

Decision Support For The Development Of Green Growth Tourism Strategies: Managing Complexity

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ABSTRACT:

The term 'green growth' refers to a system whereby material wealth is realized with due regard to environmental and social factors. Development of appropriate green growth policies is a complex task and, consequently, decision support technologies can be used to advantage here. The design and use of one such tourism destination decision support system is described in this paper. Key features of the system are that it facilitates the effective management of the inherent complexity of the analysis domain and allows iterative development with minimum impact on previous versions.

Keywords: *Decision support, Green growth, Tourism, Managing complexity*

1. Introduction

An increasing number of tourism destinations have investigated the adoption of 'green' strategies as a means of addressing a variety of critical issues (Scott et al., 2008). These include: i) climate change; ii) severe environmental and social problems such as pollution, critical energy, water and land shortages, acute traffic congestion and rising unemployment and crime rates; iii) the need to rejuvenate destinations that have reached the decline stage of their life-cycles; and iv) an apparent willingness on the part of visitors to pay a premium where sound environmental practices are employed (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 of data be analysed. 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 (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 (DSSs) can be used to advantage in evaluating the possible impacts of proposed strategies. This assumes, however, that required data can be captured, organized and accessed conveniently. Moreover, given that an iterative approach is required for DSS development and maintenance (because of the need to apply the software sequentially in a range of

destinations), the system design must allow for convenient modification with minimum impact on previous versions.

In this paper, the design and application of a DSS that meets these requirements is detailed. The system is called *GETS (Green Economy Tourism System)* and, to date, it has been applied in the field in separate studies at two locations; Sharm El Sheik in Egypt and Bali, Indonesia. For a detailed description of the Sharm El Sheik study, the reader is referred to (Law et al, 2011). This paper is more conceptual and technical, with a focus on the system features that permit iterative development, low-impact maintenance and information-sharing. In particular, the importance of data abstraction (Feldman and Miller, 1986) and the use of the ISO 3-schema architecture (van Griethuysen, 1982) are highlighted.

The paper is organized as follows: some necessary background is presented in the following section. The research approach is then overviewed and this is followed by a discussion of the system architecture and the framework employed to integrate system models at different levels of detail. The Bali case study is then introduced and examples of how different GETS components share data and utilize previously-developed functionality are outlined. The final section contains concluding remarks.

2. Background

2.1. Green Growth Tourism

Currently, tourism is estimated to contribute around 5% to the world's total anthropogenic greenhouse gas (GHG) emissions (Scott et al., 2008; WEF, 2009). Worse still, estimates show that tourism's GHG emissions could grow by 161% by 2035 in a 'business as usual' scenario (Scott, et al., 2008). In the context of global decarbonisation trends, such estimates highlight the need for climate change mitigation and adaptation in the tourism sector and emphasise the need to adopt a more sustainable path.

Of course, all industry sectors (and society in general) stand to be impacted substantially by climate change (UNEP, 2010). However, tourism faces some unique challenges and must contend with a number of specific factors and variables. These include:

- ❖ Tourism is highly energy-intensive which, as noted above, strongly suggests that action be taken to minimize GHG emissions.
- ❖ Gossling (2005) asserts that direct water use in tourism varies substantially, ranging between 100-2,000 litres per guest night. High water usage tends to be in resort-style hotels and, in particular, those with golf courses.
- ❖ Tourists tend to generate more waste than the population at large (see e.g. Hamele and Eckhardt, 2006). UNEP (2010) estimate that higher rates of waste recycling and recovery could reduce global net waste disposal by 57 million tonnes by 2050.

- ❖ Among visitors, destination choice is increasingly being influenced by green growth commitment. For example, according to a *TripAdvisor* survey, 38% of travellers stated that environmentally-friendly tourism influenced their choice of destination, 38% had stayed at an environmentally-friendly hotel and 34% were willing to pay more to stay in these (Hawkins and Bohdanowicz, 2011). While the precise economic benefits that result from destination commitment to green growth and sustainability are difficult to quantify at this point, there is an increasing body of evidenced that suggests that the phenomenon does indeed exist (see e.g. Naidoo and Adamowickz, 2005).

Furthermore, green growth tourism planning is a complex process, characterized by high levels of uncertainty. For targeted adaptation strategies, the relationships and interdependencies between the green economy drivers must be understood. However, a planning framework (of this type) for a green economy transition in tourism destinations does not currently exist. In addition, the domain is extremely complex, making strategy development even more difficult. We turn our attention to this important aspect in the following (sub) sections.

