondingly smart mobility can provide a better experience for tourists by crowd management, dynamic routing, geolocation offers, and many more (Giffinger & Pichler-Milanović, 2007; Pencarelli, 2019; Zawieska & Pieriegud, 2018). Additionally, it can be argued that conventional mobility mainly focuses on physical infrastructure and aims to improve mobility, especially for vehicles rather than on humans. On the contrary, the sustainable view of mobility promotes reducing environmental and social impacts, shifting the multimodal transport, and using ride-sharing platforms (Banister, 2008; Kumar et al., 2020; Lom & Pribyl, 2020).

6.4. Smart Environment

The rapid population growth has brought about many imbalances, causing crucial challenges for resource management, economic growth, environment, and sustainability in destinations. The perpetual excessive use of natural resources mostly causes pollution, congestion, negative consumption patterns, waste production, CO2 emission (Aletà et al., 2017; Gil-Garcia et al., 2015; Vinod Kumar, 2020). Destinations as complex interconnected ecosystems require efficient and effective systems to manage multiple infrastructures such as; energy (Shifting from fossil fuels to alternative energy sources), water (water sanitation, sewage, and leakage management), waste (monitoring, recycling management), environment (conservation). Effective use of public natural resources means avoiding fossil fuels, reducing carbon footprint, meeting energy needs from alternative energy sources, and using clean energy in transportation to manage the environment (Lom & Pribyl, 2020; Lombardi et al., 2012; Manville et al., 2014; Stratigea et al., 2017). Subsequently, promoting smartness can be deemed a viable and effective solution for managing the repercussions of overpopulation and addressing environmental

sustainability and livability. Hence, smart environment as one the main building blocks of smart destinations is where residents are continuously interacting through embedded sensors, smart devices, and seamlessly use of technology to improve their quality of life and contribute to the sustainable management of natural resources (Chourabi et al., 2012; Höjer & Wangel, 2014; Stratigea et al., 2015, 2017).

6.5. Smart Governance

Tourism destinations are complex systems wherein directly or indirectly utilizing urban infrastructures. Additionally, planning, development, operation, and maintenance of such places are costly, complex, and sluggish (Bifulco et al., 2016; Razaghi & Finger, 2018). A new form of governance in tourism destinations where surpass their carrying capacities and capabilities is required. Subsequently, the integration of new aspects such as transparency, employment of disruptive technological innovation, and participation in decision making draws the attention to the new term of smart governance (De Guimarães et al., 2020; Meijer et al., 2015; Pencarelli, 2019; Razaghi & Finger, 2018). The investment in new technologies, real-time data analytics, participatory platforms, and assimilation of human and social capital results in a cost-effective, well-managed and sustainable governance system that ultimately improves the quality of life of the citizens (Bifulco et al., 2016; Caragliu et al., 2011; Giffinger & Pichler-Milanović, 2007; Gretzel, Werthner, et al., 2015).

6.6. Smart People

Improving the quality of life by integrating smart infrastructure into physical and social infrastructure is one of the main goals of smart cities. Therefore, the aforementioned infrastructures form an intricate network of applications delivering services to people, an interconnected network where all components of the systems interact, and a delicate foundation of sensors and devices for acquiring data (Pouryazdan & Kantarci, 2016; Razaghi & Finger, 2018). The smart services prevail in a multitude of subsectors in smart cities ranging from administration, education, public health, to safety, and many more (Giffinger & Pichler-Milanović, 2007; Woetzel et al., 2018; Woetzel & Kuznetsova, 2018). The emergence of IoT has transformed people's lifestyle and been scaling up to become more ubiquitous; therefore, the IoT platforms are connecting smart devices and sensors to enhance and improve people's everyday lives and coined the term of "people as sensors". Smart people, as one of the main building blocks of smart cities, play an essential role in monitoring and decision-making process by using smart devices

(smartphones and wearable devices) to contribute to data generation (Choe & Fesenmaier, 2017; Nam & Pardo, 2011; Wilson et al., 2015). More importantly, by adopting ICT and using smart connected devices, the tourism industry enables tourism ecosystems to augment tourists' experiences. Within this context, smart tourists consciously use wearable devices and technologies to provide context-aware data and contribute to the tourist experience (Gretzel, Werthner, et al., 2015; Porter & Heppelmann, 2015).

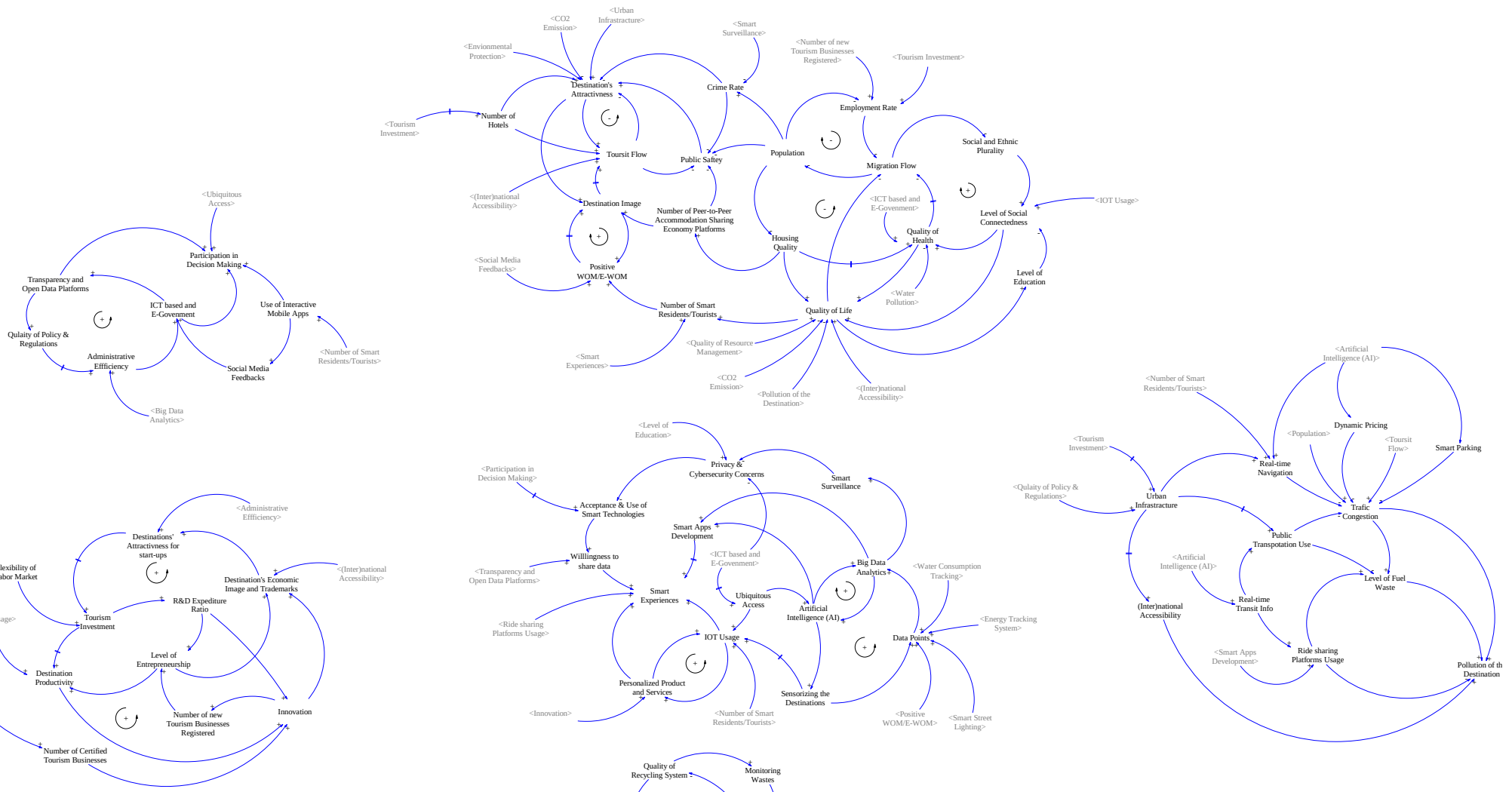

Fig 3. CLD Model of Smart Tourism Ecosystems

7. Conclusion

The concept of sustainable smart tourism ecosystems is an amalgam of several complex concepts ranging from smart cities, smart tourism, sustainability, and ecosystems heavily interrelated and forming a complex system of systems. Thus, smart tourism ecosystems are a networked system of multilateral players complemented by ICT, where stakeholders are encouraged to move towards an innovative and sustainable environment and achieve a better quality of life through collaboration and networking. The sustainability of tourism destinations is not necessarily dependent on ICTs implementation, and similarly, the implication of ICTs can have ramifications rather than contributions. However, putting more emphasis on combining these two concepts requires applying a holistic view to raise awareness, create a joint vision, and a new framework to develop a panacea to address strategic issues related to sustainable smart tourism ecosystems holistically.

Digital ecosystems as complex adaptive systems with attributes such as self-organization & scalability and thought to solve complex dynamic problems have gradually become an indispensable context for fundamentally transforming the entire tourism industry through the smart solutions offered to address the social, economic, and environmental sustainability of the tourism systems. Information and communication technologies have disruptively transformed traditional tourism systems and made it smarter. Even though studies on both smart tourism and sustainability concepts are still ongoing, there is room for further improvement of causal and contextual awareness in these regards; many scholars have contributed to these topics through different lenses and perspectives. Consequently, bearing the previously presented literature, it can be concluded that migrating to a systemic and holistic approach can be facilitated through smart technologies. Moreover, this approach further applies to the tourism industry as a complex system where systems thinking has proven to be a viable approach for better understanding the complexities of tourism industries regarding the economy, environment, governance, people, and others, and interrelationships among several systems in smart destinations. Nevertheless, research on the role of sustainability within smart tourism ecosystems, more particularly, the interrelations and cause and effects among complex building blocks of smart tourism ecosystems, yet to be thoroughly scrutinized from a holistic perspective.

The systems thinking approach offers alternative tools and ways of carefully observing and depicting the world, which affects the policy planning and decision-making process.

Smart tourism research can take advantage of this approach to understand the complex interrelationships, underlying values, and stakeholders' perceptions to gain a holistic preceptive, which allows the intervention within the ecosystem and ultimately ensuring the prevalence of sustainable tourism development. Therefore, to elucidate the problem, this paper first has discussed in detail the interconnection and foundation of smart tourism ecosystems by proposing a general conceptual model describing the transformation of traditional tourism through ICTs to become smart tourism ecosystems. Second, by explicating each building blocks of smart tourism ecosystems and using systems thinking method and modeling to break down the complex system of smart tourism's roles and components. According to the model illustrated in this paper, it can be concluded that to ensure an equilibrium, ICTs adoption can empower residents/tourists' experiences by allowing seamless co-creation and involvement with the smart ecosystems; unequivocally, it can be concluded that smart governance plays a significant role in this process. The causal loop diagram proposed in this study considers sustainability as one of the main concerns and trying to shed some light on intricate networks of businesses, socio-economic, and environmental subsystems in smart tourism destinations that are performing distinctively, yet interdependent.

The CLD model proposed in this paper represents smart tourism ecosystems describing the implication of ICTs and considering sustainability as intrinsic concerns for this study. This CLD model is likely to be of interest to academics and practitioners to augment their understanding of an interconnected system of systems. More importantly, to fathom the prerequisites for developing and implementing sustainable strategies regarding smart tourism destination. Smart solutions, thus, are improving and optimizing the smart tourism destinations' core systems' performance by utilizing instrumented, interconnected, and intelligent capabilities of smart destinations. Wherefore, these solutions should be built upon strategies developed through citizen-centric, people-centric, or human-centered approaches. The model acknowledges the significant role of smart people in multitude aspects of smart destinations, such as a) ubiquitous access and transparency enable ICT based governments with more robust participatory policies for involving people in the decision-making process and strategic planning; b) smart people/tourists and businesses activities can be improved due to their dependency on the disruptive impact of smart infrastructure on transportation, service industry, and communication systems; c) pervasiveness and cost efficiency of smart technologies

realize the instrumentation of smart destinations for data gathering; d) IoT enable seamless interconnections among people and systems, wherein cloud computing will treat data to generate predictive insights for decision-makers and residents/tourists, consequently, improving the residents' quality of life and tourists' experience.

Sensorizing the destination will lead to the generation of the massive amount of data coupled with AI and big data analytics, allow the smart infrastructure to offer smart solutions to different subsystems, and eventually improve the quality of life and experience of smart people. For instance, smart mobility: with real-time navigations, smart parking, ride-sharing platforms, smart environment: with smart grids, waste management, water/energy tracking systems. However, smart infrastructures generate, capture, and analyze massive amounts of public and private data, meaning that access to abundant real-time data sources raises privacy concerns, limiting governments to exploit smart technologies' full potential, concurrently, an incentive to move towards transparency and openness. Future research should focus on using the SD approach to convert the qualitative model presented in this study to quantitative modeling and simulation and put more emphasis on human-machine interaction, AI, big data analysis, and ecosystem business dynamics. An important area of investigation for future research would be to run various scenarios and empirically test and validate the results. Moreover, as the CLD model has been built as a generic model, it does not address any specific geographical context. Therefore, the model is malleable and can be adjusted by adding or deleting causal loops or developing a SD model using specific parameters to examine it further.

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Chapter 4.

MODELING SMART TOURISM ECOSYSTEMS IN FRAME OF SYSTEM DYNAMICS

Abstract

As a highly complex system, the tourism industry can be considered a major contributor to economic growth and an indispensable constituent in sustainable development. This study pursues the system dynamic approach to provide different tools and methods for attentively monitoring and analyzing the complex interrelationships, underlying values, and stakeholders' perspectives of smart tourism ecosystems, ultimately ensuring the prevalence of sustainable tourism development. Therefore, to elucidate this issue, this paper first utilizes system dynamics to discuss and analyze the dynamics of causal relationships among smart tourism ecosystems' components. Second, the proposed methodology enables simulations based on proposed scenarios in which the causality among variables over time can be tested. Third, the employed method simplifies the complex topic of smart tourism ecosystems, thus facilitating understanding the system and furnishing decision-makers with a better perspective. The proposed dynamic model stimulates the creation of economic resilience and a more sustainable economy through promotion of smart solutions for empowerment of local economy. Therefore, big data analytics and AI are considered as core elements for laying a foundation for smoother transition towards smart ecosystems, encouraging a better management system. According to the model presented in this study, ICT adoption may empower residents/tourists' experiences by permitting seamless co-creation and participation with smart ecosystems; wherein, smart governance, indisputably, plays a key role in the process of achieving sustainability.

Keywords: Tourism, Smart Ecosystems, Systems Theory, System Dynamics, Simulation

1. Introduction

As a highly complex system, the tourism industry can be considered a major contributor to economic growth and an indispensable constituent in sustainable development (R. Baggio, 2013; Sinclair-Maragh & Gursoy, 2016). The role of the tourism industry is significantly nuanced in the Portuguese economy, playing as an important sector, accounting for more than 6% of national GDP and being one of a developing country's strategic activities. Furthermore, tourist revenue considerably helps to alleviate economic problems such as unemployment as an alternative solution in many regions. Concurrently, tourists have become more active in using smart technologies to enhance their experiences, co-create, and interact in real-time (Buhalis, 2019; Matos et al., 2019; PORDATA, 2018; Soukiazis & Proença, 2008). In this vein, the Tourism board of Portugal introduced different strategies to enhance, promote, and contribute to growth and sustainability, focusing on mobility and consumer engagement while addressing the need of all stakeholders.

The brand, image, and identity of a tourism destination are salient factors for attracting tourists, and the quality of the experience. As a relatively small tourism destination, Portugal offers a wide diversity of attractions ranging from landscapes, natural parks, historical, architectural, tangible and intangible cultural, and religious heritages, gastronomy, and much more, providing accessible and unique experiences. Thus, making tourism foci in strategic planning for promoting regional planning, foreign investment, creating employment and boosting Portugal's external image. Portugal has invested significantly in external and internal promotional campaigns since branding a destination is as important as managing and promoting the brand (Moreira, 2018; Parreira et al., 2021). Portugal has envisioned different plans and frameworks namely "Tourism Strategy 2027" (Portugal, 2017), and "+ Sustainable Tourism Plan 20-23" (Portugal, 2021) with the purpose of developing an open, dynamic, and collaborative strategy. Promoting Portugal, fostering economic growth, enhancing knowledge, and improving connectivity are some of the envisaged axes of the plan.

