A MULTI-PARTICIPANT SPATIAL DECISION SUPPORT SYSTEM FOR PLANNING TOURISM-RELATED LAND USE CHANGE IN SMALL ISLAND STATES

by

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Abstract

Strategic land use issues are typically complex and non-routine decision problems that require consideration of several, and often conflicting, viewpoints, objectives and possible solution strategies. Although GIS can provide important capabilities for manipulating and displaying spatial data, they lack the capabilities required to assist multiple decision makers to craft consensual land development strategies. Interest has grown in recent years in addressing this shortcoming by coupling GIS with the subjective evaluation and multi-participant capabilities of multi-criteria analysis (MCA) techniques.

This thesis presents a methodology based on integrating selected GIS and MCA functionality within a Spatial Decision Support System (SDSS) that is designed for land use and tourism planning in small island states (SIS). Tourism has become an increasingly important economic activity in many tropical SIS that, in the absence of careful and widely-considered planning, can contribute to uncoordinated and conflict-laden patterns of land use and resource utilisation. Based on a conceptualisation of the linkages between land use planning and tourism planning in SIS, a multi-participant SDSS is developed for the task of identifying potential locations for tourist accommodation and evaluating the suitability of these sites according to differentially weighted evaluation criteria. A small sample of participants with diverse interests in land use and tourism planning issues apply this tool to a specific case study in West Bay District of Grand Cayman, British West Indies. The results of the case study and *post hoc* extensions of this research are presented with particular attention given to the degree of consensus in the participants' site rankings and the robustness of the results relative to changes in criteria weights and MCA method. Several suggestions for future research are offered based on the case study findings.

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The initial prototype of the decision support tool used in the field research was one of four such tools developed under the auspices of an International Development Research Council (IDRC) project awarded to Brent Hall and Dr. Arthur Conning of the United Nations Demographic Centre in Santiago, Chile. Both Arthur Conning and Serge Poulard deserve my thanks for their hospitality in Santiago. A wonderful sense of camaraderie developed among the members of the Waterloo contingent of the project which included Gunnar Hillgartner and Dr. Robert Bowerman. I would like to thank Bob in particular for answering what must have seemed like an endless stream of programming queries and, more importantly, for his friendship.

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Chapter One

INTRODUCTION

Geographic Information Systems (GIS) are routinely used as tools for organising, manipulating, and displaying spatial data pertinent to many local and regional planning activities. The substantial human, technical, and financial investments that these systems demand is justified most frequently with reference to improved access to critical data, greater efficiency in performing both standard and specialised tasks, and enhanced analytical capabilities. Collectively, these benefits are assumed or asserted to lead to improved decision-making capacity within the planning arena.

Experience to date suggests that the contributions of commercial GIS to the strategic level of decision-making appear to be modest, relative to their costs in time, commitment and capital outlay. However, recent advances in the technology suggest that greater modularization of software and advancements in ease-of-use will allow returns on investment to be realised more expeditiously and with greater end-use utility. In response to the difficulties that many non-expert computer users have experienced in operating monolithic GIS software packages, customised spatial decision support systems (SDSS) have been developed to provide easy-to-use spatial analysis and information management capabilities suitable for specialised problem contexts or domains. As their name suggests, these systems are designed to *support* decision-makers in applying computer information processing capabilities in concert with their own judgement to the resolution of difficult problems.

A major weakness of almost all GIS and SDSS development to date has been the focus on supporting a single decision-making perspective. Strategic-level planning issues are typically complex, poorly-defined, and involve a number of individuals or groups of varying authority and viewpoints in the decision-making process. Consequently, resolution of these issues involves exploration and evaluation of several, often conflicting, possible solution strategies in light of multiple objectives and multiple perspectives.

This thesis describes the development and application of a GIS-based multi-participant approach to strategic-level planning decision making. The technical and substantive aspects of this approach focus upon the construction of a multi-participant spatial decision support system (MP-SDSS) that integrates selected GIS functionality with multi-criteria analysis (MCA) methods to allow planning participants to identify feasible sites for specific land use activities and to evaluate the suitability of these alternatives according to diverse, and inherently subjective, judgement criteria.

The approach to multi-participant decision-making (MPDM) is examined with respect to a particularly challenging problem domain, namely, strategic-level land use and tourism development planning in tropical small island states (SIS) characteristic of the Caribbean region and the Pacific and the Indian Oceans. International tourism has become, especially in the jet age, an increasingly vital component of the economies of many of these nations. However, the impacts of tourism development can also have significant and often deleterious implications for host populations, the natural environment, and land use and activity patterns. Many of these impacts are highly localised and give rise to conflict between and within different interests in insular and, typically, post-colonial societies. It is argued in this thesis that careful and broadly-considered strategic planning strategies can reduce, if not eliminate, conflict over land development and contribute to the well-being of the host population, natural systems, and the tourism sector alike. Further, it is suggested that the MP-SDSS approach discussed in the following chapters provides a mechanism for exploring potential conflicts in a proactive manner and for generating consensual or compromise-based development strategies that allow varied participants to articulate their own development visions for land use in their country.

1.1 Rationale for the Thesis

A broad range of information technology applications have been developed to address land use planning issues such as development permit tracking, population projections, site design, and transportation management, among others (Maguire and Dangermond, 1991). Similarly, various aspects of the tourism sector employ information systems to set airline schedules, manage tours, forecast visitor arrival numbers, and so on (Poon, 1993). This thesis focuses specifically on the application of *spatial* information technology, which is designed to manipulate and display geographically-referenced data, to the intersection of strategic land use planning and land use-related tourism planning activities. Hence, the thesis does not directly examine planning practices or institutional arrangements for land management in SIS, nor does it deal with elements of tourism planning such as promotional/marketing strategies or tourist facility/site design.

Instead, tourism is regarded as one component of the broader land use system that imposes differential costs and benefits on its natural and human surroundings, while also being affected by complementary and conflicting land uses and activities. The SIS context warrants particular attention since the differential combinations of a small population base, few viable economic alternatives, fragile ecosystem, restricted developable land area, and frequent concentration of tourism development along beachfronts or near air and cruise ship gateways, tend to amplify the general impacts of land use planning and development.

The ability of Governments to use strategic land use planning to direct and co-ordinate the location of different types of tourism developments relative to required infrastructure, attractions, and complementary land uses allows potential conflicts to be identified and possible solution strategies to be crafted *prior to* development occurring rather than *ex post-facto* (Green, 1995, 96). This is particularly important in light of the challenges of increasing competitiveness in the global tourism marketplace, the desire to improve the welfare of SIS citizenry, and a growing recognition in most SIS that the economic success of the tourism sector is highly correlated to local social and ecological well-being. Although the majority of land investment and development decisions are made by individuals and private firms in most SIS, it is the public planning process that provides the framework for regulating these decisions and mediating between contradictory land use proposals.

The strategic planning decisions relevant to this thesis revolve primarily around issues of form (what type(s) of development should be considered for the area(s) under study?), location (where should different types of tourism land uses be sited?), and, to a lesser extent, time (what locations should be developed before others?). These issues are interrelated, not always easily-defined, and are often fraught with considerable uncertainties. To consider these issues properly, three needs are apparent.

First, broad participation is required in the strategic land use decision-making process if possible conflicts and opportunities are to be identified pro-actively. Representatives of various Government agencies, Non Government Organisations (NGO), private sector firms, and members of the local population each have specialised expertise or interests that cause them to respond to the above questions differently. As a result, the decision-making forum is characterised by debate and negotiation concerning the merits of multiple, sometimes conflicting, "visions" of the future.

Second, extensive and diverse databases pertaining to this broad spectrum of interests are required to facilitate the progressive redefinition and clarification of planning issues, the generation of alternative development futures, and investigation of the merits of these alternatives. Digital, or machine-readable, spatial information is of particular importance in these processes in order to assess the suitability of different areas for specific types of land uses and activities in a timely manner.

Third, spatial information tools appropriate to the SIS planning context are required to facilitate the integration, manipulation, analysis, and communication of data relevant to the various planning participants. To support effective decision-making in the SIS planning process, these tools must be designed expressly for use in multi-participant settings. Hence, they must: a) be equally relevant to and usable by individuals with expert and non-expert computer skills, b) support plurality in decision-making perspectives by permitting construction of several feasible development futures for an area, c) support recursive decision-making processes whereby problem definitions and solution strategies can be refined progressively, d) provide mechanisms to evaluate these alternatives according to the viewpoints of different participants, e) investigate trade-offs and compatibility with the overall land use pattern, and f) offer methods to assist in the building of consensual or compromise-based development strategies.

Recognition of the need for multi-participant spatial information systems with these capabilities is growing, although few examples can be found in the literature of such systems for strategic-level land use oriented tourism planning, especially in developing countries. However, there are several complementary bodies of research in a number of related application areas that this thesis builds upon. For example, a relatively large body of applied research has been amassed concerning the use of GIS in land use planning and suitability analysis in which geographically-referenced data are utilised to identify feasible sites, routes, or regions for specific land uses or activities (see, for example, Davidson et al, 1994; Diamond and Wright, 1988). In comparison, few cases can be found in the tourism literature of spatial information technology use for planning or tourism resource assessment (Boyd et al, 1994). MCA methods have been applied frequently to the problem of evaluating feasible land use strategies according to various aspects of land use planning, including instances where tourism activities are of importance (Malczewski et al, 1997; Bodini and Giavelli, 1992; Massam, 1991). Until recently, there has been few instances where the capability of GIS to produce "short lists" of feasible locations for specific land uses based on extensive data manipulation and interrogation has been coupled with the capacity for MCA techniques to facilitate the subjective evaluation of these alternatives. However, as the complementary nature of the strengths and weaknesses of GIS and MCA has grown to be more widely appreciated, more efforts have been made to integrate the two fields of research (Jankowski, 1995; Giaoutzi and Nijkamp, 1993; Pereira and Duckstein. 1993; Carver, 1991).

Efforts to extend GIS and SDSS to support multi-participant strategic land management and planning are still embryonic in their development and are proceeding along several interrelated paths. Some researchers have demonstrated the potential to modify commercial GIS software to accommodate several user perspectives (Brown et al, 1994) or to link commercial GIS with MCA and group consensus maximisation techniques (Malczewski, 1996). Another area of focus is on the technical challenges of facilitating collaborative GIS group work among individuals who are located at dispersed sites (Jones et al, 1997; Armstrong, 1994). Others have drawn upon the field of group decision support systems (GDSS) and concentrate on providing spatial decision support for group decision-making within a committee or meeting room context (Jankowski et al, 1997).

This latter body of research that has evolved into group spatial decision support systems (GSDSS or SDSS-G) for meeting room settings is of particular interest since it is tailored for the strategic level of decision-making. However, while these systems can make useful contributions to some aspects of multi-interest decision-making, it is suggested in this thesis that a less centralised approach to decision support is more appropriate to the SIS land use and tourism planning context. Specifically, an approach for facilitating broad-based participation in decision-making while also being more closely aligned with the financial, technical, and human resources of SIS is advocated. Such an approach is developed in this thesis and applied to a case study of multi-party tourism planning in the Cayman Islands, British West Indies.

1.2 Research Issues and Objectives

Several gaps can be discerned in the literature concerning spatial decision support technology and the practical application of related tools to strategic land use planning in general and land use and tourism planning in SIS in particular. This thesis seeks to address these research needs by focusing on the contributions that multi-participant SDSS, based on an integration of GIS and MCA functionality, can bring to the strategic level of land planning and decision-making in SIS, with a specific emphasis on tourism-related development.

Despite the voluminous literature concerning the use of GIS and SDSS for practical planning issues, understanding of how they can contribute to higher-order decision-making in land development planning remains limited. In part, this is due to the commercial GIS industry concentrating development on the tangible and technology-oriented problems of handling larger quantities of diverse types of data in shorter periods of time. While it is presumed that the benefits of these enhancements will "trickle-up" to higher-level decision-makers in the form of higher quality "products" (e.g. maps, tabular reports, automated procedures) and consequently lead to better quality decisions, information specialists with few, if any, strategic decision-making responsibilities appear to the main beneficiaries in practice (Campbell, 1991, 264).

Until recently, most applications of GIS and SDSS were based on an inadequate appreciation of the nature of the strategic-level decision-making process and how information technology can, and should, be of assistance. This has been reflected in the frequent assumption that information provided by GIS and SDSS are value-free "facts" that can be applied logically and consistently by any individuals to clearly-defined planning problems. Once the potential for data errors is discounted, this assumption is largely valid for procedural planning tasks. However, strategic-level planning problems are rarely clearly-delimited and are resolved most often by different interests debating the merits of several, selective interpretations of the "facts" in light of divergent objectives and preferences. Systems offering integrated MCA and GIS functionality can address multiple viewpoints in this decision-building process. However the literature concerning their extension to multi-participant planning problems is relatively sparse to date and is oriented primarily toward technical and design issues. Consequently, relatively little consideration has been given to the roles that these systems can fulfil in the strategic planning process, especially with respect to facilitating broadly-based participation and consensus-building.

This shortcoming is compounded for several reasons within the SIS planning context. First, while GIS capabilities are becoming more widely known in many SIS, financial, technical, data, and human resource constraints have limited its diffusion. Where GIS are present, they are often in the form of externally-funded projects with limited mandates or are constrained to functions relating to management of the cadastral, or land parcel, fabric. Use of spatial information technology for land use planning in SIS is less frequent and almost non-existent for tourism planning. In many instances, this can be traced to planning practices that emphasise the processing of development applications over efforts to assess the long-range or strategic implications of different development paths.

Another possible factor is uncertainty concerning the operationalisation of linkages between land use planning and tourism planning. The importance of these linkages has been noted in the tourism literature for some time in recognition of the fact that tourism-related land uses and activities cannot be planned adequately in isolation of their dependencies on, and competition with, other human activities and natural processes (Wilkinson, 1997a, 211; Green, 1995, 93; Gunn, 1994, 361). For example, strong relationships can be seen between the types and amounts of tourist accommodation that are available in a locale, the types of tourists that these facilities attract, and the impacts that are incurred by proximate ecosystems, built environments, socio-economic conditions and local cultures (Wall, 1993a, 52). Since the land use planning process can be used to regulate the construction of tourist accommodation, subject to private investment decisions and political influences, it can play a key role in ensuring the tourism development is appropriate to the local resource base.

Despite the heightened need to ensure compatibility between development and resources in SIS, the co-ordination and integration of land use planning and sectoral planning efforts are often inadequate (Galema, 1994, 249). For tourism to be successful in a SIS destination over the long-term, there must be a reasonable degree of consensus among the host population that: a) they have some degree of control over the form and growth of the sector, and b) they collectively gain some net benefits from tourism (Brohman, 1996, 61). This is particularly important at the community planning scale where the impacts of planning decisions and the interrelationships between different sectors and activities are made apparent. Participation that extends beyond merely informing residents of decisions that have already been taken, to permit a variety of participants to contribute to the creation and evaluation of alternative strategies may help ensure the economic and social viability of the tourism sector.

It is suggested that the prototype MP-SDSS developed in this thesis contributes toward satisfying the above research needs by providing: a) a mechanism for facilitating broadly-based participation in strategic-level planning, b) a practical linkage between tourism and land use planning processes and, c) methodological and technical structures appropriate to operationalising multi-participant spatial decision support in SIS. Three aspects of the decision-making process pertinent to strategic land use and tourism planning in SIS are discussed in the thesis: problem exploration, identification of feasible sites for tourism development, and multi-participant evaluation of these alternatives.

The thesis has several research objectives that relate to the development of this system, its underlying conceptual approach, and its application in a case study. These objectives are:

1. to identify the key decision support needs that are inherent to strategic land use and development planning in general and specifically in SIS;
2. to conceptualise the nexus of land use and tourism planning in SIS;
3. to develop a methodology, appropriate to conditions in and needs of SIS, that incorporates multi-participant decision support tools into the strategic level of land use and tourism planning and that operationalises the land use and tourism planning nexus;
4. to design and develop a prototype MP-SDSS that permits individuals or groups with diverse interests and objectives to construct alternative "scenarios" or development futures for an area, with specific emphasis on identifying and evaluating candidate locations for tourism development;
5. to apply the prototype MP-SDSS to a tourism planning case study in a Caribbean SIS with the aim of using it to identify consensual sites for staging tourism land use conversions based on the site selections and evaluations of a representative and differentiated sample of participants;
6. to conduct a *post hoc* assessment of the appropriateness of the methodologies used, the design of the prototype, and to examine possible extensions and improvements to both based on the case study findings.

In the process of satisfying these objectives, it is anticipated that the thesis will make several contributions that are relevant to the research needs discussed above. In terms of the application context, the significance of tourism to the economies of many SIS and the lack of control that some destinations have over the pace, form, and impacts of tourism development indicate that enhancing planning and decision-making capacity in SIS is of paramount importance. Providing methods where planning participants with diverse backgrounds, interests, objectives, and expertise can design and compare different development strategies increases the likelihood that the tourism development path of a country will be selected purposefully and with a reasonable degree of certainty concerning the areas of conflict. In this context, a further underlying goal of this thesis is to leverage existing investments in GIS by providing an approach for utilising existing spatial information in higher-level decision-making. This is especially significant in the SIS context given the substantial expenditures that many Governments are committing to GIS implementation. It is also relevant to installations in developed nations. Similarly, it is anticipated that the methodology employed to couple spatial information technology and MCA methods and the approach used to manage the participation of multiple system users will be of value in both the SIS environment and in more general settings. Finally, the thesis provides a practical illustration of how decision support methods and spatial information technology can be applied to tourism planning and consequently bolsters a weak area in the tourism and GIS/SDSS literature.

1.3 Thesis Structure

The thesis comprises seven chapters. Following this introductory chapter, the conceptual and theoretical foundations for the thesis are built in Chapter Two. The importance of land use planning in alleviating market failure and land-related conflicts is reviewed with specific reference to its interrelationships with tourism planning in Caribbean SIS. Particular attention is directed at the pluralistic and ill-structured nature of strategic land use and tourism planning issues, such as identifying and evaluating competing locations for a given land use activity. The contributions that GIS-based technology and MCA methods can make, individually and collectively, to the resolution of these decision problems are described and their shortcomings in supporting consensus- or compromise-building among individuals and groups with diverse interests are identified. An approach to incorporating a multi-participant spatial decision support system (MP-SDSS) into the land use and tourism planning processes of SIS is proposed based on this discussion.

Chapter Three focuses on the operational design of a MP-SDSS that is appropriate for strategic land use and tourism planning in SIS. The chapter begins by examining how human, technical, and organisational factors influence information technology use in SIS. Next, a set of design principles pertinent to the SIS planning and information technology context is introduced. These principles, in concert with the discussion in Chapter Two, form a base from which the functional requirements of a MP-SDSS for the SIS land use and tourism planning environment are examined. The chapter concludes with a discussion of the architecture and functionality of *Tour*Plan, a MP-SDSS that was designed and implemented for problem exploration, site selection, and site evaluation aspects of multi-participant land-related tourism planning in SIS.

Chapter Four concentrates upon the case study of West Bay District of Grand Cayman, Cayman Islands, British West Indies (BWI), in which the *Tour*Plan decision support tool is utilised. The evolving context for strategic land use and tourism planning in the case study area is described with reference to the recent growth of international tourism on Grand Cayman, the effects that this growth has had on land use change, and the planning frameworks that have been adopted to manage this change. The chapter also discusses the selection of research participants and the data they used to create their development scenarios for West Bay District.

Chapter Five presents the methodology and findings for the first stage of the case study research. The research participants described in Chapter Four apply the *Tour*Plan decision support tool to the task of identifying potential sites for future tourist accommodation in West Bay District. Preliminary indications of consensus and conflict among the participant's tourism development scenarios are developed.

The second stage of the case study research is examined in Chapter Six. Two subsets of candidate tourist accommodation sites, derived using the consensus and conflict indicators discussed in Chapter Five, are evaluated using the MCA component of *Tour*Plan with the aim of identifying sites that would be most widely-supported by the participant group as locations of future tourist accommodation. The participants' site rankings are examined both individually and collectively, with particular attention being given to the sensitivity of their rankings to changes in criteria weights and to their choice of MCA method.

Chapter Seven concludes the thesis by revisiting the main objectives and arguments and evaluating their veracity in light of the field research findings. The contributions of the thesis to the conceptual and applied knowledge bases of multi-participant spatial decision support systems, small-island tourism planning, and the more general land use planning problem are stated and suggestions are provided for future extensions to the research.