2.2. Domain Complexity

The green growth tourism domain is extremely complex. Reasons include:

- ❖ A large number of variables must be considered. These encompass the economic, environmental and social dimensions, and interactions between variables (within and between dimensions) need to be taken into account.
- ❖ The problem domain is ‘messy’, defined by Vennix (1996) as characterized by complexity, uncertainty, interrelated sub-problems, recursive dependencies and multiple interpretations of the problem’s essence.
- ❖ Strategic, scenario planning must be supported by a substantial volume of data, all of which needs to be modelled, captured, structured and stored in a way in which it can be conveniently retrieved and utilized.
- ❖ There are substantial differences between destinations in terms of their size. These range from global regions to small, local areas. Hence, it is imperative that the DSS is ‘scaleable’ – a non-trivial issue (Mueller et al., 2009).

We now turn our attention to the issue of managing this domain complexity in the design and development of the GETS DSS.

3. Managing Complexity In IS Design And Development

The information systems (IS) field is not primarily about the production of computer software: it is about the modelling and analysis of the processes, functions and data that are of relevance in whatever domain is of interest (DeMarco, 1978). From the origins of the very first modern IS (circa 1960s), these ‘domains of interest’ have become increasingly complex.

Most approaches to managing complexity in IS design and development rely to some extent on *modularization* – i.e. breaking down a problem into more manageable subparts. Serious attempts at specifying rigorous and systematic methods for accomplishing this were reported as early as the 1960s (see e.g. Dijkstra, 1968). *Functional decomposition* and *data flow diagrams* (DeMarco, 1978) proved to be particularly popular methods for breaking down processes into smaller units and remain so to this day. On the data side, *abstraction* and *generalization* (Feldman and Miller, 1986) have been put forward as one approach to decomposing *entity-relationship diagrams* (Chen, 1976) and, more recently, *object-oriented* techniques allow data and processes to be broken down and levelled as a unified whole.

Reference was made earlier to the holistic nature of the tourism domain and the importance of taking a systemic approach to the analysis of any combination of variables. *System dynamics (SD)* (Maani and Cavana, 2000) is very well-suited to this task and many (but not all) GETS models have been specified and implemented using SD techniques and software packages. The mapping approach outlined later in this paper facilitates decomposition of GETS SD modules. There are a number of examples of where SD has been used effectively in the tourism domain, an excellent example being the destination management simulation package developed by Walker et al. (1999).

The degree of complexity of a given problem domain will correspond (roughly) exponentially with the number of variables involved and, as noted, the green tourism domain is extremely complex. Management of this complexity is, of course, the central issue to be addressed in the remainder of this paper. Before that, however, we briefly introduce our research approach.

4. Research Approach: Summary

The following is a brief summary of the research approach, which is based on the idea that development of an IS may, in certain circumstances, be considered a legitimate research strategy in its own right. A more complete account is presented in (Pornphol and McGrath, 2012) and that account, in turn, borrows heavily from earlier work by Hasan (2003).

Hasan (2003: 4) claims that IS development, in many cases, should be considered a valid research activity (and method) because, not only is knowledge created about the development process itself, but also because “a deeper understanding emerges about the organizational problem that the system is designed to solve”. Markus et al. (2002) put forward a similar case in arguing that IS development is a particular instance of an *emergent knowledge process (EKP)* and that this constitutes original research where requirements elicitation, design and implementation are original and generate new knowledge on *how to proactively manage data and information in complex situations*. Hasan (2003: 6) further contends that this often involves a staged approach, where “systems evolve through a series of prototypes” with results of each stage informing requirements for the next and subsequent iterations.

Nunamaker et al. (1991) take an approach consistent with the above but draw on an alternative research tradition in case studies and, in particular, action research. Again, using ‘replication’ strategies, each new instance (case or action research activity) builds upon and refines knowledge gleaned from previous studies (Yin, 1994). Nunamaker et al. (op cit.), go on to note that IS development is enabled by the uniqueness of the technology employed (which can, as a tool, mediate knowledge generation and the communication of same).

This feature has been studied extensively by scholars in ‘activity theory’. Notably, activity theorists emphasize the holistic nature of the IS development process and, in particular, the critical nature of the cultural and social context within which systems are developed (Nardi, 1996). The socio-technical view of IS, where hardware, software, people and processes are integrated into a complex, purposeful whole, is one of the key features that make information and communication technologies “like no other in the history of mankind” (Hasan, 2003: 4).