The emergence of smart destinations, over time, impelled governments to exploit what technological advancements have to offer to improve resident's quality of life and promote social and environmental sustainability (De Guimarães et al., 2020; Kumar et al., 2020). Simply put, smart destinations provide a foundation for efficient data flow, establishing a seamless relationship between infrastructures, people, and businesses

(Cavalheiro et al., 2020). Digital ecosystems are complex adaptive systems with characteristics such as self-organization and scalability, designed to solve complex dynamic problems. They have progressively become an imperative for transforming the tourism industry through smart solutions offered, addressing the social, economic, and environmental sustainability of tourism systems. ICTs have transformed traditional tourism systems and made them smarter. Even though several scholars have contributed to smart tourism and sustainability topics through different lenses and perspectives, studies on both concepts are still in progress.

Moreover, there are no carried out analyses on sustainable smart ecosystems and the dynamic relationships between the concept components. Thereby, systems thinking has proven to be a valuable tool for illustrating the intricacies of the tourist industry in terms of economics, environment, government, people (Sedarati et al., 2021). Henceforth, the present study pursues the SD approach to provide different tools and methods for attentively monitoring and analyzing the complex interrelationships, underlying values, and stakeholders' perspectives of smart tourism ecosystems, ultimately ensuring the prevalence of sustainable tourism development. Therefore, to elucidate this issue, this paper first utilizes SD to discuss and analyze the dynamics of causal relationships among smart tourism ecosystems' components. Second, the proposed methodology enables simulations based on proposed scenarios in which the causality among variables over time can be tested. Third, the employed method simplifies the complex topic of smart tourism ecosystems, thus facilitating understanding the system and furnishing decision-makers with a better perspective. According to the model presented in this study, ICT adoption may empower residents/tourists' experiences by permitting seamless co-creation and participation with smart ecosystems; indisputably, smart governance plays a key role in the process of achieving sustainability. Analyzing the components of smart tourism ecosystems and their intricate networks of businesses, socio-economic, and environmental subsystems is a highly complex issue. No preceding study of application technology in the tourism industry through the SD approach was found in this research context. Therefore, the results of this study can shed some light to fathom the prerequisites for developing and implementing sustainable strategies regarding smart tourism ecosystems. The presented model is likely to be of interest to academics and practitioners to augment their understanding of smart ecosystems.

Considering the above premises outlined, this paper aims to discuss the path towards building a sustainable smart tourism ecosystem model by delving deep into the important

topics with speculations on smart cities' perspectives that lay a broader foundation of smart tourism destinations. Therefore, the remainder of this paper is as follows. First, the following section discusses the methodology applied and explains the steps of carrying out a SD model. Then, the study describes the roadmap of model development. Next, in-depth describes model criteria and portrays the modeling process by breaking down each building block of the system. Afterward, the results are also discussed. The final section concludes the paper by highlighting the main contributions to theory and practice and offering implications, limitations, and future research areas.

2. System Dynamic as a Method

System Dynamics is a computer-based approach to understand and analyze a system's behavior over time. The SD approach breaks down a system into smaller components and examines each element of the system to find the impacts and outcome of changes at a macro-level. System Dynamics has been applied in different contexts such as learning organizations (Senge, 1997), transportation (Egilmez & Tatari, 2012), ecological modeling (Semeniuk et al., 2010), and other different fields of study. System Dynamics is based on the notion of "industrial dynamics", which Forrester (1961) developed at the Massachusetts Institute of Technology and was initially applied to engineering and management. Internal interaction, information feedback, and cause and effect are all part of the SD method. It is an underlying premise of the SD method that its causal structure determines the system's behavior. Therefore, the ultimate goal in SD modeling is to improve understanding regarding the links between structure and behavior to seek endogenous explanations for the problematic dynamics and designing policies that can bring about the desired changes in behavior.

System Dynamics is known and proven as a powerful and practical method that is adept at modeling and studying complex systems' behavior over time. Hence, for understanding a system's problems and behaviors, it is necessary to look into the cause and effect among the elements of the system. Furthermore, it is worth mentioning that simultaneous consequences in one system would cause various effects. Therefore, by breaking down the whole system's structure into smaller segments and increasing the possibility of studying dynamic relationships among elements of the system, SD can be considered as one of the best tools for a modeler to have a holistic approach in analyzing models of the system as a whole. According to Richardson and Pugh (1981), the aim of using SD should focus on the system's problem, not the system by itself. There are two key characteristics

of dynamic problems that make them complex and difficult to analyze. The first is that these problems contain quantities that fluctuate over time. The second one is feedback structures. Feedback loop and stock and flow diagrams are the essential parts of SD modeling. The ability to determine the relations of feedback processes, stock and flow diagrams, time delays, and nonlinearities in the system is considered an art in this process (Sterman, 2000). Causal Loop Diagrams (CLD) are invaluable in structuring a mental model of the system and forming the relations among elements, illustrating all the causes and effects (Coyle, 2000). When the purpose is to analyze the system by developing quantitative simulation models, it is common to precede the development of these models with stock and flow diagrams. In these diagrams, the stocks represent the state of the system, which changes by increases or decreases in the flow rates. Also, stock and flow models provide a useful view of the status of the system's data due to the implementation of different decisions and policies. After defining the diagrams and components of the system, computer simulation will show the behavior of the past data. Then the outputs will be compared with the real behavior of the system to determine whether the model is valid. A variety of policies can be tested by running the model and comparing the results with the baseline to evaluate the distinct outcomes. Once a model has satisfied basic validity tests and has been considered satisfactory for its purpose, it can be used for policy analysis (Forrester, 1961), exploring what-if scenarios (Morecroft, 1988), optimizing key decisions (Coyle, 1985), and investigating organizational redesign (Wolstenholme, 1999).

2.1. Steps of the System Dynamics Modelling Approach

Developing an SD model and the stages involved have been a significant issue among experts and authors over the years. Richardson & Pugh (1981) presented a seven-stage procedural framework for this approach. The interaction and relationships between these stages are depicted in Figure 1. For this process, many authors have proposed a similar framework. (*e.g*. Wolstenholme, 1986; Nancy *et al*. 1994; Coyle, 1996; Sterman, 2000).

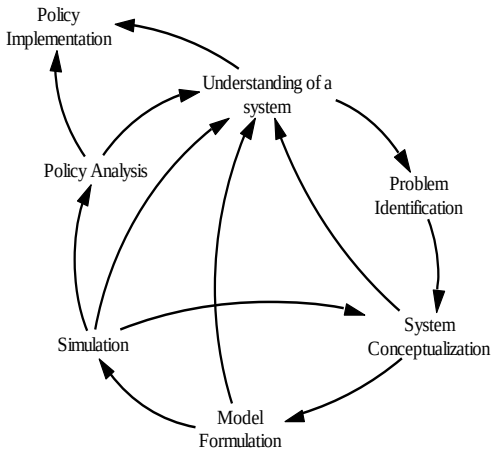


Figure 1. Steps of the System Dynamics Modelling Approach

Source: (Richardson & Pugh, 1981)

Every SD modeling method begins and ends with understanding the system, as shown in Figure 1. Thus, the SD method's primary goal is to analyze a system and understand its dynamic problems better. Each stage of the SD modeling method is described in greater detail below. For an extensive discussion on these stages, the reader is referred to Sterman (2000).

Problem Identification and Definition: When an SD intervention is planned, the first and most essential step is to identify the problem. Addressing the following questions, in particular, is critical: What is the main problem in the system? Is the problem a repercussion? In addition, understanding why a dynamic modeling intervention is being conducted might help define the problem.

System Conceptualization: Every system has specific complexities. The dynamic characteristics of the system should be identified in order to grasp the level of complexity. These attributes can be observed in the feedback loop, and stock and flow diagrams helping modelers understand how problems emerge.

Model Formulation: It is necessary to test the conceptual model once it has been developed. It is often possible to test the data set in a real system in order to validate the model. Nevertheless, due to the complexity of the real world, conducting such a test is typically daunting; therefore, a model is utilized instead. The model is transformed from a conceptual to a quantitative representation via formulation, enabling the model to be simulated and tested, providing us a better understanding and confidence in the system's behavior.

Simulation: Once the model is formalized through the writing of several equations, capturing the dynamics of the system, the model is tested with the use of specific software. In this study, Vensim software is being used. The reference model is the initial structured model of the system that illustrates all of the relationships among its variables. Comparing the simulated behavior to the behavior of the reference model can be achieved by running multiple tests.

Policy Analysis: This stage focuses on designing new policies, scenarios, and structures in the system, which entails fiddling with the system's dynamic structure. Manipulating different parameters and elements reveals the interactions and relationships among system components, elucidating the new information for future decision-making and policy planning.

Model Use or Implementation: After development and gaining enough confidence in the structure and behavior of the model, it can be used for policy design. System dynamics simulation models may provide insight into the effects of current policies and, without committing to change, they can also provide the opportunity to explore the likely effects of alternative policies.

3. Model Development

Due to the interdisciplinary nature of this study, a mixed-method approach was chosen, specifically an exploratory sequential mixed-methods approach, in which a model will be conceptualized, then quantified using SD, and finally a new model will be designed to improve the existing or proposed system. An effort to conduct a comprehensive assessment of different elements and building blocks of smart tourism destinations while taking into account the shaping factors of smart ecosystems equipped us to better grasp of the topic, thus, allowed us to propose a holistic model of smart tourism ecosystem development in this study. As a result, the proposed model facilitate the process of understanding the causal relationships among the components of smart tourism ecosystems, laying the groundwork for constructing and designing a quantitative model. The stock and flows diagram presented in the next sections allows us to simulate and anticipate the behavior of the systems overtime. Furthermore, the smart infrastructure sector in the model is incorporated as a catalyzer for generating a system of systems, where the constant flow of information combined with the analytical capacity of new

technologies and intelligent systems would shape an iterative value co-creation process. The model is depicted in Figure 2.

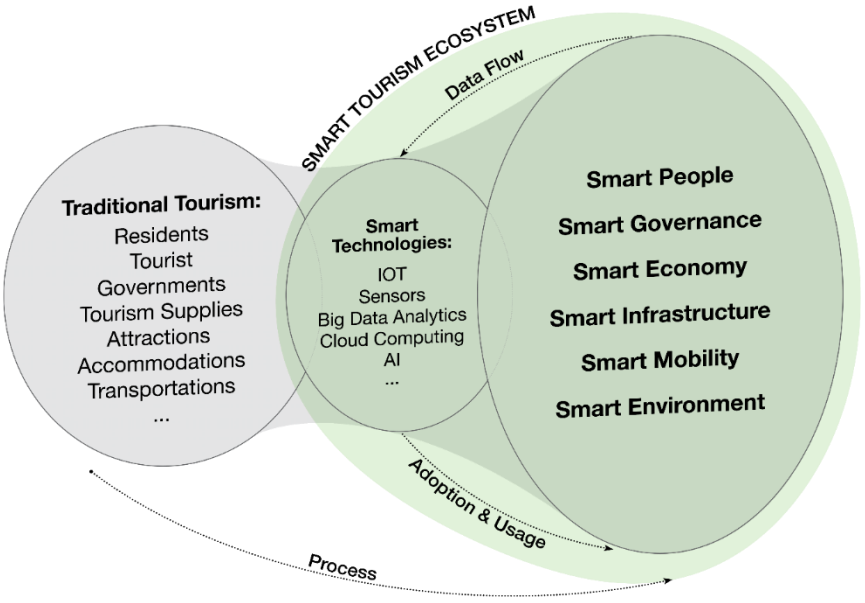


Figure 2. Smart Tourism Ecosystem Model (Sedarati et al., 2021)

3.1. Model Criteria

The advent of technological advancement and impressive enhancements in software and hardware for handling data have provided decision makers with powerful tools to foresee the future implication of different decisions as scenarios. Expansion of databases and boom and bust of interconnected sources of information has facilitated access to "Big Data". Several areas of planning and development in smart tourism destinations are constantly deal with complicated models, which might be hard to grasp or understandable by concerned stakeholders. These models are not always data-driven, and some may fail to address the proposed questions. The SD model presented in this study is based on a set of criteria adopted from extensive literature review and constant refinement to ensure an inclusive yet precise model and tool wherein all the expectations of smart tourism ecosystem are met. The first and foremost criterion is that the model must be understandable, capturing a simplified version of smart tourism ecosystems. Although the initial model inspired from the CLD model presented in the previous chapter depicts a detailed model representing a high degree of system complexity and realism, and due to the complexity of the model and lack of access to proper hardware and software for dealing with such intricate models, the stock and flow diagram has gone through multiple

refinements and simplification while maintaining the authenticity of the model. This simplified view of the smart tourism ecosystem is based on the fact that implementing smart infrastructure can significantly impact our destination's behavior.

Portugal has been investing in upgrading, delivering innovation, promoting sustainability, and internationalization in terms of tourist destinations. The image, identity, and values of a tourist destination are now fundamental for attracting tourists, and the quality of the tourist experience is directly related to the destination's brand. Therefore, the management and promotion of a destination's brand are just as imperative as its branding. Sustaining the perception and improving the image is facilitated by the fact that ICT-based technologies have accelerated this movement further through the pursuit of social networks and mobility-related features to help travelers. The expansion of digital technology and the widespread use of mobile devices have facilitated the personalization of tourism experiences (Buhalis, 2000; Egger & Buhalis, 2011; Gretzel, Sigala, et al., 2015; Leung et al., 2013; Qu et al., 2011). Another development criterion of the SD model is to build an operational that the simulation outputs are based on high-quality, reliable sources of data and expert opinions, not on best guesses. Nevertheless, as a pioneering work, this study puts efforts into developing an optimal model rather than modeling a realistic illustration of the world.

The scope of our model (Figure 3), while encompassing smart tourism ecosystems issues such as the adoption of technology, IoT usage, development of ICT based governance through citizen-centric approach, crowding factor, does not extend to all the components of the ecosystem, so the impact of any tourist volume is restricted to its effect seasonality. We have analyzed the impact on public transport and ride-sharing services, ultimately reducing the crowding factor resulting from the implementation and utilization of smart infrastructure. This study focuses on two different scenarios to assess the impact of change in AI power, which has an arbitrary scale from 0 to 100, manipulating the tourist length of stay and expenditure per day.

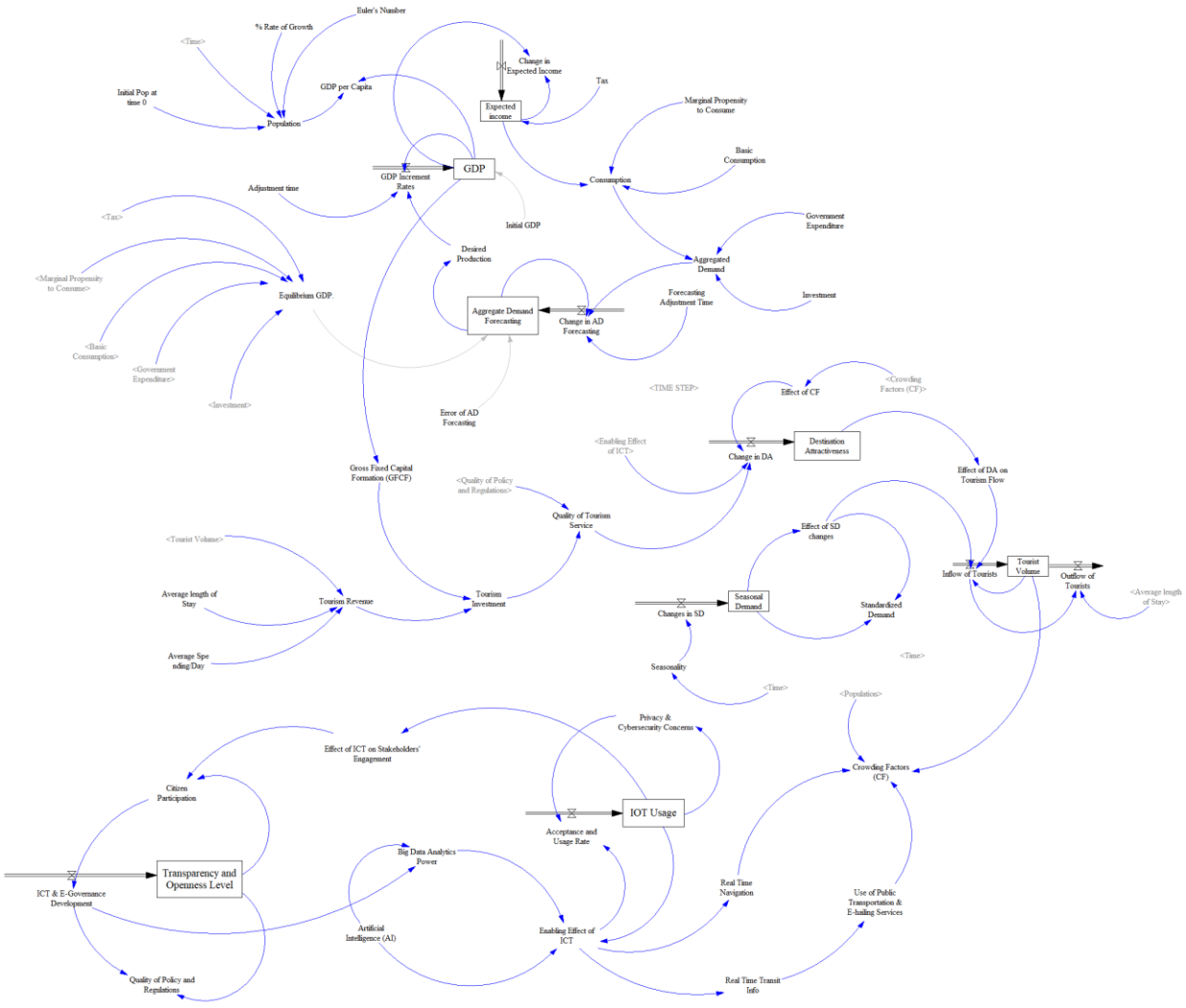


Figure 3. Stock and Flow diagram of Smart Tourism Ecosystems (Sedarati et al.)