Chapter Two

CONCEPTUALISING THE USE OF SPATIAL DECISION SUPPORT TOOLS FOR LAND USE AND TOURISM PLANNING IN SMALL ISLAND STATES

The preceding chapter stated the objectives and the overall organisation of this thesis. Its conceptual and theoretical foundations are constructed in this chapter through a discussion that centres on the interrelationships between four main themes, namely: 1) planning and the management of land-related conflicts, 2) the land and tourism planning nexus in Small Island States (SIS), with a particular focus on the Caribbean region, 3) spatial decision support tools and their uses in planning, and 4) multi-participant spatial decision support tools and strategic tourism-related land use planning in SIS. Following the contextual discussion in Section 2.1, the use of GIS and MCA for decision support in land use and tourism planning is examined in Section 2.2. The next section expands upon this by reviewing current decision support research that is targeted at multiple participants or group environments. A multi-participant spatial decision support approach that is appropriate to the task of strategic tourism-related land use planning in SIS is then presented and discussed.

2.1 Land Use Planning and the Management of Land Related Conflicts

2.1.1 The Rationale for Land Use Planning and the Nature of Planning Problems

The term 'planning' has been interpreted as both an activity and a process in literature pertaining to land use change and development. Prior to World War II, the activity of planning could be described in most western nations as the creative and aesthetic art of designing the built environment. Planning was seen to be primarily a private sector activity employing individuals with architectural, engineering or landscape design backgrounds (Hague, 1991, 297). In the post-World War II period, this viewpoint was replaced by a largely rational-comprehensive perspective that portrays planning as a procedural and goal-oriented activity rooted in the application of scientific techniques to public policy-making (Poulton, 1991, 230; Faludi, 1973, 1). Public policy-making is, in turn, utilised as a tool for consciously intervening in land development and other processes with the aim of altering their operation and outcome (Cartwright, 1973, 179).

Rapid and frequently conflicting development pressures in the post-war period led Governments in many parts of the western world to employ planning professionals directly to ameliorate conflicts between individual landowners and between landowners and society as a whole. This transformed planning from an activity centred on designing urban form, to one largely based on administrative or technocratic roles geared toward providing advice to decision makers within Government. It also institutionalised planning within Government and, through the forces of bureaucratisation and politicisation, caused the activity of planning in the public sector to be subsumed within the wider process of Government (Beauregard, 1986, 173).

Batty (1993, 58-59) describes the planning process as being comprised of two related but distinct sets of activities. The first of these is a "process of highly formalised strategic planning based on an explicit process of rational decision making which is conducted on a cycle of months or years". Building on the work of Simon (1976, 40-41), this perspective views medium- to long-range strategic planning activity as a stepwise progression through the stages of problem identification, goal and objective setting, a comprehensive search for alternatives or solutions, and concludes with the selection of the optimal solution as indicated by the gathered information (Webster, 1993, 711).

Figure 2.1 illustrates that this is not usually an entirely linear progression but is characterised by multiple recursive feedback loops as problem definitions, goals and objectives, and evaluation criteria are refined and preceding steps in the process are repeated until an alternative is selected and implemented. After implementation, monitoring procedures loop back to the original problem which, itself, may be redefined on subsequent iterations.

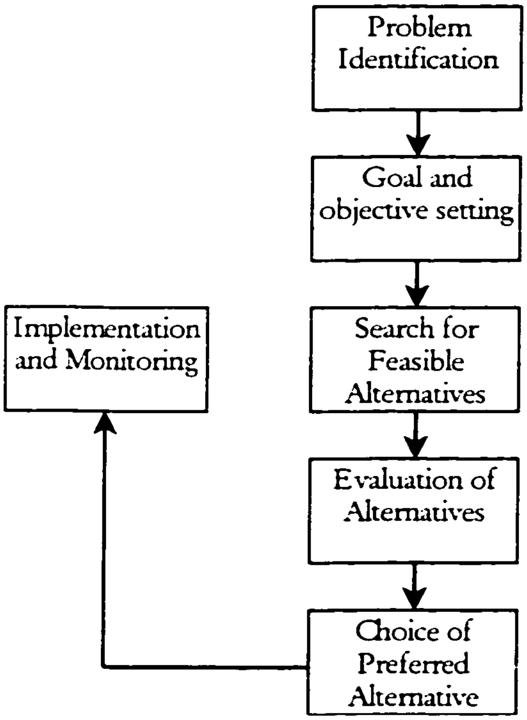


FIGURE 2.1 PHASES OF STRATEGIC-LEVEL PLANNING DECISION MAKING

The second planning activity identified by Batty is a complementary set of operational procedures, used on a daily basis, to ensure that incremental land use change decisions are in concert with the objectives and principles embodied in medium- to long-range strategic plans. Recognising that the context of strategic and operational phases of planning can influence how planning is conducted, others have extended their interpretation of the process of planning to encompass a wider 'planning system' composed of "the entire set of procedures, resources, institutional arrangements that together guide land use change and management" (Healey et al, 1988, 2).

From the rational-comprehensive perspective, the need for public intervention in the land and property markets drives the decision support requirements of the planning system. There are three important types of tensions and conflicts that arise from the uncoordinated actions of multiple private landholders. First, since individuals seek to maximise the benefits accruing from land ownership and use, there is little incentive for any one landholder to provide socially demanded 'public goods', such as roads, protected habitats, and physical infrastructure, which cannot be supplied profitably or adequately through market mechanisms (Musgrave, 1959, 8-12). Second, some land use decisions impart third party effects on others. Spatially-specific conflict can arise from these externalities since their intensity often decays with distance from their source and because landowners' fixed capital investments preclude them from responding easily to changes in the overall configuration of locational advantages (Scott and Roweis, 1977, 1106). Other types of externalities, such as traffic congestion and ribbon settlement patterns, result from the aggregate impact of multiple individual land use decisions and impose more broadly distributed costs accruing from such development on a population. Finally, stability in the land market is enhanced by direct and indirect public investments and by the planning system's known regulatory and administrative frameworks, as represented by long-range development plans and building code standards (Diamond, 1995, 133).

As a consequence of these factors, strategic land use planning issues typically display three types of characteristics. First, most strategic land use planning issues are multi-faceted, as they introduce differential amounts and types of change to one or more relevant socio-cultural, economic or environmental realms. Second, land use issues are often multi-dimensional given the temporal variability of land use change impacts and the spatial specificity of market failure, externality effects, and land ownership. Third, land use planning issues are inherently pluralistic both in terms of the distribution of their impacts and the underlying decision making processes. Within the public sector, this plurality is manifested administratively through the activities of domain-specific departments, ministries and agencies that participate in the planning process and politically through the presence of multiple elected and/or appointed decision makers at various levels of the planning decision process. Outside the realm of government, plurality is reflected by the individual citizens and groups that lobby for particular outcomes from planning. Within this framework, participants are only likely to be concerned with selected aspects of a given problem and are unlikely to have complete information concerning the central interests of other involved parties (Thompson and Gonzalez, 1997, 76). As a result, participants in the planning process often differ in their underlying objectives, their perception of the significant problem areas, their access to and ability to use information, and their relative influence and authority in the decision making forum (Janssen, 1992, 45).

These factors, in association with intangible quality-of-life issues, often cause medium- and long-range strategic land use planning decision issues to be ill-structured or poorly defined. Within this multi-objective and multi-participant decision making environment, decision makers are not always able to indicate clearly exactly what problem they are attempting to address, what their objectives are, or how they will judge the acceptability of alternative solution strategies (Densham, 1991, 403). Unlike more clearly-defined operational problems (for example, 'does this proposed land use conform to zoning by-laws?' or 'is a minor variance permissible?'), strategic decision problems (such as, 'should further tourism development be encouraged?') are sufficiently general that they cannot be resolved entirely through issue-structuring procedures, rules or past experience but instead require the application of personal judgement.

The resolution of ill-structured problems is judged as often on the quality of the decision making process itself as on the validity of its outcomes. The continued legitimacy of the planning process as a mechanism for guiding and regulating land development depends upon how accountable, transparent, and participatory it is perceived to be and by the extent to which it relies upon the application of appropriate scientific, historical and legal information (Campbell, 1991, 256; Lake, 1993, 166). This observation is equally true for small and large nations as for organisations and agencies charged with planning tasks within nations. However, in some contexts, the implications of planning decisions and their irreversibility are especially profound. This is certainly the case in the Small Island States (SIS) of the Caribbean region (and elsewhere), to which the discussion now turns.

2.1.2 Land Use Change and Planning in SIS of the Caribbean

The land use planning concepts discussed in Section 2.1.1 are very relevant to the SIS of the Caribbean, Indian Ocean and the Pacific. However, while many land use planning issues and decision making procedures appear, at least superficially, similar to those encountered in the 'generic' western planning context, the challenges and circumstances confronting SIS are sufficiently similar to each other, yet different from other contexts, to warrant special attention. The following discussion concentrates on the SIS of the Caribbean although much of it also pertains to SIS beyond this region.

The evolution of land use planning and development in Caribbean SIS can be seen as a function of both the physical characteristics of the region as a whole and the historical-cultural development experience of individual countries. These elements continue to contribute directly and indirectly to the types of planning issues that decision makers are confronted with, the structure and operation of the decision making systems that are in place, and the impacts associated with development-oriented land use change. The significance of the physical dimension to the land use planning nexus in the Caribbean is readily apparent. As a geographic region, the Caribbean is composed of several thousand small islands dispersed across some 4000 kilometres of sea that is bounded by North, Central and South America and the Atlantic to the East. Social, cultural and economic linkages extend the general region to include Belize on the Central American peninsula, Guyana, French Guyana and Suriname located on continental South America, and the Atlantic islands of The Bahamas and Turks and Caicos. Termed "a continent of islands" by Kurlansky (1993), the individual nations of this region have many shared characteristics, including a susceptibility to natural disasters such as hurricanes and volcanoes and physical insularity resulting from expensive and often inconvenient air and sea linkages within and beyond the region. Beyond these common attributes, a considerable physical diversity exists among the individual nations comprising the Caribbean as land area, population size, density, topography, climate, vegetation and economy vary, often substantially.

Despite this geographic diversity, the elements of a common land use planning context are manifest in most, if not all, instances through a list of recurrent issues, stated in no order of priority:

1. uncoordinated, inefficient and unnecessary land use development that is often incongruous with historical or cultural architectural norms;
2. few large remaining natural or undeveloped tracts of land;
3. overuse of natural attractions such as coral reefs and beach front coastal zones;
4. insufficient stock of good quality housing;
5. inadequate sewage, water, road and electrical infrastructure;
6. few employment opportunities;
7. rapid population growth; and
8. multi-national cultural, historical, and colonial influences.

This list is not exhaustive, nor are its items unrelated. Many items are symptomatic of deeper structural problems that are at least partially a function of the cultural, historical and political detritus that these nations have been built upon. For most Caribbean nations, the cornerstone of this foundation was laid through the colonial expansion of Spain, England, France, the Netherlands and, more recently, the United States. From the age of discovery during the late fifteenth century, Caribbean peoples have been vulnerable to the dictates of western nations' militaristic, political and economic requirements (Harrigan, 1974, 14). A succession of mono-cultural, plantation-based socio-economic systems were established on many islands for the purposes of exporting commodities back to the parent nations.

This commodity economy and form of development was fuelled initially by the slave trade and progressed subsequently in the post-slavery, post-colonial era to focus on basic export-oriented agricultural products including sugar cane, salt, bananas, spices, mineral products such as bauxite, and oil. Economically and socially, the legacy of colonialism remains visible through the following characteristics:

1. highly open economies with over-concentration on a single or, at best, a few export-based commodities;
2. vulnerability to foreign markets, substitution effects and changing terms of trade;
3. insufficient indigenous sources of capital and entrepreneurial knowledge;
4. inadequate local markets and production of goods and services required for domestic consumption;
5. externally-derived institutional and political structures;
6. western-influenced cultures;
7. limited range and depth of skills in labour force and a consequent reliance on expatriate labour; and
8. poor regional cohesion due to past and current competition effects and governance.

Following World War II, at the time when the rational-comprehensive approach to planning was being adopted in the developed world, the remnant colonial powers began to reduce their direct support and administration of Caribbean states and encouraged them to move toward independence. Frequently, this involved supporting efforts to augment or replace former agricultural exports with other mono-cultural production such as enterprise zone industrialisation and international tourism. The immediate post-war period also saw the genesis of land use planning throughout much of the Caribbean as an incidental and project-based activity, often related to post-colonial development aid (Conway, 1989, 69).

In this initial form, the scope of land use planning was limited sectorally and spatially to the immediate concerns of providing hard service infrastructure (roads, water, electrical), social infrastructure (housing, schools), and commercial infrastructure (harbour and airport facilities). For the former or remnant colonial powers that continued to provide assistance, planning served as a control mechanism designed to ensure that development aid funds were utilised in an effective and demonstrable manner. The recipients of aid saw the practice of planning, at least initially, as a means of creating favourable conditions or impressions necessary to secure aid from abroad. Baldacchino (1993, 36) terms this behaviour the "non-strategy of opportunistic pragmatism" of small nations that is characterised by a willingness to remain sufficiently flexible to make the best out of every opportunity that is presented. Unfortunately, planning activities in this context tend to be fragmented and often contradictory, as opportunism and the project-based focus of development aid causes different Government departments and non-Government agencies in both the donor and the recipient administrations to compete for funding.

The profile of this project-oriented activity increased in the 1960s, 1970s and early 1980s as more Caribbean SIS moved toward either complete independence or more autonomy in decision making relative to their previous arrangements. Development projects were, and continue to be, highly significant in political symbolism to the young nations of the region (Kurlansky, 1993, 2-7; Conway, 1989, 70). At the same time, the interpretation of planning expanded from simply a means to control or secure development aid projects to become an end or a 'project' in its own right. Aid providers and the newly independent nations alike saw the production of comprehensive mid- and long-range strategic land use plans as being of vital importance in setting the agenda for dealing with pressing economic and social problems.

However, as politically-charged 'products', medium- and long-range development plans proved to be difficult to create, implement and revise. Conway (1989, 71) notes that the original development plan in Trinidad was initiated in 1960 and it took until 1982 for a much-modified version to be passed by the Government. Similar difficulties were encountered in the Cayman Islands as the first revision of the 1977 development plan was not passed until 1996, despite earlier attempts in 1982 and 1986. Also, the same problems are currently being experienced in Turks and Caicos (LesFouris, 1999, pers. comm.) and some nations, such as Haiti and Grenada, simply do not have well-defined national development plans at all (Kurlansky, 1993).

If, as Tobler's (1970, 236) first law of geography states, "everything is related to everything else, but near things are more related than distant things", then the politicisation of planning in the SIS of the Caribbean is due at least partially to their compact physical settings and high population densities, which accentuate the relationships and conflict between fragile natural systems and diverse, competing human interests. Harrigan (1974, 22) terms this "the macro-state emulation syndrome" where SIS attempt to accommodate the number and breadth of functions expected of, or desired by, larger nation states whether or not this is necessary or even relevant to local conditions. With the compressed and multi-functional administrative and political structures that result from these ambitions, localised land use conflict is often elevated to the national political arena and the spatial aspects of land use change are subsumed within national economic development and political concerns (Potter and Wilson, 1989, 127).

The emphasis in planning activity that was, and in many cases still is, given to operational activities associated with development control is understandable when viewed with reference to the rapid rate of urbanisation and land use change in many Caribbean SIS during the post-War period. Urbanisation and land development in general were fuelled by factors such as high natural population growth, perceptions of better employment opportunities in cities and towns, the disintegration of the plantation economy, and a gradual tightening of emigration to the former colonial powers.

These factors have confronted planners in SIS with an ever-increasing workload consisting mainly of implementing and checking building and construction standards, policing 'informal' and unapproved residential construction, managing often incomplete or ambiguous cadastral systems, and conducting site inspections (Hudson, 1989, 206; Potter and Wilson, 1989, 126). Hence, planning activity in the Caribbean tends to be much more operational than strategic and, inevitably, the task of medium- to long-range strategic land development planning is often forgotten. The importance of this problem, albeit poorly understood or appreciated, is magnified in the context of SIS as critical thresholds pertaining to various ecological, socio-cultural and economic realms are often exceeded with little forewarning, as the effects of sporadic and rapid periods of land use change accumulate (Johnson and Thomas, 1996, 123-124; Mathieson and Wall, 1982, 21). With land development being evaluated on a site-by-site basis, and usually only in terms of operational guidelines, the cumulative impacts of multiple instances of individual land parcel conversions are not considered until landscapes begin to change visibly. In some SIS this does not occur until relatively late in the development process and planning is forced to become reactive to current development, rather than proactive in guiding development toward strategic planning objectives.

One of the major sources, perhaps even the single largest catalyst, of localised landscape and physical land use change in the post-War era in Caribbean SIS states is the tourism industry. This is discussed in the next section.

2.1.3 Tourism as a Contributing Factor to Land Use Change in SIS

International tourism grew rapidly throughout the world in the post-World War II period, due largely to the advent of commercial air travel and rising levels of disposable incomes in developed countries. This growth has continued into the latter years of the current century. The majority of all tourist flows are between nations of the developed world but selected areas of the developing world continue to experience high rates of growth in visitor numbers (Ryan, 1995, 79).

While it is generally agreed that tourism is a multi-faceted and geographically complex phenomenon, there is some variance in the definition of the term. Mathieson and Wall (1982, 1), for example, define tourism as "the temporary movement of people to destinations outside their normal places of work and residence, the activities undertaken during their stay in those destinations, and the facilities created to cater to their needs." Other definitions are more specific and include length of stay, minimum travel distance, and trip purpose criteria to distinguish tourism from other types of business, leisure and education-related travel (Harrison, 1992, 2; Pearce, 1989, 1; Theobald, 1995, 9). Certainly, tourism encompasses a complex and indeterminately bounded sector that spans and is partially inclusive of a wide variety of industries, sectors and activities including air, sea and ground transportation, marketing, tours, shopping, accommodation, and attractions that are distributed spatially between several distinct geographical locations. The composite nature of this sector is a critical factor that can sometimes obscure its impact on economic, social and ecological factors and it also introduces competition, uncertainty and conflict into the decision making processes underlying its operation, regulation and planning.

Due to the composite nature of the tourism sector, the term 'tourism development' can also take on an equally broad and multi-facetted meaning that embodies components of both the tourism and the development literature. However, given that the focus of this thesis is on providing strategic-level decision support for land use planning related to tourism development, the term refers here to the physical manifestations of the tourism sector on the host nation's land use and built environment.

Based on this interpretation, tourism development refers in the following discussion to four key elements: 1) accommodation, 2) natural and human attractions, 3) supporting facilities such as restaurants, banks, retailing, and 4) infrastructure directly related to tourism such as cruise ship docking facilities and airports. Hence, tourism development can occur through some combination of direct creation of new tangible structures such as hotel buildings or resort complexes, the conversion or reallocation of pre-existing structures and land uses to tourism-supporting functions such as the restoration of heritage sites, or through revised appraisals of pre-existing natural or socio-cultural resources, such as the creation of ecological parks.

Rapid growth in international tourism was seen by many SIS governments as a potential catalyst that could alleviate problems of poverty, unemployment and foreign exchange shortages, through the development of untapped or under-utilised human and natural resources. Unlike other economic development options, such as light manufacturing, there is a close correspondence between the resource requirements of international tourism and the few resources that SIS have in abundance – a pleasant vacation environment combined with an abundant and inexpensive labour force. Thus, Caribbean SIS embarked, to differing extents, on the sale of 'paradise' - essential elements of which centre around sun, sand, and sea but also depend heavily on images and perceptions of remoteness and difference as well as the virtual absence of industry (Kurlansky, 1993, 25; Butler, 1993b, 71). Today international tourism is either the cornerstone or at least a significant contributor to the economies of the majority of Caribbean SIS.

Inflows of foreign capital and expertise provide SIS with benefits in terms of employment during the construction of resorts and servicing after construction. However, promotion in source markets and establishment of airline or cruise ship connections place a high level of dependency on foreign involvement. This equates to a corresponding surrender of autonomy and leverage on the nature and rate of land use and social change associated with the growth of the tourism sector (Colin and Baum, 1995, 6). Leverage is reduced further by the high degree of substitutability that most tourists place on SIS destinations, a highly competitive global tourism marketplace, and the extreme reliance that most British Caribbean SIS have on visitors from a few source nations, typically the United States, Canada, and the United Kingdom (although emergent markets in Germany, Spain and Italy are also important). These factors leave destinations highly vulnerable to changes in the spending behaviour and travel preferences of tourists from source countries and to reports of political instability, crime or violence in the destination countries. Repatriation of profits and increased levels of imported of foodstuffs, building materials and other goods also reduce the anticipated economic benefits of tourism and help to maintain this state of vulnerability and dependency (Barry et al, 1984, 77).