Thus, to summarize: the development of our DSS is a legitimate research activity in its own right, which draws on the more established, traditional research approaches of the design sciences and especially case study/action research. Each new application of the DSS (e.g. to a new destination) produces a new version of our prototype and extends our knowledge of the green tourism economy research domain. This is akin to employing a multi-case (study) research strategy - with each new case refining and extending results of previous iterations - and finally, many research findings and outputs are actually inherent in the various conceptual models (and implementations of these) that constitute the DSS.

5. System Architecture

The key to managing complexity within GETS is the system architecture employed, a high-level view of which is presented in Figure 1. A fundamental objective of the GETS project is to produce a system that is iterative, scalable and open, *Iterative* (in this instance) means that each application (e.g. to a new destination or aspect of a destination) produces a new prototype that increases or refines our knowledge of the green economy domain; *scalable* means that the system must be able to cope equally effectively with large and small destinations; and *open* means that GETS must be capable of handling any type of data, irrespective of source or format.

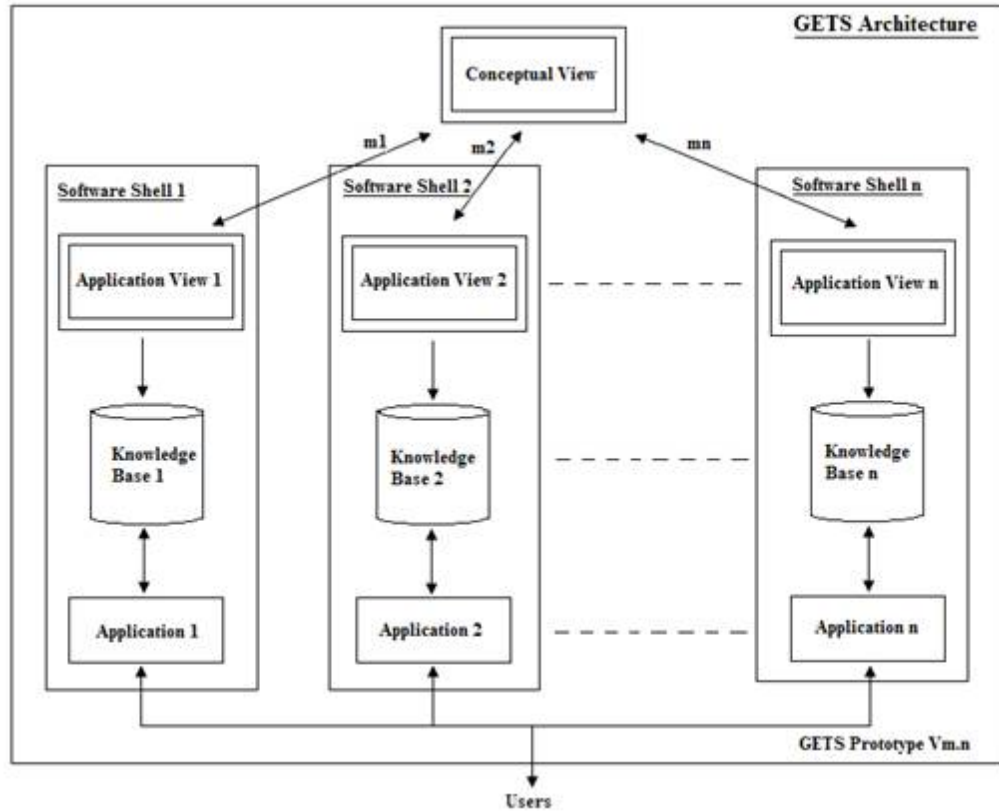


Figure 1: GETS Architecture – High-Level View.

One of the keys to realizing both an iterative and a scalable system is developing all code (and higher-order applications) around abstracted data models. Essentially, the aim is to allow new functionality to be added (e.g. as issues associated with a new destination introduce new system requirements) without having to revise existing applications.

The open systems objective is realized by adopting a design for GETS consistent with ISO '3-Schema Architecture' principles (van Griethuysen, 1982). With this approach, the *Conceptual View* is a highly abstracted model of the total system, completely free of any implementation-level detail. *Application View 1*, ..., *Application View n* are external-level schemas developed for individual applications, implemented within specific software shells (*Software Shell 1*, ..., *Software Shell n*). Examples of these (used in applications implemented to date) are *Excel*TM, *Access*TM, a rule-based expert systems shell called *Flex*TM and the system dynamics simulator, *PowerSim*TM.