3.2. Model Breakdown Terminology

The smart tourism ecosystems' SD model incorporates the following sectors: governance, economy, transportation, tourism flow, technology infrastructure. The model simulates generic tourism behavior and simulates the growth of Portuguese tourism from 2018 to the 2023. Thus, using months as the basic time unit, the end time is 60.

Smart Economy; tourism plays a critical role in the economy of destinations, having an undeniable influence on several interconnected industries, while each sector independently is a complex system (Chourabi et al., 2012; Matos et al., 2019). Furthermore, the gradual transition to a circular economy has become more apparent by becoming more innovative, competitive, digital, and sustainable. As a result, incorporating ICT into all economic activities provides an opportunity and helps the

implementation of the smart economy in a tourism destination's complex system (Ribes & Baidal, 2018; Kumar & Dahiya, 2017; WEF, 2018). Eger (2009) further entails the role of smart cities in the transformation of the cities structure for a new economy and a society with clear and convincing community benefits. Smart tourism destinations can improve tourism experiences and competitiveness by encouraging ICT growth, resulting in economic, environmental, and social sustainability within a smart tourism ecosystem (Gallarza et al., 2002; Gretzel, Sigala, et al., 2015; Perles Ribes & Ivars Baidal, 2018; Shafiee et al., 2019). The dynamic system modeled the economy as an impetus for establishing smart tourism ecosystems and the interrelations between the model components. Thereafter, an analysis of the behavior of the dynamic model in response to changes in its components and observe the impact on Gross Fixed Capital Formation (GFCF), tourism investment, and destination attractiveness, hence, impacting the tourism volume. The model's objective is to simulate the behavior of GDP over 5 years assuming a closed macroeconomic system; hence, the foreign sector is not considered in this simplified model. The Keynesian SD model of GDP of Yamaguchi (2015, 2016) was used as a reference. The equation for each component of the Keynesian SD model of GDP is presented in the annex.

Smart Infrastructure; **s**uffice to say that smart tourism destinations share the same features of smart cities wherein ICTs lay the foundation for a complex interconnected ecosystem trying to tackle the economic, social, and environmental challenges (R. Baggio & Del Chiappa, 2014; Boes et al., 2015; Dirks & Keeling, 2009; Jovicic, 2019; Pencarelli, 2019). The technological advancement impels traditional infrastructures to shift towards smart infrastructures by deploying IoT, AI, and big data analytics for gathering a considerable amount of data, subsequently, manage and improve the quality of services and the residents' quality of life (Pencarelli, 2019; Shafiee et al., 2019; Stratigea et al., 2015). Smart infrastructures comprise an intricate network between devices and people constantly gathering data on various sectors thus, delivering smart solutions and establishing a holistic monitoring system (C. Harrison et al., 2010; Colin Harrison & Donnelly, 2011; Lea, 2017; Lom & Pribyl, 2020; Woetzel et al., 2018). Smart technologies have profoundly altered traditional infrastructures by forming an accessible, interconnected, open platform through the actuation of countless embedded sensors in destinations' infrastructure. Additionally, due to the cost-efficiency and accessibility of IoT technology, businesses are capturing and analyzing the data generated by users

(residents/visitors) to help users make more optimized and intelligent decisions (Caragliu et al., 2011; Gretzel, Sigala, et al., 2015; Lara et al., 2016; Shafiee et al., 2019; Thaler & Tucker, 2013). Consequently, the implications of such advancements offer several smart solutions addressing socio-economic, economic, and environmental challenges in addition to improving quality of life and achieving a level of sustainability (Ahvenniemi et al., 2017; Bifulco et al., 2016; Capdevila & Zarlenga, 2015; Gössling, 2017; Gretzel, Werthner, et al., 2015; Matos et al., 2019; Sharifi, 2020; Stratigea et al., 2017).

*Smart Mobility; a*s one of the important sectors of tourism destinations, mobility significantly impacts the systems' behavior producing a series of negative impacts affecting stakeholders' quality of life (Benevolo et al., 2016; Neirotti et al., 2014). Cities are recoursing to smart mobility as a viable solution because of pollution, traffic congestion, long commute times, parking problems, and high-priced public transportation. Smart mobility is a multifaceted issue that can contribute to environmental footprint reduction, traffic optimization, and collecting citizens' (user) generated content regarding the quality of transportation, livability of cities, ultimately improving the quality of life and reducing costs for all stakeholders (Giffinger & Pichler-Milanović, 2007; Pencarelli, 2019; Zawieska & Pieriegud, 2018). Furthermore, it can be claimed that conventional mobility mainly focuses on physical infrastructure and aims to improve mobility, especially vehicles, rather than improving the delivered services. In contrast, the sustainable mobility approach encourages reducing environmental and social impacts, shifting towards multimodal transport, and endorsing ride-sharing platforms (Banister, 2008; Kumar et al., 2020; Lom & Pribyl, 2020).

Smart Environment; the rapid population growth and urban sprawl have brought about many imbalances, posing critical challenges for resource management, economic growth, environment, and sustainability in destinations. The excessive use of natural resources mainly causes pollution, congestion, negative consumption patterns, waste production, CO2 emission (Aletà et al., 2017; Gil-Garcia et al., 2015; Vinod Kumar, 2020). As complex interconnected ecosystems, tourism destinations entail the exitance of efficient and effective systems to manage multiple infrastructures such as; energy (moving towards renewable energies), water (water sanitation and water cycle management), waste (recycling management), and environmental conservation (Lom & Pribyl, 2020; Lombardi et al., 2012; Manville et al., 2014; Stratigea et al., 2017). Consequently, smartness can be a practical and effective solution for managing the ramifications of

overpopulation and addressing environmental sustainability and livability. Henceforth, as one of the main building blocks of smart tourism ecosystems, the smart environment is where constant interaction of residents through embedded sensors, smart devices, and seamless use of technology improve residents' quality of life and contribute to the sustainable management of resources (Chourabi et al., 2012; Höjer & Wangel, 2014; Stratigea et al., 2015, 2017).

Smart Governance; tourism destinations are complex systems reliant on urban infrastructures, wherein the planning, development, and maintenance of such places are costly, complex, and with delays (Bifulco et al., 2016; Razaghi & Finger, 2018). Therefore, a new form of governance in tourism destinations is necessary for the incorporation of new aspects such as transparency, disruptive technologies, and participation of citizens in the decision-making process, drawing attention to the new term of smart governance (De Guimarães et al., 2020; Meijer et al., 2015; Pencarelli, 2019; Razaghi & Finger, 2018). The investment in new technologies, real-time data analytics, participatory platforms, and assimilation of human and social capital results in a cost-effective, well-managed and sustainable governance system that ultimately improves the quality of life of the citizens (Bifulco et al., 2016; Caragliu et al., 2011; Giffinger & Pichler-Milanović, 2007; Gretzel, Werthner, et al., 2015).

Smart People; forming a complex system of applications delivering services to people, a network where all components of the systems interact, and a delicate foundation of sensors and devices for acquiring data and ultimately improving the quality of life of residents is one of the main goals of smart cities (Pouryazdan & Kantarci, 2016; Razaghi & Finger, 2018). Smart services are prevalent in a wide range of areas in smart cities, including administration, education, public health, and safety, among others (Giffinger & Pichler-Milanović, 2007; Woetzel et al., 2018; Woetzel & Kuznetsova, 2018). People's lifestyle have been influenced by the IoT, which has been scaling up to become more pervasive; therefore, smart people, as one of the vital components of smart cities, play an important part in the monitoring and decision-making process by contributing to data creation via smart devices (Choe & Fesenmaier, 2017; Nam & Pardo, 2011; Wilson et al., 2015). More importantly, through smart connected devices, the tourism industry enables tourism ecosystems to augment tourists' experiences. In this vein, smart tourists deliberately use wearable devices for more context-aware data for optimized decision-

making and eventually improving their experiences (Gretzel, Werthner, et al., 2015; Porter & Heppelmann, 2015).

4. Simulation Results

4.1. Model Verification and Validation

It is inevitable to neglect verification and validation, which ensures the credibility of SD models, wherein breaking down the model into detailed bits of variables, equations, and causal relationships improves the replicability of the conducted study. To enhance user confidence, model testing is being utilized. One of the most crucial aspects of model validation is determining whether the model is appropriate and applicable for its purpose (Barlas, 1989; Forrester, 1961; Rebs et al., 2019; Sargent, 2013; Sterman, 2000). Unfortunately, there has not been any model evaluating the impact of technology on tourism ecosystems from a holistic view in Portugal. Our study indicates a decent level of feasibility, yet the prospect cannot be assured as a contingency. Two vital issues must be raised here in modeling sustainable smart tourism ecosystems; how to avoid a 'Tragedy of the Commons' scenario: wherein the ramifications for the entire tourism industry arises from overtourism with low willingness to pay. Many tourism destinations have been dealing with such an issue (Hardin, 1968; Pintassilgo & Silva, 2007), and a fire-fighting syndrome: the unplanned allocation of resources to fix problems discovered in the development cycle (Abrahamson, 2004; Mowry, 2008; Repenning et al., 2001). Consequently, the model's efficiency has to be judged in respect of possible consequences that formulation exhibits. The process of building a SD model entails a critical stage called model testing for increasing users' confidence in the model. Richardson and Pugh (1981) emphasize that 'a SD model addresses a problem, not a system, and is designed to answer a reasonably well-defined set of questions'.

Eventually, the elaborated model can provide a basis for evaluating real systems assessing the systems' behavior, and improving the model by introducing specific policies (Barlas, 1996). Nevertheless, a significant challenge remains in modeling sustainable smart tourism ecosystems due to their intricate natures. The model structure can be verified in a variety of methods. The first step in validating a model is parameter verification, which compares model data to real data. However, as compared to the pattern prediction test, parameter verification is not necessarily the most efficient procedure (Forrester & Senge, 1980). Another method of verification is behavior reproduction. The pattern prediction

test determines if a model creates an appropriate qualitatively impending behavior. The ultimate goal of this study is to fully recognize the general patterns of smart tourism ecosystems, and consequently, pattern verification is adopted.

System dynamics software are quite user-friendly (*e.g.*, Powersim, Stella, and Vensim), and researchers should not have difficulties utilizing the software. Nevertheless, as with any modeling tool, user-friendliness may unintentionally lead to the development of poor models. Consequently, the importance of quality data, sensitivity analysis, and detailed model testing should not be neglected. However, initial models can be developed based on expert opinion/judgment and using qualitative data when proper data is not available. Such models are particularly effective when the scenarios are too complex (Burchill & Fine, 1997). Different studies showed that data limitations are a common problem in modeling complex systems among many case studies. Even when longitudinal datasets are available for few state variables, the chance of finding sufficient data for all variables in SD models is pretty low (Elsawah et al., 2017; Sedarati et al., 2018; Sedarati et al., 2021).

4.2. Behavioral Reproduction Test

The *coefficient of determination, R^2*, a popular metric used to test a model's capacity to replicate system behavior, quantifies the variance in the data explained by the model as a dimensionless fraction. The square of the correlation coefficient, R, indicates the degree to which two series co-vary is the coefficient of determination. Unfortunately, R^2 is not very practical, even though it is widely reported. For instance, two series with the same error might have very different R^2 values depending on their trend (Sterman, 2000, p. 874).

Therefore, the statistical comparison of observed data with simulated outputs is the most frequent method for model testing. In cases where adequate data were available, a variety of goodness-of-fit metrics were used to assess SD models, including the correlation coefficient, *root mean squared error (MSE)*, mean absolute relative error, maximum relative error, and discrepancy coefficient (Elsawah et al., 2017; Georgantzas, 2003; Hassanzadeh et al., 2014; Sterman, 2000). Normally, SD models are not expected to reproduce highly accurate outputs with emphasis more on replicating system behavior. Consequently, the patterns generated by the model may be used to evaluate the model's performance. The analysis conducted (MSE) demonstrates some level of accuracy in the modeling of sustainable smart tourism ecosystems for long-term policies and the

similarities of historical data to the output were assessed at a high level of abstraction, which seems satisfactory.

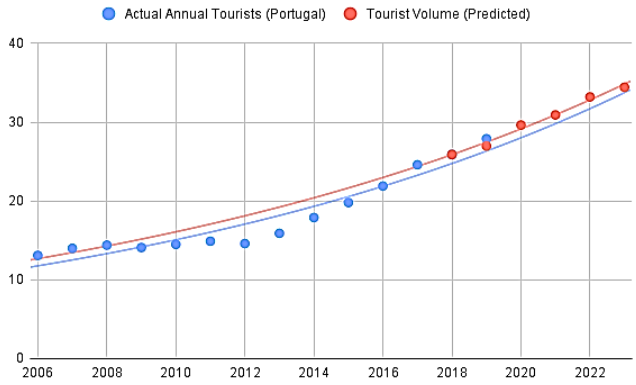


Figure 4. Behavioral Testing

Behavioral testing can rely on multiple lines of evidence. For example, in developing sustainable smart tourism ecosystems, SD model results were tested compared to the years of data available, which included the number of tourists arriving per year in Portugal using the simulation results compared with the pattern of the actual numbers. This comparison showed that the SD model not only simulated system processes more realistically but also reproduced existing patterns considering the fact that this model was developed pre-pandemic.

Structural testing, another approach to validate SD models is structural testing, wherein experts, users, or modelers can be asked to evaluate and examine the validity of the model structure. This can be conducted through the iterative assessment of the model by disputing the components and how well it corresponds to the knowledge about the real-world system (including boundaries, problem representation, casual relationships, parameters) and iterative examination of the modeling process for its usefulness. Depending on the level of complexity, experts from different domains can assess the sections of the model based on their expertise. Experts from various fields of Cybernetics, Management and Economic, Sustainable Governance, Systems Information and Marketing were invited to discuss assumptions and causal relations, comment on different stages of the model development and corroborate the outputs of the model.

Sensitivity analysis is a valuable approach to behavioral and structural testing, whereby parameters' values are manipulated to assess and gain a better perspective over the reliability of the model outputs. Different behaviors such as growth and collapse patterns

ensue when parameters are varied. In this study, the effects of various factors in the model development phase wherein technology is playing a backbone for sustaining the equilibrium of a system have been tested. An exogenous factor with a high level of impact should be deemed while considering the time necessary for the component to have an impact for reaching a tipping point. The performed sensitivity analysis on the parameters of the key drivers in the system such as changes in artificial intelligence, tourists' daily expenditure, and disruptive changes due to uncalled disasters (*e.g.*, Covid-19), providing a means to test some of the constraining model assumptions. These parameters were identified, which significantly impacted the model behavior, thereby portraying a future path for better policymaking (Elsawah et al., 2017; Sterman, 2000; Struben & Sterman, 2008). Considering the golden rules of Balci (2010); "The only exhaustive testing there is, is so much testing that the tester is exhausted", time and resource constraints are one of the reasons uncertainty and robustness test are not frequently performed. Therefore, iterative model testing is essential to expose the fundamental problems arising during the model building process to avoid further significant amendments at the final model testing phase.