A generic model of tourism development, based on the product life-cycle concept, which portrays tourism growth in a destination as a cyclical progression through a number of stages, is provided by Butler (1980, 7-9). In this model, initial tourism growth is relatively slow, usually taking the form of a few, low-density and indigenously-owned facilities, and has relatively little impact on the local economic or social structures. As awareness of the destination grows and more facilities are provided, higher rates of tourist arrivals occur and tourism becomes an integral, if not central, element in the economy. The form and type of tourism changes fundamentally during this stage as facilities become larger, less indicative of the locality, and more likely to be controlled by external interests. Corresponding increases in the impacts on the host environment and population are evident as development intensifies and tourism solidifies a dominant position in the economy (McElroy and de Albuquerque, 1995, 50).

At some point of the development process, real or perceived capacity pressures may cause growth rates to fall and eventually plateau as the destination enters the consolidation and stagnation stages of Butler's model. If the capacity constraints can be overcome through redevelopment or refocusing the destination on new and often artificial attractions, it may be rejuvenated, otherwise it will gradually become less attractive to tourists than competing destinations and arrivals will continue to trend downward. This stage-based progression is not necessarily deterministic as some destinations may never attract or support large volumes of tourists while others, like Cancun in Mexico, may be 'artificially' initiated as high-density tourism landscapes (Butler, 1980, 11). Within this model, wealthier SIS like Bermuda and the Cayman Islands are able to maintain a higher degree of local ownership and control in the later stages of the resort cycle than poorer nations (Weaver, 1990, 15).

Different types of tourists and types of tourism are associated with each stage of this model beginning with innovating and pioneering tourists with locally-supportable demands and moving eventually through to large volumes of price-sensitive mass tourists dependent upon "international" standards of goods and services. In this context, Butler's (1980) descriptive resort cycle model complements the work of others such as V. Smith (1989), who has portrayed a complementary staging of tourist types (Table 2.1).

Evidence supporting these models can be found both within the Caribbean region as a whole as well as within individual island destinations. For example, SIS that receive relatively small numbers of visitor inflows and have correspondingly few, small-scale tourist facilities, such as Dominica and Anguilla, can be seen to be at the earlier stages of Butler's (1980) development phase. In contrast, St. Maarten, the Bahamas and Antigua are representative of more mature destinations that depend upon substantially higher volumes of tourists staying at their larger and more numerous resorts. Other SIS display growth stage differentials across their constituent parts as illustrated by the contrasts between the highly-developed area of Seven Mile Beach on Grand Cayman and the limited tourism activities found on the Sister Islands of Little Cayman and Cayman Brac.

Type of Tourist	Number of Tourists	Adaptations to local norms
Explorer	Very limited	Accepts fully
Elite	Rarely seen	Adapts fully
Off-beat	Uncommon but seen	Adapts well
Unusual	Occasional	Adapts somewhat
Incipient mass	Steady flow	Seeks western amenities
Mass	Continuous influx	Expects western amenities
Charter	Massive arrivals	Demands western amenities

Source: V.L. Smith (1989, 12)

TABLE 2.1 TOURIST TYPES, NUMBERS AND BEHAVIOUR

The general morphology of tourism development in Caribbean SIS can be accounted for, in part, by the stage of the resort cycle model that a destination has attained. As noted earlier, it is also a function of international tourist demand, opportunities and constraints presented by natural environments in the host countries. Several physical factors restrict the supply of building sites capable of supporting highly-demanded waterfront development to a small number of scattered stretches and pockets of sandy coastline. Moreover, the limited developable land area of SIS is also a major factor and others include: the presence of pre-existing urban settlements, topographical variations, which render some areas too steeply sloped or too susceptible to flooding for development, and variations in the stability, material composition, slope, and sea conditions of coastal zones.

These factors assist in understanding the macro-level planning context within which tourism-oriented land use activities and decision making occur in SIS. However, tourism development affects land use change and planning more directly through a series of impacts, both positive and negative, that have significant spatial dimensions. Localised benefits or gains include outcomes such as:

1. the provision of employment opportunities in or near both urban and more remote areas of need;
2. improvements to roadway, electrical, telecommunications, water, and sewage infrastructure;
3. regional diversification of economic growth;
4. protection or rehabilitation of natural habitats and features are integral to the attractiveness of the locality to tourists;
5. restoration, promotion and maintenance of local heritage sites and interest in community history.

Correspondingly, localised disbenefits or costs include outcomes such as:

1. changes in traditional employment patterns due to wage competition from the tourism sector;
2. increased land prices that encourage removal of undeveloped land from production and progressively exclude locals from the real estate market;
3. diversion of scarce public funding to maintain a spatially dispersed and economically unviable settlement pattern;
4. seasonal overburdening of electricity, water, road and sewage systems;
5. resort-by-resort servicing patterns adversely affect community-wide access to and benefit from public infrastructure;
6. common property marine and terrestrial ecosystems are negatively impacted (coral reef destruction from sedimentation and effluent discharge, infilling of mangrove swamps for development cause loss of bio-diversity and bird breeding areas, etc.);
7. coastal focus of development may reduce residents' access to and use of beachfront recreational areas;
8. hardening of local attitudes to tourists from effects of high tourist-to-host ratios, changing life styles and economic dependency.

Such localised benefits and costs of tourism development vary considerably from one locale to another and over time, due to differentials in local resource endowments, socio-cultural structures, and the amount and type of development. Equally important factors in terms of land use change are the spatial and temporal concentration of tourism-related land uses and, in particular, the catalytic role that tourism development can have on the urbanisation of land (Cohen, 1978, 226). Together, these three interrelated dimensions of space, time and form underlie what can be conceptualised as a mutual dependency between tourism development and the broader processes of land use change within SIS.

Clearly, the tourism sector is a dynamic element of land use change and activity that can have significant long-term implications for the well-being of the social, environmental, and economic systems of SIS. The descriptive and staged-based models of Butler (1980) and Smith (1989), among others, assist in understanding how factors such as accommodation type, intensity of land use, land ownership and pricing, and tourist types and activities can change over time in a destination. Transitions between development stages are not necessarily gradual or free of conflict or displacement due to the capriciousness of international demand and the physical reality that adjustments to local accommodation supply occur in large, capital-intensive increments and therefore can cause the tourism landscape to change episodically even over short time periods.

Without careful management, planning and co-ordination, the tourism sector can be a latently unsustainable impetus for land use change and development that has the potential, like the inconsistent and overspecialised export agriculture economies it has largely replaced, to exhaust the long-term viability of SIS in a relatively short period of time. The next section explores how strategic land use and development planning can provide SIS with a framework for exercising some measure of control over tourism-induced land use change, while, at the same time, fostering long-term viability of the tourism sector.

2.1.4 *Integrating Tourism Planning and Land Use Planning*

The preceding sections have discussed the context and evolution of land use planning in general, in Caribbean SIS in particular, and the increasingly important role of international tourism in this region. In order to manage tourism growth and its localised impacts, it is necessary to integrate specific aspects of tourism planning within the broader strategic land use planning process of individual nations. It is argued here that at the strategic level, the land use planning process can provide both an overall framework for evaluating competing tourism development projects, while also facilitating many of the operational and regulatory functions of planning. It is recognised that tourist satisfaction and private sector profitability are necessary precursors for the long-term viability of tourism. However, this thesis centres more upon expanding the planning and decision making function of Government and non-Government agencies in guiding tourism growth and less upon improving decision making for agents of the tourism industry in the private sector.

Agreement on the *need* for tourism planning does not, necessarily imply consensus on what tourism planning actually entails. At the simplest level the activity comprises three main dimensions: problem domain, spatial scale, and sectoral interest. The first of these dimensions captures the diversity in the issues involved in tourism planning. A representative list of the tasks and activities that the term has been applied to include: marketing and promotion, product development, visitor management, demand forecasting, air and cruise line scheduling, site and building design, mediation of social or environmental impacts, and creation of medium- to long-range tourism and physical development plans.

The second dimension, recognises the need for different types of tourism planning functions to be performed at national, regional, and local levels. Examples of national tourism planning issues include developing marketing plans and delineating sub-national 'destination zones' that have what Gunn (1993, 27) terms a "critical mass" of attraction, accommodation, and services required by tourists. The latter task recognises explicitly that "locations, regions, resources, amenities and infrastructures have unequal potential and capacity for particular forms, types and scales of development" (Fagence, 1991, 10). In the context of a SIS, regional tourism planning focuses on assessing the tourism resource base within a particular destination zone and planning comprehensively its operation and development. Local level tourism planning is more detailed yet and focuses directly on the problems and aspirations of community members with respect to the tourism sector.

The sectoral dimension of tourism planning reflects the composite nature of tourism and recognises that different aspects of tourism planning are conducted by a variety of public, private and non-Governmental interests. Individual members of these three contributing sectors concentrate on specific types of problem domains and, accordingly, conceive of 'tourism planning' in a manner that is consistent with their overriding mandates. Hence, private businesses are concerned foremost with the profitability of their own operations and, to a lesser extent, the 'industry' as a whole; non-Government interests concentrate on planning habitat or heritage sites that reflect their mandates; and Governments are largely concerned with establishing the physical and promotional conditions necessary to maximise their economic returns from tourism (Holder, 1991, 283). This does not suggest that these sectors are internally monolithic or that each sector engages in only one dimension of tourism planning. For example, Poetschke (1995) and Jenkins (1994) note that partnerships between different members of one sector (e.g. hotel associations) or across different sectors (e.g. public-private Tourism Authorities or Boards) are central to planning of marketing and product development in tourism.

Within the public sector, *de jure* tourism planning and policy-making is restricted typically to marketing programs, fiscal incentives for new investors, and national development plans that specify where tourism facilities such as hotels and condominiums can be built and the construction standards that they must attain for approval. *De facto* public involvement in tourism planning is addressed through a patchwork system of often isolated and even contradictory policies and practices that emerge from different levels and organisations within the broader institutional structure (Pearce, 1989, 277). Some of these planning efforts are directly related to tourism, such as the planning of transportation and parks, while others, such as basic infrastructure planning and measures to rehabilitate marine habitats, can affect the capacity and the success of tourism greatly, although their underlying rationale may have little to do with tourism *per se*.

While each of these different facets of tourism planning is important, the tourism planning capabilities of SIS must be strengthened by forging a closer alliance with the processes and institutions that are maintained for broader land use planning purposes. Hence, issues related to economic planning, market planning and forecasting, and site design are only addressed tangentially in the following discussion. Instead, the remainder of this section focuses on utilising the land use planning process to ensure that decisions concerning the location and amount of tourism-related land use change in SIS are, in Fagence's (1991, 9) words, "strategically appropriate" over the medium- to long-term. Moreover, it is argued that the general land use planning system in SIS enhances the potential for accommodating three inherently difficult elements of tourism planning, namely to ensure that tourism development is integrated into an area's physical, economic and social fabrics (Inskeep, 1988, 361); to increase the amount of control or leverage that an SIS has over its future land resource; and to facilitate compromise and consensus on development options among the competing objectives and viewpoints that are inherent to the tourism sector.

The relationships between tourism development and other forms of land use can be established based upon their functional, organisational, and institutional linkages. Functional linkages can be summarised as having four interrelated elements. First, all land uses are dependent upon the same physical, human and fiscal resource base which, as noted earlier in the case of SIS, is both limited in scope and spatially-confined. Second, there is competition between different land uses for these scarce resources necessitating choices to be made between different development options. Third, displacement occurs when decisions dedicate resources to one land use over other competing options. Displacement may be either reversible, such as a decision to maintain open space as community pasture land for the next five years, or irrevocable, as in the case of building high density condominium or hotel projects on land reclaimed from mangrove swamps. Fourth, some forms of land use can initiate further rounds of change in their immediate proximity. Examples of these elements of dependency, competition, and displacement were mentioned earlier in this section and in the preceding discussion.

The most apparent linkages between tourism planning and general land use planning are the mechanisms used to control and influence tourism development in SIS. Given the importance of tourism to most Caribbean SIS, and the elevated foreign presence in the sector, the planning task clearly cannot be left entirely to the private sector (Lui and Jenkins, 1996, 101) and control mechanisms such as the following can be used locally to influence the level of development activity:

1. formalise visitor management strategies which provide various incentives or disincentives to particular tourist activities and visitation patterns (Mathieson and Wall, 1982, 179);
2. target public and private marketing efforts to influence tourist numbers and types – may be applied aspatially to the island as a whole or distinguish between destination zones;
3. provide Government financial grants and incentives (tax holidays, waiving of import duties for new hotel construction, subsidisation of infrastructure) to encourage particular types of new investment (Pearce, 1989, 245);
4. establish development control measures to ensure that proposals for land use change and building construction satisfy a pre-determined set of structural and aesthetic standards as well as permissible structure types (e.g. hotels versus guest houses versus condominiums); and
5. establish medium- to long-range development plans that detail strategies for land utilisation, service provision, population distribution, the integration of economic activities, and can in turn define the nature of development control measures.

The first three control mechanisms listed above are not directly related to the land use planning system. However, visitor management, marketing, and fiscal incentives can be characterised as tactical management and implementation devices that can be adapted in the short- to medium-term to prevailing conditions but should remain consistent with the overall context specified in mid- to long-term strategic plans.

Development control is itself not a sufficient tool for managing land resources but it can provide the regulatory and institutional context for controlling the type of tourism development that occurs if it is crafted with specific strategic objectives in mind. Wall (1993a, 52) has noted the strong relationship between the type of tourism accommodation and the types of tourists that are attracted to a destination. In turn, the structures and activities associated with different types of tourists are significant determinants of how tourism impacts on the economy, ecosystems and the host population. However, in most instances development control is primarily concerned with structural matters on an application-by-application basis and normative or strategic matters are infrequently addressed.

For islands with few development alternatives other than tourism, Wilkinson's (1989, 157) claim to the "inevitability of tourism" is most likely appropriate. Further, although there are no conceptual reasons for the development path inherent to the resort cycle to be inevitable in SIS, most evidence to date appears to point in that direction (Butler, 1991, 204; Wilkinson, 1989, 171). However, the key planning question is not whether a SIS can stop the resort cycle at a particular stage and maintain a vibrant tourism economy indefinitely, but how can the inevitable trade-offs that are characteristic to tourism-induced land use change be managed over the medium- to long-term? Addressing this question requires a long-term commitment to the issues of land development in general and tourism growth specifically if a SIS is to avoid having the sector become another example of Holder's (1991, 280) "self-destruct theory of tourism".

Commitment of this nature requires some form of consensus between members of the private sector, Government, and the local community concerning the overall strategic direction of the tourism sector (Dann and Potter, 1997, 213). Within the tourism sector itself, achieving consensus across multiple decision makers has proven to be difficult, given its composite and competitive nature. As a first step toward generating either consensus or compromise strategies, it is necessary to have available mechanisms and resources for soliciting and assembling input from a wide variety of individuals and groups. The land use planning process in most Caribbean SIS typically does provide facilities, albeit at times inadequate ones, for this task through procedures for circulating development applications to agencies with problem-specific knowledge and expertise and for facilitating public participation on particular issues. The implementation, regulatory, and review structures that are needed to ensure that tourism development strategies can be put in place, enforced, and modified as needed can also be found in most land use planning systems. Unfortunately, while the presence of these structures increases the potential for multi-participant decision making to achieve compromise solutions to land-related problems, recent Caribbean history demonstrates that major policy decisions relating to high-profile land use and tourism issues are dominated frequently by short-term political factors (Dann and Potter, 1997, 212).

Notwithstanding this reality, it is clear that there are several advantages of a tighter integration of land use planning and tourism development in SIS. Tourism is a morphogenic form of land use that can change its own form and the built form of its host nation substantially over a generation (de Albequerque and McElroy, 1995, 25). As the growth of tourism in the Caribbean demonstrates, a key survival strategy for small nations has been their ability to adapt quickly to unexpected opportunities or problems (Baldacchino, 1993, 37). Another key to the survival of these small nations has been their ability to mobilise large segments of their societies to work towards particulars goals (Streeten, 1993, 200). In order to maintain this capacity to manoeuvre, tourism development in SIS must be planned carefully with overriding commitments to the long-term management of scarce land, human and ecological resources and the integration of tourism with other forms of land use activities. Planning of this nature necessarily involves facilitating debate and decision making among multiple and often conflicting interests that span a variety of specialised problem domains. The diversity of objectives and the spatial ramifications of many forms of land use change place high demands on access to large volumes of land-related information, mechanisms for communicating that information, and facilities for representing differing priorities and values.

The potential to generate compromise or consensual land-related decision making can be increased if decision makers can debate the merits and validity of competing and selectively-produced information bundles within a common evaluation framework. A succession of developments in decision support technology over the past decade have increased the viability of both producing and applying such a framework to land use planning and decision making issues. Spatial information tools designed expressly to support the multi-participant decision making (MPDM) context of land use and tourism planning can make important contributions toward meeting these requirements. These tools are introduced in the next section and then applied to the land use planning and tourism development nexus in the last section of the chapter.

2.2 Decision Support for Planning and Managing Land Use Change

2.2.1 Decision Support Systems

Reviews of the considerable debate and ambiguity surrounding the definition and the use of the term Decision Support System (DSS) can be found in Alter (1980), Ginzberg and Stohr (1982), and Silver (1991) among others. In the introductory chapter, DSS were defined as computer-based information systems that support, but do not replace, decision makers' use of judgement in problem-solving activities. Ideally, DSS combine the information management strengths of computer systems with human creativity and intelligence. DSS have been applied to a wide variety of application areas that range from simple and repetitive problem-solving cases in production control through to highly complex, non-routine choice and evaluation activities in public and private sector decision making. DSS are technological artefacts that are built for specific and practical problem contexts and, as a result, vary a great deal in terms of their underlying purpose, structure and functionality. The DSS examined in this thesis belong to a large group of DSS designed to assist primarily upper-level decision makers to resolve complex, ill-defined or semi-structured problems that cannot be addressed completely with mathematical methods alone.

Densham and Rushton (1988, 58, 62) distinguish between tangible information, which can be expressed through abstract conceptual structures such as mathematics, and intangible information that can be expressed only through natural languages. Problems for which decision makers can clearly state their objectives and solution space constraints using tangible measures are highly tractable in a computational sense. The role of decision makers is limited therefore to providing input parameters to an analyst at the onset of an optimising decision aid procedure and then performing a rational evaluation of the resulting model outputs. Semi-structured problem environments, which are characteristic of most strategic-level planning problems, contain relatively high proportions of value-based intangible information that cannot be expressed adequately using abstract mathematical constructs (Malczewski and Ogryczak, 1995, 1935). Decision makers are required in these cases to participate actively in each phase of the solution process by contributing their knowledge and judgement of the intangible aspects of the problem. Hence, as noted earlier, the computer system does not make decisions but rather supports the decision maker's use of both tangible and intangible information to navigate, explore and resolve difficult choice problems.

In addition to supporting the use of judgement in poorly-structured problem contexts, the following characteristics are most commonly ascribed to DSS irrespective of their application domain:

1. they provide an adaptive problem-solving environment that can be altered readily to different decision making contexts (Giaoutzi & Nijkamp, 1993, 213);
2. they are designed with advanced graphical user interfaces (GUI) to ease interactive use by non-technical personnel;
3. while DSS can provide efficiencies in decision making, their overriding purpose is to enhance the effectiveness or quality of decision making; (Silver, 1991, 12)
4. they provide flexible methods for combining modelling and analytical capabilities with data access capabilities (Sprague and Carlson, 1982, 6);
5. they are designed either for specific problem domains or for specific types of decision problems;
6. DSS support and encourage an interactive and recursive approach to problem exploration and problem-solving as opposed to the more conventional serial approach (Geoffrion, 1983).

These characteristics are referenced in the next section, as the discussion turns to the use of spatial information technologies such as Geographic Information Systems (GIS) for decision support in tourism and other types of land use planning in SIS.

2.2.2 *Geographic Information Systems And Spatial Decision Support Systems for Land Use Planning*

GIS can be defined generally as computer systems with facilities for the storage, retrieval, manipulation and display of spatially referenced data. GIS are not usually regarded as complete DSS *per se*, but are instead information tools that provide critical types of support for decision making purposes.

