

Construction and Use of a 'Green Growth' Tourism Decision Support System: A Multi-Model Approach

G. Michael McGrath

Victoria University
Michael.McGrath@vu.edu.au

Geoffrey Lipman

Victoria University
Greenearth Travel

Abstract

For design, development, implementation and use of an information system (IS) to constitute a valid research activity, the system should support the solution of a non-trivial and important problem and it should be original, drawing on existing theories and knowledge. The design of one such system is described in this paper: specifically, a decision support system (DSS) designed to support the development of 'Green Growth' (GG) strategies for Travelism (Travel & Tourism) destinations. A sound GG strategy is important: first, because tourism is a major contributor to the global economy - particularly for developing and island states; second because it represents some 5% of greenhouse gas (GHG) emissions and these are increasing faster than the global norm; and third because the environment is an essential element of destination attractiveness. Thus, the problem domain is certainly non-trivial and important. It is further argued that the design of the DSS artefact described is original and novel in the sense that: i) it supports the entire GG strategy development process (which is actually cyclical); ii) it allows for the sharing of data, functionality and knowledge between different DSS applications and different strategy development exercises in a seamless, integrated manner; and iii) it will be deployed in a global community based program in 2016. System design draws heavily on previous IS, information management and software engineering research; particularly with regard to use of abstraction and interfaces in support of component sharing and reuse.

Keywords: decision support systems; green growth strategies; tourism; travel; travelism; design science.

1 Introduction

Travelism is a complex socio-economic phenomenon, consisting of transport, hospitality, events, travel services, as well as the soft and hard infrastructure that enables the movement of people and their related goods (Lipman, DeLacy, Vorster, Hawkins and Jiang, 2012). It has emerged in the past half century, as a strong and growing part of global, regional, national and local economies, trade and development, and has many societal benefits.

An increasing number of tourism destinations have investigated the adoption of 'green growth (GG)' strategies as a means of addressing a variety of critical concerns and issues (Simpson et al., 2008; Scott et al., 2008). These include: i) climate change and its current and future impacts (Scott, DeFreitas, and Matzarakis, 2009); ii) severe environmental and social problems such as pollution, degradation and loss of forest, bushland and coastal land areas, critical energy, water and land shortages, acute traffic congestion and other major infrastructure problems, and rising unemployment, crime and delinquency rates (UNEP, 2010); iii) the need to rejuvenate destinations that have reached the stagnation or decline stages of their life-cycles (Butler, 2006); and iv) an apparent willingness on the part of visitors to pay a premium where tourism business operators have adopted sound environmental practices (Hawkins and Bohdanowicz, 2011).

Development of appropriate strategies is, however, not a simple matter. In part, this is because the policy development process demands that a substantial volume (and diverse range) of data

be analyzed. In addition, the policy domain contains a large number of variables, covering the economic, environmental and social dimensions, with variables interacting with each other in a complex myriad of ways; i.e a classic case of a “wicked” or ‘messy’ problem (Buchanan, 1992; Vennix, 1996). Obviously, information technology can assist in managing this complexity and, in addition, the analytical tools, scenario generation functionality and simulation capabilities characteristic of modern decision support systems (DSS) can be used to advantage in evaluating the possible impacts of proposed strategies.

While much research and tourism industry activity has focused on the design of DSS that address part of the GG strategy development process, there is no current tool that supports the total, end-to-end process: from benchmarking, through forecasting, to the specification of adaptation and mitigation strategies. Given that each of the later phases in the total process depends heavily on earlier phases, and the major variable interactions within and between the three fundamental dimensions of the sustainable tourism domain (economic, environmental and social) (Brundtland, 1987), it would seem reasonable to require that a GG strategy development tool should be highly-integrated. The design of such an integrated DSS is presented in this paper. From a design science (DS) research perspective, our DSS artefact represents a ‘new solution for a known problem’ (categorised as “Improvement” by Gregor and Hevner, 2013, p345), with a major contribution being the detailed specification of the end-to-end GG strategy development process as a DS ‘method’ (March and Smith, 1995). The design artefact has been instantiated as a working DSS and used in the field to assist in the development of GG strategies at a number of tourism destinations, with further applications planned.

The paper is organized as follows: relevant, background literature is presented in the following section, the research approach is detailed in Section 3 and this is followed (in Sections 4-8) by a discussion of the construction and use of our ‘Green Economy Tourism System’ (GETS) DSS, broken down into the design science research phases identified by Peffers, Tuunanen, Rothenberger and Chatterjee (2007-08): specifically problem identification and motivation, solution objectives, design and development, demonstration and evaluation, and communication. Section 9 contains concluding remarks.

2 Background

It is estimated by UNWTO (2015) that more than a billion people a year travel away from their normal place of residence, across international borders, for business or leisure purposes. The number travelling domestically is estimated at 3-4 times that figure. Furthermore, tourism’s economic impact is calculated by WTTC (2012) at 3-10% of direct, indirect and induced global GDP, with similar impacts on jobs, trade and investment. Travel and tourism, labelled ‘travelism’ Lipman et al. (2012), have consistently grown ahead of GDP at an average of 4% per annum for the past 3 decades and is estimated to show similar results for the next twenty years (UNWTO, 2015).

Travelism is, at the same time, a major source of greenhouse gas (GHG) emissions worldwide (Scott et al., 2008; Gossling and Peeters, 2015; Scott, Gossling, Hall and Peeters, 2015), as well as having significant waste, water food and other resource impacts. In parallel with this, many tourism destinations are facing serious problems as a result of an over-emphasis on economic objectives and too little attention being paid to environmental and social needs (Brundtland, 1987; Lipman et al., 2012).

As a consequence, an increasing number of destinations have embarked upon strategic planning exercises centred upon a ‘green growth’ premise (McGrath, Law and DeLacy, 2012). GG strategy development though, is an extremely complex process and, as such, it is our contention that strategy development teams could benefit very much from the use of an appropriate DSS.

A generic GG strategy development process is illustrated in Figure 1 and a key requirement of the DSS is that it must be capable of providing useful advice to strategy developers at each

process step. At the top-most level, the key steps are: i) *benchmarking*, where crucial current metrics (e.g. for water and energy usage, waste and GHG emissions, tourism growth and development, and for transport and infrastructure) are located or derived; ii) *projections and forecasts*, which involves predicting future trends for all key measures – both under ‘Business-as-Usual’ (BAU) and alternative scenarios; iii) *mitigation*, where strategies to alleviate the worst impacts of projected, future difficulties are developed and evaluated; iv) *adaptation*, including mitigation strategies, but supplemented with plans to deal with events that cannot be prevented (e.g. low-lying island flooding due to global climate change); v) *resilience*, collectively the cumulative results of all previous steps, involving the adaptation, reorganization, and evolution of a destination into a more desirable configuration that improves its sustainability; and, finally, vi) *validation*, the ongoing evaluation and feedback of the accuracy and effectiveness of all measures, projections, strategies and impacts: making for a self-correcting long-term ecosystem.

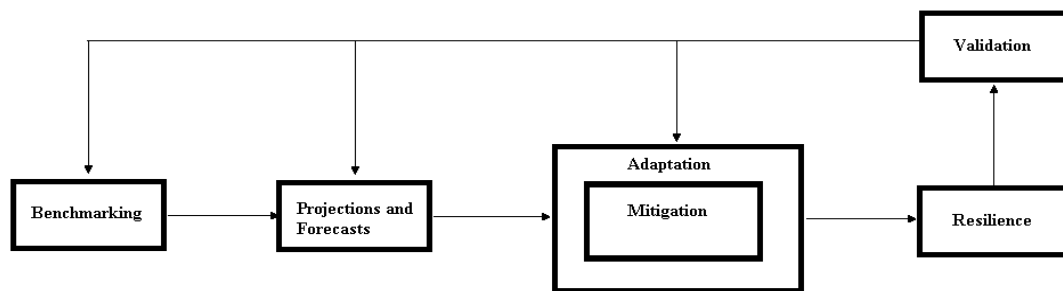


Figure 1: Generic GG strategy development process (derived from a GG activity classification scheme developed by Law, 2015).