5. Dynamic Analysis of Sustainable Smart Tourism Ecosystems

System dynamics models are powerful tools to provide decision-makers with interactive systems in which variable interrelations, feedback loops, and cause and effect relations are being examined (Ghaffarzadegan et al., 2011; Maani & Cavana, 2000; Sterman, 2000). Therefore, SD expedites fathoming the overtime system analysis, behaviors, implications, and impacts of a model holistically. The advent of technology in the context of smart ecosystems, as an intricately folded topic, is continuously streamlining new patterns (Femenia-Serra et al., 2019; Sharifi, 2020), wherein SD serves as an apparatus to unravel the repercussions and reveal important and often counterintuitive behaviors, which can be helpful for policymaking. Therefore, simulations and scenarios were run using the stock and flow diagram presented above (Fig. 3). Based on the proposed model, the leading stocks that play a dominant role in our study are IoT Usage, Transparency and Openness Level, Tourists Volume, and GDP, are trying to encapsulate and illustrate the overtime behavior. The simulation is running for 60 months, trying to capture the behavior of a system where technology is adequately implemented and has a long-term perspective in terms of adoption and usage of technology. Subsequently, improving the citizens' quality of life while delivering a memorable experience for tourists. These

variables are linked with their inflows and outflows which are interconnected to variables and components of the system, either an auxiliary or a constant.

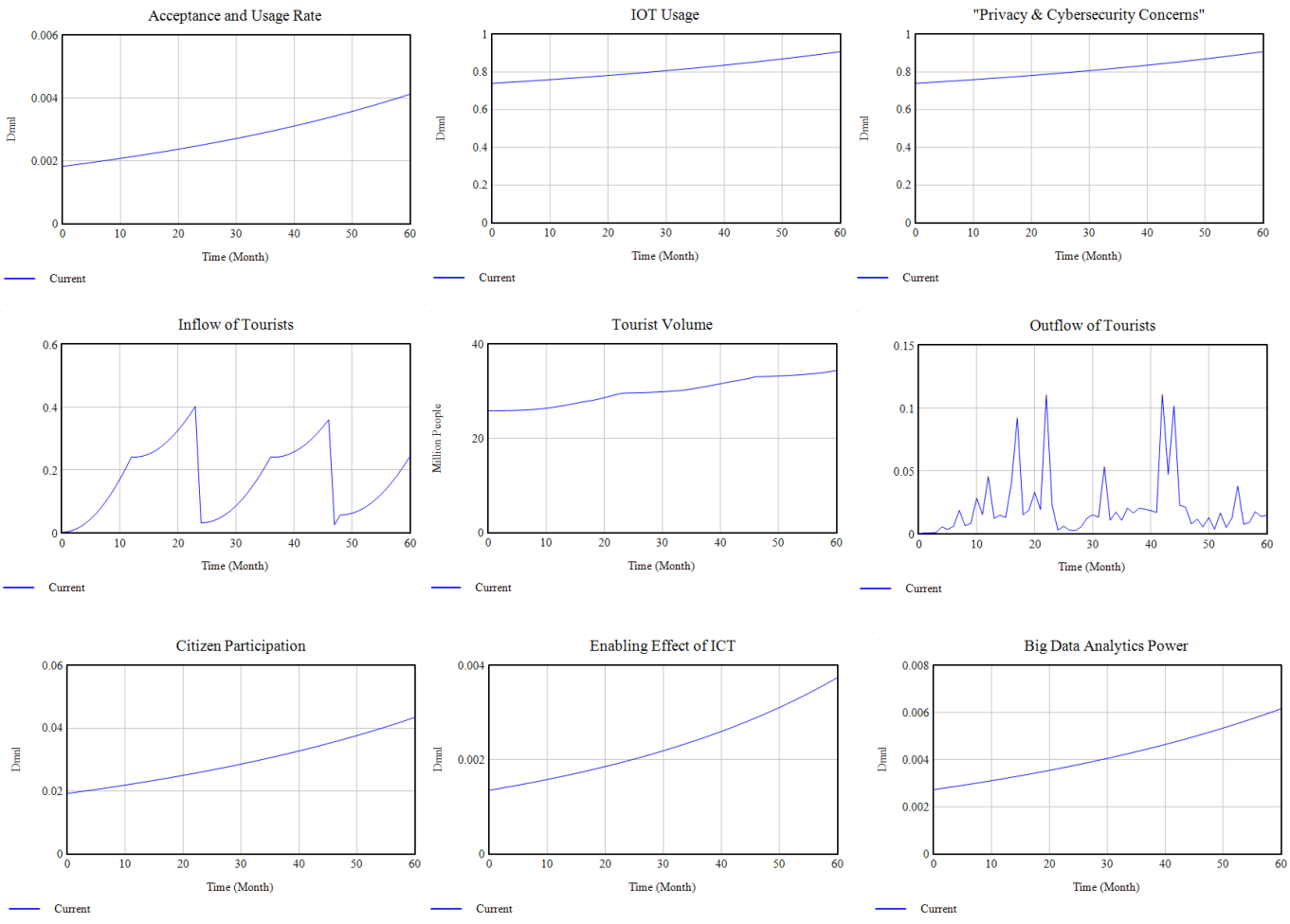
5.1. Scenarios

5.1.1. Business as Usual

The base run of smart tourism ecosystems starts in 2018 when the tourism industry has already started to experience the hype of smart tourism and continues until 2023. Timespan of 60 months has been chosen due to the rapid pace of technological changes in different industries, including tourism. The base run is simulated to replicate and anticipate the implementation of technology in the tourism industry, providing a tool for understanding the intricacy of smart tourism ecosystems. The initial simulation began with a holistic analysis which consisted of measuring the leading variables with a higher level of priority for our study purpose. The purpose is to replicate Portugal's longitudinal development to provide a foundation for understanding the interconnection among building blocks of smart ecosystems and policy planning. The significant policies or strategies in this model pivot around (1) promoting Portugal as a tourism destination while considering the drawbacks of overtourism, specifically, the tragedy of commons. (2) The implementation and application of technology mandating a shift towards smart infrastructures to manage and improve the quality of services, consequently, the residents' quality of life and tourists' experiences. (3) Development of an ICT-based government to improve the quality of policy and regulation; consequently, features such as transparency, disruptive technological innovation, and citizen participation underline the new term of smart governance. There are additional assumptions considered in our proposed model. Technology acceptance in Portugal can alleviate the crowding factors through a smart mobility policy that can contribute to CO2 footprint reduction, optimization of traffic congestion, and collecting data, ultimately improving the quality of life and reducing costs for all stakeholders. We also assume that Portugal, as a tourism-dependent destination, relies on the increase in tourism as the fundamental driving force for economic growth.

Distinct changes can be identified from the base run (Figure 5). The first change The smart infrastructure section, as expected, experienced an incremental growth in which a slight change in adoption and usage rate impacts people's behavior in terms of using technology. The values of the determinants were changed to indicate the positive impacts associated with the increase resulted from the enabling effect of ICT. The factors involved were artificial intelligence, big data analytics power, digitization of the destination

realized by the smart governance, and data collection. The figures (Fig. 5) confirmed users' susceptibility to the expansion of the IoT, ubiquitous access, and the widespread adoption of mobile devices for more efficient services, increasing value over time. The change in the value of IoT Usage over time demonstrates the cause and effect relationships between smart infrastructure and citizen-centered e-government systems, hence causing more than one variation in the model. Tourist volume changes over time consist of oscillation of tourists' inflow and fluctuation of tourists' outflow, representing the seasonality of Portugal as a tourism destination and arbitrary changes in the length of stay, wherein the intervention of these factors depicts the upward trend in the number of tourists. It is needless to mention that this simulation is conducted pre-covid; thus, the numbers presented in the figures are the anticipation of what could have happened. The variables affected were: crowding factors where the use of modern technology in the transportation system, infrastructures, logistics will result in a better quality of life and decreased environmental impacts and tourism revenue where tourism boosts the revenue of the economy.



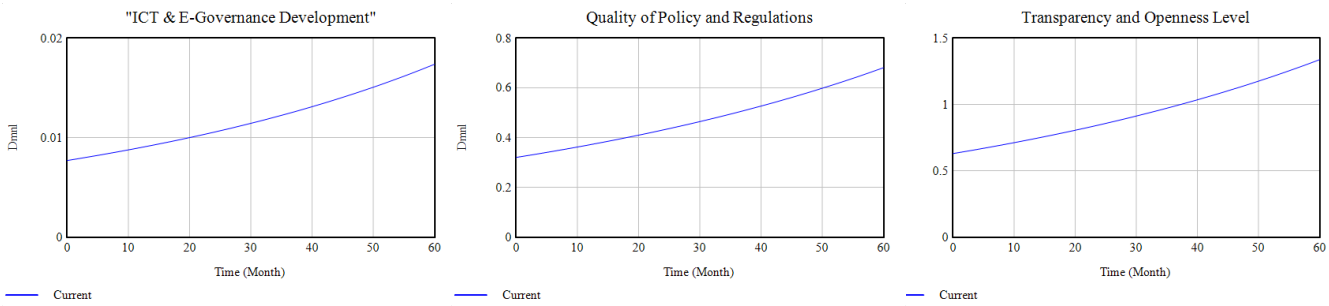


Figure 5. The Business as Usual Scenario

The implication of the preceding assumptions is that the calculated impacts of the model are precisely related to the pace of technology advancement and projection of adoption and usage of users which is based on the assumption that Portugal is perceived as technologically advanced country.

5.1.2. Artificial Intelligence (AI) Modification Scenario

The analysis carried out in this section scrutinizes the variation of AI as a consequence of foundational technology advancement to underline the impact of prominent variables stocks such as IoT Usage, Transparency and Openness Level, Tourism Volume, and Destination Attractiveness. This scenario is considering the fire-fighting syndrome and all possible repercussions affecting smart tourism ecosystems. Two simulations were conducted to examine the implementation of artificial intelligence, impacting different variables of smart tourism ecosystems. Two values of AI to 0.75 and 0.95 were introduced to the model to study the behaviors. To observe the rate of change, annual improvements in electronic devices must be examined, where improvements are iteratively made depending on the cost of computation and volume of data. Running algorithm in real-time coupled with artificial intelligence can be an indication of disruptive services within the smart ecosystems ranging from the use of energy, location-based services, real-time transit information, which are all being fed to operators, citizens, and travelers in real-time, and many more, laying a foundation for impressive advancements in the future. Undoubtedly, the development of AI will expand our understanding of how smart ecosystems function, but still, there is a long road ahead for dominating policy planning and decision making. The simulation also has proven that the advancement of artificial intelligence did not heavily impact the IoT usage of the users. Data collection is almost possible in all sectors of smart ecosystems, wherein a new horizon in use of resources, making informed decisions and understanding the complexity of the system. Smart cities

in general and smart destinations in particular have adopted these technologies as a means to increase efficiency and performance by endorsing ubiquitous access leading to the creation of an unprecedented amount of data, consequently empowering platforms to gather and analyze data.

IoT touches upon several entities such as governments, organizations, and businesses, wherein through digitization, the generated data in conjunction with ICT allows decision-makers to collect data and make informed and responsive policies. Nevertheless, pointing out all the positive potentials such technologies offer, the blind adoption and endorsement of such technologies are risky and require careful calibration and contextualization to build a sustainable smart tourism ecosystem. Furthermore, the rapid growth of urbanization intertwined with ICT development increase the complexity and dynamics of policy planning and decision making. Therefore, accommodating a multitude of institutional challenges posits the emergence of smart governance wherein citizens can influence the process of solving emerging challenges.

Moreover, the scenario also intends to illustrate such impacts on tourism growth in which the number of tourists slightly increased over five years. This situation had a positive impact since the more powerful the platforms are, the easier word of mouth spreads, given that smart tourism destinations are connected with their users. Additionally, the model shows a strong interaction between indicators of different building blocks of the model. The modifications made in the model yield important insight into the role of artificial intelligence on users, however, some changes might be transparent due to the short period simulation, but some factors definitely feel them. This surge of big data analytics and artificial intelligence brings new possibilities of boosting economic growth and quality of life. A more livable destination through data processing and AI can ensure a better environment for attracting investors to support that local economy. Moreover, a slight increase in the number of tourists will lead to revenue generation, ultimately fostering economic growth. The proposed model does not intend to stress on the role of technology as a salvation, and rather suggests that technology can play a fundamental role in smart tourism ecosystems. However, through technology, prominent dimensions of people, institutions collectively move towards increasing the quality of life rather than sole economic purposes.

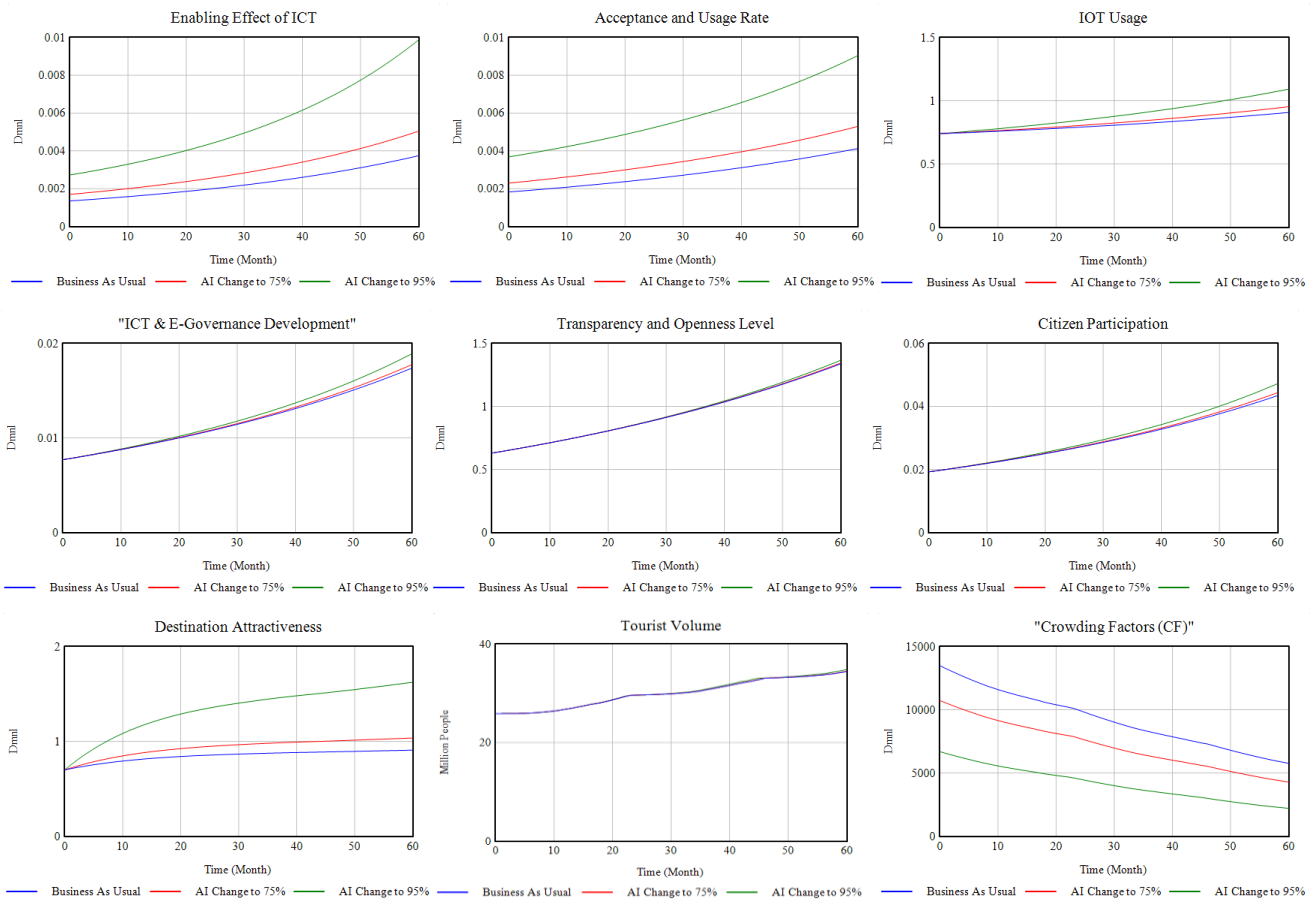


Figure 6. Artificial Intelligence (AI) Modification Scenario

5.1.3. Tourists' Daily Expenditure Scenario

The final scenario analyzed in this study was influenced by economic determinants of the tourism industry, in which the rapid pace of ICT development has evolved and differentiated the services the tourism industry offers. In this vein, adopting alternative business models to gain competitive advantage has been supported in tourism destinations, and rules and regulations thanks to technology have become more flexible. Therefore, such significant transformations have segmented the market, thus demanding more sophisticated tools. In this study, the changes to which indicator of daily spending of tourists subjected reflects the impacts on tourism revenue and other variables. The simulation was run to clarify the impacts of a positive change in which Portugal become a more expensive destination to visit, showed a noticeable result. The simulation indicated that the number of tourists in the short run of five years cannot be significantly affected, yet an increase in tourism revenue can be observed. The scenario consisted of increase of daily expenditure which affects the tourism revenue, quality of tourism services after proper investment, subsequently improving destination attractiveness and ultimately

slightly increasing the number of tourists. The conducted simulation makes it possible to forecast the variations made in tourism revenue when the amount of spending per day changes. Therefore, not only tourism products should be seen as a potential demand but also should be considered as a means of making profit, wherein shaving off the tourists who spent very little result in addition to revenue. Implementing an inclusive and decentralized policy while incrementally introducing Portugal as a more expensive destination, and simultaneously employing promotion campaigns to target users with higher level of expenditure. This approach might be applicable to mature destinations, where it is possible to create more revenue using resources that go beyond the existing attractions, thus, unloading pressure from other resources. Nevertheless, proposing such policy without considering multitude of determinants might be insufficient for some application, and exploring the socio-economic profile of the visitors was beyond the scope of this research, future studies can investigate the possibilities of breaking down the system into a detailed model to gain a better perspective over the behavior of visitors and their expenditure patterns. An arbitrary scenario of increasing the average daily expenditure of tourists from 34 Euros/day to 70 Euros/day assess the potential effect on tourism revenue. Whereas, due to the short span of simulation, tourist volume is not affected and we try to predict what might happen over the next 60 months if we implement such scenario.