Four basic types of capabilities that GIS offer are particularly relevant to land use planning and management. First, GIS provide a coherent data management framework that has mechanisms to integrate, organise, and manipulate the wide diversity of spatial and non-spatial data sets that are required to address the comprehensive and multi-objective land use planning issues. Spatial data are defined here as data that describe the geographical, or co-ordinate, attributes of entities represented symbolically using graphic primitives such as points, lines, raster grid cells, or irregular polygons. In contrast, non-spatial or aspatial data contain the descriptive properties of a specific geographic entity. Location serves as the common attribute for relating together data sets that may differ substantially in their source, thematic content, digital format, and geographic extent. This capability is of particular advantage to land use planning as it allows relationships between the specifics of the local (i.e. site or neighbourhood-level) and the broader regional (i.e. jurisdictional and interjurisdictional) scales to be explored and interrelated. Similarly, information pertaining to and originating from specialised natural or human-based problem domains can be readily combined within a flexible location-based framework. GIS' integrative capabilities are complemented by data construction tools that permit new data to be created from external sources. The translation of hard-copy maps into digital map "layers" through digitising and the generation of new spatial features using Global Positioning System (GPS) co-ordinates are two examples of this data creation function.

Second, most commercial GIS have macro-programming facilities that allow their operation to be adapted and extended to suit a user's particular needs. These features are often used to automate certain types of tasks and to construct problem-specific application tools that are more suitable to a wider variety of user skill sets than the traditional and general purpose, and frequently command-line driven, GIS toolbox. The benefits of these capabilities to land use planning contexts have been realised primarily in terms of improving efficiencies in completing repetitive operational tasks such as querying housing stock databases and processing applications for minor amendments to zoning by-laws.

Spatial analysis forms the third basic capability that GIS confers to land use planning and management. Section 2.1 cited externalities, indivisibilities, public good provision, and the spatially inelastic character of land ownership in the short- to medium-term as key factors underlying the importance of space to land-related issues. The suite of available spatial analysis tools available to address these factors varies from one commercial GIS to another but they generally centre upon the geographic and mathematical concepts of proximity, intersection, union, and connectivity and a limited set of statistical facilities. GIS-base spatial analysis tends to be relatively simple in land use planning operations and includes, for example, creating building exclusion zones by buffering sensitive natural features by a distance factor, overlaying multiple data layers to identify the spatial coincidence of features with specific characteristics, and constructing extensive queries to determine if one set of features (e.g. identified habitats) lie within the geographic confines of another type of feature (e.g. officially protected zones) (Birkin et al, 1987, 6). Several researchers have noted the dearth of advanced forms of spatial analysis in commercial GIS (Openshaw, 1998; Unwin, 1995). Shortcomings in the areas of modelling, spatial statistics, automated pattern recognition, and methods for representing priorities and choice have been noted and are addressed in part through linkages with external programs and/or macro programming (Brown et al, 1994; Goodchild, 1992; Openshaw, 1991; Birkin et al, 1987).

Finally, the graphical display of data in map form can enhance significantly the abilities of individuals to identify patterns in data or features, conceptualise spatial relationships among different phenomena, and communicate spatial and non-spatial ideas to others. In contrast to traditional hard-copy map outputs, this form of data visualisation is highly flexible, as map content and techniques can be changed relatively easily. The processes of exploring, understanding and communicating the ramifications of complex policy alternatives can be aided greatly through visualisation (Langendorf, 1992, 723-724). These improvements extend beyond the benefits arising from alternative media for presenting information and also include gains that can be associated with interactive use of map displays as "indexes" to guide and direct information search processes (Webster, 1993, 722).

The success of GIS as a decision support tool for land use planning has been more apparent at the operational end of the decision making spectrum than in the more complex instance of strategic planning (Couclelis, 1991, 9). Operational decisions in the planning realm are clearly-defined problems of regulatory enforcement or plan implementation for which the data management and task automation capabilities of GIS are ideally suited. For this application domain, rapid access to large quantities information is seen generally to be unambiguously beneficial to decision making in most, if not all, planning agencies. The GIS industry has reinforced this premise explicitly in its promotional materials and also implicitly through a continued emphasis of software and hardware development on the technical matters of producing faster methods of manipulating larger and more diverse quantities of data.

The focus on data processing is based ultimately on the assumption that strong linkages exist between information inputs and the quality of decision outputs. While this may be valid for some types of operational decision problems, it is important to note that decision making activities and their information demands are not uniform throughout an organisation or planning context. Scholten and Padding (1990, 407-408) distinguish between the following four types of users of spatial information based upon their "functional specialisations": information specialists, policy preparers, policy decision makers, and interested citizens including members of the public, lower level Government agencies, or social organisations.

A hierarchical dependency exists among the first three user types as policy decision makers make choices based upon the alternatives developed by policy preparers who are themselves reliant upon the data processing of information specialists. As one moves up the hierarchy from the information specialist to the policy decision maker, decision problems become less clear, demands for technical data management skills decline, and more intangible information is utilised. A similar progression is apparent in spatial information system requirements as technical specialists need general purpose and customisable GIS for data processing, policy developers value systems with enhanced analytical capabilities, and decision makers demand user-friendly and problem-specific tools to assist in the evaluation of alternatives. The needs of interested citizens are confined, at the most, to smaller systems designed to provide easy access to current but not necessarily detailed or strategic information, or at least to outputs from these systems. Hence, as noted in Section 2.1.1, there is a close relationship between information use and participation in planning decision support.

Actual demands for spatial decision support within a particular planning context will vary from this generic typology. First, a given individual may act as a policy-developer who serves as a professional advisor to higher level policy-makers and also have limited direct decision making abilities of their own particularly over the operationalisation of plans and policies. Hence, the term decision maker is interpreted relatively broadly in this thesis to include both of these types of users. Second, some planners (policy preparers) may be technically adept, and due to their local circumstances, may process the raw data required for their analyses. More likely, planners will be infrequent users of spatial information technology and will instead rely heavily upon the efforts of information technologists (Ottens, 1990, 20). Finally, Silver (1991, 34) notes that complex societal decision making contexts are often defined by a multiplicity of interactions within and between a hierarchy of subordinate decision making contexts. Policy preparation in land use planning, for example, often occurs in a multi-departmental or multi-agency environment with contributions being made by a number of individuals or groups. Similarly, the concerns of "interested citizens" extends beyond simply being informed of decision outcomes but instead revolves around demands for more meaningful methods of participation in land use and management decision processes. Notwithstanding any localised variations, it is apparent that it will be difficult to satisfy the whole spectrum of spatial information needs and system requirements with one or more general purpose GIS.

GIS have not demonstrated much success as decision support tools for the more strategic problem needs of policy developers and decision makers. There are two interrelated reasons for this, namely, limitations in implementation and limitations in content. The former include a wide variety of technological and institutional factors which together limit the effectiveness of GIS for providing organisational decision support. One of the most significant implementation limitations associated with GIS is their resource intensive nature. Despite decreasing hardware and software costs and increased availability of spatial data, far more of the resources directed at GIS are consumed by practical problems of data acquisition and maintenance than are devoted to transforming data into useful information for planning purposes (Yeh, 1991, 8). This problem is often exacerbated in enterprise-wide contexts where one group of users with moderate data quality, currency, or accuracy requirements may be forced to maintain their own data to much higher standards in order to permit system-wide integration with data maintained by other departments with different requirements.

The complex and "user-unfriendly" character of many commercial GIS also place high demands on human resources since specialised training and expertise are required to operate and maintain larger installations or develop simplified applications through macro or open development environment (ODE) programming. In the final analysis, all technology, including GIS, is a social construct that is defined and shaped by the conceptualisations of individuals and their use of it to perform tasks they consider to be useful (Innes and Simpson, 1993, 231). Thus, although GIS are becoming commonplace tools in Governments and larger private sector companies, they are somewhat amorphous creations at the decision making level and can often be characterised as "solutions looking for problems". This ambiguity is often reflected in planners' vague perceptions of how GIS functionality can be applied beneficially to practical land use and planning issues.

Two types of content limitations can be identified in GIS – analytical content limitations and structural content limitations. Efforts to address the analytical shortcomings of GIS include research on linking or integrating domain-specific models, such as population forecasting, spatial interaction and network routing models, to the general GIS framework. Other research, much of it closely related to spatial modelling, has been undertaken to strengthen the geo-statistical resources that analysts can employ to obtain, for example, advanced measures of spatial clustering or association (Gatrell et al, 1996; Anselin, 1995; Fotheringham and Rogerson, 1993). Other research has grown out of a recognition of the complex and subjective nature of spatial entities and the divergencies in interpretations of geographical features. Significant conceptual and technical advances have been made in the capacity of GIS to manage the indeterminate nature of many spatial boundaries, the temporal dimension of many socio-economic and natural phenomena, as well as alternate means of improving cognition through visualisation (Burrough and Frank, 1996; Wang and Hall, 1996; Langren, 1991; Hearnshaw and Unwin 1994).

Some structural limitations of GIS are related to the analytical content deficiencies discussed above. Others are related directly to their lack of facilities for accommodating critical aspects of the decision making process. In section 2.1, the rational model of decision making common to medium- to long-range planning was described in terms of six identifiable phases: problem identification, goal setting, generation of alternatives, evaluation of alternatives and choice of a preferred option, implementation, and monitoring. To date, GIS have been used most successfully to generate sets of choice alternatives within problem frameworks, such as facility siting operations, that are recognised as having an explicit spatial dimension (Arentze et al, 1996b, 191; Jankowski, 1995, 253). For planning problems of this nature, the capacity of GIS to perform suitability analysis using map overlay and distance-based queries across thematically heterogeneous spatial and attribute databases enhances the speed with which alternatives can be generated or modified and, potentially, the comprehensiveness of the analysis. However, GIS have proven to be of less assistance in practice for the remaining stages in the decision making process. Problem identification and monitoring are closely interrelated in a continuous planning cycle and both can be enhanced through GIS visualisation and facilities for spatial processing and advanced data management. These facilities are of similar use during the evaluation and choice phases although GIS-based decision support is limited largely to simple map and tabular data presentation and is again most applicable to planning problems with an explicit spatial character.

For spatial information technology to provide meaningful decision support for medium- to long-term land use planning, three critical structural limitations must be overcome. First, flexible problem-solving environments are required to accommodate a multi-pass decision process that permits problem definitions and resolution alternatives to be refined and redefined as necessary. Within this environment, facilities to represent different interpretations of planning issues and competing solution strategies or scenarios are required to facilitate this process of exploration and refinement (Hall et al, 1997a, 74). Second, the multi-participant character of land use planning issues must be acknowledged and supported explicitly within decision support procedures using methods that ease conflicts and assist in the generation of consensus or compromise solutions. Closely associated with the requirement for multi-participant support is a need for mechanisms that allow participants in the decision making process to express choice and priority. Not only do most analytical methods in commercial GIS disregard the presence of multiple decision makers, but many common operations, such as overlay procedures, also assume implicitly that all data are of equal importance to the decision maker(s) (Carver, 1991, 326; Janssen and Reitveld, 1990, 132). This factor alone curtails severely the evaluation capabilities of GIS once a "short-list" of suitable candidate locations has been identified using overlay or query procedures (Heywood et al, 1994, 632).

The limitations in implementation, structural content and analytical content have together restricted the suitability of GIS for decision support to the highly technical data processing needs of information specialists. As both Eastman (1993b, 1) and Heywood et al (1994, 638) note, GIS development should be driven by the needs of decision making participants. However, it is assumed often, if only implicitly, that that human decision processes can and should be modified to accommodate the capabilities of GIS. Veregin

(1995, 97) also notes the implications of such recursivity in the relationship between information technology tools and decision making processes. Specifically, he comments that use of GIS technology allows existing decision making to be executed in a more efficient manner than is otherwise possible. However, there remains the possibility of "reverse adaptation" whereby existing goals are modified to be more compatible with the capabilities of the technology. Clearly, the latter case is a technological externality that is neither desirable nor practical when issues that require multiple inputs and that are of national significance are under review. To minimise the problem of reverse adaptation where technology leads decision making rather than being directed by it, GIS development must be refocused in order for policy developers, decision makers and members of the public to exploit improvements in information management, display and analytical capabilities and to participate more fully in the decision building process itself.

A substantial amount of development effort has been directed at bundling the spatial analysis and data management capabilities of GIS with the flexible problem-solving environment of DSS. Hybrid Spatial Decision Support Systems (SDSS) are designed to alleviate many of the implementation and content limitations of current commercial GIS by providing non-technical users with advanced, but easy-to-use, analytical and modelling tools that are applicable to poorly-structured and limited problem domains. This chapter concludes with a description of a conceptual framework for such a SDSS suitable for the multiple participant decision making (MPDM) context of strategic-level land use and tourism planning in the Caribbean and other SIS. Facilitating users to include their priorities in the evaluation of alternative tourism-related land use futures is a central element in the design of a SDSS. Consequently, the next section of the chapter describes a group of techniques, known collectively as Multiple Criteria Analysis (MCA) methods, that have been developed expressly for this purpose.

2.2.3 *Multi-criteria Analysis Techniques for Choice Problems in Land Use Planning*

In response to the structural limitations of GIS as a higher-order decision support tool, interest has been expressed in the literature on the potential for integrating multiple criteria analysis (MCA) techniques with spatial information technologies. MCA methods complement GIS in a number of ways, the most significant being the mechanisms that MCA have for capturing the diverse preferences and objectives of multiple decision makers. Based upon this capability, MCA can provide decision makers with a flexible environment for exploring the sources and intensity of land use-centred conflict, generating compromise solutions, and ranking planning alternatives according to their value-based preferences (Janssen and Rietveld, 1990, 129).

The semi-structured character of strategic-level land use planning issues largely precludes the use of decision support methods that seek to produce an optimal or pareto-optimal solution. Instead, decision makers are more commonly confronted with the need to evaluate a limited and known set of *negotiated* alternatives. Discrete MCA methods facilitate this mode of decision making by allowing decision makers to rank order a set of choice alternatives based upon multiple judgement criteria and divergent priorities. The decision problem may involve selecting one land use planning scenario out of a set of proposed scenarios. The use of MCA in practical land use planning contexts to evaluate competing regional development plans, routes for infrastructure expansion, and potential facility sites is demonstrated in several applications (see, for example, Shefer et al (1997), Guimarães Pereira (1996), Jankowski and Richard (1994), and Carver (1991)).

The multi-faceted and multi-participant elements of strategic-level decision problems are incorporated directly into the MCA evaluation process in two distinct ways. First, the performance of each alternative across different aspects of the decision problem is indicated through a series of criteria scores. Second, the relative importance of each decision criterion to a given decision maker is captured as a criterion weight. As illustrated in Figure 2.2, criteria scores are represented typically in an evaluation or project effect matrix, E, defined by a set of alternatives i (1,... ,I) to be evaluated and a set of attributes, or criteria j (1,... J), that describe the relevant characteristics of each alternative. The relative attractiveness or suitability of different choice alternatives is determined by mathematically combining criteria scores with criteria weighting values that are stored in a priority vector W (Lin et al, 1997, 405). The resultant values are recorded in an associated vector of appraisal scores a (1, ... , I).

$$E = \begin{bmatrix} e_{11} & \cdots & e_{1I} \\ \vdots & & \vdots \\ e_{J1} & \cdots & e_{JI} \end{bmatrix},$$

where E_{JI} is the criterion score,

$W = (w_1, \; w_2 \; \ldots \; w_J)$, and

$$\sum_{j=1}^{J} w_j = 1$$

$$\begin{bmatrix} e_{11} & \cdots & e_{1I} \\ \vdots & & \vdots \\ e_{J1} & \cdots & e_{JI} \end{bmatrix} \quad \textit{operation} \quad \begin{bmatrix} w_1 \\ \vdots \\ w_J \end{bmatrix} = \begin{bmatrix} a_1 \\ \vdots \\ a_I \end{bmatrix}. \qquad 2.1$$

Source: after Voogd (1983)

FIGURE 2.2 A GENERAL MODEL OF MCA METHODS

Three general types of MCA methods are available for producing appraisal scores from the weighting vector and criteria value matrix. Outranking techniques, of which the Electre family is most widely known, rely upon pair-wise comparisons of alternatives to derive a subset of alternatives that outrank or dominate all other alternatives (Vinke, 1992, 58). Techniques based on multi-attribute utility theory (MAUT), such as the weighted summation method, calculate appraisal scores for each alternative by multiplying criterion scores by their corresponding weighting value and then summing the resultant products. Multi-dimensional scaling methods are based upon the concept that an ideal point that is preferred to all other values can be identified for each evaluation criterion (Won, 1990, 122). Alternatives are ranked based on how far they deviate in *n*-dimensional space in total from these weighted optimum values.

A variety of procedures are also available for transforming a decision maker's stated preferences into priority weights. The merits and operational details of these procedures as well as the MCA methods referred to above are discussed in greater detail in Chapter Three and are also reviewed in Olson (1996), Vinke (1992), Janssen (1992), Nijkamp et al (1990), and Voogd (1983). The weighting procedures most commonly encountered in the literature include:

1. ranking: criteria are ordered from most important to least important (full ranking) or are first divided into subsets of significant and less significant criteria and then ordered according to importance (partial ranking);
2. translation of semantic statements: intervals on a 5 to 9 point numeric scale are linked with corresponding statements that indicate that a criterion is of "very low importance", "low importance", through to "very high importance";
3. rating: decision makers distribute a fixed number of points (usually 100) amongst the individual criteria;
4. paired comparison: the decision maker examines all possible pairs of criteria and uses integer ratios (usually between 1 and 9) to indicate the degree to which criterion a is of more or less importance than criterion b;
5. trade-off method: ratio weights are established by asking each decision maker how many units of improvement in criterion a would be required to equal a one unit improvement in criterion b.

Depending upon the technique employed, the measurement scales and quality of the data, and the manner in which priorities are expressed, the following types of results can be realised from an MCA evaluation (Janssen, 1992, 51; Vinke, 1992, 28):

1. a complete ranking of the set of alternatives from best to worst such that A >B >C >D;
2. an incomplete ranking of alternatives where A >(B, C, D) or (A, B) >(C, D);
3. one alternative is identified as being better than the other choices: A >(B, C, D);
4. the set of alternatives is divided into acceptable and not acceptable subset such that (A, B, C) >D.

In contrast to GIS, MCA evaluation methods are targeted at the decision making needs and methodologies of higher-level policy developers and decision makers. The arguments that individuals put forward in the negotiation process inherent to multi-participant decision making are based first on a selective assessment of the available information to determine which facets of a land use issue can be used to judge the suitability of different alternatives. These processes are replicated directly within an MCA framework through the selection of judgement criteria and the establishment of criteria weights - both of which can be refined quickly to respond to an unsystematic assignment of problem characteristics or negotiating tactics.

In addition to facilitating the testing of different solution strategies and assisting decision makers to learn more about the issue at hand, MCA can contribute in several other ways to the development of consensual or compromise solutions. As a first step, the need for all decision making participants to consider and weight a common set of criteria can help focus debate on the difficult task of differentiating between acceptable and unacceptable alternatives. Subsequent rounds of problem redefinition and alternative refinement may be induced by this requirement but the end result will be the emergence of either a better considered solution or a more sophisticated negotiation strategy. Second, the need to justify criteria and weight choices can contribute to openness, traceability and accountability in the decision making process, three factors which are demanded increasingly of public decisions and private decisions that affect scarce public resources such as land and its associated uses (Voogd, 1983, 33). Third, the ability to examine a set of alternatives from several different viewpoints provides a mechanism for expanding the variety of interest groups who can participate in land use decision making and enhancing their individual contributions towards problem-solving (Nijkamp et al, 1990, 6). Finally, MCA allows the intangible aspects of land use decision issues, such as political importance or amenity values, and the intangible aspects of a decision maker's knowledge base, as represented by experience, values, and sense of place, to be incorporated into the evaluation explicitly as judgement criteria or implicitly through criteria weighting values (Gottsegen, 1997, 1)

Voogd (1983, 345) stresses that "multicriteria evaluation only gives *conditional* results, subject to postulated value statements (e.g. priorities, criteria, etc.). Such *postulated* statements may be based on research (e.g. preference or other analyses), but they always remain arbitrary expressions." This is not so much a weakness of this group of techniques but a recognition of the reality that no "correct" answers exist for many multi-faceted decision problems and that the validity of the assumptions underlying an MCA evaluation affects resulting outcomes (Vinke, 1992, 29-30).

However, there are a number of general limitations to MCA methods that can hinder their use for land use planning and decision making. First, Carver (1991, 328) noted that many MCA methods exist only as mathematical procedures that must be programmed and supplied with data management and reporting capabilities. Since the time of his comments, more of the better known MCA techniques have become commercial products but their highly-specific capabilities and their focus on strategic decision problems limit their day-to-day applicability. Second, MCA methods are poor at accommodating the temporal and the spatial dimensions of choice problems (Janssen, 1992, 90; Tkach and Simonovic 1997, 29). This is a critical shortcoming given the importance of these dimensions to understanding the processes and differential impacts of land use change, such as those discussed earlier in this chapter.