Over the years, a considerable number of DSS addressing elements of this total strategy development process have been developed. Much early work was designed and developed using the ‘systems dynamics’ (SD) approach (Senge, 1990; Vennix, 1996). Examples include the ‘Tourism Futures Simulator’ of Walker et al., 1999), the ‘Hotel Value Chain Profitability’ model of Georgantzias (2003) and the ‘Tourism Enterprise Planning System’ (TEPS) of McGrath, (2007). Perhaps the most comprehensive set of models and simulators developed under the broad SD umbrella is the UNEP ‘Green Economy Report’s’ ‘Threshold 21 (T21) World’ model (UNEP, 2010). More recently, a number of agent-based tourism demand prediction tools have begun to appear. Better-known examples include the scenario generation and analysis system, ‘AuronzoWinSim’ (Balbi et al., 2010), a simulator designed to estimate the impact of climate change on tourism water consumption (Soboll and Schmude, 2011) and Baggio’s (2011) ‘TourDestMem’ model and simulator, which assesses the impacts of tourism destination marketing initiatives (and consequential impacts on competitors).

To our knowledge though, there is no existing GG strategic planning DSS that assists with every stage (see Figure 1) of the strategy development process. The GETS DSS described in this paper provides end-to-end decision support for this process and does so in an integrated, seamless manner. Notable features of the system are that: i) all data is defined consistently with an abstracted conceptual schema and may be shared between activities at each process step; ii) data may also be seamlessly shared between system functions (applications), regardless of the software platform on which they have been constructed and implemented; and iii) knowledge-based outcomes and lessons learned in earlier strategy development exercises are available for reuse in later studies. A feature of our study is that it is based on a DS research methodology (Hevener, March and Park, 2004), where the major objective is the design, construction, implementation and evaluation of a research artifact: in our case the GETS DSS. For a discussion of the use of design science in DSS research, see Arnott and Pervan (2008).

Gregor and Hevner (2013), building upon Wilson’s (2002) argument, assert that a DS research project must be ‘interesting’, meaning that it: i) should advance knowledge of theory, methods or applications; ii) should be an advance on previous work; iii) might be used to solve

important problems elsewhere; and iv) should clarify our understanding of the research area addressed.

According to Gregor (2006), a theory is a form of knowledge, an abstract entity comprised of a set of connected statements that aims to describe, explain enhance understanding and, possibly, make predictions. Gregor goes on to argue that design theories are what Merton (1968, p39) has described as “theories of the middle range”: neither the routine heuristics or hypotheses that inevitably arise during a research study or unified, all-inclusive grand theories, but somewhere in between. In general, such theories are concerned more with prescriptive, rather than descriptive, knowledge.

Goes (2014) asserts that DS research is not so much concerned with creating or testing theory as with problem solving through the design and development of artifacts. As such, it is not necessary that a DS research study should be explicitly tied to theory. Nevertheless, Gregor and Jones (2007) have stressed the importance of ‘justificatory knowledge’: knowledge used to inform design science research (including formal heuristics from field practitioners) and a concept that builds upon the ‘kernel theories’ idea of Walls, Widemeyer and El Sawy (1992, p41).

Within the DS research community, it now seems to be generally accepted that an IS artifact is comprised of *constructs, models, methods* and *instantiations* (March and Smith, 1995). The strategy development process depicted in Figure 1 is the highest-level view of the GETS ‘method’. This process has been broken down into much more-detailed views (see McGrath, Meijerink and Gutterson, 2014 for examples) and it is contended that, given that the GG strategy development process seems to be only very loosely-specified in the mainstream sustainable tourism literature, this detailed process specification (at various levels of abstraction) represents a considerable contribution to the domain.

Gregor and Hevner (2013) have argued that a DS research project’s knowledge contribution should be assessed in terms of *problem maturity* and *solution maturity*. Furthermore, *improvement* involves developing “... *new solutions for known problems* (p345) and we contend that our research fits into this category: specifically, while the sustainable tourism literature is rich in policy development studies focused on elements of the strategic planning process (see e.g. Inskeep, 1991; Bramwell and Lane, 1993; Lane, 1994), the concept of building GG ‘roadmaps’ (encompassing every area of a tourism destination’s activities) is relatively new, with most major studies having taken place within the past five years. Moreover, the most-comprehensive and widely-used of the integrated, sustainable tourism policy development and decision support frameworks and aids (see Richie and Crouch, 2003) are not automated and do not allow seamless sharing of data and processes between activities.

A novel feature of the GETS artifact is that data and processes of all components are integrated and integrated in a way that allows for: i) maintenance and enhancements to be realized without impacts (e.g. significant code rewrites) on existing models and instantiations; and ii) modules (e.g forecasting applications) developed using multiple tools and software platforms to communicate without modification. This end-to-end process integration is due to two DS ‘models’ that largely inform the design and development of the GETS artifact and its implementation as the GETS DSS: specifically, we refer to the highly-abstracted (and levelled) data models (Feldman and Miller, 1986) and the accompanying ISO 3-Schema architecture (Van Griethuysen, 1986). Neither abstracted data modelling nor the 3-Schema architecture are new of course but, as was the case 20 years back, truly-integrated instances of complex, multi-application DSSs (and indeed any sort of IS) would appear to be still rare today.

For example, at a recent US DoD conference, it was reported that database and IS integration efforts are still characterized more by failure than success and that more than 50% of all large, commercial data warehouse programs (which are underpinned by the assumption of effective integration of multiple datasets) fail (Curtis and Campbell, 2015).

Care needs to be taken though, when discussing DSS integration. In presenting a framework for evaluating DSS integration, Liu, Duffy, Whitfield and Boyle (2009) argued that integration

extent can be assessed according to: *perspective* (data, model, process, service and presentation); *dimension* (horizontal and vertical); *level* (null, in-project and generic); and *type* (tight and loose). In this project we are concerned with loose integration, where components interact via middleware according to some ‘agreement’ (Linthicum, 2003) (encapsulated in our case in a common, abstracted conceptual schema). We also require high levels of both horizontal integration (i.e. where multiple parties can work on common activities) and vertical integration (seamless integration between upstream and downstream activities), and we have a focus on data, model and process perspectives. We are less-concerned with service and presentation integration, taking the view that, at the model interaction level, a common user interface is of less value than interfaces designed specifically for model and process types - i.e. a ‘horses for courses’ approach (Curtis, Kellner and Over, 1992).

3 Research Approach

The last two decades have seen the rise of the DS research approach; sometimes described as the ‘Design Science Research Methodology’ (DSRM) (Peppers et al., 2007-08). As far back as the 1960s, Simon (1969, p55) argued “*Whereas natural sciences and social sciences try to understand reality, design science attempts to create things that serve human purposes*”. Hevner et al. (2004) proposed seven guidelines for conducting DS research. These are: i) that the research must produce an “*artefact created to address a problem*”; ii) the artifact should be relevant to the solution of a “*heretofore unsolved and important business problem*”; iii) its “*utility, quality, and efficacy*” must be rigorously evaluated; iv) the research should represent a verifiable contribution; v) rigor must be applied in both the development of the artifact and its evaluation; vi) the development of the artifact should be a search process that draws from existing theories and knowledge to come up with a solution to a defined problem; and, finally, vii) the research must be effectively communicated to appropriate audiences.

Pfeffers et al. (2007-08) reviewed much of the DS research and specified the process model presented in Figure 2 as a consensus of the better-known DSRMs proposed to that point in time. This represents the research design of our study and further detail will be presented in the following sections, which are broken up consistent with the major phases of the model.