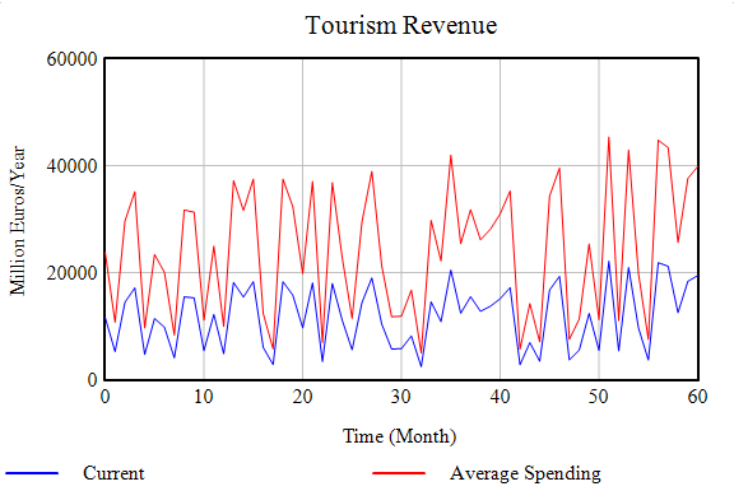
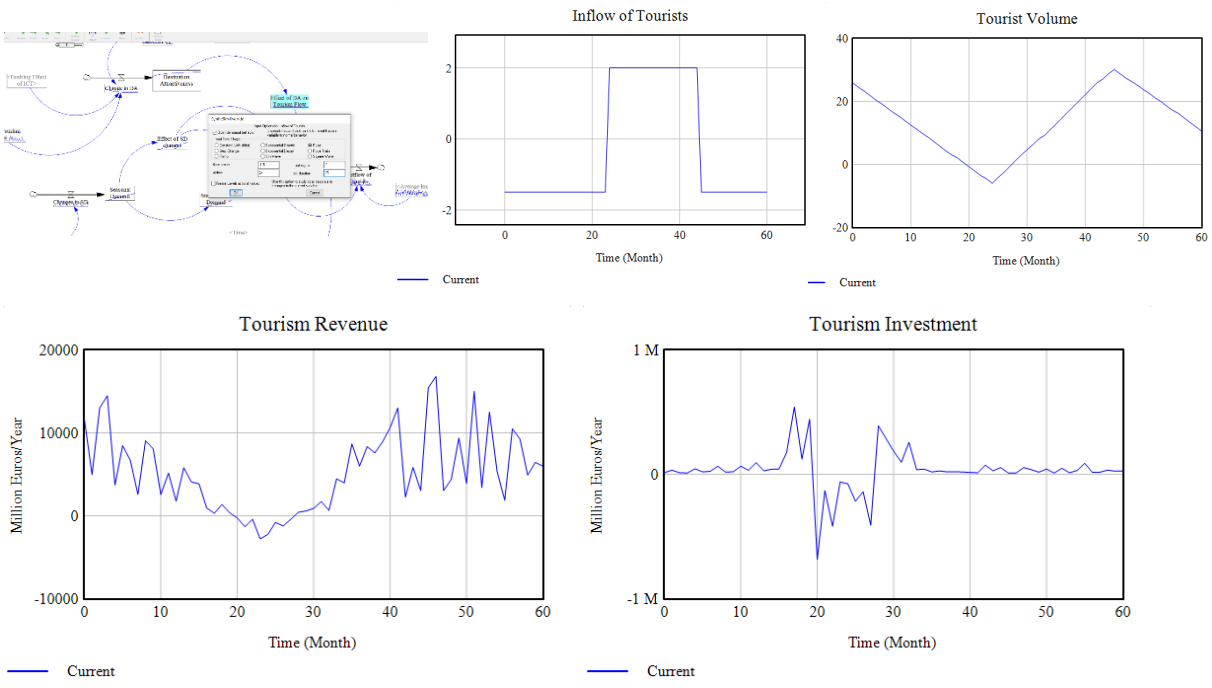


Figure 7. Tourists' Daily Expenditure Scenario

5.1.4. COVID- 19: A challenge

The Covid-19 pandemic has caught tourism destinations, regions, and governments by surprise. Governments were not prepared for such a pandemic, and no speculations about the possible implications of the Covid-19 pandemic existed. Several institutions resorted to the power of technology by collecting data to analyze and interpret the possible

scenarios. Covid-19 coerced people, institutions, industries, and service providers into adapting a virtual and digitalized approach. Governments proactively participated in providing digital infrastructure, hasten to deliver e-government system. The pandemic may have changed the daily lifestyle and travel behaviors but impacted many trends by spurring innovation and social innovation as the core element of smart cities. ICT was an enabler to take action during the crisis by restricting the regular activities, wherein the role of preexisting infrastructure should not be neglected to restrain the repercussions of the pandemic. The significant negative impact of covid-19 on the world economy and itsheavy effect on the tourism industry causing a drastic decline in revenue pushed smart tourism destinations to consider customized virtual content as an alternative for tourists' experiences. In this vein, the current situation demands further exploration in terms of such crisis. Although the presented model in this study forecasts the behavior of the system before the pandemic, a simple scenario of how the pandemic would have impacted the tourism industry in Portugal has been proposed. The presented scenario only intends to depict the severity of the pressure the tourism industry endured due to the pandemic. Moreover exploring further ramifications of covid-19 requires a sophisticated model of pandemic tailored for Portugal. Therefore, a pulse function was introduced to the model to illustrate the impact of pandemic on different variables such as tourist volume, crowding factor, tourism revenue, tourism investment, and destination attractiveness.



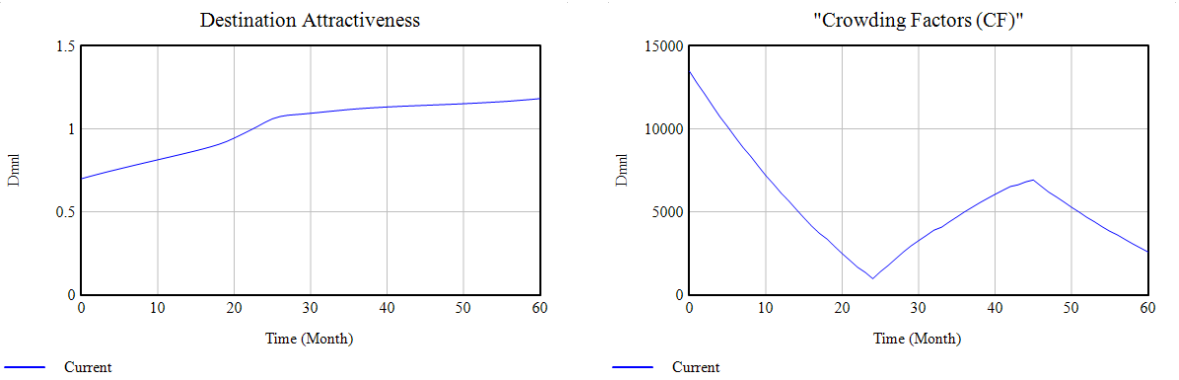


Figure 8. Impact of COVID-19 Scenario

6. Conclusions

Due to the rapid growth of technology, tourism destinations have experienced several changes instigated concepts such as smart destinations, intelligent cities, sustainable destinations, resilient destinations, and many more. Prompted by urban development, population growth, and service demand, the transition from traditional to smart regions was supported. Smart destinations take on the responsibility of fighting against climate change by deploying smart solutions to improve destinations' efficiency. These solutions should be inclusive, integrative, cost and resource-efficient while targeting all aspects of sustainability (De Guimarães et al., 2020; Shafiee et al., 2019). Improvements in building blocks of smart cities, ranging from transportation, security, healthcare services, economy, have exhibited the capacity technology has to offer. Nevertheless, despite all constructive outcomes, due to the precipitous growth of population and urban sprawl, destinations are facing an array of challenges such as traffic congestion, insecurity, environmental problems, housing quality, and evidently more. As ICT becomes an increasingly important element of daily life, a focus on smart cities appears to be an unavoidable measure for the future of cities. The challenge in delineating smart cities arises from their prevalence in every aspect of the city, nonetheless, this complexity does not imply their undesirability or unlikeliness to be realized. On the contrary, smart cities are inevitable part of the foreseeable future, striving for increased efficiency, livability, and sustainability that smart cities may provide. Rapid pace of transformation in smart ecosystems necessitates a robust, comprehensive, and analytical approach. Realizing smart ecosystems require an iterative assessment to ensure all the determinants of such complex systems running efficiently.

Therefore, this study tries to demonstrate the promising results that technologies such as AI and big data analysis can deliver in the management of smart destinations. The

proposed model in this study supports the implementation of smart technologies to customize services appropriately and ultimately improve the residents' quality of life. Moreover, the presented SD model is based on a preceding causal loop diagram which facilitated the process of defining, interpreting and utilizing our determinants from each building block of the smart tourism ecosystems. The methodology applies the SD approach to explain the interconnection among components of the systems and, consequently, run simulations to study and verify possible behaviors of the system. Using the constructivist approach, SD enabled us to demonstrate a holistic view of smart tourism ecosystems as a complex topic and proved a powerful tool for attaining relevant results. As expected from any simulation, the performed analysis is not without limitations; nevertheless, the prelimited objectives were achieved. In a nutshell, the proposed model is an oversimplification of the real-world, making it challenging to generalize. However, the nature of the model allows any further manipulations and adjustments to ensure a promising results.

This study presented results based on in depth literature reviews, cognitive modeling, existing models, inputs of expert panels, available trends and data which have elucidated the process of model development. Using SD enables us to breakdown the components of smart cities in detail, allowing us to distinctly explicate the structure for better understanding the systems. The simulation results show how implementation of technology can be a prominent factor for sustaining sustainability of smart tourism ecosystems. In fact, the proposed model is complex enough to carry out the extrapolations of the past trends, granting us to anticipate the possible future. This study is a preliminary assessment of smart tourism ecosystems and much more complex processes are required to examine the historical behaviors for more effective policy planning. Future research should focus on exploring the complementary feed-back loop structures to generate more complex and accurate behavior than the initial model. For instance, feedback loops on economic impact of tourism and effect of technology on reducing seasonality of tourism are absent and much more sophisticated model is required to carry out such analysis. In conclusion, this study should encourage future studies on smart tourism ecosystems and continuous refinement and testing as an essential step for verifying dynamic complexity. Whilst, no methodology is perfect, including SD, any research will leave rooms for further investigations. The proposed model supports the implementation of technology to increase the quality of services provided. This is possible due to the widespread use of

IoT devices creating a vast network of interconnected devices. Consequently, the ubiquitous access provides interconnection between the fabrics of the cities, allowing the collection of data. Harnessing the power of AI and big data analytics, the gathered data are analyzed and interpreted in real-time for optimized and efficient decision making. Today, city managers are utilizing modern technologies as decision-making tools in upgrading urban infrastructure, which has a significant influence on the urban economy and has a beneficial impact on a wider, national, and regional scale. The purpose of using smart solutions and implementing new technologies is to assist the common challenges in the cities such as housing problems by introducing smart sensing, reducing commute time by controlling traffic congestions, aiding in automation, thus, allowing residents to experience quality, efficient and timely services.

The proposed dynamic model stimulates the creation of economic resilience and a more sustainable economy through promotion of smart solutions for empowerment of local economy. Therefore, big data analytics and AI are considered as core elements for laying a foundation for smoother transition towards smart ecosystems, encouraging a better management system. Future research should focus on using more complex and detailed SD models in which longitudinal data can be properly interpreted and fed to the model. More emphasis is suggested on contribution of human-machine interaction, AI, big data analysis, and ecosystem business dynamics. An important area of investigation for future research would be to run various scenarios and empirically test and validate the results. Moreover, the stock and flow model is representing Portugal, concurrently serving as malleable and adjustable model in which by adding or deleting causal loops or developing a SD model using specific parameters further examination would be possible.

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Chapter 5.

GENERAL CONCLUSION

Significant Findings of the Thesis

Tourism destinations are increasingly turning towards specialized technologies to address issues related to society, ecology, urban environment, and many others, entailing the emergence of smart ecosystems concepts as a means to encourage the efficiency and performance of urban fabrics. However, population growth, urban sprawl, and tourism growth can inflict significant challenges as a serious threat. Though, providing opportunities for tourism destinations to reshape their future for sustainable tourism development. Currently, information technology is widely integrated into people's work and daily lives. Residents expect higher levels of public management and public service, as well as participation in urban management. Citizens' well-being has become a focus in several countries, which is also considered an important indicator in smart city evaluation systems. Moreover, user perceptions can influence performance. Therefore, it should be noted that a measure of usefulness is how satisfied users are with a particular service. According to this definition, the term 'perception of smart infrastructure' primarily refers to the way in which urban residents perceive the information and service they receive from smart infrastructures, which can help them improve their quality of life and job prospects in the long-term.

Issues of sustainable development are inherently systemic, and the solutions to address these issues must incorporate a holistic approach. The changes in the system should be harmonious, and changing an induvial unit is not sufficient to fully grasp the impact on the system. Therefore, partial solutions are likely to be ineffective and exacerbate the situation. Additionally, the nonlinearities and complexity of sustainable development issues make them adamant about presenting meticulous solutions. As a result, model testing brings an acceptable level of user confidence to validate any derived assumption from the simulation. This study, hence, shows that developing a mental model is an intrinsic issue in understanding the role of technology for sustainable tourism development (Research goal 2 listed in chapter one). The models proposed in this thesis determine the number of essential feedback structures that profoundly affect the development of sustainable smart tourism ecosystems. Rather than just forecasting a preset future, the model explores different scenarios while developing a holistic framework for realizing the objectives and aspirations of the sustainable development of smart tourism ecosystems. The main objective of this thesis is to outline the concept smart tourism ecosystems by scrutinizing the tourism industry, smart tourism, complex systems,

SD, consequently conducting research to identify gaps and complementarities between research and practice. Furthermore, SD enables us to better understand smart tourism ecosystems, all the cause and effect relationships among the components and studying their dynamic behaviors. Thereupon, proposing alternative strategies for policy makers and practitioners. To this end, three separate but intertwined studies conducted.

1. Assessment the application of SD in tourism industry by conducting an in- depth systematic literature review.
2. Conceptualizing a holistic model that captures the most important variables and interrelationships;
3. Carrying out a detailed analysis and simulation based on integration of hard and soft data and methodologies;

The first study has addressed some gaps in the literature with the goal of assessing the application of the SD method in planning and development of the tourism industry. For this purpose, a systematic literature review (SLR) was performed and a set of 27 papers was selected. The analysis of the papers shows the applicability of the SD method to address a multitude of different problems. Overall, however, it can be concluded that whilst the SD method has shown considerable potential to provide tourism decision makers and regulators with tools for strategic and operational policy development at many different levels of analysis, the number of applications in this sector is still limited. Therefore, it is recommended that the use of SD modelling in the tourism industry be extended in order to promote a holistic understanding of the complex issues faced by this industry and to assist in the development of more effective policies. This study contributed to finding the literature on the application of SD to the tourism industry but many issues remain to be analyzed by this technique. The majority of papers have focused on the sectors that independently can be considered as a complex industry. Nonetheless, for future work, it is important to bear in mind that SD has the potential to analyze tourism systems either in particular or in general. The most important and necessary work is to concentrate more on different types of tourism by applying a holistic approach to this industry.