In addition to these technical limitations, MCA methods share several structural limitations that restrict their overall usefulness in a MPDM forum. Foremost among these limitations are a series of uncertainties concerning the method being used in the analysis (method uncertainty) and whether all of the relevant criteria have been included in the analysis and are weighted properly (criteria and priority uncertainties). One aspect of method uncertainty relates to the fact that although most MCA techniques are conceptually simple, they can be overly complex for non-experts to understand and operate successfully (Won, 1990, 137). This can be a serious deficiency as decision makers accountable to investors or to the electorate are usually unwilling to base their decisions and consume limited time on methods that they do not have confidence in. Moreover, the assumptions underlying individual MCA techniques and weighting procedures are sufficiently unlike that they behave differently in trade-offs between alternatives thereby permitting different results to be produced from the same evaluation matrix (Carver, 1991, 328; Voogd, 1983, 191). Here again, the main difficulty is more a problem of decision makers not understanding fully the methodological principles underlying a particular technique, than a problem with the techniques *per se*. For this reason, Heywood et al (1994, 635) and Jankowski and Richards (1994, 325-326), among others, encourage the use of more than one MCA method and also applying some form of sensitivity analysis to allow decision makers to ascertain how a change to a specific priority or criterion score affects decision outcomes.

Despite these weaknesses, MCA methods offer significant capabilities directly related to the multi-faceted MPDM context inherent to strategic land use planning. The next section describes how an integration of GIS and MCA can capitalise on the best characteristics of each to produce the foundation for a SDSS targeted specifically at providing decision support for land use-related tourism planning in SIS.

2.2.4 *Integration of GIS and MCA Technologies for Land Use Planning*

The previous two sections have outlined some of the significant, but limited, forms of decision support that both MCA and GIS can provide individually to semi-structured land use planning problems. Both also have significant weaknesses which have restricted their acceptance and success for higher order decision making. Most significantly, however, the capabilities and shortcomings of GIS and MCA are largely complementary in nature. GIS have strengths in the areas of data management and integration, spatial representation and analysis of diverse phenomena, and visualisation while offering poor accommodation of the numerous and diverse interests, viewpoints and priorities that permeate land use issues. As a result, GIS diffusion as a decision support tool has been restricted largely to data processing and mapping functions within the realms of information specialists and technically-adept policy developers. MCA methods, in contrast, are designed specifically to recognise the political "or vested interests" aspects of decision making by facilitating the inclusion of multiple viewpoints and by permitting differential amounts of emphasis to be assigned to specific problem elements. These advantages have not been exploited to their fullest in practice due to a variety of reasons including their general lack of data management functions, an inability to account properly for spatial data, the problem of method uncertainty, and their operational complexity for non-expert users.

Hence, an integration of GIS and MCA offers the potential to construct a SDSS that supports strategic-level choice problems. The following two questions are central to the integration of GIS and MCA functionality:

1. How should GIS or spatial information technology in a broader sense, be linked with MCA models?
2. What groups of potential users can benefit most from different types of GIS and MCA linkages?

In response to the first question, two strategies have been identified for integrating modelling and analytical tools such as MCA with GIS. The earliest efforts followed what has been referred to as a "loose-coupling" or "shallow-coupling" approach where separate stand-alone GIS and MCA software packages were linked through an intermediate file exchange mechanism. From an operational perspective, the GIS serves as both a source of input data for the model as well as a destination for model results to be displayed and manipulated further (Fedra, 1996, 413). Although little customisation is required to integrate different systems in this way, the users' cognitive processes are hindered by the need to readapt continually to the peculiarities of dissimilar user interfaces and procedures, as illustrated in Figure 2.3. This problem is accentuated if the GIS is linked in this fashion to several different modelling packages. "Tight-" or "deep-" coupling eliminates the difficulties associated with incompatible user interfaces and the inconvenience of relying upon file exchange linkages to transfer information between the systems. Using this approach, MCA routines are incorporated directly within the general GIS toolbox. This approach has been adopted for a number of customised applications, as described in Lin et al (1997) and Wu (1998), and in the limited MCA capabilities incorporated within the overlay procedures of the IDRISI and SPANS commercial GIS products.

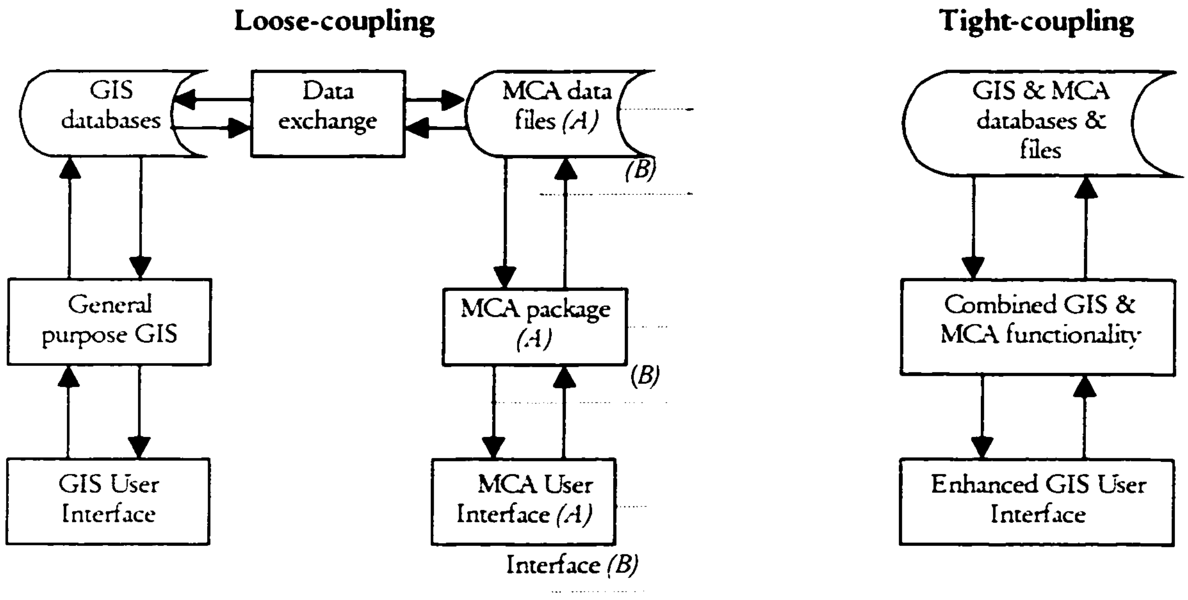


FIGURE 2.3 METHODS FOR LINKING GIS AND MCA

In terms of the second question, the issues of integration methodology and the target user community for the resultant decision support functionality are highly related. Technical information specialists, while not involved directly in the decision making or policy development stages of strategic-level planning, generate data processing outputs that are critical sources of input to higher-order analysis and decision operations. An ability to move beyond the deterministic map layer overlay procedures of most commercial GIS and selectively weight and prioritise different data elements will produce more relevant and realistic information products. The MCA capabilities of IDRISI and SPANS mentioned above are a first step toward this end, as they permit factor weighting within map overlay procedures. The application of GIS to planning issues, however, encompasses more than overlay routines and a viable role can be identified also for more loosely-integrated systems exemplified by the efforts of Jankowski and Richard (1994), Pereira and Duckstein (1993), and Carver (1991), among others. Through the use of these tools, technically-adept users can make better quality data available as input to the domain-specific SDSS that are required by higher policy developers and makers.

However, it is apparent that even efforts to integrate MCA methods tightly within the general GIS toolbox will suffer from the same structural limitations that hinder current GIS in terms of providing higher-order decision support. Carver (1991, 337) notes that a technically-skilled GIS operator would likely be required to act as an intermediary between the enhanced GIS and the decision makers, many of whom may have only minimal knowledge, interest, or experience with GIS or computing. While the use of a technical specialist is justified in many instances because of the complexity of most full-featured GIS and the advanced knowledge that is required of planning procedures and analyses, some decision makers may be uncomfortable with the need to translate their preferences into terms compatible with a computer system (Heywood et al, 1994, 633). Hence, for this approach to succeed, decision makers must surrender a certain amount of control over the means used to arrive at a decision to an intermediate, and perhaps non-neutral, person.

As a result, more attention is being directed at integrating limited GIS functionality and MCA methods within tightly-coupled and highly-focused SDSS. The decision-assisting orientation of these SDSS and their easy-to-navigate interfaces place less of a premium on technical skills and data processing functionality and therefore allow them to be useful to a wider spectrum of individuals. This broader cross-section of potential users includes higher-level policy-developers and perhaps even policy-makers directly within planning agencies and may also include members of other groups or agencies, including the public, that may be involved with planning issues on a less frequent basis. Within the SIS land use and tourism planning context, potential system users may include representatives of different facets of Government (Planning, Tourism, Economic Development, Environment, etc.), foreign and domestic property developers and landowners, community associations, NGOs, various business associations, among others.

Constructing a multi-participant SDSS to assist with consensus- and compromise-building in this complex problem environment is a task that can include but also extends beyond a marriage of GIS and MCA capabilities. Specific facilities, for instance, need to be provided to facilitate and manage intra- and inter-group information exchange. Many of the developments in the field of Group Support Systems (GSS) and its sub-field of Group Decision Support Systems (GDSS) are relevant to information system use for SIS planning. The next section provides an overview of pertinent GDSS research, explores how GDSS have influenced recent spatial information systems development, and conceptualises the use of multi-participant spatial information tools within the SIS land use and tourism planning context.

2.3 Multi-Participant Spatial Decision Support Systems for SIS Land Use Planning

2.3.1 Group Decision Support Systems and Group Spatial Decision Support Systems

Recently, attention has been directed in the literature at GSS and GDSS as organisational structures have shifted from hierarchical arrangements to more flexible project- or team-based methods of production that are reliant upon group-based problem-solving (Ngwenyama et al, 1996, 155). The strength of GDSS "lies in their ability to enhance individual and group information-handling capacity, to provide additional media for interpersonal communication, and to provide data resources and process structures for group work" (Poole et al, 1993, 177). To this list, MacDonald (1997, 512-513) adds that GDSS can aid in documenting decision processes and also reduce the tendency for one or more members to dominate discussion.

A detailed study of the impacts that are most frequently attributed to GDSS was conducted by Poole et al (1993, 180-187), who compared computer-supported and non-supported group decision making. The impacts were divided into two broad categories: "External system" impacts affect how the group organises itself and interacts with its external environment while conducting its work, while "internal system" impacts are associated with the processes that the group uses to express the interrelationships and sentiments of its members to each other (Poole et al, 1993, 180). Table 2.2 lists the impacts and indicates how they are thought to affect group decision making.

Impact	Quality	Consensus Change	Solution Satisfaction	Decision Process Satisfaction
Impacts on the external system				
Work process structure				
More organised decision processes	↑	↑	↑	↑
Increased procedural insight	↑	↑	↑	↑
Task-communication fit				
Increased task-communication fit	↑	↑	↑	↑
Depth of analysis				
Increase number of ideas	↑	↑	↑	↑
Increased critical scrutiny of ideas	↑	↑ or ↓	↑ or ↓	↑
Increased ideational connection	↑	↑	?	↑
Increased use of formal idea	↑ or ↓	↑ or ↓	↑	↑ or ↓
Impacts on the internal system				
Attentional focus				
Increased task focus	↑	↑	↑	↑
Start-up friction	↓	↓	↓	↓
Mechanical friction	↑	↑	↑	↑
Influence processes				
Equalisation of participation	↑	↑	↑	↑
Less clear leadership emergence	↓	↓	↓	↓
Amount of communication				
Less verbal communication	?	?	?	?

Note: Effects of GDSS on group decision making: ↑ = increased impact, ↓ = decreased impact, ? = nature of impact varies.
Source: Adapted from Poole et al (1993, 182)

TABLE 2.2 HYPOTHESISED IMPACTS OF GDSS ON DECISION MAKING

The results that Poole et al (1993) recorded for the specific GDSS under study and those realised in the field in general have been mixed. For example, some studies have indicated that meeting times have decreased when GDSS are utilised, while others have observed the opposite effect (Ngwenyama et al, 1996, 155). Group decision theory and methods have established histories in the literature but the application of computer technology to group problems is still largely in its infancy. The growth in computing power coupled with decreasing computer prices have made it possible for complex and previously manual methodologies to be automated just as it has made GIS a viable tool in data-intensive application arenas. Despite these advances, significant improvements to hardware and specialised software (groupware) still remain to be realised and, moreover, the conceptual frameworks have yet to be developed for applying this technology effectively to specific problem areas (Armstrong, 1994, 674).

GDSS implementations are frequently classified with respect to the whether the decision makers are either dispersed or co-located and whether they communicate in a synchronous or an asynchronous manner (Copas, 1993, 162). Based on these dimensions of spatial and temporal proximity, four broad operational forms of GDSS are apparent:

1. same location, same time: participants meet together at the same location (i.e. conference room) and work collaboratively on resolving the problem at hand using a GDSS based on a Local Area Network (LAN);
2. same location, different time: participants leave their contributions to a group problem-solving task at a common location using either a LAN or Wide Area Network (WAN);
3. different location, same time: participants collaborate using interactive teleconferencing over a WAN or satellite link;
4. different location, different time: participants contribute to decision making using tools, such as e-mail, which are designed to be both time- and location-independent.

Most GDSS efforts to date have been focused on the first alternative where decision makers work together at a specially-equipped decision room or conference room (Silver, 1991, 225). As DeSanctis (1993, 208) notes, "the presumption is that the dilemma is so complex as to require the involvement of multiple experts or stakeholders; hence, the systems are designed for use in group settings, especially face-to-face meetings." In the space and time coincident conference room model, each decision maker has a private work area on their own networked workstation and contributes to problem resolution by submitting input to and receiving the input of others from large public display screens and accompanying data storage and exchange facilities (Copas, 1993, 162).

Two approaches have been advanced to operationalise the decision room GDSS model. Multi-user systems are the most complex variant as they supplement access to public facilities and resources with the ability for users to interact directly with one another (DeSanctis, 1993, 212). Consequently, these systems can support direct user-to-user communication and negotiation sessions simultaneously as well as sessions that include all decision making participants. While few restrictions are placed on computer-related communication, intra-group equity can be problematic when users differ substantially in terms of computing skills (Lemburg, 1997, 2). In contrast, single-user systems channel all user communication through one system administrator whose role in the group decision making process can range substantially. For instance, with moderated or "chauffeured" GDSS, a system operator who is highly conversant with the technical and methodological issues surrounding the problem domain controls what information, communications, and resources are available publicly to the group (Armstrong, 1994, 673). Alternatively, the intermediary can function as a facilitator who guides the group discussions by suggesting which methods or information may be appropriate at a given stage (MacDonald, 1997, 516). Lastly, with user-driven GDSS the operator takes on a passive role limited to responding to group member directives as required (Silver, 1991, 226).

Recently, more attention has been directed at utilising the methodological and technological foundations of the GDSS field to extend GIS and SDSS beyond their predominantly single-user form through specific capabilities to accommodate group or multi-participant decision making. In 1996, the NCGIA (National Center for Geographic Information and Analysis) launched Initiative 17 to spur research into Collaborative Spatial Decision Making (CSDM). Other terms employed in the literature for these research efforts include Group Spatial Decision Support Systems (GSDSS), Spatial Decision Support Systems for Groups (SDSS-G), and Multi-Participant Spatial Decision Support Systems (MP-SDSS). For convenience, these terms are used interchangeably throughout this thesis.

Although the literature on multi-participant GIS or MP-SDSS is relatively sparse to date, three broad areas of research can be discerned. First, commercial, single-user GIS has been applied to a variety of problem contexts in a "participatory" manner that is inclusive of a broad and, often atypical, spectrum of community members. Generally, this research focuses upon conceptual and methodological issues of incorporating local knowledge from multiple individuals into GIS and improving grassroots access to the technology. Thus, Harris et al (1995) refer to the need for participatory GIS that can represent a "social definition of land use potential" for rural land reform in South Africa while Eastman et al (1995; 1993b) demonstrate how a GIS operator can facilitate debate amongst group members and apply subsequently the group's results to an operation such as criteria weighting. Both of these contributions are grounded in a desire to "democratise" the use and control of GIS and recognise the political dimension to information systems – a need that Towers (1997) illustrates clearly in his examination of GIS use by the US Forest Service for determining new power line corridors in West Virginia.

A second body of research focuses more directly upon determining design requirements and developing capabilities that are specifically attuned to multi-participant or group use of spatial information technology in a MPDM setting. Godschalk et al (1992) discuss their Hypothetical City Development Dispute instructional tool that utilises a customised GIS platform (pc ARC/INFO software) to permit users to address the conflictual aspects of land use planning and land suitability through role-playing. Different user teams, each operating an independent GIS and representing particular interests in the development process (e.g. environmentalist, developer, planner, etc.) can identify land parcels suitable for development based upon weighted map overlays. The resultant maps and database listings are then collated by a system manager and used as a basis for negotiation toward a compromise or consensual solution (Godschalk et al, 1992, 1211). Brown et al (1994) extend the ARC/INFO GIS to a multi-scenario form that allows different viewpoints concerning the trade-offs between forestry and wildlife preservation to be compared and provide an avenue for building consensus.

More interest is being expressed recently about adapting group-specific functionality developed in the GDSS field to spatial information technology. While Jankowski and Stasik (1997) illustrate that some research activity is beginning to coalesce around the use of the Internet and the World Wide Web to accommodate dispersed decision making, the conference-room operational paradigm has garnered more attention to date (MacDonald, 1997, 516; Copas, 1993, 162). Jankowski et al (1997), for example, have developed an innovative prototype SDSS-G for site selection purposes named Spatial Group Choice that is based upon a loose-coupling of ArcView and an MCA software package named Group Choice. This facilitator-led SDSS-G offers the advantages of GIS and MCA integration as well as specific enhancements for the multi-participant decision making context in the areas of consensus-related mapping symbology and group voting procedures.

If the promise of GDSS is to be realised fully in a spatial framework, there are numerous technical and methodological difficulties that remain to be resolved in areas such as shared map graphics, data protection, collective modelling capabilities, and methods for reconciling differences between the positions of various participants (Armstrong, 1994, 673; 679; Copas, 1993, 162). Of equal importance is the need to identify the subset of GIS capabilities that groups will most likely require, the generic and domain-specific queries and reporting outputs, and critical issues of interface design and group usability (Armstrong, 1994, 675). This latter group of issues are confronted in Chapter Three where specific design considerations are discussed. However, in order for these issues to be addressed properly with respect to the SIS land use planning context, the potential contributions that MP-SDSS can offer and their role in the planning process must be clarified. The next section describes how these decision support tools can be incorporated successfully into SIS land use and tourism planning practices.

2.3.2 *The Role of Multi-Participant Decision Support Tools in SIS Tourism and Land Use Planning*

In one of the most frequently cited models in the decision support literature, Simon (1976, 40-41) identifies the following four stages of decision making processes:

1. intelligence – determining the need for decision making or problem-solving;
2. design – preparing alternative courses of action;
3. choice – evaluating alternatives and selecting the most appropriate strategy; and
4. review – assessing past choices.

As Silver (1991, 31) notes, most discussions of decision making processes, including that of Simon (1976), concentrate on the intelligence, design, and choice phases. In more complex decision making environments, decision making progresses through a circuitous and often repetitive route through these phases (Sprague and Carlson, 1982, 98). In terms of SIS land use and tourism planning, these decision making phases can be translated into three generic types of MPDM tasks that most participants in strategic-level and land-related tourism decision making build their decisions from:

1. problem exploration facilitating the "discovery" and appraisal of local resources as well as current and future conditions from divergent perspectives, alternative problem definitions, and performance indicators (e.g. population density, amount of undeveloped subdivided land, etc.);
2. identification and creation of development alternatives which may represent competing locations for a given type of facility (e.g. coastal resort) or may involve the specification of more comprehensive development strategies by different participants for a particular region under study (e.g. administrative district, functional destination zone, etc.);
3. evaluating the available choice alternatives and selecting the most desirable strategy from a consensus or compromise-seeking perspective given divergent viewpoints and priorities that may be encapsulated in different development strategies.

Previous discussions have suggested that land use decision making occurs within and across a series of co-related and, relative to the wider planning process, subordinate decision making contexts that reflect the domain-specific interests of various individuals, groups, and organisations. Consequently, the overall land use planning decision making context is characterised by both sequential and concurrent instances of these intelligence, design, and choice activities.