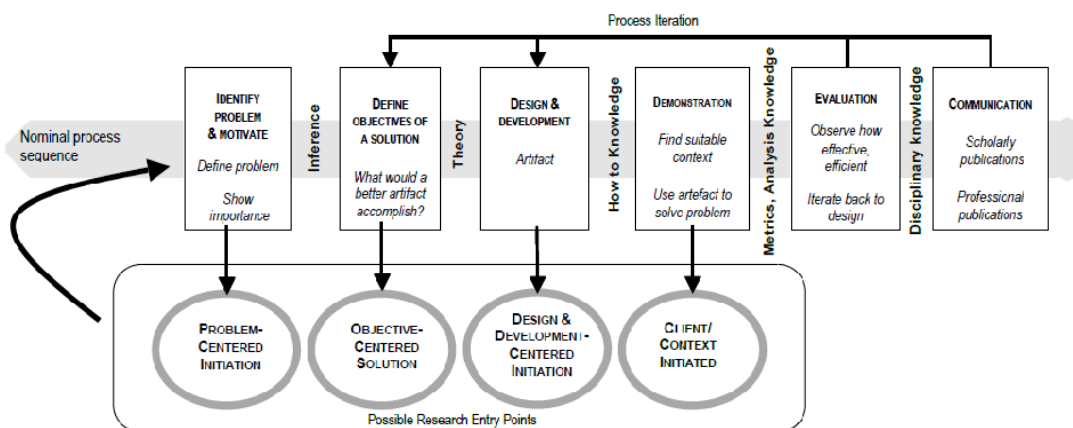


Figure 2: DSRM process model (reproduced from Hevner et al., 200, p52).

Nunamaker, Chen and Purdin (1991) have argued that IS design using prototyping is similar to case study research, with each new prototype version building upon experience gained with previous versions. A prototyping approach underpinned the design and development of the DSS described in this paper, with the system undergoing the following major revisions: i) an initial version was developed circa 2009, building on lessons learned in developing an earlier DSS based largely on the ‘Tourism Area Life Cycle’ (Pornphol and McGrath, 2011); ii) this

initial version was refined and extended during the period 2010-11, when employed to assist with a GG strategy development exercise at Sharm El Sheik, Egypt (Law, DeLacy, McGrath, Whitelaw, Lipman and Buckley, 2012); and iii) the system underwent further major refinement (circa 2012-14) when used in follow-up GG strategy development exercises at Jeju Island in the Republic of South Korea (Lipman, DeLacy and Whitelaw, 2013) and in Bali, Indonesia (McGrath, Law and DeLacy, 2015). As detailed in Section 7, it is anticipated that additional extensions will result from further studies anticipated to take place during 2016-18

Finally, as noted by Peffers et al. (op cit.), there are two sets of DS literature. One revolves around issues of actually doing academic design work; i.e., *design research*, while the second set addresses the meta-level of conducting research at a higher level of abstraction; it is *research about design research*. Our study contributes to the first of these research areas.

4 Problem Identification and Motivation

This process involves defining the research problem and justifying the value of a solution (Peffers et al., 2007-08, p52). In this instance, the research problem is to:

“Develop and implement a DSS designed to support and assist those parties involved in the specification of GG strategies within Travelism destinations.”

As noted by McGrath et al. (2012), the GG domain is extremely complex, comprised as it is of a large number of variable types and instances. Reasons for this complexity include: i) the relevant variables encompass the economic, environmental and social dimensions (and relations within and between these); ii) the GG domain is a classical instance of a ‘messy’ problem (Vennix, 1996), characterised (among other features) by a wide variety of vicious (and virtuous) circles; iii) the substantial volume and diversity of data referred to above needs to be modelled, structured and organized; and iv) tourism destinations vary greatly in terms of both their size and character, ranging as they do from large, semi-global regions to much smaller, special-purpose areas (e.g. ski and beach resorts). Thus, any DSS strategic planning aid must be both ‘scaleable’ and amenable to convenient customization.

While development of a DSS that addresses the needs detailed above is probably a worthwhile exercise from a pure, technical DSS standpoint alone, the research problem (and, more specifically, the solution) aims to contribute towards the realization of a very important environmental and social objective: specifically, the maintenance of sustainable environmental and social goals while promoting economic growth (Brundtland, 1987), Moreover to quote from the ‘Leaders Declaration’ at the G20 meeting held in Mexico during 2012 (G20, 2012, pp12-13):

“We highlight that green growth and sustainable development have strong potential to stimulate long-term prosperity and well-being. . . . We recognize the role of travel and tourism as a vehicle for job creation, economic growth and development, and, while recognizing the sovereign right of States to control the entry of foreign nationals, we will work towards developing travel facilitation initiatives in support of job creation, quality work, poverty reduction and global growth.”

However, as noted, travelism is a major contributor to global greenhouse gas (GHG) emissions and Scott et al. (2008) estimate that emissions could grow by 161% by 2035¹. Given the new tough national carbon reduction commitments and global targets agreed at the recent *UN Climate Change Conference* in Paris (*COP21*) during December 2015, climate change mitigation, adaptation and resilience is an increasingly critical issue for many travelism destinations. In addition, the sector faces a number of industry-specific problems; notably: it is highly energy-intensive - with aviation likely to be highly-dependent on fossil fuel for the foreseeable future, water use can be extremely high (Gossling, 2005) and tourists tend to generate (relatively) very high levels of waste (Hamele and Eckhardt, 2006; UNEP, 2010).

¹ These figures were recently updated by Gossling and Peeters (2015), with similar conclusions.

Moreover, GG strategy development is resource-intensive. For example, in the case study detailed in (Law et al., 2012) a team of ten researchers was involved for a period of close to six months. Moreover, two senior researchers and a principal research assistant were involved in the study on a close to full-time basis. Cost is also an issue, in that many (newer and evolving tourism destinations especially) may not be able to easily afford the outlays demanded by commercial consultancy firms required for development of a comprehensive GG roadmap, which can easily run into millions of dollars. All of this, we believe, points to the need for some sort of automated strategy development support: specifically, the need for a DSS that provides appropriate process guidance, allows the sharing of knowledge, experience and results in an affordable and convenient way so that local communities may chart their own lifestyle destiny.

Finally, GG strategy development is a complicated process, characterized by highly-complex and uncertain relationships between GG drivers and inhibitors. To our knowledge, currently there is no existing, automated planning framework designed to assist GG strategy developers in understanding and leveraging key causal connections among these inhibitors and drivers. This, together with the other factors mentioned above, point to the need for the type of DSS intended as the principal output artefact of this design-based research project.

5 Solution Objectives

The purpose of this phase is to: *“Infer the objectives of a solution from the problem definition and knowledge of what is possible and feasible”* (Peffer et al., 2007-08, p53). Thus, the major objective is to:

“Specify, develop, implement, evaluate and validate a GG strategy development support DSS for use within tourism destinations of all types and sizes.”

Again, referring to Peffer et al. (2007-08), objectives should flow directly from the problem specification and, ideally, both of these (problem and solution) should be *“atomized”* and represented *“conceptually”* (p53). In this instance, we have chosen to represent our solution as the requirements taxonomy presented in Figure 3.