The second study intends to discuss the path towards building a sustainable smart tourism ecosystem model by delving deep into the pivotal topics with interesting speculations on smart cities' perspectives that lay a broader foundation of smart tourism destinations. First, it discusses the interconnections and foundation of smart tourism ecosystems by

proposing a general conceptual model describing traditional tourism transformation through ICTs. Second, by explicating each building blocks of smart tourism ecosystems and using systems methodology (systems thinking method and qualitative modeling in a frame of system dynamics) to break down the complex system of smart tourism's roles and components. The proposed causal loop diagram considers sustainability as one of the main concerns and trying to shed some light on intricate networks of businesses, socio-economic, and environmental subsystems in smart tourism destinations that are performing distinctively yet interdependent. The systems thinking approach offers alternative tools and ways of carefully observing and depicting the world, which affects the policy planning and decision-making process. Smart tourism research can take advantage of this approach to understand the complex interrelationships, underlying values, and stakeholders' perceptions to gain a holistic preceptive, which allows the intervention within the ecosystem and ultimately ensuring the prevalence of sustainable tourism development. Therefore, to elucidate the problem, this paper first has discussed in detail the interconnection and foundation of smart tourism ecosystems by proposing a general conceptual model describing the transformation of traditional tourism through ICTs to become smart tourism ecosystems. Second, by explicating each building blocks of smart tourism ecosystems and using systems thinking method and modeling to break down the complex system of smart tourism's roles and components. According to the model illustrated in this paper, it can be concluded that to ensure an equilibrium, ICTs adoption can empower residents/tourists' experiences by allowing seamless co-creation and involvement with the smart ecosystems; unequivocally, it can be concluded that smart governance plays a significant role in this process. The causal loop diagram proposed in this study considers sustainability as one of the main concerns and trying to shed some light on intricate networks of businesses, socio-economic, and environmental subsystems in smart tourism destinations that are performing distinctively, yet interdependent.

The third study pursues the SD approach to provide different tools and methods for attentively monitoring and analyzing the complex interrelationships, underlying values, and stakeholders' perspectives of smart tourism ecosystems, ultimately ensuring the prevalence of sustainable tourism development. Therefore, to elucidate this issue, this paper first utilizes SD to discuss and analyze the dynamics of causal relationships among smart tourism ecosystems' components. Second, the proposed methodology enables simulations based on proposed scenarios in which the causality among variables over

time can be tested. Third, the employed method simplifies the complex topic of smart tourism ecosystems, thus facilitating understanding the system and furnishing decision-makers with a better perspective.

According to the model presented in this study, ICT adoption may empower residents/tourists' experiences by permitting seamless co-creation and participation with smart ecosystems; indisputably, smart governance plays a key role in the process of achieving sustainability. Analyzing the components of smart tourism ecosystems and their intricate networks of businesses, socio-economic, and environmental subsystems is a highly complex issue. No preceding study of application technology in the tourism industry through the SD approach was found in this research context. Therefore, the results of this study can shed some light to fathom the prerequisites for developing and implementing sustainable strategies regarding smart tourism ecosystems. The presented model is likely to be of interest to academics and practitioners to augment their understanding of smart ecosystems. This study presented results based on in depth literature reviews, cognitive modeling, existing models, inputs of expert panels, available trends and data which have elucidated the process of model development. Using SD enables us to breakdown the components of smart cities in detail, allowing us to distinctly explicate the structure for better understanding the systems.

The simulation results show how implementation of technology can be a prominent factor for sustaining sustainability of smart tourism ecosystems. In fact, the proposed model is complex enough to carry out the extrapolations of the past trends, granting us to anticipate the possible future. Whilst, no methodology is perfect, including SD, any research will leave rooms for further investigations. The proposed model supports the implementation of technology to increase the quality of services provided. This is possible due to the widespread use of IoT devices creating a vast network of interconnected devices. Consequently, the ubiquitous access provides interconnection between the fabrics of the cities, allowing the collection of data. Harnessing the power of AI and big data analytics, the gathered data are analyzed and interpreted in real-time for optimized and efficient decision making. Today, city managers are utilizing modern technologies as decision-making tools in upgrading urban infrastructure, which has a significant influence on the urban economy and has a beneficial impact on a wider, national, and regional scale.

The purpose of using smart solutions and implementing new technologies is to assist the common challenges in the cities such as housing problems by introducing smart sensing,

reducing commute time by controlling traffic congestions, aiding in automation, thus, allowing residents to experience quality, efficient and timely services. The proposed dynamic model stimulates the creation of economic resilience and a more sustainable economy through promotion of smart solutions for empowerment of local economy. Therefore, big data analytics and AI are considered as core elements for laying a foundation for smoother transition towards smart ecosystems, encouraging a better management system. Future research should focus on using more complex and detailed SD models in which longitudinal data can be properly interpreted and fed to the model.

The Efficacy of System Dynamics Modeling for Development of Sustainable Smart Tourism Ecosystems

1. System dynamics modeling can serve to integrate multiple data resources and methods from an extended range of disciplines.
2. In SD models, rigorous mapping and analysis of feedback structures enables an in-depth understanding of dynamic behavior and improves the quality of the discussion.
3. System dynamics modeling can contribute to the body of knowledge by adopting inductive and deductive reasoning approaches.
4. System dynamics simulations furnished us with a way of visualizing smart tourism ecosystems as an integrated system, encompassing technological, cultural, economic, and governance factors, precisely study their impacts and performances through quantification and computer-based simulation.
5. The system theory and the system dynamics modeling process compelled us to question everything and discuss all aspects profoundly. Moreover, it teaches us to think about plausible prospects constantly.

From the aforementioned conclusion, this thesis shows that SD models enables us to breakdown the components of smart cities in detail, allowing us to distinctly explicate the structure for better understanding the systems, hence, contributing to the creation of knowledge. The presented results show how implementation of technology can be a prominent factor for sustaining sustainability of smart tourism ecosystems. (Research goals 2 & 3 listed in chapter 1).

Limitation

The major limitations are the definition of new ICT trends and technological classifications within the smart destinations, missing data, and difficulties with international comparability, especially comparable indices, and the characterization of activities. The data obtained for this study only allowed for an examination of feasibility and behavioral patterns. However, this study aims at examining the long-term pattern of implementing technology in tourism destinations. As a result, the forecasts are just indicative and not precise. If a comprehensive simulation for a specific destination is needed, further data gathering for suitable parameterization is required. The outcomes of this thesis do not explicitly address the cultural aspect of sustainability, but rather focus on suggesting how all of the components of a sustainable ecosystem are interconnected.

Future Areas of Investigation

It goes without saying that a good research journey is interminable and rooms for improvement could always be found. Future works can be derived from the analysis and discussions presented in this thesis. For instance, for social interactions to be successful, all countries must formulate and implement policies that strengthen tolerance, social cohesion, and justice. In order to achieve this, universal human rights must be incorporated into a framework of citizen participation, inclusion, equity, and effective political governance. Concomitantly, technology and innovation can be promoted by the UN since research shows that the trade-off between environmental and economic outcomes, for instance, can be resolved through the use of technology and innovation (Collste et al., 2017). In particular, Breuer et al. (2019) assert that the UN should establish feedback loops that ensure all responsible entities are held accountable for ensuring that the SDGs are actually implemented by not just government officials, but also the private sector, NGOs, and civil society.

Furthermore, SDGs have the distinguishing feature of being interdependent and interrelated. Apparently, the SDGs encompass both complementarities and synergies in addition to tradeoffs and tensions which have implications for both global and national contexts. The complementarities imply that addressing one goal may also enable other goals to be addressed simultaneously. Addressing the issue of climate change, for example, could have co-benefits for energy security, health, biodiversity, and oceans. The

SDGs should not be taken as a stand-alone objective. Hence, one can argue that they are interdependent, meaning that achieving one would lead to achieving another, and thus they should be viewed as indispensable pieces of a huge puzzle (Tosun & Leininger, 2017).

Moreover, the generic model is malleable and can be parameterized to represent the dynamics of sustainable smart tourism ecosystems for a particular destination more precisely, by collecting more data and information. In addition the general conceptual model and modeling process presented in this thesis can be applied to other long-term sustainable development approaches, such as sustainable urban development, quality of life, and sustainable regional development. Eventually, more emphasis is suggested on contribution of human-machine interaction, AI, big data analysis, and ecosystem business dynamics. An important area of investigation for future research would be to run various scenarios and empirically test and validate the results. Moreover, the stock and flow model is representing Portugal, concurrently serving as malleable and adjustable model in which by adding or deleting causal loops or developing a SD model using specific parameters further examination would be possible.

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Appendix A: SLR Tables

Table A1 – Summary of the studies that have used System Dynamics in Tourism

Authors	Journal	General Objective of the Paper	Location	Stakeholders' Involvement	Qualitative /Quantitative	Purpose of using SD	Sector
Carlsen, 1999	Systems Research and Behavioural Science	Showing the necessity of having a systems approach to the management of economic and environmental resources in islands tourism destinations	General Model	Information not provided	Qualitative	Showing how soft system management can be helpful to better understand the social, environmental and economic factors of islands tourism	Attractions Sector
Chang, Hong, & Lee, 2008	Ecological Modelling	Exploring an integrated approach for sustainable coral reef management in order to deal with coastal zone management	Taiwan	Information not provided	Both	Solving the complex problems of coastal zone management	Attractions Sector
Chen, 2004	Journal of Computer	Using a decision support system to assess different	USA	Information not provided	Both	Studying the natural resources based tourism system, and using causal	Multisector

	Information Systems	environmental and investment scenarios				feedback loops to show the system structure	
Chen, Chang, & Chen, 2014	Environmental Management	Evaluating sustainable wetland management with focus on the environmental and socioeconomic impacts of the yacht industry	Taiwan	1. Teachers; 2. Representatives of local residents; 3. Conservationists	Both	Modelling the dynamics of the wetland environment and the impacts caused by the yacht industry	Attractions Sector
Farsari, 2012	Hospitality Marketing & Management	Demonstrating the relationships between several policy issues by using a conceptual model of sustainable tourism	North Mediterranean countries	Information not provided	Qualitative	Building a framework of sustainable tourism focused on political dimensions to help policy makers	Multisector
Georgantzas, 2003	System Dynamics Review	Modelling a dynamic structure to forecast the future of Cyprus' tourism by assessing the hotel value chain system, tourism growth and tourism seasonality	Cyprus	Information not provided	Quantitative	Modelling the stock and flow structure of Cyprus' hotel value chain	Accommodation Sector

Table A1 – Continued

Authors	Journal	General Objective of the Paper	Location	Stakeholders' Involvement	Qualitative /Quantitative	Purpose of using SD	Sector
Golob & Jere, 2014	Singidunum	Demonstrating how the quality of organizations can play an important role in event tourism	Slovenia	Information not provided	Qualitative	Explaining the event tourism system in a more understandable and rational way	Event Sector
Honggang, 2003	Systems Analysis Modelling Simulation	Assessing the impacts of cultural tourism developments on a cultural heritage destination	China	Information not provided	Both	Analyzing time delays, nonlinearities and feedbacks to explore the development of effective policies for cultural tourism	Attractions Sector (Cultural)
Law et al., 2012	Journal of Sustainable Tourism	Characterizing the complexity of tourism destination development for green economy planning in tourism	Egypt	Information not provided	Both	Showing how decision support systems can help tourism destinations to transform into a green economy	Accommodation Sector
Lazanski & Kljajić, 2006	Kybernetes	Exploring the complex systems' approach to study Slovenian tourism system	Slovenia	Information not provided	Both	Using causal loop diagrams to explain the Slovenian tourism market and discuss different categories of problems	Multisector

Li, Zhang, Xu, & Jiang, 2015	Discrete Dynamics in Nature and Society	Analyzing the impact of transportation infrastructure on tourism development in destinations that share the same market	China	1. Management; committees of Xidi and Hongcun; 2. Travel agencies; 3. Local business owners; 4. Local residents; 5.Tourists	Both	Modelling road infrastructure investments to serve multiple tourism destinations	Transportation Sector
Liu & Chen, 2014	Asia Pacific Journal of Tourism Research	Integrating management of cultural tourism into a system with multiple objectives	China	1. Residents; 2. Tourists; 3. Businesses	Both	Identifying critical factors related to the evolution of the cultural tourism system	Attractions Sector (Cultural)

Table A1 – Continued

Authors	**Journal**	**General Objective of the Paper**	**Location**	**Stakeholders' Involvement**	**Qualitative /Quantitative**	**Purpose of using SD**	**Sector**
Mao, Meng, & Wang, 2014	Land Use Policy	Assessing the impact of tourism on the environment considering different land use management policies	China	Information not provided	Both	Exploring the relationships between the socioeconomic system and the land use system under different scenarios	Attractions Sector

Mavrommati, Baustian, & Dreelin, 2014	Ambio	Improving policy making for managing ecosystem services through a framework that identifies the interrelationship between natural and human systems	USA	1.Individuals with various expertise (*e.g.*, ecology, community planning, engineering, economics, public health); 2. Various organizations (*e.g.*, public utilities, universities, county, state and federal agencies)	Qualitative	Using causal loop diagrams to show the complexity and the various feedback loops on water use and recreation	Attractions Sector
Morris, Oreszczyn, Blackmore, Ison, & Martin, 2006	Local Environment	Proposing a systemic approach to model and identify the main problems associated with sustainable land use	UK	Information not provided	Qualitative	Showing an alternative approach for studying the land use system	Attractions Sector (Land use)

Peric & Djurkin, 2014	Kybernetes	Proposing an alternative community based tourism enterprise structure grounded on social responsibility	Croatia	1. Local Government; 2. Private Sector; 3. NGOs; 4. Community residents	Qualitative	Understanding, simplifying and clarifying the complexities of the tourism industry	Multisector
Ropret, Jakulin, & Likar, 2014	Kybernetes	Analyzing whether and how Slovenian policy development plans can be improved systematically and systemically	Slovenia	Information not provided	Qualitative	Developing a qualitative model to identify the strengths and weaknesses of the current state of the system	Multisector

Table A1 – Continued

Authors	**Journal**	**General Objective of the Paper**	**Location**	**Stakeholders' Involvement**	**Qualitative /Quantitative**	**Purpose of using SD**	**Sector**
Schianetz et al., 2009	International Journal of Tourism Research	Using the system thinking approach to model the learning tourism destination concept	Australia	1. Local and state authorities; 2. Research institutions; 3. Tourism operator; 4.	Qualitative	Showing that systems thinking can be a capable tool to promote the concept of learning tourism destination	Attractions Sector

				Accommodation owner; 5. NGOs with an interest in the region			
Schianetz, Kavanagh, & Lockington, 2007	Tourism Management	Discussing case studies which use SD modelling in order to demonstrate the effectiveness of this technique to assess sustainability and encourage learning processes	General Model	1. Tourism Organizations; 2. Regional Planners; 3. National Government; 4. International Organizations; 5. Scientists	Qualitative	Assessing sustainability and showing how it can be improved through the learning tourism destination concept	Multisector
Stipanovic & Rudan, 2014	Tourism and Hospitality Management	Investigating ways to innovate logistic processes in the hospitality industry in order to transform resources into competitive advantages	Croatia	Information not provided	Qualitative	Using causal loop diagrams to model new strategic approaches on logistic processes in the hospitality industry	Accommodation Sector

van den Bergh & Nijkamp, 1994	Annals of Operations Research	Exploring the conflict between environmental conservation and rapid tourism growth by using a dynamic model	Greece	Information not provided	Both	Understanding the relationships, causality, and feedback mechanisms between the economic system and the environmental system	Attractions Sector
Vugteveen, Rouwette, Stouten, van Katwijk, & Hanssen, 2015	Ocean & Coastal Management	Using an integrative system approach in order to understand and solve social-ecological coastal problems	Netherlands	1. Participants of the tourism workshop; 2. Consultancies; 3.Regional Government; 4.NGOs; 5.Tourist organizations	Both	Understanding socio-ecological problems in integrated coastal management	Attractions Sector