Three generic MPDM contexts or environments related to land use change and management can be identified where MP-SDSS can potentially be of assistance: 1) homogeneous groups, 2) heterogeneous groups, and 3) across several groups (homogeneous or heterogeneous) or individuals. In the first case, group members share an understanding of their main objectives, their role in the overall planning process, and the thematic aspects of land use change that are of primary interest. A central decision support need therefore is to facilitate the formulation of group strategies concerning these interests among a number of individuals having similar value sets. Examples of this type of context include several Government planners working collaboratively to evaluate the suitability of a major development proposal, members of a National Trust NGO identifying and prioritising collectively habitat areas for preservation, and staff of a large private sector land development firm meeting to determine the best location for a new retail outlet for a set of candidate locations.

The heterogeneous group context is more complex as some members may have related but not entirely coincident objectives or preferences, while others may be in direct conflict and/or competition. In these cases, the main group decision task is to craft an aggregate policy response from a diverse group membership to current or anticipated future conditions. Thus, a developers' association may lobby Government collectively to oppose new planning regulations that substantially limit development potential in scenic or culturally-sensitive areas and, in doing so, produce alternative land use plans or regulations more closely aligned with the priorities of their individual members.

The multi-group context is the most complex and potentially conflict-laden context as it encompasses the interactions within and between several groups and the outcomes of their prior, and often independent, decision making activities. The most visible types of land use decision making are made in the multi-group context as it is here that long-term land use strategies and individual development proposals are approved, modified, or rejected. Decision making *per se* may, for example, take the form of a development review committee and is often confined to elected or appointed officials. Community or group members, many of whom may be responsible for decision making in other contexts, participate primarily as representatives who present submissions, lobby through formal or informal channels, or voice their opinions concerning proposed policy decisions. Sample participants and decision making issues relevant to SIS land use and tourism planning for each of the three generic decision making contexts are listed in Table 2.3 below.

The interdependence of these three generic decision making contexts has several important implications for the use of MP-SDSS and related decision support technologies. First, decision making related to land use change does not take place at a single point in time, as it is distributed across several interrelated geographic, thematic, and contextual levels due to varying competition, expertise, and mandate related objectives. Second, decision making problems generally become less structured as one moves from the homogeneous group context through to the multiple group environment, reflecting corresponding changes in the diversity of values and objectives of the different participants. The nature of decision making procedures can also be expected to differ as well with homogeneous groups adopting a more rationalistic approach to decision making in general, while the multiple-group environment would rely comparatively more on an interactionist or a negotiation-based approach. Third, the participants in decision making and their specific roles may change from one context to another. Thus, scientific, technical and policy experts within a given Government agency may act collectively as decision makers while generating different land use scenarios that satisfy their departmental objectives and concerns. A subset of these individuals may then take on an advisory or representative role when presenting these strategies as input to heterogeneous group contexts involving, for instance, several Government agencies or in the multiple group context of the formal land use planning forum. Fourth, in order to assist with compromise-based problem-solving, MP-SDSS must be sufficiently broad in scope to support a variety of decision making styles and facilitate the integration of multiple context-specific analyses.

Generic Group Context	Sample Decision Problem	Potential Participants
Homogeneous (Development firm)	Locate site for new hotel	Staff planners, engineers, architects, investors
Homogeneous (National Trust NGO)	Designate and prioritise areas for preservation	Technical staff, membership, volunteers
Homogeneous (Government Planning Dept.)	Designate parcels for future tourism-related land-uses	Development control and long-range planners
Heterogeneous (Tourist Board)	Respond to Tourism Ministry's draft long-term plans	Hoteliers, tour operators, restaurant owners.
Heterogeneous (Government Administration)	Evaluate and recommend modifications to proposal for new tourist resort	Government agencies responsible for Tourism, Physical Planning, Water Authority, Social Planning, Environment, Public Works, etc.
Multi-group (Community Planning Committee)	Devise a community development strategy based on small-scale tourism plant	Community members, investors, elected/appointed decision makers, government representatives, etc.
Multi-group (groups with adversarial land use and management positions)	Resolve impasse over tourist use of specific habitat (e.g. numbers of divers permitted at specific reefs)	NGO environmental and private dive operator associations, Government environment & planning representatives as mediators/facilitators

TABLE 2.3 SAMPLE GENERIC DECISION MAKING CONTEXTS FOR MP-SDSS USE

When these factors are taken into consideration, the appropriateness of the decision-room SDSS-G model to the SIS planning environment appears to be somewhat limited. Although this approach can be used conceivably in all three generic decision making contexts, its associated financial, technical, and human resource demands preclude widespread investment in this type of approach. Resource-related constraints and other considerations particular to the SIS environment are discussed in greater detail in Chapter Three. A number of human factors also limit its appeal. Participants who are uncomfortable using computer technology may feel disadvantaged relative to other computer-conversant group members who may dominate computer-led group discussions and analyses. Others may, for personal or competitive reasons, want to maintain their anonymity and develop their contributions toward group problem-solving in more private individual or homogeneous group settings. This can be particularly relevant when attempting to build a compromise solution among potentially adversarial participants who often adopt extreme positions when negotiating with each other in hopes of settling on a solution close to their actual requirements (Saaty, 1989, 65). These difficulties can be circumvented to some extent through the asynchronous and/or dispersed GDSS approaches but this is again an instance of applying more technology to a problem rather than altering the technology to suit the decision making reality.

The alternative methodology for MP-SDSS use in SIS is based upon the premise that while the technology should support use in a networked environment, it should also be sufficiently portable that it can be utilised outside a conference room setting and sufficiently affordable that it can be distributed among different decision making contexts. One major criticism of GIS and SDSS as decision support tools is that they can accentuate the centralising effect of bureaucracies on information access and analytical capabilities and, further, that they have the potential for being used as an instrument of selective information control and processing (Pickles, 1991, 84; Honey et al, 1991, 62). Investments in extensive databases, hardware, software, and expertise are, particularly in the SIS case, heavily concentrated within Government and to a much less extent within larger private firms resulting in compromised information equity for those unable to access or adapt to the new decision support facilities and built-in biases in the data collection and structuring methodologies.

Centralisation of information access is clearly at odds with repeated calls in the literature to improve planning outcomes and reduce land-related conflicts by broadening participation in land-related decision making beyond the traditional domination of elites (Harris et al, 1995, 217). In an effort to democratise planning efforts and address local conditions, a community-centred approach has been advocated as a means of integrating activities such as tourism into the local social, economic, and ecological structures (Brohman, 1996, 60). This is one setting where MP-SDSS appear to be particularly appropriate, given that communities are far from homogeneous in their desires, resources, and levels of influence. Consequently, consensus- and compromise-building capabilities would be of real value (Harrison, 1996, 77; Wall, 1996, 136).

With a MP-SDSS that is not dependent upon specialised facilities in a fixed location (i.e. operated on a laptop PC or installed on one or more computers within a community), the tendency for computerisation of analytical and decision making activities to insulate analysts and decision makers from the real-world problems that they are attempting to resolve can be alleviated to some degree. In part, this is due to decision makers becoming "passively disengaged" from the implications of their actions due to their reliance upon and acceptance of the simplified representation of reality that SIT display (Veregin, 1995, 101). Thus, boundaries of ecological zones are perceived as crisp lines of demarcation, human needs are defined with reference to indicators available in census data, and so on according to the need to generalise reality for cartographic or data modelling purposes.

The capacity of GIS to permit analyses of secondary data sources and with the absence of any field-based verification and augmentation of the data merely serves to accentuate the problem of passive disengagement. Spatial databases, for instance, are initialised often by digitising existing paper maps or converting digital data maintained in complementary systems such as CAD. These data sets are, as Flowerdew (1998, 297) notes, socially-constructed and reflect the inherent biases and viewpoints of their creators. Consequently, in the absence of any descriptive meta-data or any field-based verification of the currency, accuracy, and purpose of input data sets, the uncritical integration of multi-source data can prove to be almost as much of a weakness as a strength for spatial information technology.

Several researchers have noted that field-based data collection and verification has been in a general decline for decades due in part to increased technical and statistical capabilities of computer systems and higher productivity demands limit the time available for field research (Towers, 1997, 118; Rundstrom and Kenzer, 1989, 301). A MP-SDSS that can be utilised within a community setting has the potential to alleviate these problems to some degree by facilitating the inclusion of local participants and local knowledge in the community planning process. While local knowledge is not monolithic, can often be difficult to incorporate within computerised frameworks, and may not be adequate for assessing complex development proposals, including it in decision making does cause experts and elites to justify their assertions (Harris et al, 1995, 216; Tisdell, 1993, 214).

Three related roles exist for MP-SDSS in SIS land use and tourism planning that accommodate all three generic decision making contexts. The first relates to the need to promote compromise- and consensus-building in the multi-group context. This can consist of providing an avenue for local community members to contribute, in either a formal or informal manner, to the generation of medium- to long-term development strategies and the evaluation of larger development projects proposed for the near-future. At a minimum, this input could be confined to the evaluation of plans or projects at the concept or pre-submission stage (Pearce, 1995, 118). To be valid, this form of participation must take place in the area under study and not solely in the offices of the national Government. This could counteract, to some extent, the inherent biases that planning systems often display in favour of the frequently and vigorously articulated interests of the powerful (Porteous, 1989, 225).

The second role that is suggested for MP-SDSS relates to the development of land-related initiatives and decisions within a variety of individual homogeneous or heterogeneous groups. Compared with the role proposed above, participation here is decidedly limited and most likely would not include members of the public. For instance, staff within a large land development firm could identify and assess collectively the suitability of several potential sites where a specific type of tourism-related activity or facilities could be located in light of competitive and complementary factors. Given the transnational nature of many components of the tourism sector, these analyses could feasibly extend across several different SIS simultaneously.

Third, MP-SDSS could also be used by Government planning staff or staff of other public agencies as a tool to adapt Etzioni's (1967) mixed scanning decision making approach to the tasks of defining planning issues and possible solution strategies. While the previous two roles would most likely emphasise the design and choice phases of decision making, the role suggested here focuses more on intelligence-gathering that can be utilised in preliminary policy discussions prior to initiating public planning exercises. While the second dimension of the multi-group role concentrates on remedial conflict amelioration, the effort here is focused more on the proactive identification of existing or potential areas of conflict and trade-offs.

The potential of an MP-SDSS or any group decision making aid depends in part on resource-related factors (e.g. data, staff training, technical infrastructure, and finances, etc.) and technical aspects of the system itself (e.g. functional capabilities, user-interface, etc.). These factors are discussed in detail in Chapter Three.

However, it is ultimately human factors that determine how successful decision support tools can be in any of the roles suggested above. Perhaps the most important human factor here is the willingness of the most powerful participants in the land use planning process to cede some of their decision making authority and build compromise-based planning solutions on a foundation of negotiation rather than decree (Saaty, 1989, 60). This would require that these decision makers, whether they are politicians or entrepreneurs, agree to accept a certain loss in power, the exposure of their priorities, and the introduction of further delays and uncertainty into the planning process. Based on the history of centralised planning, control, and decision making in general throughout the Caribbean, it is unlikely the high-level politicians would be willing to accept these costs (Dann and Potter, 1997, 212).

The potential for bureaucratic use of MP-SDSS, either within the departmental confines of Government or in broader multi-group consultations, is greater given their long-term professional interest in resolving conflicts and their need to be accountable to both the general public and to elected officials. Relative to some of the other methods that Governments have for facilitating participation in land use and tourism planning such as the Delphi method, nominal group technique, and round-table discussions, among others, MP-SDSS provide domain-specific and complementary decision support with substantial analytical capabilities (Bui, 1987; Hwang and Lin, 1987). The next chapter discusses the design of such a tool for land and tourism planning in SIS.

2.4 Summary

This chapter has outlined in broad terms the need for strategic land use planning to co-ordinate individual land use activities, stabilise land markets, and mitigate against market failures. The decision making context inherent to such strategic-level land use planning and management was described in terms of the interchanges between multiple participants, multiple dimensions, and multiple facets. Within this ill-structured problem environment, land-related issues are resolved usually through negotiation and bargaining as various interests must collectively make trade-offs and compromises between conflicting preferences for current and future land use patterns and activities. While information tends to be deployed selectively by individual participants in the decision making process, there is a fundamental need to accommodate large volumes of thematically-diverse data within an integrative framework that recognises explicitly the importance of the spatial dimension to land-related processes and issues. GIS can satisfy many of the information management, analysis, and communication demands of this MPDM forum but they have inadequate capabilities in several critical decision-focused areas of functionality. Consequently, more attention is being directed at integrating MCA and GIS capabilities within a multi-participant SDSS framework to facilitate better decision makers' needs to be able to evaluate alternatives, express priorities, and examine trade-offs between different objectives and land use strategies.

The broad issue of decision support for land use planning is brought into a more immediate focus by examining it within the land use planning and management context of SIS. Tourism development is a critical economic activity in most SIS of the Caribbean, affecting host populations, natural ecosystems, and land use and activity patterns. The magnitude and character of these impacts depend largely on the type and scale of tourism development and the resiliency of the host population and common property resources. The general trend of tourism development in the Caribbean is toward larger and higher-density resorts and a rapidly expanding cruise ship industry. The positive impacts of this type of development are largely national in scope and economic or political in nature. However, most of the negative effects are highly-localised, due to the concentration of tourism land uses and activities near the coastal (accommodations) and port (cruise ship facilities) attractions, the general decay of many effects with distance from their point of origin, limited local opportunities for the population to benefit from tourism activities, and the confined land area of SIS. Conflict, inefficiencies and deterioration in the quality of both tourist attractions and the living space of the resident population are frequent results of this form of land use development.

It is argued throughout this thesis that a land use-oriented approach to managing and planning SIS tourism development can make important contributions to ensuring the well-being of the tourism sector as well as the host population and environments and that this approach can be operationalised through a multi-participant SDSS. Moreover, it is suggested that MP-SDSS built specifically for the SIS land use and tourism planning context be implemented in a manner that is sufficiently portable that they can facilitate consensus and compromise-building within and across divergent and dispersed decision making settings. The issue of operationalising such a system is examined directly in the next chapter through a discussion of the design of such a multi-participant SDSS.

Chapter Three

THE ARCHITECTURE OF A MULTI-PARTICIPANT SPATIAL DECISION SUPPORT SYSTEM FOR LAND USE AND TOURISM PLANNING IN SIS

This chapter describes the design and proposed utilisation of a compact MP-SDSS appropriate to the problem of land use and tourism planning in SIS. The following broad interdependent issues and questions are addressed:

1. what specific decision support needs should the MP-SDSS satisfy?
2. what factors particular to the SIS decision-making context influence MP-SDSS design?
3. who will use it and in what capacity?
4. what functionality is required maximally and minimally to meet the decision support needs?
5. what types of data are required and/or desired for the system?
6. how can the MP-SDSS contribute to and integrate with the land use and tourism planning processes in SIS?

Some of these issues were discussed at a conceptual level in Chapter Two. Here, they are examined in terms of their effect on the operational design of a MP-SDSS for SIS land use and tourism planning. The following section, for example, derives a set of design principles relevant to the SIS planning context based upon the human, technical, and organisational factors that define collectively the local environment for information systems use. Next, the functional requirements of a MP-SDSS suitable for SIS land use and tourism planning are described. The architecture and capabilities of *Tour*Plan, a system developed and tested in the Cayman Islands but appropriate to all SIS, are reviewed next with specific attention focused on its facilities for multi-participant use, its appropriateness to the resource capacities of most SIS and its site selection and site evaluation functionality.

3.1 Information Technology Use in SIS

3.1.1 Local Factors Affecting Information Technology Use in SIS

The level of success that is realised by applying technological aids to human activities is governed by two sets of factors – those related to the technology itself and those concerned with the human, institutional, and organisational settings in which the technology is utilised. For information systems such as GIS and SDSS, most attention has been focused on how technology, as embodied in the various hardware, software, and specialised data components, can lead to improvements in spatial data processing. Typically, problems such as unco-ordinated urban sprawl or resource depletion are addressed first by identifying shortcomings in information access or analytical capabilities and a technology-based remedy like GIS is prescribed. If the technology does not deliver improved understanding or decision-making capabilities with respect to the problem, then efforts are directed most frequently at applying more, and often increasingly sophisticated forms of technology, rather than determining if the technology was appropriate in the first instance (Campbell and Masser, 1995, 28; Hall, 1993, 7).

Hence, while technological innovations such as GIS and SDSS are usually of some value to decision-making, they often fall short of expectations because they are ill-suited to the organisational context in which they are used (Taylor, 1991b, 3). This context includes but extends beyond the structural limitations of GIS mentioned in the last chapter to encompass a variety of factors that define collectively the local conditions in which information technology is applied (Subaryono, 1996; Veregin, 1995; Obermeyer and Pinto, 1994; Campbell 1991; 1992). For instance, an organisation's autonomy, internal power relationships, leadership, stability, and level of uncertainty regarding information system needs are key determinants of information system success, or lack thereof, in developing countries (Zinn, 1993, 177; Masser and Campbell, 1991, 59; 64).

Resource availability and use issues affect local conditions to a significant extent in SIS. Hardware, software and maintenance contracts are typically purchased from off-island sources using limited foreign exchange reserves or are supplied for a finite and project-specific length of time through international aid organisations (Masser and Campbell, 1991, 64). Human resources are limited typically in absolute numbers and in the breadth and depth of available technical skills (Hall et al, 1997b, 83). These effects are accentuated in SIS relative to other locations as the multi-functional portfolios of many government agencies (e.g. Cayman Islands Ministry of Education and Planning; Grenada's Ministry of Finance, Planning and Development, Trade and Industry) limit the potential for individual skills to be developed in depth in any one field (Kersell, 1987, 95-96). Ongoing training of staff to utilise information systems properly and to develop self-supporting data maintenance and collection procedures is hampered by this factor and by the financial constraints mentioned above. As a result, technical resources, such as skilled support staff and existing computing infrastructure, are usually limited. Lastly, data resources in SIS are frequently inadequate in terms of their availability, quality, currency, and relevance to the decision-making problems at hand, particularly with respect to geo-referenced or map data that are central to the success of GIS and SDSS (Hall et al, 1997b, 82-83; Yeh, 1996, 11).

Beyond these general influences, two other contextual influences are particularly relevant to spatial information use in strategic land use and tourism planning in SIS. First, the complex and multi-dimensional nature of the problem environment, noted earlier in this chapter and in Chapter Two, obscures the types of decision support needs to which information technology can be applied, whose needs precisely should be targeted for assistance, and the manner in which these needs can be addressed. Second, Yeh (1991, 14) notes that planners in developing countries have only general knowledge of what computer technology such as GIS can or cannot do – an observation that parallels those made by Innes and Simpson (1993, 231) and Klosterman (1990, 181) with respect to North American planners. This can be extrapolated to the broader context of decision support for land use and tourism planning in SIS given the tendency for planning activities to focus on short-term application processing or promotion issues.

3.1.2 Design Principles Underlying MP-SDSS Design for Land Use and Tourism Planning in SIS

Based on local constraints on information technology use and the need for participatory planning and decision-making, several principles underpin the design of a MP-SDSS for SIS land use and tourism planning. These design principles, modified from Hall et al (1997a, 75), include:

1. relevance and applicability to the wide variety of subordinate problem domains that comprise the SIS land use and tourism planning context;
2. ease of use for a broad spectrum of computer skill levels ranging from policy-preparers, decision-makers, and members of the public with little or no computer experience through to individuals highly conversant with information systems;
3. modest hardware requirements such that the software can operate on a personal computer (PC) with a minimal system configuration of a 486 processor and 8 megabytes of RAM, VGA graphics, while hard disk requirements will be a function of local database size;
4. modest data demands that can be satisfied through commonly available GIS and database data files;
5. require little training to use and facilitate users to learn as they use the software;
6. compatibility with software and the graphical user interface (GUI) of operating systems that are familiar to most users (i.e. MS Windows 3.1, Windows 95, and Windows NT);
7. low purchase price, free of license restrictions, and easy to maintain so that it is feasible to distribute it to a variety of participants in land use decision-making;
8. mechanisms to accommodate explicitly the MPDM character of SIS land use and tourism planning;
9. an open architecture that permits developers to customise the application or add functions as required.

Collectively, these design principles preclude the feasibility of satisfying the decision support needs identified earlier through the use and modification of commercial GIS or MCA products. For example, the absence of multi-participant facilities in commercial GIS software, their general orientation toward technically-adept users, and licensing requirements were highlighted in Chapter Two. The general lack of software with integrated MCA and spatial analysis capabilities and the resultant demands for user-controlled data exchange between dissimilar and separate software packages (e.g. loose-coupling) was noted as well.