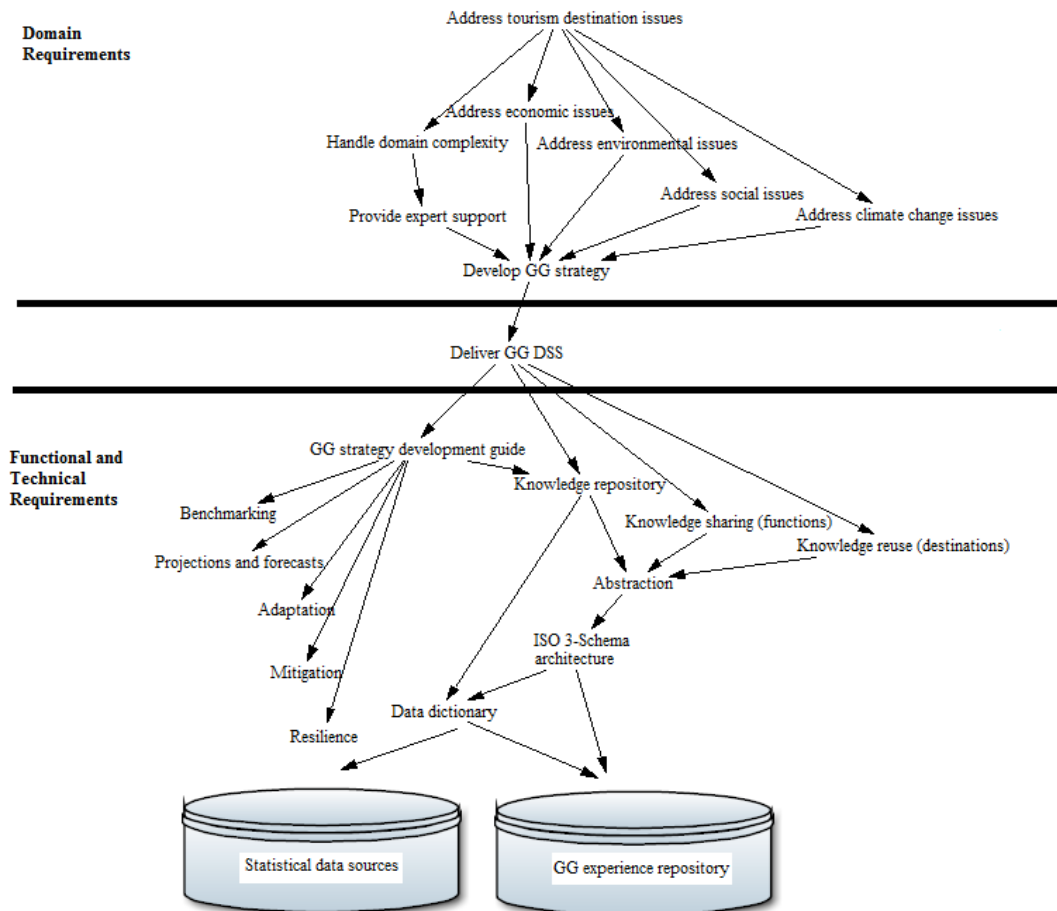


Figure 3: Solution objectives – requirements taxonomy.

Problem-solution linkages can be verified easily enough by referring back to Section 4. In Figure 3, the topmost section deals with domain requirements and the bottom section deals with supporting, DSS functional and technical needs.

Thus, the overriding objective for tourism destinations is to address critical issues they are confronting; particularly those related to climate change, projected rapid increases in GHG emissions and the consequent need to conserve precious resources (notably energy, water and land). As noted in the previous section, strategy development must address the economic, environmental, social and climate change dimensions, and interactions between key variables, within and between dimensions, results in substantial domain complexity. Any GG strategy developed and implemented must take adequate account of these interactions or risk serious, unintended consequences (Senge, 1990).

This brings us to our major research objective (shown in the central section of Figure 3), as specified at the beginning of this section; the design, development, implementation, evaluation and validation of our GG strategy development DSS. The DSS must include the following (top-level) functions: a strategy development guide, establishment, maintenance and access to a GG knowledge repository, knowledge sharing between all DSS functions and the ability to reuse both DSS functionality and accumulated experience from one destination to another. Further detail on lower-level functionality is provided in the following section.

6 Design and Development

6.1 Overview

During the design and development phase, the artifact is created. As Peffers et al. (2007-08, p53) have noted:

“Such artifacts are potentially constructs, models, methods, or instantiations (each defined broadly) ----. Conceptually, a design research artifact can be any designed object in which a research contribution is embedded in the design. This activity includes determining the artifact’s desired functionality and its architecture and then creating the actual artifact.”

A view of the GETS domain and its representation is presented in Figure 7. The *domain* (or, more accurately, an instance of a domain) is what van Griethuysen (1982) asserts to be the *Universe of Discourse (UoD)* - *that collection of objects, from a real or postulated world that is being described*. In our case, the world of interest is centered on green growth travelism, as a contributor to better sustainable community lifestyles. Further detail on domain representation is presented in the following section but its specification is encapsulated in the conceptual schema (at the top of Figure 4). The conceptual schema is a highly-abstracted specification of the UoD and a set of mappings is employed to translate this view to and from external schemas associated with the individual applications that constitute the GETS system².

These applications are represented in Figure 4 at the centre of the diagram. All decision support applications utilise the data captured and organized during benchmarking. As noted earlier, the applications themselves are developed using a variety of languages and software platforms and are concerned with forecasts, validation, the discovery and application of expert rules and connections to previous, similar cases through case-based reasoning (CBR – and discussed in more detail in Section 6.4).

Markus et al. (2002) have argued that IS development constitutes original research where the development and implementation are original and new knowledge is generated about how to manage data and information in complex situations. We argue that the GETS domain is certainly complex. Specifically: i) a large number of data types and a large volume of data must be managed; and ii) the system must be capable of controlling the evolution of database schemas (and associated data manipulation code) as the system is employed with each new destination and as new functionality is added. Concerning the other criterion, effective and efficient data and information management is a key objective of the GETS system: specifically, we contend that the following aspects of our research constitute novel and ‘original’ contributions:

- i) The system provides end-to-end support for the GG strategy development process and allows for automated, integrated data sharing and reuse within and between all major sub-processes (see Figure 4);

² Thus, the GETS design is essentially based on the ISO 3-Schema architecture (van Griethuysen, 1982). Beyond the conceptual and external schemas are the internal-level schemas, the details of which are outside the scope of this paper.