The *conceptual model* defines the objects of the 'Universe of Discourse', including rules governing allowable classifications, states, transitions and constraints (van Griethuysen, 1982). An illustration of part of the conceptual model is presented in Figure 2. The model is represented in entity-relationship form (Chen, 1976), it is highly abstracted and consists only of the core domain constructs, without any peripheral or presentation-level detail. The entity-relationship approach was employed

largely because the principal motivation for Chen's (op cit.) research was to produce a conceptual modelling approach that allows a unified view of data.

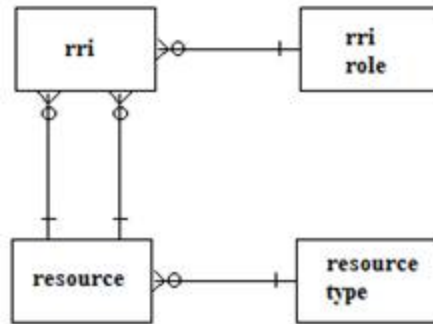


Figure 2: Conceptual Model (Partial).

Implemented as a relational database application, the intersecting entity, *rri* (*resource-resource involvement*), would translate to something like the *Access*TM table presented in Figure 3. This table details some of the important subtype relationships that need to be captured. In this case, *energy* is specified as a *resource* subtype, *energy* may be decomposed further into *airTransportEnergy*, *accmdnEnergy*, *attractionEnergy* and *activityEnergy* and these, in turn, may be broken down even further (as illustrated in Figure 3).

rri : Table				
	mild	resType1	resType2	rriRole
	22	resource	energy	subtype
	23	energy	airTransportEnergy	subtype
	24	energy	accmdnEnergy	subtype
	25	energy	attractionEnergy	subtype
	26	energy	activityEnergy	subtype
	27	accmdnEnergy	hotelEnergy	subtype
	28	accmdnEnergy	motelEnergy	subtype
	29	accmdnEnergy	bedAndBEnergy	subtype
	30	hotelEnergy	airConEnergy	subtype
	31	hotelEnergy	lightingEnergy	subtype
	32	hotelEnergy	appliancesEnergy	subtype
	33	hotelEnergy	transportEnergy	subtype
	(AutoNumber)			

Figure 3: Access Implementation Of rri Conceptual Model Relationship.

Representing the conceptual model in an abstracted form produces a number of benefits, including: i) where appropriate, common functionality may be coded around the abstracted view, leading to a reduction in system development effort; ii) integration of DSS applications, developed around external views, is facilitated because core data types are all mapped back to the common conceptual view (model); iii) better integration means that functionality may be more conveniently shared between

applications (which also means less coding effort); and iv) ongoing system maintenance is reduced (again resulting in a reduction of total development effort).

An external model or user view is a mapping from all or part of a conceptual model to a language or representational form of the user's choosing (van Griethuysen, 1982). In addition, it must be possible to map in the reverse direction: i.e. from external to conceptual model. As noted, a number of key GETS functions are implemented as external components using SD and, specifically, the SD product Powersim™ (2003). We shall now illustrate the mapping process and provide an example of an external model/application through the example presented in Figure 4 below.

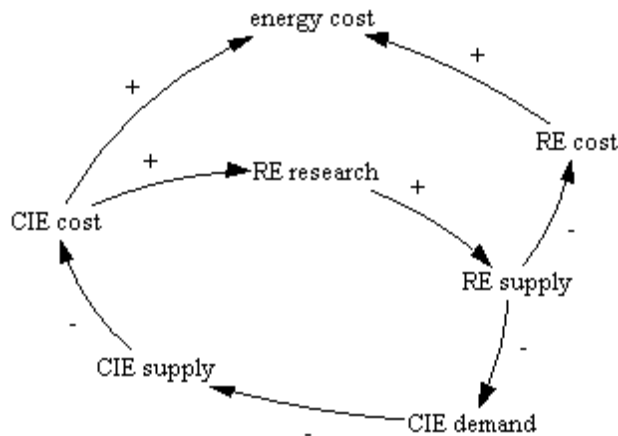


Figure 4: Energy Usage External Application Model (Partial).