3.2 Functional Requirements of a MP-SDSS for SIS Land Use and Tourism Planning

3.2.1 A Functional View of Key Strategic Land Use Planning Tasks in SIS

The process of designing a decision support tool can be described as an attempt to attain the best possible match between the requirements of the decision-making environment and the capabilities that the tool is intended to provide to support these requirements (Silver, 1991, 83). With a clear understanding of the former, the design issue is reduced to searching for the means to satisfy best the stated decision support needs.

In the case of strategic land use and tourism planning in SIS, however, gaining an unambiguous and succinct depiction of the decision-making environment and its constituent needs is far from straightforward. Medyckyj-Scott (1993, 92-93) characterises the specification of these requirements as being a function of: a) the technical setting, b) organisational goals, and c) the contexts of use which encompasses task domain, user characteristics, and physical and social environments. An overview of some of these factors, in particular the technical setting for information technology use, was provided in the preceding section on local conditions. The remaining two factors, as discussed in Chapter Two, are areas of considerable complexity given the multi-context, multi-objective, and multi-participant decision-making environment characteristic to land use planning in SIS. For instance, the "ideal" MP-SDSS design for supporting inter-departmental decision-making within Government assumes relatively constant managerial-level group membership, face-to-face communication, clearly-defined mandates, and a general emphasis on rule-based procedures encoded in regulations, laws, and professional practices. In contrast, a design to support planning at the community-level must accommodate a more fluid environment characterised by dynamic groups, concerns for anonymity, and a wide range of decision issues and task types that need to be addressed.

Despite this complexity, three basic decision tasks were identified in Chapter Two as being common to land use and tourism planning in SIS. These tasks include: explore local resources and conditions in order to define and redefine planning problems; generate choice alternatives, either as candidate sites suitable for one aspect of the wider land use pattern or by extending this process to produce more comprehensive land use plans; and to evaluate these choice alternatives according to the priorities of different participants.

The latter tasks of site selection and evaluation are driven often by the need to satisfy five- or ten-year targets for visitors or accommodation units produced through a combination of analytical, arbitrary, and exogenous inputs. Hence, decision-making participants must determine collectively where to locate specific types of tourism land uses, subject to competing claims by other land uses and divergent assessments of the suitability of alternative locations. The results of these negotiations are encapsulated as land use zone designations and regulations within national or sub-national long-range development plans. Once these designations are in place, the need to identify and evaluate alternatives can emerge in a reactive and *ad hoc* manner as development initiatives are submitted incrementally. Decisions concerning the spatial and temporal phasing of development, which specific types of permissible land uses to encourage in a given zone, and the suitability of different variations of a large development proposal are three examples of decisions that are strategic or tactical in nature but are often determined on a land development application-by-application basis.

The site selection and evaluation decision tasks can, from a functional perspective, be decomposed into a number of lower level stages. Jankowski et al (1997, 584) and Nyerges (1995, 318) list five decision-making steps that are conducted with an SDSS-G during a site selection exercise: 1) problem exploration, 2) criteria selection, 3) criteria prioritisation, 4) alternative evaluation, and 5) consensus negotiation. Based upon the roles suggested earlier for MP-SDSS in the SIS planning process, these steps could be repeated in a series or concurrently across several departmental or interest-group-specific contexts.

In the sections that follow, the functional capabilities that an MP-SDSS requires to support these selection and evaluation tasks are examined in detail. However, prior to this, it is necessary to consider what DeSanctis (1993, 212) terms the "holistic attributes" of GDSS and how these properties factor into the design process. This shifts the focal point of the discussion temporarily away from concerns of "what can the system do specifically?" to broader questions such as "how well does the system suit its target decision-making environment?", "how, and to what extent, is the system likely be used?", and "what are the probable effects of system use on group decision-making?".

3.2.2 *Restrictiveness, Decision Guidance, and Comprehensiveness in MP-SDSS Design*

The attributes of a DSS, including subtypes such as SDSS, GDSS, and MP-SDSS, are described most frequently in terms of three dimensions: restrictiveness, comprehensiveness, and decision guidance. Silver (1991, 115) defines restrictiveness as "the degree to which, and manner in which, a DSS limits its users' decision-making processes to a subset of all possible outcomes." Two facets of restrictiveness can be discerned in this definition. The first concerns the range of functions and interface presentations that are incorporated within a DSS. Irrespective of the decision-making and design environments, a certain amount of restrictiveness is unavoidable since time, cost and technological limits allow only a finite amount of functionality to be provided within any information system.

Sprague and Carlson (1982, 99) cite four other factors that contribute to this aspect of restrictiveness in a DSS: a) a DSS is only one of the aids that are employed typically in problem-solving, b) the decision problem is necessarily represented in a simplified manner within a DSS relative to conceptualisations of its user(s), c) DSS impose often new demands for particular skills and/or approaches to problem-solving, and d) not all decision-making activities can be supported through computerised means. DeSanctis (1993, 212) and

Jankowski et al (1997, 585) refer to this component of restrictiveness as a distinct attribute of comprehensiveness. Thus, more comprehensive systems are applicable to a broader spectrum of decision problems but their complexity tends to make them more difficult to operate than less comprehensive systems that are targeted at specific problem issues.

The second facet of restrictiveness centres upon the extent that a DSS enforces some form of structure upon the decision-making process. More restrictive systems require users to follow a particular sequence of operations or to adopt a specific approach to problem-solving while less restrictive variants permit users to define their own decision path by selecting procedures as required from a "tool box" and setting parameters as they see fit (Jankowski et al, 1997, 585).

While restrictiveness affects what a user can or cannot do with a DSS, decision guidance reflects the extent to which the user is provided with direction in the use of the system's capabilities and in the structuring of the decision-making process (Silver, 1991, 158). Decision guidance can be either deliberately or inadvertently provided by a system. Deliberate guidance can be informative, where users are provided with unbiased information concerning the choice of options, procedures, or data without indicating a preferred choice, or it can be suggestive in nature in that recommendations are provided for choices (DeSanctis, 1993, 212). Inadvertent guidance can be thought of as a form of unintended externality associated with a system's design that in some manner affects how users perceive or utilise the system. The order that choices are arranged on a menu tree may, for example, affect how often individuals remember and use a particular procedure (Silver, 1991, 183). The importance of a system's interface as the main vehicle for supplying decision guidance and influencing the general usability of the system is described in a subsequent section.

Clearly, there are important interrelationships between the attributes of restrictiveness, comprehensiveness, and decision guidance. Restrictiveness arises, in part, from a real or perceived need to simplify and structure problem-solving by supplying a limited range of methods or procedures that a user has to consider and learn. SDSS, for instance, are constructed typically around a subset of GIS and other analytical functionality that is pertinent to limited task domains. The environment that a DSS is designed for, which encompasses the anticipated user community, the decision problems to be addressed, and the local conditions discussed above, is also a key determinant of system restrictiveness and decision guidance. Complex and multi-dimensional decision-making environments, like those of SIS land use development and tourism planning, may require that comparatively few absolute restrictions be placed on the choice of data or decision-making procedures. However, a high degree of suggestive decision guidance is necessary to permit users with widely ranging skill and knowledge sets to navigate and utilise the system effectively.

The potential contributions that a DSS can make to decision-making are described most often by enumerating the functional capabilities of the system or, in other words, what the system can do. The above discussion has pointed out the need also to be cognisant of what a system cannot do (restrictiveness) and how decision-makers can be deliberately and inadvertently influenced in its use (decision guidance). With these considerations in mind, the specific functional and user-interface requirements of an MP-SDSS built for the SIS planning context are outlined next. The discussions concerning the functionality required to satisfy the decision tasks of site identification and evaluation are organised below to reflect the usual practice of compartmentalising system design in a number of quasi-independent modules (Figure 3.1). Where notable differences are found between desired levels of functionality and that which is required minimally, these are noted.

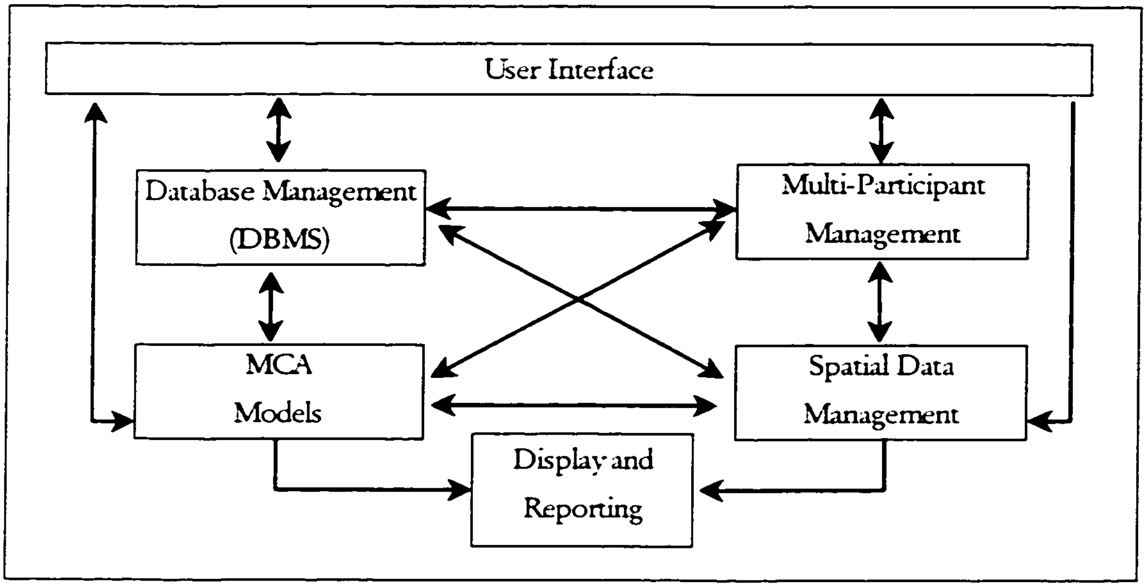


FIGURE 3.1 GENERIC FUNCTIONAL MODULES OF A MP-SDSS

3.2.3 *User Interface Requirements*

The user interface (UI) serves as the gateway through which selected aspects of a system's internal functionality are revealed to the user(s) and all interaction with the system is channelled. The UI, which may be built around command line input, menu options, or iconic representations, is the model through which users map their tasks onto a system's available suite of commands, functions, and procedures. The UI component of a DSS can therefore be seen as the cornerstone on which the "conceptual link between human intention and what the computer can offer as a decision support environment" is formed (Gould, 1993, 102). The strength of this linkage is based on how closely the UI model corresponds to the mental model that the user holds of the system's operation (Davies and Medyckyj-Scott, 1995, 124).

Several factors introduce difficulties into designing a UI for a MP-SDSS for the land use planning context in SIS. First, there are numerous feasible means and paths available by which a given suite of functions can be represented (Silver, 1991, 91). Second, the choice of how to represent a bundle of functions and processes is determined largely by characteristics/capabilities of the end-users and the environment in which they operate. In the SIS context, the end-user community has been described as being particularly diverse in terms of their computing skills, domain-specific knowledge, underlying objectives, approaches to problem-solving, and the context within which decision support is to be provided (e.g. policy-builder versus policy-maker, individual versus group decision-making, adversarial versus consensual, etc.). Third, as it is aimed at decision support and not decision-taking, a MP-SDSS must not impose a particular decision-making style on its users, but instead, should be capable of supporting a number of different approaches and cognitive models (Sprague and Carlson, 1982, 98-99).

Collectively, these factors necessitate a UI design that is sufficiently flexible and easy-to-use that experts and non-experts alike can access required functions intuitively through a number of often redundant pathways (Densham and Armstrong, 1995, 180-181). Some commercial GIS, such as the widely utilised ARC/INFO GIS, fail to meet these needs due to their reliance on a command line driven interface as a chief means of user input and control. While technically-adept users can become proficient with hundreds or even several thousand thematically-organised commands, the command line UI model is a significant barrier to infrequent users who can have great difficulty translating their decision problem to unfamiliar spatial concepts and commands. Alternatively, a customised interface can be constructed through macro language (e.g. AML - Arc Macro Language) or by ODE programming (e.g. Visual Basic).

Graphical user interfaces (GUI), which permit user interaction through a variety of menu types (i.e. pull-down, pop-up, forms), iconic representations (i.e. toolbars and button bars) and input sources (keyboard, mouse, etc.), have proven to be a much more suitable method of facilitating human-computer interaction. GUIs have gained, with few exceptions, an almost universal acceptance across a wide spectrum of software. Properly designed GUIs can help conceptualise a system's operation, aid memory and recall, and reduce learning curves significantly for a wide variety of users (Gould, 1993, 105).

Two broad perspectives exist in GUI design. First, decision tasks and system operation can be represented through a data-oriented approach where emphasis is placed on the manipulation and display of relevant quantitative information (DeSanctis, 1993, 212). In the case of an MP-SDSS, the GUI needs to provide opportunities for the presentation of interactive maps and tabular displays of the attributes of spatial phenomena as well as facilitate analytical procedures. Second, a process- or task-oriented approach to UI design focuses more upon assisting the user through the various steps or choices required to address a decision problem. Thus, the GUI may be designed to help specifically with problem-structuring, the creation and evaluation of different strategies or the choice of techniques to be applied to an issue while data factors are relegated to a secondary level of interest (Jankowski et al, 1997, 585). General purpose GIS generally display a data-oriented emphasis in their UI design, while specialised multi-participant software built expressly for supporting negotiation or idea generation typically employ process-oriented UI designs.

The MP-SDSS that is proposed for use in SIS land use planning requires elements of both approaches, with an emphasis being given to process-oriented methodology. The data-oriented aspect of the GUI should allow decision-makers to interact with spatial and tabular data simultaneously and examine the impacts of making changes or selections in one view and seeing the effects in the other (Densham, 1991, 410). While these facilities can help users to explore and visualise various aspects of the problem environment, elements of a process-oriented interface provide structured paths to assist with more complex decision tasks of selecting sites and evaluating the suitability of candidate sites based on multiple criteria. Navigational aids that are built into the GUI can provide a significant amount of decision guidance for these multi-phase tasks.. Popularised in commercial PC software as "wizards" or "assistants", these aids help increase the system's responsiveness and encourage "learn-by-doing", by guiding the user through complicated sequences of operations and choices of options, parameters, and data.

Lastly, the GUI must be configured to facilitate use in a multi-participant decision-making environment. This issue is discussed below in the context of the specific MPDM functionality that is proposed for the MP-SDSS.

3.2.4 *Scenario and Multi-Participant Management*

Malczewski et al (1997, 370) list three properties that an analytical framework must possess in order to provide meaningful support for resolving land-related conflicts: 1) the system must be credible to involved interest groups, 2) it must be tailored specifically to the needs of a participatory planning process, and 3) it must be interactive and consultative in its operation if the system is to aid and promote consensus-building. The issue of credibility is addressed through the forthcoming discussions of spatial, DBMS, and MCA functionality (what can the system do?) and in the preceding GUI design section (how are these functions represented to the users?). Although GUI design can contribute positively to the second and third properties listed by Malczewski et al, the multi-participant aspect of the planning problem generates needs for other capabilities as well.

A scenario-based approach is a particularly appropriate way to satisfy these needs in light of the multi-context and ill-structured land-related planning environment. Development options or "scenarios" are simply stored records of the choices that an individual or group makes during a problem-solving session. From a technical perspective, scenarios can provide some measure of control over the integrity of valuable base-line data sets that should not be deliberately or inadvertently modified by any user (DePinto et al, 1996, 274). The mechanics of adding and deleting individuals from a group decision-making procedure, which may be necessitated in a dynamic group context, can be incorporated within the realm of scenario management as well (Mandviwalla and Olfman, 1994, 254).

In terms of how the user interacts with the software, there are several other advantages to this approach. First, decisions concerning the data sets that are utilised in a site selection or evaluation procedure, the participants engaged in the analysis, parameter value settings, and so on, are saved in the scenario for later recall or modification. This provides a facility for experimentation and learning as users are able to record the impact of altering assumptions, data sources, objectives, etc. in distinct scenario files for subsequent comparison and analysis (Hall et al, 1997a, 78). Second, strategic planning decisions tend to occur intermittently, thereby making the ability to recall saved scenarios of value to group and individual memory – an important element of multi-participant decision-making (Mandviwalla and Olfman, 1994, 254). Meta data stored in the scenario contributes to this memory aid function by documenting the choices and actions that define collectively an analysis and justify the results. Meta data, or "information about information", can be of an automated form, such as records associated with command logging, or may be of a more discretionary nature where individual users can associate different explanatory comments with specific selections or parameter settings within one or several scenarios.

Finally, a scenario-based approach offers a mechanism for consensus- and compromise-building through both synchronous and asynchronous participation. Several participants can store their analyses within one scenario and, in the process of doing so, learn from each other and potentially work toward a joint solution. In conflict-laden situations or where anonymity is desirable, several groups or individuals can work independently and generate separate scenarios. A master scenario file can then be compiled by a facilitator (e.g. planning agency member) and distributed subsequently to the participants or be used as the starting point for internal consensus-building efforts. Neutral nomenclature, such as "user1", "user2", "user3", and so on, can be used within a master scenario to ensure confidentiality when it is a concern. While this general methodology is less sophisticated and more restrictive of face-to-face communication than the decision-room model utilised in some GDSS, it is applicable to all three of the generic group decision-making contexts discussed in Chapter Two (homogeneous, heterogeneous, multi-group) and is more technologically appropriate to the conditions that characterise SIS.

3.2.5 Spatial Functionality

GIS are described often according to their capabilities to store, manipulate, display, and provide analytical support for geo-referenced data sets. Maguire and Dangermond (1991, 326-327) have organised these various capabilities into the following ten generic functional classes:

1. data capture (input of data from digitising hardcopy maps, GPS, scanned images, etc.);

2. data transfer (moving digital data from one format to another);
3. validation and editing (checking and removal of errors);
4. storage and structuring (ensuring data conforms to specific data models – raster, vector, etc.);
5. restructuring (changing data sets from one data model to another – e.g. vector to raster conversion);
6. generalisation (simplifying and/or aggregating individual data entities);
7. transformation (altering the scale or projection of a data set);
8. query (retrieval of information concerning one or more data entities);
9. analysis (creation of new information (temporary or permanent) by manipulating data sets);
10. presentation (displaying spatial or tabular information in map or report formats).

In practice, there is a great deal of overlap and dependency among these functional categories. For instance, the output of certain analytical procedures, such as digital map overlay methods, may need to be validated and structured according to the internal data model requirements of a GIS through the construction of stored (topological) relationships prior to use.

In order to satisfy the mandate of decision support rather than data processing, spatial functionality within SDSS is often restricted to the subset of GIS query, analysis, and presentation capabilities that are most pertinent to their target use environment. Queries can be based on either the descriptive attributes associated with geographical features (e.g. "select all census zones with a population of more than 500") or location (e.g. "select all properties within 300 metres of a nature reserve"), and they may be initiated through logical expressions or graphical selection (i.e. mouse). Often selection criteria are defined on an interactive and *ad hoc* basis by establishing a series of spatial and non-spatial constraints (e.g. "select all properties within 300 metres of a nature reserve that have not been built upon") (Egenhofer and Herring, 1993, 124). These capabilities form the baseline spatial query requirements for a MP-SDSS for strategic level decision support. Beyond this, more sophisticated capabilities that permit users to explore the ambiguities of many geographical features, such as the indeterminate nature of concepts like "close", "far", "low", "adjacent" etc., and access alternative measures of distance, (Euclidean, network, time-based, etc.) can be used to address issues within specific problem domains (Wang and Hall, 1996; Wang, 1994).

As noted above, specifying the spatial analysis capabilities that are required for the SIS land use and tourism development planning arena is a particularly difficult task due to the heterogeneous objectives, skills, and problem domains of its participants. Individuals or groups concerned about development impacts on the natural environment may want specialised spatial functionality for examining localised changes to runoff flows into marine ecosystems, whereas planners may want expert system capabilities to automate subdivision design procedures, spatial statistical capabilities may be requested by others, and so on. Attempts to satisfy all of these specialised needs within one MP-SDSS is not feasible from a technical perspective and, moreover, it is not necessarily desirable for group decision-making. Copas (1993, 163) and MacDonald (1997, 518) suggest that computationally-intensive and/or technically-complex operations be conducted prior to group meetings since individuals unfamiliar with complicated procedures may be intimidated and also because it may shift the focus of debate from goals and priorities to detailed technical matters. This is particularly relevant in the multi-group context where the use of particular information and procedures is determined through consensus or majority rule. Facilitating interoperability with other software permits homogeneous groups with technically-skilled members to exchange data between the MP-SDSS and external domain-specific models.