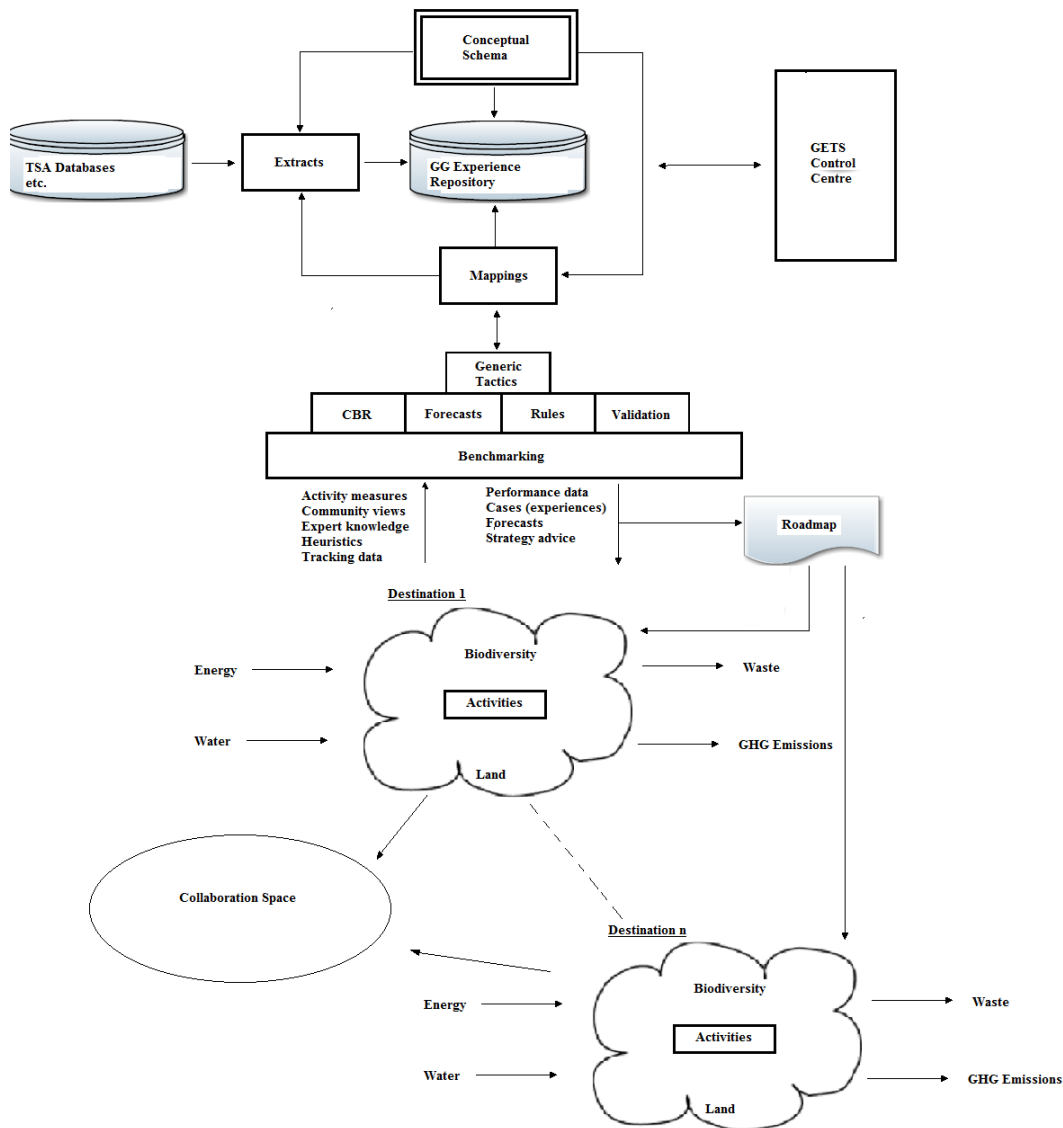


Figure 4: The GETS domain and its representation.

- ii) The system is truly-integrated, in the sense that data may be seamlessly shared between different applications regardless of type and the supporting software platform³; and
- iii) Data, findings and knowledge may be conveniently shared among destinations conducting (or who have previously conducted) GG strategy development exercises. This is facilitated by the common experience repository, containing the accumulated sum of all strategy development (and follow-up) exercises, the entire contents of which must conform to a common conceptual schema.

A key function of the DSS is its use as a guide, providing useful advice to strategy developers at each process step. It also encompasses the basic functionality required to support all strategy development process steps. In the remainder of this section, we provide an overview of this functionality, along with a description of the system architecture and its models. The discussion is broken down consistent with the process steps specified in Figure 2.

³ For example, time series data produced by a system dynamics simulation may be input to a rule-based expert system.

6.2 Benchmarking

In Figure 5, an abstracted view of the core of the benchmarking guide model is illustrated. The model is presented in Entity-Relationship (ER) form (Chen, 1976) and the modelling approach utilised is based on the ‘resources-events-agency’ approach proposed by McCarthy (1982).

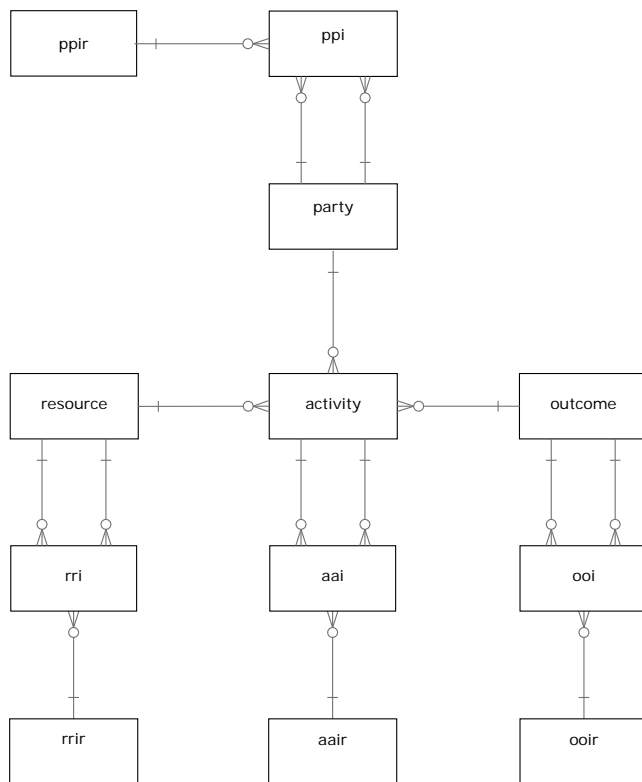


Figure 5: Abstracted core of the benchmarking guide model.

Benchmarking is primarily concerned with measuring activities. In an *activity*, a *party* uses a *resource*, resulting in some *outcome*. Examples are: a hotel using energy and producing GHG emissions; a resident using transport and, again, producing GHG emissions; and a visitor consuming food and producing waste. Parties, resources, activities and events or all related to themselves in specific *involvement roles*. A particularly important involvement role is the *subtype*. Examples are presented in Figure 6, where it can be seen that instances of all fundamental entities are related to each other in subtype hierarchies. Thus, provided measures at the lowest level of the hierarchy are captured, measures at higher levels can be easily derived using (for example) *Prolog* code (Bratko, 1986) such as:

supertype(EntityX, EntityY) :-

ppi(EntityX, EntityY, subtype) ; rri(EntityX, EntityY, subtype).

supertype(EntityX, EntityY) :-

ppi(EntityZ, EntityY) ; rri(EntityZ, EntityY),

supertype(EntityX, EntityZ).

Thus, using the above and the set of assertive facts presented in Figure 6 (plus the corresponding set of actual instances for a particular destination), we could automatically derive higher-level measures such as total energy usage for all accommodation operators and overnight visitors, carbon-intensive energy (CIE) usage for all tourism visitors etc. Note that, should we like to employ different hierarchies (e.g. separating accommodation enterprises into hotels, motels and resorts), no application recoding is necessary: all that is required is to

modify our database entries. This demonstrates one of the major advantages of the abstracted modelling approach: more convenient maintenance (Feldman and Miller, 1986).

ppi_id	party_1	party_2	ppir
1	party	visitor	subtype
2	visitor	businessVisitor	subtype
3	visitor	tourismVisitor	subtype
4	tourismVisitor	vfrVisitor	subtype
5	tourismVisitor	daytripVisitor	subtype
6	tourismVisitor	overnightVisitor	subtype
7	party	tourismEntOperator	subtype
8	tourismEntOperator	accommodationOperator	subtype
9	tourismEntOperator	restaurantOperator	subtype
10	tourismEntOperator	ancilServicesOperator	subtype
11	tourismEntOperator	attractionsOperator	subtype
12	tourismEntOperator	activitiesOperator	subtype
13	tourismEntOperator	eventsOperator	subtype
14	accommodationOperator	fiveStarHotelOperator	subtype

rri_id	resource_1	resource-2	rrir
1	resource	energy	subtype
2	energy	carbonIntensiveEnergy	subtype
3	energy	renewableEnergy	subtype
4	carbonIntensiveEnergy	electricity	subtype
5	carbonIntensiveEnergy	coal	subtype
6	carbonIntensiveEnergy	gas	subtype
7	carbonIntensiveEnergy	petrol	subtype
8	carbonIntensiveEnergy	diesel	subtype
9	renewableEnergy	windPower	subtype
10	renewableEnergy	solarPower	subtype

Figure 6: Sample benchmarking guide instances.

The benchmarking process though, can be abstracted further. Specifically, each activity must be measured (at the lowest level); either to assess activity resource consumption or outcome production (see Figure 4). This meta-process is illustrated in Figure 7, where it can be seen that each *roadmap exercise* involves many *benchmarking measures* and, in turn, each measure must be associated with one *usage* instance. Each usage instance applies to one *activity*, one *period* and one *usage direction* (input or output), and there is one *derivation algorithm* that applies to each measure (which, inversely, may apply to many usage measures). Finally, there is a *data sources set* linked to each derivation algorithm, which is an instance of one of the three *generic approaches* (bottom-up, top-down or combination) identified by Becken and Patterson (2006).