Figure 4 is represented in 'causal-loop diagram' (CLD) form. For a detailed introduction to CLDs, the reader is referred to Manni and Cavana (2000) but, in their simplest form, only one modeling construct is employed; an arrow connecting two domain variables, indicating a causal connection between them. Arrows are generally annotated with either a '+' or '-'; a '+' symbol meaning that both variables move in the same direction (i.e. increase or decrease together) and a '-' symbol meaning that the variables move in opposite directions. Generally, when developing a SD model though, the customary method is to firstly specify it in CLD form and then to translate it to the more complex *stock-flow* form used by commercial SD software products.

Within a green economy context, a distinction needs to be made between traditional *carbon-intensive energy (CIE)* (oil, coal and natural gas) and *renewable energy (RE)* (hydro, wind, biomass, waste etc.) sources. Obviously, the total *energy cost* is dependent on the respective CIE and RE costs. If the *CIE cost* is high though, it is likely that more will be invested in *RE research* and this, in turn, should increase the *RE supply*. If the *RE supply* is high the *CIE demand* may drop, thus placing less pressure on *CIE supply* and, finally, without this supply pressure, the *CIE cost* should be less. This, of course, is the rough basis for the various carbon pricing and taxing schemes being introduced in many countries throughout the world (see e.g. Callan et al., 2009).

Part of the SD external application's model dealing with this particular set of relationships is presented in Figure 5. Specifically, this is a Powersim™ model and a major reason for converting the CLD to this particular form is to take advantage of the package's powerful simulation and scenario generation/evaluation capabilities.

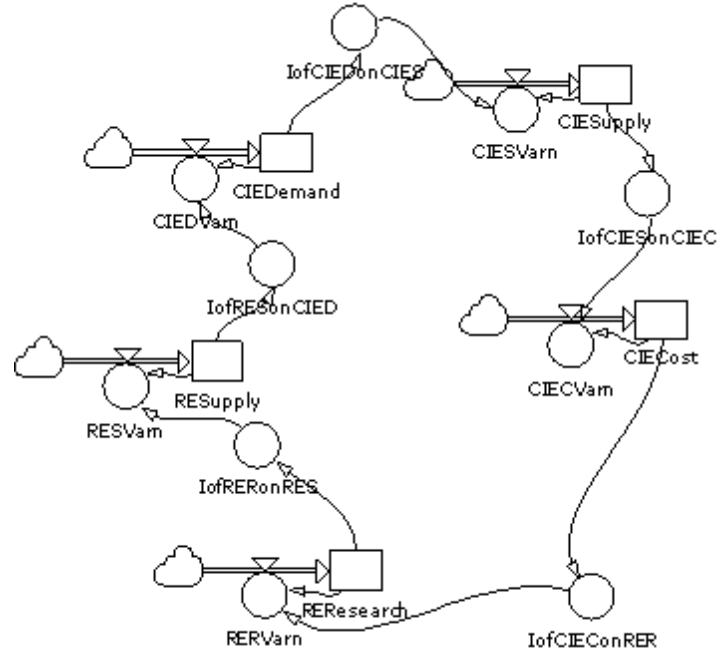


Figure 5: Stock-Flow Representation Of Figure 3 CLD (Partial).

The basic building blocks of SD (stock-flow) models are *stocks* (represented as rectangles), *flows* (represented as arrows with circular flow regulators attached), *converters* (represented as circles) and *constants* (represented as diamonds). In our model, examples of stocks are *RECost* and *CIEDemand*. There is a level associated with each stock, which can be an actual value or a value bounded by some artificial scale. Stock levels vary with flows, which may be *inflows*, *outflows* or *bidirectional*. For example, *CIEDVarn* (CIE demand variation) is a bidirectional flow such that:

$$CIEDemand_t = f(CIEDemand_{t-1}, CIEDVarn_t)$$

That is, in our model, the CIE demand level at time, t , is a function (f) of the CIE demand level at time, $t-1$, and its variation at time, t . These equations are the foundation of Powersim's formidable simulation capabilities. Moreover, values of each model variable at each simulation time-step may be captured and stored as instances of yet another *rri* subtype, with the general form:

$$rri(RRId, RT_s, RT_e, timeChange)$$

and this data may then be used in other external applications. An example is presented in the following section.