Table A1 – Continued

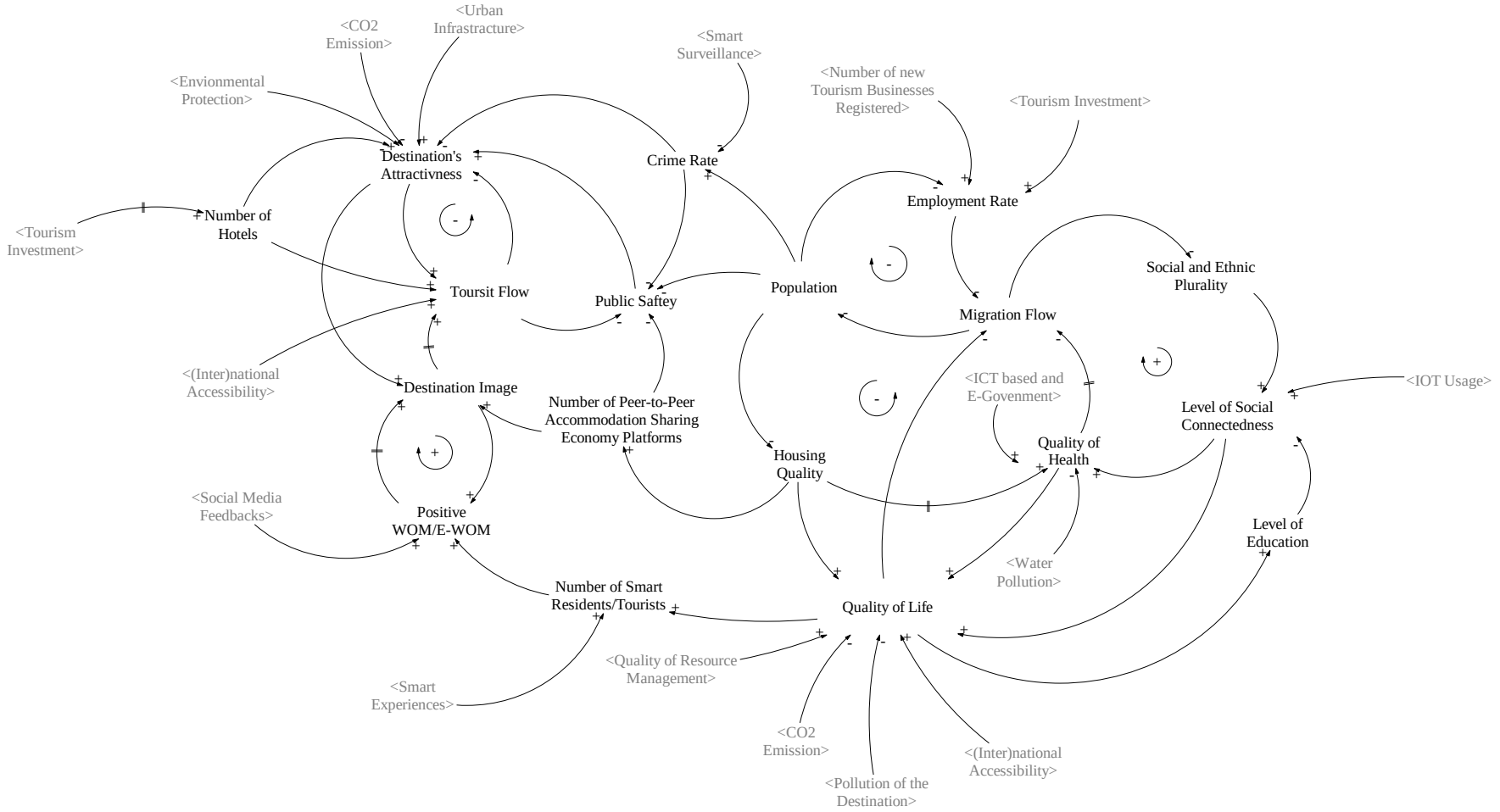
Authors	**Journal**	**General Objective of the Paper**	**Location**	**Stakeholders' Involvement**	**Qualitative /Quantitative**	**Purpose of using SD**	**Sector**

Walker, Greiner, McDonald, & Lyne, 1998	Environmental Modelling & Software	Proposing a framework to simultaneously evaluate social, economic and environmental factors which affect the tourism activity	Australia	1. Representatives of the accommodation sector; 2. Representatives of the restaurant, food outlets, and retail sectors; 3. Land-based and marine tour operators; 4. Planning agencies	Both	Creating a tourism future simulator system in order to explore the impacts of different scenarios	Attractions Sector
Woodside, 2009	Journal of Travel Research	Assessing how golf tourism can contribute to economic welfare of a region while avoiding its social and environmental destruction	General Model	Information not provided	Both	Showing the possibility of achieving sustainable golf tourism	Adventure & Outdoor Recreation Sector
Xing & Dangerfield, 2010	Journal of the Operational Research Society	Demonstrating the ability of SD to analyze the sustainability of mass tourism in island destinations	Southern European Islands	Information not provided	Both	Promoting sustainable tourism development by evaluating the impacts of mass tourism in island destinations	Attractions Sector

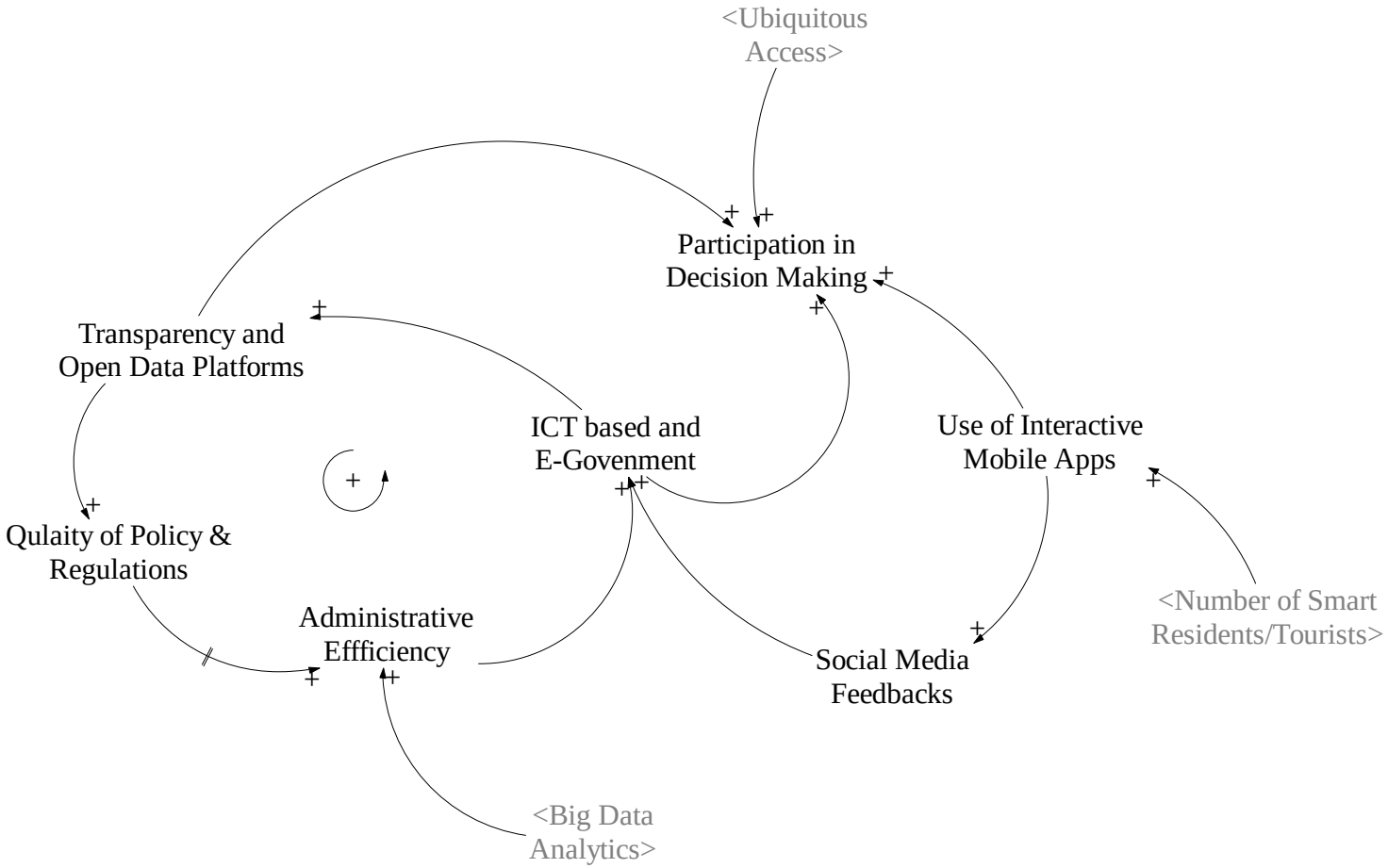
Xu & Dai, 2012	Current Issues in Tourism	Assessing sustainable policies by modelling tourism and community development in heritage sites	China	1.Tourists; 2.Local Community; 3.Local Government	Both	Understanding the complexities and interrelationships of the community in a heritage site	Attractions Sector (Cultural)
Zhang, Ji, & Zhang, 2015	Ecological Indicators	Using a dynamic method to evaluate tourism sustainability in Tibet and find the indicators that contribute to sustainable development in the region	Tibet Autonomous Region	1. Researchers; 2. Tourism operators; 3. Policymakers; 4. Residents	Both	Providing a systematic approach to evaluate tourism sustainability in Tibet	Multisector