Basically, the bottom-up approach uses detailed activity data while, with the top-down approach, estimates are made from macroeconomic data. For example, road transport GHG emissions measures would employ actual data on distances travelled by individuals or vehicles in a bottom-up approach but might (for example) use data on tourism fuel purchases, plus shares of destination-wide fuel usage and known GHG fuel-type emission factors, when estimating top-down. Once appropriate benchmark data has been collected, it is then used in later strategy construction stages: particularly projections/forecasts and the development of adaption, mitigation and resilience policies and procedures.

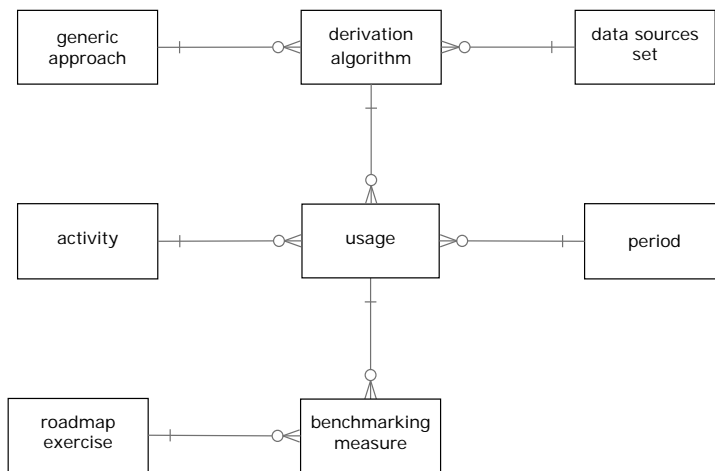


Figure 7: Abstracted view of the benchmarking activity measuring process.

6.3 Projections and Forecasts

Once adequate benchmarking data has been gathered in a roadmap exercise, this can be utilised in the projections and forecasts phase of strategy development: a task that often involves simulation and ‘what-if’ style testing of generated, possible future scenarios. Within GETS, most projection and forecasting functionality applications implemented to date have been specified using system dynamics (SD) constructs and software.

With a SD approach, models are generally initially specified using ‘causal-loop-diagrams’ (CLDs) (Manni and Cavana, 2000). An example of a CLD model concerned with energy supply and cost is presented in Figure 8⁴. At *Level 1*, high *energy demand* leads to greater *energy usage* (and vice versa) and greater usage, in turn, leads to a diminished *energy supply*. If energy supply is low though, this will probably lead to an increase in *energy cost* and this may have a consequent negative impact on *economic activity*. This leads us back to our starting point. Note though that there are additional constructs at the bottom of *Level 1*: specifically, if the cost of energy is high, companies will be more inclined to involve themselves in increased *energy exploration* and, in turn, one would hope (and probably expect) that this will ultimately increase the *energy supply*.

Aspects of this model may be decomposed further however: specifically, the relationship between traditional *carbon-intensive energy (CIE)* (oil, coal and natural gas) and *renewable energy (RE)* (hydro, wind, biomass, waste etc.) needs to be taken into account. The CLD in Level 2 is the result of breaking down the variable, *energy cost*, into greater detail. The total *energy cost* is a function of both the *CIE cost* and *RE cost*. A high *CIE cost* may result in more *RE research*, leading to greater *RE supply*. This may reduce *CIE demand* and, in turn, also reduce *CIE supply*. Finally, less supply may make CIE more expensive. This logic, roughly speaking, underpins the many carbon pricing and ETS schemes currently being introduced worldwide (see e.g. Callan et al., 2009).

⁴ An arrow indicates a causal connection and may be annotated with a ‘+’ or ‘-’. The former means that both variables move in the same direction while the latter means they move in opposite directions.

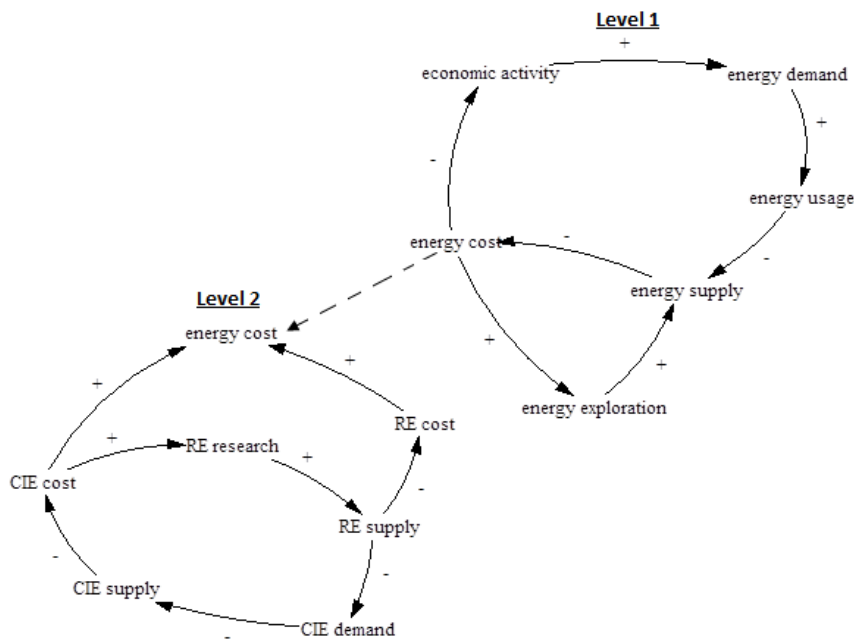


Figure 8: CLD for energy supply and demand forecasting.

In SD both time and feedback loops are important. In our example: i) RE research may well escalate as a result of increasing CIE prices but this will probably not be immediate; and ii) *RE research* → *RE supply* → *CIE demand* → *CIE supply* → *CIE cost* → *RE research* is a classic feedback loop. Time dependencies (e.g. delays) and feedback loops are common in tourism models (see e.g. Ritchie and Crouch, 2003, pp60-78) and Richardson and Pugh (1981) have noted that SD is ideally-suited to this type of modelling exercise.

As noted previously, a further strength of CLDs is their simplicity and this facilitates modelling sessions where key problem stakeholders can fully participate. Generally, however, translation to stock-flow form is undertaken by expert modellers, proficient in the particular SD modelling and simulation package employed. This process is more complex but it does allow the impacts of major external incidents to be factored into models (as well as providing the capacity to deal with phenomena such as queues, delays, step functions and other discrete events). The reader interested in this is referred to McGrath et al. (2015). This paper contains an example demonstrating how time series data generated by a SD simulation may be exported to other applications via the conceptual schema.