6 (Mini) Case Study: A Green Growth Road Map For Bali

The case study is concerned with a recent research/consultancy exercise conducted by Victoria University's Centre for Tourism and Services research (CTSR) with Indonesian government authorities on the island of Bali, Indonesia. The study was conducted during the latter part of 2011 and the major output was the 'green growth roadmap' detailed in (Lipman et al., 2011).

Bali is an extremely popular tourism destination, and, on the surface, its future looks bright with, between 2011 and 2020: i) annual visitor numbers expected to increase from 7.1 to 14.4 million (Turner, 2011); ii) annual tourism GDP predicted to increase from \$US2.95 billion to \$US5.38 billion (Hoque, 2011); and iii) tourism-related employment demand forecast to increase from 1.1 million to 2.0 million (Hoque, 2011).

While the economic future looks extremely bright, the anticipated rapid growth is not, however, without its downside. The more significant potential problems and issues identified include traffic congestion, excessive and unsightly waste and pollution, inadequate roads and infrastructure and major environmental damage (Filep, 2011). Consequently, the green growth roadmap emphasized minimizing negative environmental impacts by attracting fewer tourists willing to pay more (i.e. increasing visitor yield).

This objective is encapsulated in the CLD presented in Figure 6, where (at the top of the diagram) it can be seen that an improvement in *environment quality* can reasonably be expected to result in an increase in *visitor goodwill* (Hawkins and Bohdanowicz, 2011) and this, in turn, should allow tourism operators to increase *prices*, resulting in both an increase in *visitor yield* and a drop in *visitors*.

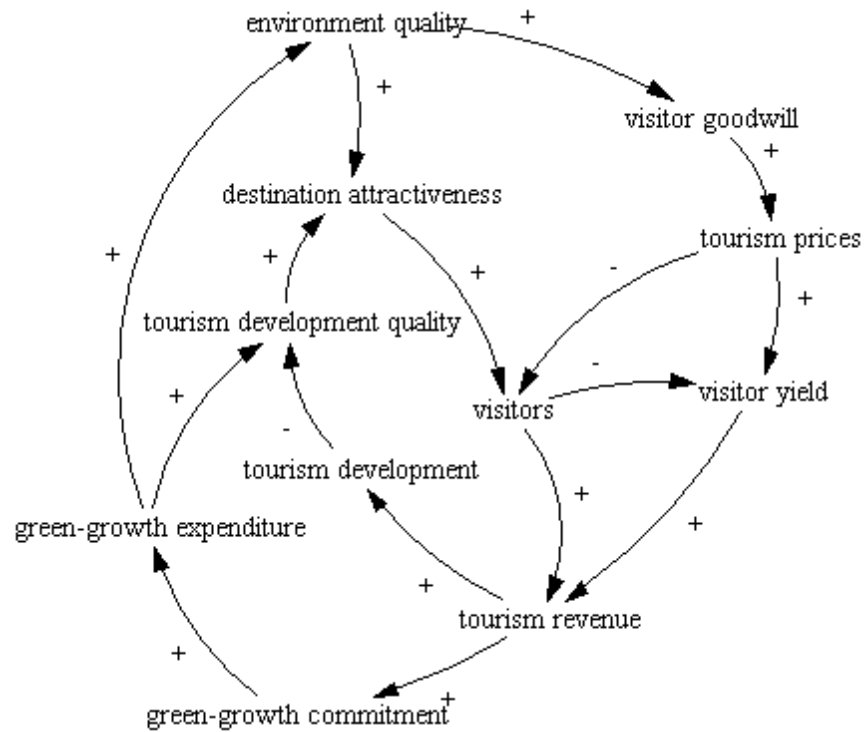


Figure 6: Some Key Relationships In Increasing Visitor Yield.

The roadmap identifies many environmental-improvement strategies, one of which is: “Based on the open space plan, establish more protected areas, having strong development controls and recognizing a minimum forest cover of 30%” (Lipman et al., 2011: 38). The (somewhat simplified) core of the external DSS application dealing with land use is illustrated in Figure 7. It shows that, over time, forest (and wilderness) land is claimed for agricultural and farming purposes and this land, in turn, may be converted into settlement land. Deforestation and settlement land increase rates determine the speeds at which these land conversions occur and a reforestation rate represents efforts to reclaim lost forests through replanting programs. Finally, some agricultural land is lost to desert forever (because of drought, over-harvesting, water stress, climate change etc.) and this is represented by the agricultural land – productive land losses transition.