Appendix B: Causal Loops

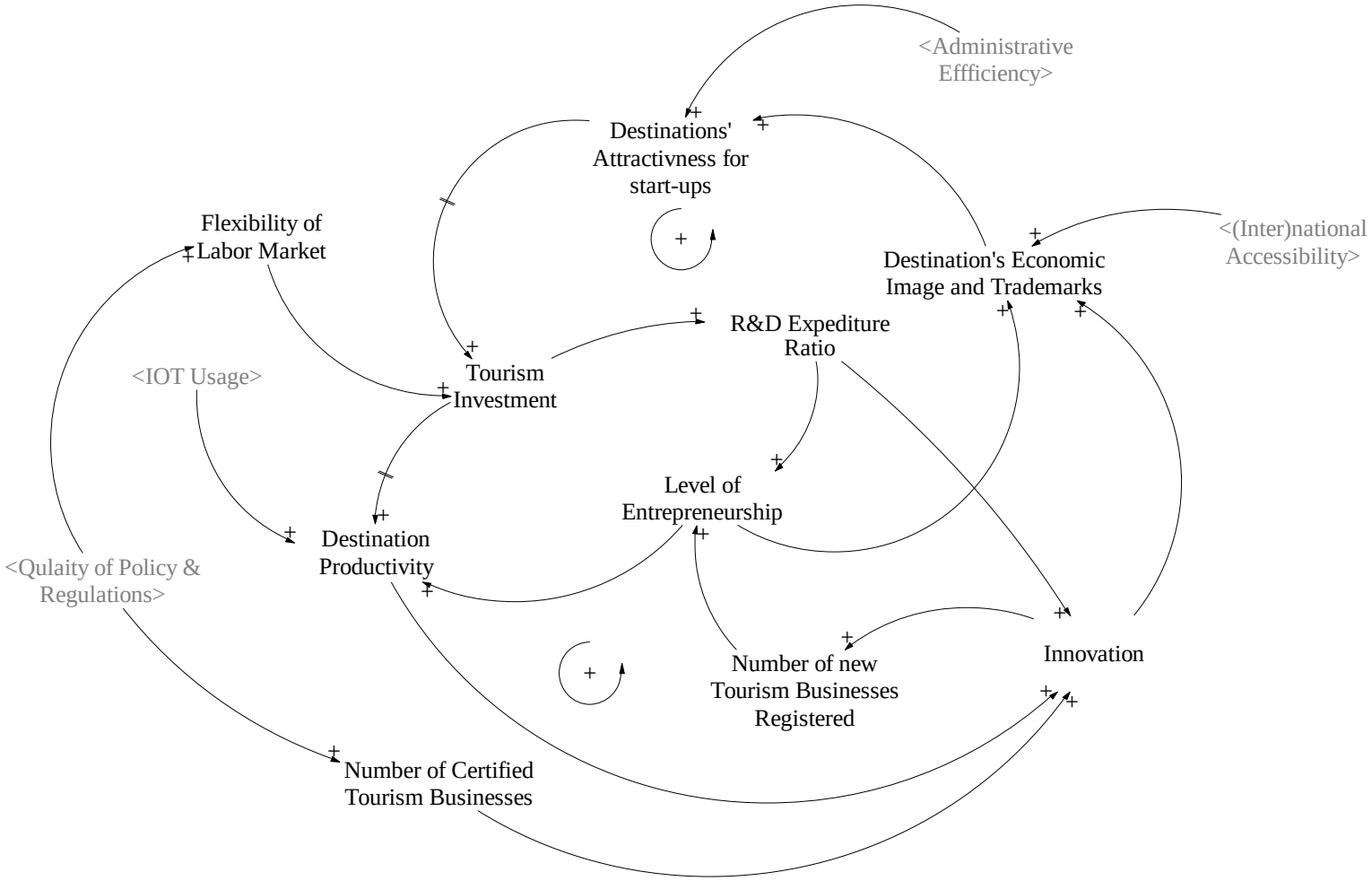
Smart People



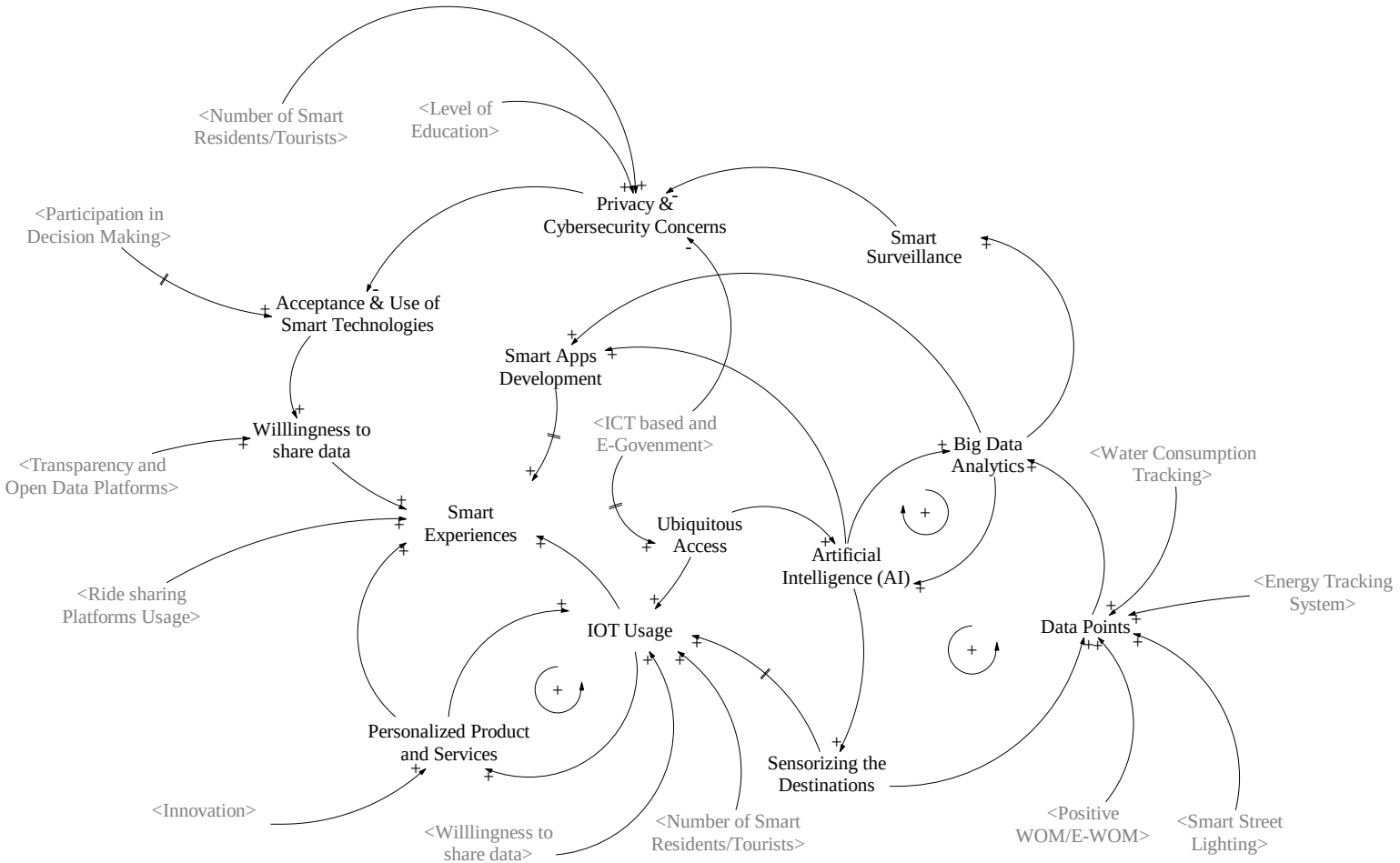
Smart Governance



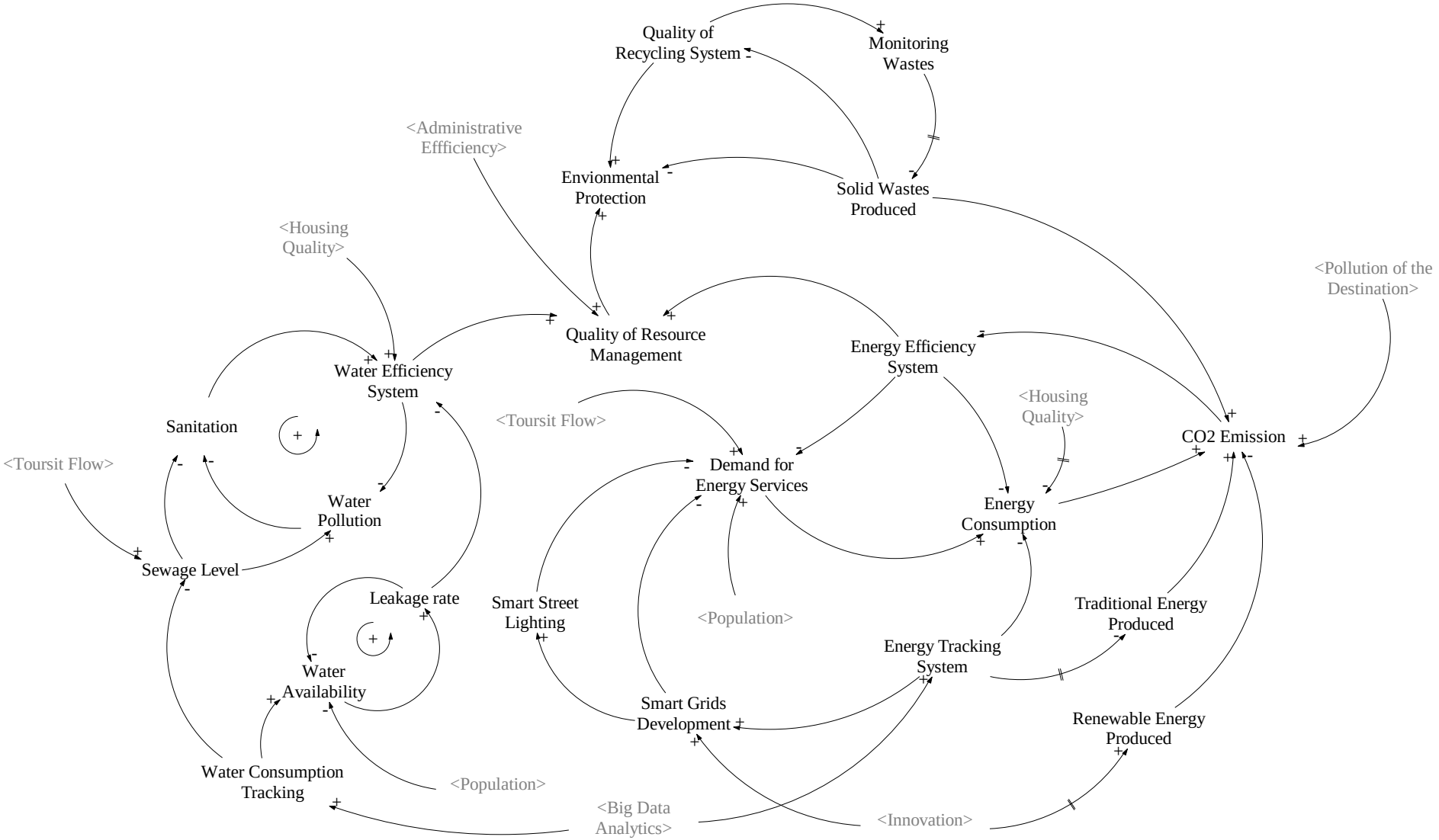
Smart Economy



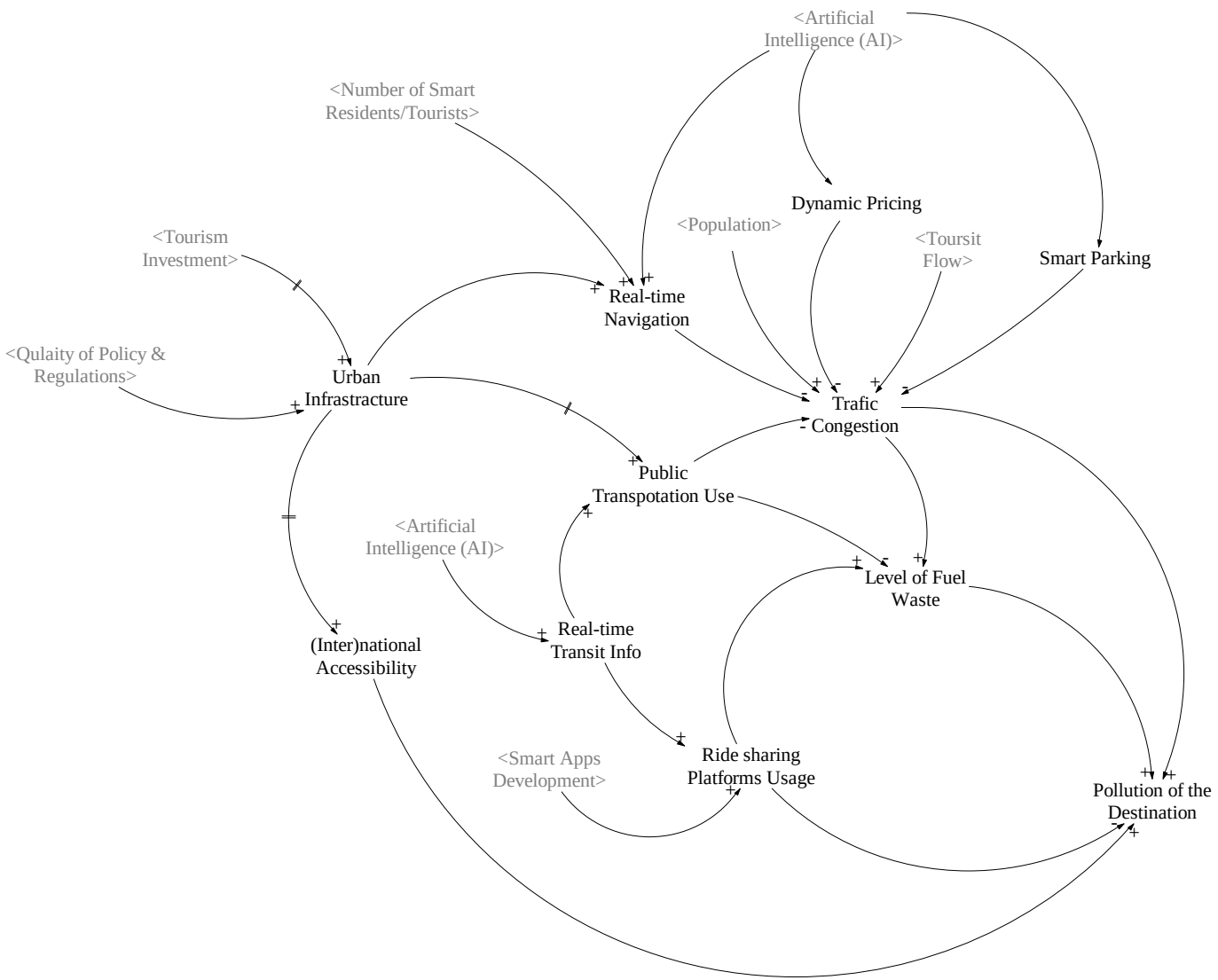
Smart Infrastructure



Smart Environment



Smart Mobility



Appendix C: Formula

(01) "% Rate of Growth"=
-0.0031
Units: Dmnl

(02) Acceptance and Usage Rate=
Enabling Effect of ICT/"Privacy & Cybersecurity Concerns"
Units: Dmnl

(03) Adjustment time=
1
Units: Year

(04) Aggregate Demand Forecasting= INTEG (
Change in AD Forecasting,
Error of AD Forecasting*"Equilibrium GDP.")
Units: Euro/Year

(05) Aggregated Demand=
Consumption+Government Expenditure+Investment
Units: Euro/Year

(06) "Artificial Intelligence (AI)"=
0.669
Units: Dmnl
https://www.oxfordinsights.com/ai-readiness2019
https://www.idc.com/getdoc.jsp?containerId=prUS47482321#:
:text=The%20AI%20Services%20category%20grew,reaching%20%2437.9%20
billion%20by%202024.

(07) Average length of Stay=
RANDOM UNIFORM(1, 20, 6)
Units: Days

(08) "Average Spending/Day"=
34.2
Units: Euro/Day
https://www.pordata.pt/en/Portugal/Average+daily+expenditure+per+
tourist+total++by+main+purpose+and+by+destination+of+the+trip-262
6

(09) Basic Consumption=
64.3
Units: Euro/Year

(10) Big Data Analytics Power=
(0.53*"Artificial Intelligence (AI)")*"ICT & E-Governance Development"
Units: Dmnl

Mendonça, C. M. C., Andrade, A. M. V. (2018). Dynamic Capabilities and Their Relations with Elements of Digital Transformation in Portugal. Journal of Information Systems Engineering & Management, 2018, 3(3), 23

(11) Change in AD Forecasting=
(Aggregated Demand-Aggregate Demand Forecasting)/Forecasting Adjustment Time
Units: Euro/Day

(12) Change in DA=
DELAY1(Quality of Tourism Service*Enabling Effect of ICT, 12)/Effect of CF
Units: **undefined**

(13) Change in Expected Income=
(GDP-Expected income)
Units: Euro/Year

(14) Changes in SD=
Seasonality
Units: Dmnl

(15) Citizen Participation=
Effect of ICT on Stakeholders' Engagement*Transparency and Openness Level
Units: Dmnl
http://reports.weforum.org/global-competitiveness-report-2018/competitiveness-rankings/#series=UNPANEPARTIDX
https://www.oecd.org/gov/open-government/
https://www.sciencedirect.com/science/article/pii/B9780081002513000123
https://www.sciencedirect.com/science/article/pii/B9780128166390000041

(16) Consumption=
Basic Consumption+(Expected income*Marginal Propensity to Consume)
Units: Euro/Year

(17) "Crowding Factors (CF)"=
(Population+Tourist Volume)/(Real Time Navigation+"Use of Public Transportation & E-hailing Services"
)
Units: Dmnl

(18) Desired Production=
Aggregate Demand Forecasting
Units: Euro/Year

(19) Destination Attractiveness= INTEG (
Change in DA,
0.7)
Units: Dmnl [0,1]

https://www.weforum.org/reports/the-travel-tourism-competitivenes
s-report-2019

(20) Effect of CF=
"Crowding Factors (CF)"
Units: **undefined**

(21) Effect of DA on Tourism Flow = WITH LOOKUP (
Destination Attractiveness,
([(0,0)-(60,1)],(0.550459,0.0877193),(8.07339,0.131579),(15.4128,0.175439
),(21.2844,0.223684),(25.6881,0.27193),(31.9266,0.350877),(36.5138,0.421053
),(44.0367,0.539474),(48.4404,0.596491),(54.1284,0.675439),(56.6972,0.754386
),(59.2661,0.828947)))
Units: **undefined** [0,1]

(22) Effect of ICT on Stakeholders' Engagement = WITH LOOKUP (
IOT Usage,
([(0,0)-(60,1)],(0.366972,0.0263158),(4.22018,0.0701754),(8.62385,0.114035
),(14.3119,0.171053),(17.7982,0.20614),(21.6514
,0.267544),(25.1376,0.315789),(27.8899,0.328947),(30.6422,0.399123),(33.945
,0.460526),(37.4312,0.561404),(41.1009,0.600877

),(46.2385,0.635965),(51.9266,0.679825),(55.5963,0.776316),(58.8991,0.894737
),(59.8165,0.982456)))
Units: **undefined**

(23) Effect of SD changes=
Seasonal Demand
Units: Dmnl

(24) Enabling Effect of ICT=
"Artificial Intelligence (AI)"*Big Data Analytics Power*IOT Usage
Units: Dmnl [0,1]

(25) "Equilibrium GDP."=
(Basic Consumption-(Marginal Propensity to Consume * Tax) + Investment +
Government Expenditure) / (1 - Marginal Propensity to Consume)
Units: Euro/Year

(26) Error of AD Forcasting=
0.43
Units: Dmnl

(27) Euler's Number==
2.71828
Units: Dmnl

(28) Expected income= INTEG (
Change in Expected Income-Tax,
33119)

Units: Euro/Year

(29) FINAL TIME = 60
Units: Month
The final time for the simulation.

(30) Forecasting Adjustment Time=
1
Units: Year

(31) GDP= INTEG (
GDP Increment Rates,
Initial GDP)
Units: Billion Euros
198438

(32) GDP Increment Rates=
(Desired Production-GDP)/Adjustment time
Units: **undefined**

(33) GDP per Capita=
GDP/Population
Units: Euros/Person

(34) Government Expenditure=
88722.5
Units: Million Euros/Year
https://www.pordata.pt/en/Portugal/General+Government+expenditure+total++current+and+capital+(2016)-2790

(35) "Gross Fixed Capital Formation (GFCF)"=
(0.175*GDP)
Units: Billion Euros/Year
https://data.worldbank.org/indicator/NE.GDI.FTOT.ZS?end=2019&start=2019&view=map&year=2018 Gross fixed capital formation: Gross fixed capital formation is defined as the value of institutional units' acquisitions less disposals of fixed assets. Fixed assets are produced assets (such as machinery, equipment, buildings or other structures) that are used repeatedly or continuously in production over several accounting periods (more than one year) (SNA 2008, 1.52).
https://www.unwto.org/glossary-tourism-terms

(36) "ICT & E-Governance Development"= ACTIVE INITIAL (
0.4*Citizen Participation,
0.803)
Units: Dmnl [0,1]
https://publicadministration.un.org/egovkb/en-us/about/unegovdd-framework https://e-estonia.com/solutions/e-governance/

(37) Inflow of Tourists=
MODULO(Effect of SD changes*Effect of DA on Tourism Flow, 12)/Tourist Volume
Units: **undefined**

(38) Initial GDP=
198438
Units: Billion Euros/Year

(39) Initial Pop at time 0=
10.56
Units: Person

(40) INITIAL TIME = 0
Units: Month
The initial time for the simulation.

(41) Investment=
20
Units: Billion Euros/Year
https://www.bportugal.pt/en/comunicado/statistical-press-release-investment-funds-september-2018

(42) IOT Usage= INTEG (
Acceptance and Usage Rate,
0.74)
Units: Dmnl
https://ncsi.ega.ee/ncsi-index/

(43) Marginal Propensity to Consume=
0.8
Units: Dmnl

(44) Outflow of Tourists=
Inflow of Tourists/Average length of Stay
Units: **undefined**

(45) Population= ACTIVE INITIAL (
Initial Pop at time 0*Euler's Number^("% Rate of Growth"*Time),
10.29)
Units: Person
https://www.macrotrends.net/countries/PRT/portugal/population

(46) "Privacy & Cybersecurity Concerns"=
IOT Usage
Units: Dmnl

(47) Quality of Policy and Regulations=
((0.5*Transparency and Openness Level)+(0.71*"ICT & E-Governance Development"
))

Units: Dmnl [0,1]
https://www.oecd-ilibrary.org/docserver/8ccf5c38-en.pdf?expires=1

624643727&id=id&accname=guest&checksum=1F0D8F0D03F9D4020F12260FFF
742AF3

(48) Quality of Tourism Service=
DELAY1(0.1*Tourism Investment, 0.6*Quality of Policy and Regulations)
Units: Dmnl [0,1]

(49) Real Time Navigation=
Enabling Effect of ICT
Units: Dmnl

(50) Real Time Transit Info=
Enabling Effect of ICT
Units: Dmnl

(51) SAVEPER =
TIME STEP
Units: Month [0,?]
The frequency with which output is stored.

(52) Seasonal Demand= INTEG (
Changes in SD,
0.36)
Units: Dmnl [0,1]

(53) Seasonality=
MODULO(Time, 12)
Units: Dmnl

(54) Standardized Demand=
Effect of SD changes*Seasonal Demand
Units: Dmnl
DELAY1(Effect of SD changes, 12)

(55) Tax=
0.3
Units: Euro/Year

(56) TIME STEP = 1
Units: Month [0,?]
The time step for the simulation.

(57) Tourism Investment=
DELAY1(0.35*"Gross Fixed Capital Formation (GFCF)",Tourism Revenue)
Units: Million Euros/Year

(58) Tourism Revenue=

Tourist Volume*"Average Spending/Day"*Average length of Stay
Units: Million Euros/Year

(59) Tourist Volume= INTEG (
Inflow of Tourists-Outflow of Tourists,
25.9)
Units: Person [0,40]

(60) Transparency and Openness Level= INTEG (
"ICT & E-Governance Development",
0.63)
Units: Dmnl [0,1]
http://reports.weforum.org/global-competitiveness-report-2018/com
petitiveness-rankings/#series=GCI4.A.01.05

(61) "Use of Public Transportation & E-hailing Services"=
Real Time Transit Info
Units: Dmnl