6.4 Adaptation, Mitigation and Resilience

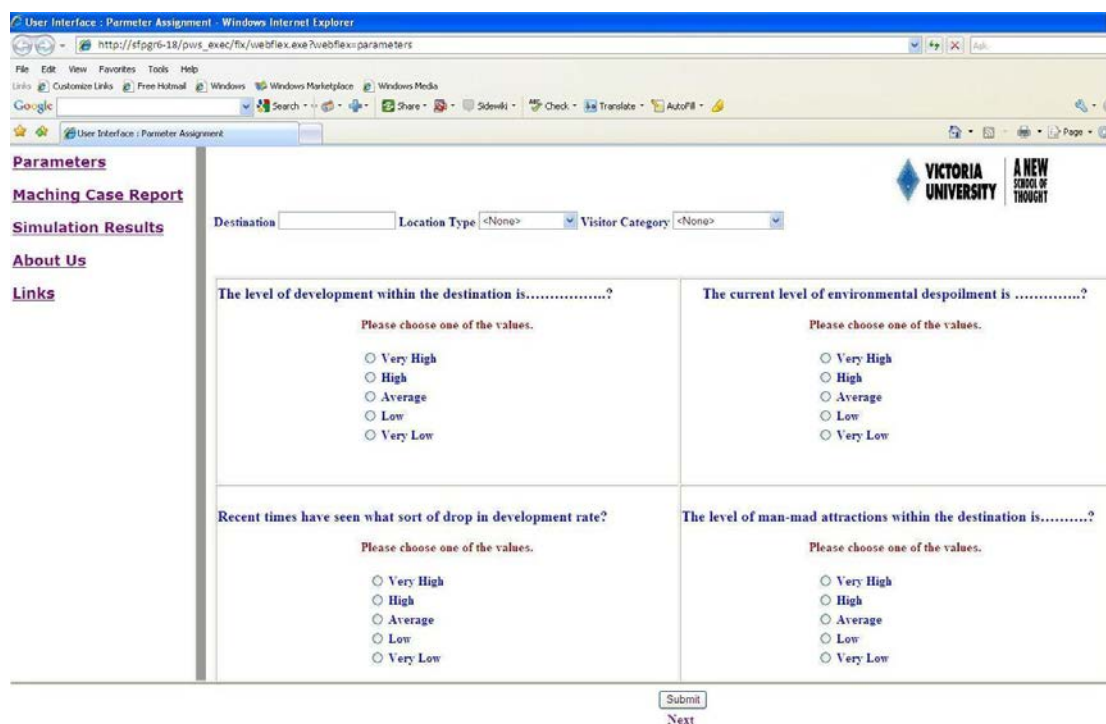
In Section 6.3 the GETS forecasting modules were described: functionality that relies on information captured, structured and classified during benchmarking (see section 6.2). Basically, much of the forecasting process stage involves evaluating tactics, strategies and policy changes aimed at mitigating (or adapting to) the worst impacts of potential, critical problems and issues exposed during GG strategy development. These tactics etc. however, need to be identified and this is accomplished using a combination of rule-based and case-based reasoning.

Development of this GETS component builds upon previous research (Pornphol and McGrath, 2011) aimed at constructing a DSS based upon the ‘Tourism Area Life Cycle’ (TALC). According to TALC theory (Butler, 1980), destinations evolve through a number of stages. Highly-developed destinations tend to experience a number of problems associated with high visitor numbers and over-exploitation of resources (e.g. environmental degradation). At this point, a destination may stagnate and go into decline or it may embark upon a rejuvenation plan. Various heuristics are associated with rejuvenation strategies and these, along with a collection of actual rejuvenation cases, were ported into the GETS *GG Experience Repository* (see Figure

4). As new strategy development exercises are undertaken, new case material is added to the experience repository and existing rules, taxonomies, data structures etc. are modified in light of new knowledge gained. Furthermore, stakeholders in previous destinations where GETS has been used are able to access much of this new knowledge and may also take advantage of a virtual *Collaboration Space* (again, see Figure 4) to discuss latest developments with each other (and also, perhaps, to offer advice relevant to the current roadmap exercise in light of their own post-strategy development experiences). This iterative knowledge evolution process is illustrated in the remainder of this (sub) section.

Adaptation, mitigation and resilience functionality is based largely on a case-based reasoning (CBR) approach. With CBR (Kim, 2004), users are gradually and iteratively guided towards a solution from a range of options (previous cases). Beemer and Gregg (2008) have argued that the case-based approach is more effective than the traditional approach to expert systems development based upon rules elicited from experts. In part, this seems to be due to the fact that users seem to find descriptions of the actual application of successful strategies and methods (i.e. actual cases) more convincing than logic-based justifications of why combinations of rules are correct (Hammond, 1989).

Part of the CBR functionality user interface is presented in Figure 9. Users are required to rate various, key parameters related to the economic, environmental and social health of the destination they are concerned with. Collectively, these parameter assignments define a *new case*. The new case is then compared to existing cases, with a *similarity measure*⁵ being calculated for each of these. Existing cases are then ranked in order of their similarity measures and the user may then access case summaries in turn (normally, of course, starting with the most similar cases). A link at the bottom of the webpage to a complete description of the case is provided (specifically, a copy of the paper cited in the summary).



The screenshot shows a web browser window titled "User Interface : Parameter Assignment - Windows Internet Explorer". The address bar shows the URL "http://stpgb-18/pwv_exec/fix/webfix.exe?webfix=parameters". The browser's menu bar includes File, Edit, View, Favorites, Tools, and Help. The address bar contains a search engine (Google) and various utility icons. The main content area displays a form for parameter assignment. At the top left, there are navigation links: Parameters, Matching Case Report, Simulation Results, About Us, and Links. On the top right, there are logos for Victoria University and A New School of Thought. The form includes a "Destination" text input field, "Location Type" and "Visitor Category" dropdown menus, and four rating questions, each with five radio button options: Very High, High, Average, Low, and Very Low. The questions are: "The level of development within the destination is.....?", "The current level of environmental despoilment is.....?", "Recent times have seen what sort of drop in development rate?", and "The level of man-made attractions within the destination is.....?". At the bottom of the form, there are "Submit" and "Next" buttons.

Figure 9: User interface for CBR functionality.

⁵ Briefly, for each parameter, the distance between the new case and the existing case is calculated. These are then summed and normalized, so that the result is a value between 0 and 1, with higher values indicating greater similarity. It must be noted that measures are dependent on parameter assignments and these, of course, are (with some exceptions) subjective. The key to accuracy is getting input from as wide a range of experts within a destination as possible.

Concerning types of rejuvenation strategies, various tourism researchers have suggested classification schemes and frameworks for these. Choy (1992) divides strategic responses to decline into life-cycle extension and new product development, Cooper (1995) sees the choice of strategic options as being determined by a destination's competitive position in the market place and its life-cycle characteristics, and Agarwal (2002) suggests that common elements across strategies can be classified as either product reorganization or product transformation.

Oft-cited examples of (what so far appear to be) successful rejuvenation attempts include:

- i) The introduction of casinos at Atlantic City (Stansfield, 1978);
- ii) Convention centres and a focus on business events at Brighton and Bridlington in the UK and Boston and Waikiki in the USA (Cooper, 2006);
- iii) New attractions – such as aquaria at Rhyl, Wales and Long Beach, USA (Harmon, 1999) and theme parks and water parks at Acapulco in Mexico and Port Aventura in Spain (Curtis, 1997) – to update tired resorts; and
- iv) Coordinated action by regional and national tourism authorities in Wales (Wales Tourist Board, 2000) and Ireland (Irish Tourist Board, 2001).

Increasingly, rejuvenation strategies appear to have a strong environmental quality enhancement focus (see e.g. Jordan, 2000; Agarwal, 2002; Smith, 2002) and this is precisely why TALC and GG research overlap so much. A very good recent example of a GG strategy development exercise is that undertaken in Sharm El-Sheik (Law et al., 2012), a popular Egyptian diving and water sports resort, with excellent beaches, a coral reef and diverse marine life. Local authorities have determined that, if things continue as they are⁶, the destination will not be sustainable as a tourist resort in the medium-to-long term (Elfrefaie, 2007). Consequently, they have embarked upon an aggressive environmental enhancement initiative consisting of the following 10 'Green Sustaining and Enabling Programs' (Booz, 2009): i) green air access; ii) green energy infrastructure; iii) operational efficiency improvement for hotels; iv) operational efficiency improvement for other buildings; v) green building design; vi) green land transport; vii) green water transport; viii) resilient water supply; ix) effective waste management; and x) conservation of bio-diversity.

These 10 initiative types provide quite a useful framework for classifying cases of rejuvenation actions with an environmental enhancement component. The problem is, however, that the types are not mutually exclusive and are linked to each other in a variety of ways. This complexity is magnified when dealing with specific actions within types, as higher-level relationships may or may not be inherited. Consequently, a reasonably complex ontology is needed to assist in guiding the search for nearest cases when either producing a 'best match' report for a new case or searching for appropriate GG transformation strategies. For a more detailed discussion of this ontology, the reader is referred to Pornphol and McGrath (2011).