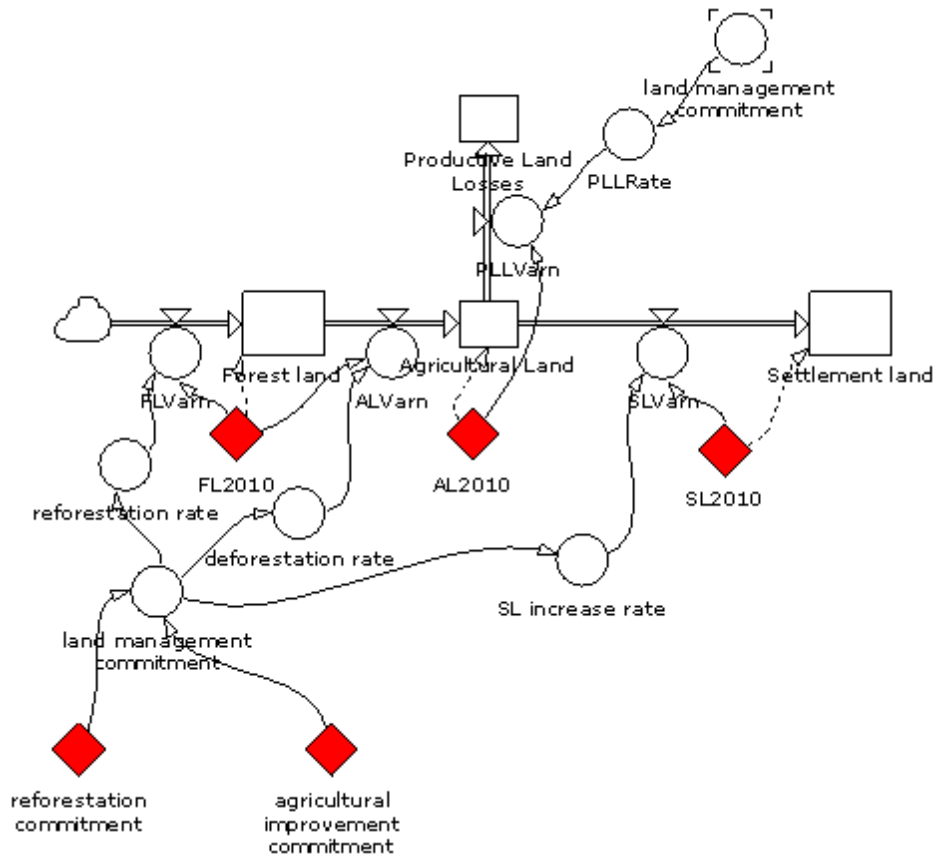


Figure 7: Land Use External Application (Partial).

An initial, generic version of the application was implemented using data derived from (UNEP, 2010). This version simulates changes in global land categories between 2010 and 2050 and, under a 'business-as-usual' scenario, the simulation suggests that the total global forest area will drop from 3,940 million hectares (Mha) to 3,700Mha during this period. However, under a 'green' scenario' (with the equivalent of 2% of global GDP invested in various green and climate change mitigation initiatives) total forest land is actually expected to increase to 4,500Mha.

This model was then customized for Bali. Overall, forest degradation in Indonesia has been recognized as a major problem for some time, with 40% of total forest area having been cleared between 1950-2000 (a drop from 162Mha to 92Mha) and an apparent, recent (i.e. from the mid-1990s) acceleration in the forest loss rate to around 2Mha/year (WRI, 1998). There is general agreement that, while Bali forests only comprise around 0.1% of the national total, past and current degradation rates are consistent with the national experience (at around 2.5%/year). This figure was used for the deforestation rate in the customized model, along with the most recent data that could be found for other model variables (specifically, BPS, 2010: 193-198). This resulted in forest, agricultural and settlement land stocks being initialized with values corresponding (respectively) to 22.3%, 63.2% and 14.5% of the land total. Obviously, the region has some way to go if it is to realize the 30% forest cover objective specified in the roadmap.

There is probably a good chance that efforts to reverse the current very high rate of forest losses in Indonesia would be received favourably by future visitors to Bali. This issue is of such importance to the realization of the roadmap's broad objectives that it was decided that it warrants a dedicated external application in its own right. Since this application though, is required to advise on actions and strategies, a rule-based, advisory expert system platform was considered to be a more suitable platform (than SD) in this case.