The rule-based and CBR approaches though, are by no means incompatible and, in our implementation, we employ rules to supplement CBR similarity matches in our search for the most relevant cases. A more complete account of this has been detailed by Pornphol and McGrath (2011) but one important outcome was the decision table presented in Figure 10. This table was employed as the basis for an initial attempt at the implementation of a module designed to guide users towards the type of rejuvenation strategies that might be appropriate for their destinations. This module was implemented in the Flex expert system shell, with each of the columns in Figure 10 translated into a rule. An actual example of one of our rules (from Column 5) is:

⁶ i.e. with an economy based primarily on low-cost, mass tourism and with relatively poor energy, water and waste management practices.

rule solnCat04a

*if the stagDeclineInd of solnInds is greater than 0.7
 and the economicProblemsInd of solnInds is greater than 0.7
 and the envtSocialProblemsInd of solnInds is greater than 0.7
 and the eSPReversalInd of solnInds is yes
 and the visDropReversalInd of solnInds is yes
 then the productMixChangeInd of solnInds becomes maybe
 and the yieldImproveInd of solnInds becomes easierOptions
 and write('Improving or changing the prod mix may be an option') and nl .*

and, in this instance the rule suggests that, because there may be opportunities to reverse both environmental and social problems and a current drop in visitor numbers, improvement of the current product mix may be the way to go – as distinct from a radical product transformation (specifically, e.g., targeting fewer, higher-yielding visitors seeking an exotic/exclusive location). Note that the ‘x’ reference in the actions section of Figure 10 refers to a rule number.

	Cases									
Conditions	1	2	3	4	5	6	7	8	9	
Stagnation/decline?	n	y	y	y	y	y	y	y	y	
Economic problems?		n	y	y	y	y	y	y	y	
Envt/social problems (esp)?			n	y	y	y	y	y	y	
Esp reversal if vis. no's increase?				n	y	y	y	n	n	
Esp reversal if vis. no's decrease?				y				n	n	
Increase yield if esp reversal?				y						
Current facilities and products poor?					y	n	y/n	n	n	
High seasonality?							y	n	n	
Economic alternatives to tourism?								y	n	
Actions										
NFA	x (1a)									
Warning signs - take care		x (2a)								
Product transformation - move to exotic/exclusive				x (5)						
Product reorganisation - improve current product mix			x (3b)		x (4a, 6)					
Product reorganisation - add to current product mix						x (4a, 6a)				
Decrease seasonality via product reorganisation							x (6c)			
Move to tourism alternatives								x (6d)		
?????									x (6e)	

Figure 10: Decision table for DSS GG strategy rule derivation.

The arguments of this rule are compound variables derived from 16 parameter values, input by users and related to destination economic, environmental and social health. The actual parameters are *Location Type, Visitor Category, Destination Development, Development Rate Drop, Environment Despoilment, Man-Made Attractions Level, Man-Made Attractions State, Heritage Attractions State, Tourism Alternatives Level, Seasonality, Crime, Vandalism, Visitor Antipathy, Disruption, Access Denial, Character Incompatibility, Lost Opportunity Cost, Visitor Numbers, Visitor Numbers Drop, Visitor Yield, Business Visitors, Profitability, Profitability Drop, Closures, Ownership Turnover and Facilities Standard*. These variables were derived from work done on evaluating tourism event success by Fredline, Deery and Jago (2006).

It is demonstrated that, as the DSS evolves through a number of cycles (each cycle being the result of DSS application to a new destination), our knowledge of the GG strategy development

domain is enhanced and refined in much the same way as would occur with a more conventional case study approach.

7 Demonstration and Evaluation

These two phases are closely related. According to Peffers et al. (2007-08, p54), demonstration involves:

“---use of the artifact to solve one or more instances of the problem.”

while evaluation:

“---involves comparing the objectives of a solution to actual observed results from the use of the artifact in the demonstration.----At the end of this activity the researchers can decide to iterate back to step three to try to improve the effectiveness of the artifact or to continue on to communication.”

Over the past six years, GETS has been successfully employed to assist with GG strategy development in the field at two locations, Sharm El-Sheik, Egypt and Bali, Indonesia. Each of these exercises was undertaken as a research case study, the details of which (including use of the DSS) have been reported by Law et al. (2012), Lipman et al. (2012), Lipman et al. (2013), DeLacy, Jiang, Lipman and Vorster (2014) and McGrath et al. (2015). During and after each of these studies, additional functionality was added to the system.

This was done without the need to undertake extensive modifications of existing system applications, thereby demonstrating the realization of a number of key objectives detailed in Section 6: namely, convenient maintenance, knowledge sharing between applications and studies, and reuse of functionality. It is anticipated that the DSS will be extended further during proposed strategy development exercises in China (Qiqihar province), Australia (Alpine Shire, Victoria) and Belgium (Genk) to be undertaken during the period 2016-18 (DeLacy et al., 2015).

In a related, further important initiative, GETS is the key software component of “The Sun Program”, launched in December 2015 by Greenerth Travel (Tjolle, 2015). This is a global initiative designed to help Travel & Tourism destinations develop through sustainable Green Growth. Aligned with the post-2015 climate and sustainability agenda, SUN helps communities achieve climate resilience, the Sustainable Development Goals (SDGs) and emergency responses (to climate-induced and other disasters). Linking dedicated solar powered SUN-ARKS, through the internet cloud and manned by trained local post-graduates, each SUN-ARK is compact, efficient and low cost and facilitates the engagement of public, private, academic and civil society partners in market-responsive, inclusionary, long term change.

SUN's single goal is to help communities and their stakeholders move along the Green Growth and Travelism adaptation path, including: i) understanding the system dynamics and focusing on targets; ii) monitoring numbers and analytics; iii) helping local policy makers/stakeholders stay on track; iv) seeking out and building upon replicable good practice, innovation and investment cases; v) linking local culture with Green Growth and Climate Resilience; and vi) serving as a focal point for response to emergencies

It is intended that the GETS model will be available to destinations joining the ‘SUN-ARK Community’. The first SUN-ARK was announced for April 2016 in Limburg in Belgium as part of the National Park Climate Response, Science Project in conjunction with the University of Hasselt and Victoria University Melbourne.

8 Communication

The task here (Peffers et al., 2007-08: 55) is to:

“Communicate the problem and its importance, the artifact, its utility and novelty, the rigor of its design, and its effectiveness to researchers and other relevant audiences.”

As detailed in the previous section, the GETS DSS has been discussed in a number of scholarly papers over recent years (specifically Law et al., 2012; McGrath et al., 2012; McGrath et al., 2015). It is anticipated that further papers will flow from the case studies detailed in Section 7. These may well focus on additional functionality to be built during these studies and consequent issues of knowledge sharing, knowledge reuse and system maintenance, modification and enhancement.

9 Conclusion

We have described the construction of a GG strategy development DSS using a classical design science approach. While it is now close to six years since system construction commenced, the system continues to undergo major modification and enhancement, particularly on the occasions it has been used to support major strategic planning exercises in the field. Significantly, to date, enhancements have been accomplished without the need to make major changes to existing code or schemas, thereby providing some evidence that reuse and maintenance objectives have been realized. Furthermore, application modules have been developed using system dynamics, rule-based expert systems, CBR, *Prolog* and *Excel* platforms, with data being shared between all modules in a way that is invisible to users. Thus, seamless integration and data sharing objectives have been realized as well.

With each new strategic planning exercise, the DSS knowledge repository has grown, with the addition of new cases (and supporting case material) constituting a particularly valuable practitioner and researcher resource. Thus, it is probably fair to say that the DSS now has value beyond its original purpose (i.e. supporting the production of individual, destination-specific, GG strategy roadmaps see Section 4). We believe that integration into the SUN Program will provide a clear development trajectory to help communities better meet their post-2015 Agenda targets (SDG and Climate) through GG and travelism.

With design science, the problem statement drives objectives and system design. The fact that, with time, use of a system does not entirely match its specified, formal problem statement does not invalidate its design and construction. Rather, Carlsson and Turban (2002) have identified the issue of designing DSS for flexible use, through separation of data and application processes, as one of four main areas urgently in need of design science research. This, outside of any tourism domain-specific significance, constitutes the major contribution of our research.

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