First, however, the new application requires land area trend data generated by the SD application discussed above and the abstracted conceptual model provides the basic framework for this transfer. That is, the SD application simulation produces streams of trend data on variations of areas of each land category over time and these are all specific instances of the *rri* subtype with the *timeChange* involvement role introduced earlier.

A decision tree example, related to whether action to remedy predicted deforestation at some future time, *t*, is required is presented in Figure 8.

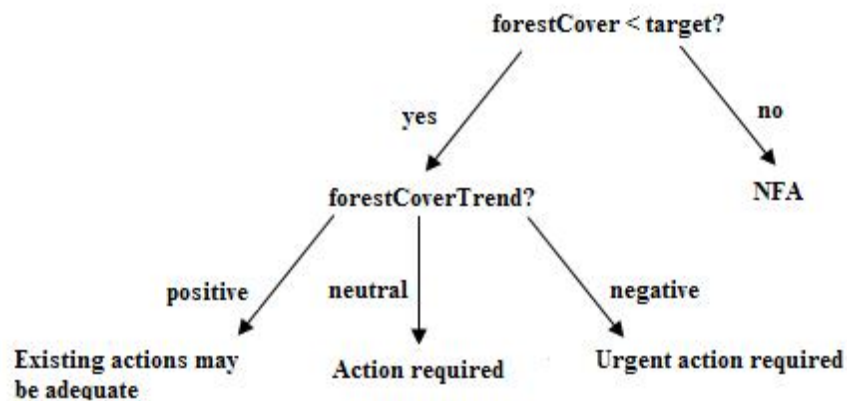


Figure 8: Decision Tree For Deforestation Mitigation Necessity Rules.

An example of a typical rule extracted from this representation is:

```

if forestCovert < targetForestCover
  and forestCoverTrendt is negative
  then advise 'Urgent action required at time t'
  
```

and the underlying *Prolog* code (utilizing *rri* data generated by the SD application) required to determine if the forest cover trend is negative is:

```

forestCoverTrendt is negative if
  rri(RRId, FCt-1, FCt, timeChange) and
  resourceType(RRId, forestLand) and
  t - t-1 is 1 year and
  FCt < FCt-1.
  
```

Digging a little deeper, inappropriate forest land use and allocation decisions are a major cause of current problems and, as an example, the WRI (1998) has reported that, in 75% of cases where forest land has been allocated for clearing and replanting, this has never taken place. This underpins one application rule which advises the user to explore ways in which dormant land in this category might be freed up for its original purpose (i.e. for use as an industrial timber plantation).

This is only possible after forest land has been classified consistent with the schema presented in Figure 9. This is a conceptual-level specification and, as such, outputs from this particular external application can be transmitted to further applications which might require this data. Thus, in this example, we have demonstrated how external applications may both generate data for, and utilize data from, other applications (developed using different software platforms) and that it is, primarily, the abstracted, conceptual data view that makes this possible.

rriId	resType1	resType2	rriRole
22	resource	land	subtype
23	land	forestLand	subtype
24	forestLand	clearedForestLand	subtype
25	clearedForestLand	loggingLand	subtype
26	loggingLand	plantationLand	subtype
27	plantationLand	replantedLand	subtype
28	clearedForestLand	agriculturalLand	subtype
29	forestLand	otherLostLand	subtype
(AutoNumber)			

Figure 9: Further rri Subtypes – Forest Land.

7. Conclusion

Green growth strategy development is a highly-complex process, demanding that a wide range and considerable volume of data be captured, structured and analysed. Furthermore, depending on the objectives of different aspects of policy development, certain information modelling and analysis methods may be more appropriate than others: i.e. a ‘horses for courses’ approach is required when developing specific decision support applications.

At the same time, whatever methods and software platforms are employed in developing various system components, the overall strategy development domain is so tightly integrated that some mechanism is required to allow information-sharing between applications. In our DSS, this is realized through the use of an abstracted conceptual model and a system design based on the ISO 3-schema architecture. Examples of data sharing between external applications developed using the rule-based expert systems and SD paradigms (approaches that, on the surface, appear to have little in common) were presented and discussed.

Finally, parallels between DSS development and case study research were emphasized: in particular, it was noted that each new external application added to the DSS extends our knowledge of the overall study domain in much the same way as new cases build upon and refine previous iterations in multi-case study research. Thus, the version of the DSS described in this paper, the result of an initial system specification and two subsequent field applications, represents the beginning, rather than the end, of this particular green growth tourism strategy research project.

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