At a more generic level, Arentze et al (1996b, 194) list four general classes of spatial functions that are used to select, create, and structure data for the purpose of spatial analysis:

1. create or define new spatial entities by buffering or overlaying point, line, and polygon features;
2. derive new attributes for spatial entities by calculating feature-to-feature distances (e.g. distance from each hotel to a selected attraction) or the number of point features that lie within a polygon zone;
3. select features that satisfy user-specified locational and attribute characteristics;
4. permit the aggregation of large-scale data to suitable smaller scale representations (e.g. dissolving polygons of like characteristics into larger polygons, assigning point level data to zonal features, etc.).

When SDSS are based on a commercial, general purpose GIS, such as Spans, MapInfo or ARC/INFO, the SDSS tool developer is able to access generic functionality as required. Somewhat fewer capabilities are available to the developer when a SDSS is built upon a spatial data viewer platform (e.g. ArcView, Spans Explorer, etc.) or visual programming controls that contain GIS functionality (e.g. MapX, MapObjects, etc.), especially in terms of spatial data processing. While each of these alternatives can provide a robust foundation for SDSS development, their licensing restrictions, hardware demands, and purchase costs violate several of the design principles set out earlier in this chapter, especially in the context of developing nations. Utilising a public domain GIS digital mapping kernel to provide spatial data handling capabilities generally trades these constraints off against the breadth of available functionality. The MP-SDSS developer must then apportion development efforts between duplicating existing GIS functionality (e.g. overlay, vector to raster conversion, etc.) in the MP-SDSS and concentrating on building new functionality that is targeted specifically at the SIS decision support domain.

Irrespective of the spatial analysis capabilities that are incorporated within public domain MP-SDSS, they will remain dependent upon commercial GIS for lower-level data creation and processing. As mentioned above, this drawback is not likely to be a significant impediment to decision-making, given the desirability to conduct computationally-intensive data processing operations outside of the decision-making forum.

3.2.6 *Database management functionality*

The database management system (DBMS) used in SDSS tool development provides several types of functionality that are of central importance to the usefulness of the tool in multi-participant applications. Perhaps the most important of these roles is to store and manage all of the attribute data that describe the properties of various spatial features (Densham, 1991, 408). This storage function imposes a logical and consistent structure on the available digital data and ease-of-access while simultaneously influencing how users conceptualise the data and, ultimately, the issues that the data can be applied to (Armstrong and Densham, 1990, 7). The most widely encountered database model that is relevant to MP-SDSS is the relational model which structures data thematically into tables (relations) defined through a set of rows (tuples) and columns (fields or keys). Details of the relational database model and other structures, such as object-oriented, network and hierarchical, can be found in Burrough and McDonnell (1998), Healy (1991), Armstrong and Densham (1990), and Date (1986), among others.

In addition to the storage function, the DBMS provides end-users with capabilities to modify tables by adding or deleting fields, basic editing of the values of fields, and to create new tables. Relational joins between two or more database tables allow records with identical values in common link, or "key", fields to be accessed easily on an *ad hoc* basis irrespective of how they are subdivided into distinct logical tables. This capability permits domain-specific or confidential data that may be maintained external to the MP-SDSS to be utilised within an analysis scenario. Staff in the Ministry of Tourism, for instance, could gain a spatial view of tourist concentration by joining a database table containing hotel-by-hotel occupancy rates to the attribute table of hotel point locations. Similarly, the DBMS must permit tabular data from within the MP-SDSS, such as evaluation matrices, to be exported and used by other software applications.

Finally, the design principles listed above influence the form and functionality of the DBMS component of the MP-SDSS. The foremost requirement is compatibility with widely-used hardware, software, and operating systems in order to leverage existing investments in computing facilities and user skills. It also must be inexpensive to distribute to potential user groups.

3.2.7 *MCA functionality*

The role of the MCA (multiple criteria analysis) component of the MP-SDSS is to assist decision-makers to order and choose from a limited and known set of discrete alternatives based upon value-based criteria weights that they specify. These alternatives may be a set of feasible locations for a proposed land use or activity or a set of competing development strategies for an area under study. In the first case, the decision problem can consist of eliminating inferior sites, identifying one or more acceptable sites, or establishing a complete ranking from best to worst across the entire set. In the latter instance, the decision problem is restricted to one of choosing the one option that is considered to be superior to the others.

Four types of functionality are required in the MCA component of the MP-SDSS in order to:

1. establish criteria weights;
2. calculate appraisal scores and ranks;
3. conduct sensitivity analysis; and
4. foster consensus-building and multi-participant management.

A certain amount of redundancy should be present in this core set of functionality in order to recognise the composite nature of decision support needs within the SIS land use planning context. For example, user characteristics, planning problem complexity, time and available data constraints, among other factors, can all vary substantially from one sub-context to another within the broader SIS land use planning forum and as one progresses through the stages of a decision-making process. Janssen (1992, 89) notes that the choice of MCA technique "is itself a multicriteria problem with a trade-off between comprehensiveness/objectivity and simplicity". This type of trade-off carries over to the other core areas of functionality identified above and should be acknowledged by providing the end-users with a range of methods for deriving criteria weights, calculating appraisal scores and ranks, and so on, from which they can select the tools most appropriate to their needs.

The trade-offs between comprehensiveness and simplicity are readily apparent in the calculation of criteria weights. Weights reflect the relative importance of criteria to each other and thereby have a critical impact on the outcomes of an evaluation process. Consequently, it is of paramount importance that decision-makers understand the operation of the procedures that are used to derive these weights and the way in which they are combined. Without such understanding, there is no way for a user to determine easily if their stated priorities are reflected accurately in the resultant weighting values. Ordering criteria according to importance is the least demanding means of indicating criterion importance. However since most MCA methods utilise quantitative weighting values, these values must be estimated using ancillary techniques (i.e. Expected Value, Random Value, Extreme Value) that are likely to be too complex for many decision-makers (Nijkamp et al, 1990, 57-63; Janssen, 1992, 70-72). The rating method of distributing a fixed number of points across the criteria is relatively easy for decision-makers to understand when dealing with relatively few criteria but it becomes progressively more difficult to use as the number of criteria approaches user-specific cognitive limits (usually 7 +/- 2) (Voogd, 1983, 103).

Methods based on paired-comparisons of criteria link verbal statements to integer ratios (usually between 1 and 9) to indicate whether, for example, criterion *a* is "of equal importance", "somewhat more important", etc. than criterion *b*. Criteria weights can be derived from a resultant matrix of pair-wise ratios as the eigenvector having the largest eigenvalue (Saaty, 1977; 1989) or by the weighted least squares method (Hwang and Yoon, 1981, 48). Mathematical details of selected methods for producing criteria weights are provided below in Section 3.4.3 as well as Nijkamp et al (1990) and Hwang and Yoon (1981).

The need to equip system users with a range of mechanisms for each sub-task within the MCA component of the decision process extends to the choice of method for calculating ranks. For example, the principle decision support need at the earlier stages of addressing complex problems is to screen out inferior alternatives quickly. Non-compensatory techniques, which do not allow inter-criteria trade-offs to be made, can be used to produce "shortlists" of feasible candidates with little effort by eliminating those that do not meet criteria-specific thresholds (i.e. conjunctive method) or do not score highly on the most important criteria (i.e. lexicographic method) (Hwang and Yoon, 1981, 75). The comparatively low cognitive and data demands of non-compensatory methods are offset by their inability to permit inter-criteria trade-offs and the need for consensus on threshold values or the rank order of criteria (Massam, 1993, 87-88).

Once inferior alternatives have been removed from consideration, compensatory methods are generally more suitable for evaluating multi-faceted decision problems as they permit favourable values that an alternative may have on one criterion to be counterbalanced by lower values on other criteria. Within this broad group of methods, the underlying methodology and assumptions, data requirements, and general comprehensibility to users vary substantially. From a methodological perspective, three broad families of approaches can be discerned in the literature: a) multi-attribute utility theory (MAUT), b) multi-dimensional scaling, and c) outranking. Only a brief description of the underlying concepts of each family is provided here. More detailed discussion is provided in the surveys of Olson (1996), Vinke (1992), and Voogd (1983).

Utility-based MAUT methods, such as the weighted summation or simple additive weighting (SAW) method, are some of the most widely used MCA techniques and can be seen as the core of Hill's (1968) goals achievement matrix (Voogd, 1983, 120). Appraisal scores are calculated for each alternative by multiplying each criterion score by its corresponding weighting value and summing the resultant products (e.g. criterion *a* value * criterion *a* weight + criterion *b* value * criterion *b* weight + criterion *c* value * criterion *c* weight and so on). Alternatives are ranked from highest score (most preferred) to lowest score (least preferred). Decision-makers generally perceive these methods to be easy to operate and understand. However, some individuals have difficulty with the high degree of substitutability that is assumed between the evaluation criteria where better performance on one criterion can offset poorer performance on any other criteria, subject to the effects of the criteria weights (Nijkamp et al, 1990, 68). For others, expressing the relative value of different alternatives in terms of a single dimensionless score is problematic (Massam, 1993, 94). More complex MAUT methods based on non-linear or multiplicative utility functions have yielded very similar results in practice to the weighted summation technique while requiring much higher cognitive efforts from decision-makers. Extensive assessment procedures are used to establish how decision-makers trade criteria off against one another (e.g. how much would criterion *a* have to improve to be equivalent in value to a one unit decrease in criteria *b*?) (Janssen, 1992, 58; Hwang and Yoon, 1981, 103).

Saaty's (1980) Analytical Hierarchical Priority (AHP) method is another variant of MAUT that has been applied to a wide variety of problem contexts (Wu, 1998; Banai, 1993; Golden et al, 1989). The AHP utilises a pair-wise comparison methodology in combination with a hierarchical arrangement of criteria (Lin et al, 1997, 406). For each criterion, choice alternatives are evaluated in a pair-wise fashion and assigned a score which is typically within the range of one (*a* and *b* are equally preferred) to nine (*a* is very strongly preferred to *b*). The criteria-based scores are then summed without further adjustment to produce an overall score for each alternative (Harker, 1989, 16).

Multi-dimensional scaling (MDS) or geometric scaling methods were developed originally for use in continuous problem analyses and were adapted subsequently to the discrete context. They are based upon the concept that an ideal point preferred to all other values can be identified for each evaluation criterion (Won, 1990, 122). A large body of literature has been built on MDS methods, especially in sociology and psychology. Also known as Ideal Point analysis (IPA), this group of methods compares each alternative to a theoretically optimal solution composed of all criterion-specific ideal points. Although this optimal solution is not feasible usually, it does provide a point of reference to which all alternatives are compared. For each criterion, the deviation from the ideal point is calculated and weighted by the decision-maker's preference weights. Alternatives are ranked from the lowest to the highest total weighted deviations from the ideal solution configuration. Mathematically, the distance of alternative *i*, d*i*, from the ideal can be expressed as:

$$di = \left[\sum_{j=1}^{J} (w_j \left| \hat{x}_{ji} - \max_i (\hat{x}_{ji}) \right|^p \right]^{1/p} \qquad 3.1$$

where:

w_j is the weight on criterion *j*
$\hat{x}_{ji}$ is the normalised score of alternative *i* on criterion *j*
p is a scaling coefficient

Outranking or concordance analysis (CA) techniques rely upon pair-wise comparisons of alternatives to derive a subset of alternatives that outrank or dominate all other alternatives (Vinke, 1992, 58). Two indexes lie at the core of most versions of CA. The concordance index is calculated as the sum of the priority weights for all criteria where alternative *a* is better than alternative *b* and reflects the relative dominance of alternative *a* over alternative *b* (Jankowski and Richard, 1994, 327). The discordance index captures the extent to which alternative *a* is worse than alternative *b* as the greatest difference between criteria scores where alternative *a* is considered to perform worse than alternative *b*. User-specified concordance and discordance thresholds are adjusted incrementally to eliminate dominated alternatives and identify the most preferred alternative(s).

Nijkamp et al (1990, 71) note that the Electre I method based on the use of outranking would not necessarily provide a complete ranking of alternatives. However, subsequent versions of Electre as well as complementary methods such as PROMETHEE I and II have extended the methodology greatly to allow for a complete ranking of alternatives, to accommodate fuzziness in outranking relationships, and to eliminate the need for thresholds (Vinke, 1992, 64; Voogd, 1983, 127-128). Based upon its consistent and full use of information concerning alternatives and its thorough method of comparing each alternative against every other candidate, CA methods are generally quite highly regarded within the MCA community (Phaneuf, 1990, 39; Hwang and Yoon, 1981, 127). However, depending on the variant of CA used in an evaluation, the complexities of the computational methodology underlying CA and the use of thresholds can reduce its effectiveness as a means of decision support where decision-makers are not familiar with the procedure (Yoon and Hwang, 1995, 52; Jankowski and Richard, 1994, 328; Hobbs et al, 1992, 1773).

The evaluation methods listed above are dependent upon quantitative or cardinal criteria data values. This requirement can be satisfied for many planning decisions, as relevant criteria relating to area, height, distance, costs, and so on, are recorded by ratio data. However, since these criteria are measured in different units (e.g. dollars versus metres) and techniques such as SAW, CA, and IPA produce aggregated suitability scores across decision criteria, it is necessary for these "raw" data values to be normalised on a comparable (i.e. 0 to 1) scale (Carver, 1991, 323). Voogd (1983, 77-79) and Hwang and Yoon (1981, 30-31) describe several different procedures for standardising criteria data including these commonly used methods:

1. dividing criterion values by the sum of all scores for that criterion;

$$\hat{x}_{ji} = \frac{x_{ji}}{\sum_{i=1}^{I} x_{ji}} \qquad 3.2$$

2. dividing criterion values by the maximum value for that criterion;

$$\hat{x}_{ji} = \frac{x_{ji}}{\max_{i} \left| x_{ji} \right|} \qquad 3.3$$

3. subtracting the minimum raw score from a criterion value and dividing the result by the difference between the maximum and the minimum raw scores.

$$\hat{x}_{ji} = \frac{x_{ji} - \min_{i} x_{ji}}{\max_{i} x_{ji} - \min_{i} x_{ji}} \qquad 3.4$$

where: $\hat{x}_{ji}$ is the normalised score of alternative i on criterion j

x_{ji} is the 'raw' or original score of alternative i on on criterion j

$\max_i x_{ji}$ is the maximum raw score for criterion j across all alternatives

$\min_i x_{ji}$ is the minimum raw score for criterion j across all alternatives

While the procedures listed above all scale data values for a criterion along a 0 to 1 range, the normalised scores for each alternative differ from one method to another and can, consequently, affect the outcomes of an evaluation to some degree (Janssen, 1992, 56; Massam, 1988, 33). Procedure 3.2 above, for instance, will return a comparatively narrow range of standardised values that sum to 1.0, while 3.3 and 3.4 always assign a value of 1.0 to the highest data value for the criterion. A standardised value of 0.0 is always assigned by procedure 3.4 to the minimum data value, but is only assigned by procedure 3.3 to raw data scores of 0. Further, it is possible to specify directly the minimum and maximum values used in procedures 3.3 and 3.4 in order to recognise certain practical or hypothetical limits to the rather than drawing these values directly from the underlying data (Massam, 1993, 83; Voogd, 1983, 78).

Many evaluation factors encountered in planning cannot be described on a ratio or interval scale due to their intrinsic characteristics (e.g. amenity and quality-of-life factors) or because resource constraints often prohibit extensive data collection. However, since many of these factors are assessed using an ordinal scale, it is useful to include methods for calculating appraisals that can accommodate rank order data. Some cardinal methods mentioned above, such as CA and IPA, have been modified to accommodate the reduced information content of ordinal data, as illustrated by Voogd (1983, 134-136 and 154-155). Others, such as the EVAMIX method and geometric scaling models, facilitate the use of mixed data by dividing the evaluation criteria into ordinal and cardinal sets and combining the respective ordinal and cardinal dominance indexes (Jankowski, 1989; Janssen, 1992, 66; Nijkamp et al, 1990, 85-86).

Irrespective of the actual techniques that are employed, it is necessary to test the stability of the results to changes in either criteria weights or the criteria scores (data values). These effects are most commonly gauged by: a) examining the impact of changes to weights or criteria scores on the entire set of choice alternatives and, b) examining a pair of alternatives and calculating how much the criteria weights or scores would have to change in order for the two alternatives to have an equal final ranking (Jankowski, 1995, 256). Bodini and Giavelli (1992, 641), for example, determine the stability of ranks by counting the number of times each alternative is dominant while the criteria values are varied stochastically in five percent increments. Janssen (1992, 91-100) reviews a variety of statistical methods that have been developed for this task while Jankowski et al (1997, 597) illustrate the use of a dynamic sensitivity procedure which allows users to visualise the impact of changing a criterion weight on the overall ranking outcomes. Method uncertainty is addressed most often by comparing the rankings that several MCA techniques produce for a given set of alternatives (Buede and Maxwell, 1995; Heywood et al, 1994; Van Huylenbroeck and Coppens 1995, 403).

Lastly, two broad approaches have been developed to extend MCA to accommodate the consensus-building aspect of group decision-making. The first approach focuses on deriving group criteria weights from the weights established by individuals. This can be done by assigning each participant an influence weight which reflects the relative importance of their judgement or expertise to the group's decision-making process. Group-level criteria weights are determined by applying these influence weights to each individual's criteria-level weights. Malczewski et al (1997) use this method to account for the amount of power that seven different interest groups have concerning environmental conflict issues in the Cape Region of Mexico. While this method may be satisfactory within an organisation with a formal hierarchical structure, it can be difficult politically and ethically for a central authority to apply it to disparate social groups engaged in a democratic participatory process (Voogd, 1983, 68). Using the geometric mean of the individual priorities to produce group weights is one way to avoid this problem, however individuals may attempt to skew the resultant averages through extreme positions (Harker, 1989, 21-22; Saaty, 1989, 65).

The second approach to consensus-building in a group context is to produce a group ranking of alternatives based upon manipulating the ranks produced by the individual group members. Details of a variety of procedures for producing aggregate ranks based on a variety of voting procedures are provided by Hwang and Lin (1987, 29-77). However, only the most relevant to this thesis are mentioned here. For M alternatives, the Borda function awards $m-1$ points to the alternative ranked highest by an individual, $m-2$ points for the second highest ranked alternative, and so on. This is repeated across all group members and summed to produce overall scores with the highest value being associated with the most preferred alternative (Massam, 1993, 92). The Copeland method extends this majority rule procedure to include how many times an alternative loses as well (Hwang and Yoon, 1981, 217; Massam, 1991, 32). In contrast to these voting-based procedures, Cook and Seiford (1978) define a consensus group ranking as the ranking that minimises the total absolute distance from the set of individual rankings (Hwang and Lin, 1987, 51). For M alternatives, an m by m distance matrix is calculated and an assignment algorithm is used to calculate the total distance for each possible ordering of the alternatives.

3.2.8 *Reporting and Display functionality*

The essential role of all DSS is to help users translate various types of data into useful information. Meadow and Yuan (1997, 701, 703) characterise data as symbols (e.g. alphanumeric, pictorial, etc.) that have little or no intrinsic meaning, and information as symbols that do have some meaning. This translation process involves elements of transformation, which are addressed by the analytical procedures discussed above, and communication. Both transformation and communication processes are recipient-dependent such that data for one group of individuals may be information to others or what is information to several individuals may be perceived to have different meanings.

The provision of multiple pathways through the analytical components of the MP-SDSS acknowledges the recipient-dependent dimension of data transformation by permitting users some latitude in choosing procedures that are most closely aligned with their needs. A similar amount of flexibility is required in tabular reporting and map display functionality in a MP-SDSS since they serve as the chief mechanisms for conveying the analytical outputs of the system to a diverse user community. In the case of tabular data, it is advantageous to have a subset of basic pre-defined reports suitable for general use and some ability for users to produce reports that are tailored better to their specific needs.

Flexibility in the production of hardcopy and on-screen maps can be facilitated by allowing users to alter cartographic representation of geographic features by manipulating shade, colour and texture, the orientation of point symbols, symbol size and offset, and other aspects of symbolisation. To enhance the potential for communication, avoid the production of incorrect or misleading maps (see Dorling, 1998 and Monmonier 1991), and ease the map production process for non-expert users, it is desirable for navigational aids to be built into the system's GUI. In this way, users can be supplied with decision guidance regarding the appropriateness of different symbolisation options for specific spatial primitives (i.e. point, line, area) and assistance with more complex classification procedures.

Explicit recognition of the multi-participant nature of selection and evaluation operations must be incorporated within the display component as well. Users should be able to view the selections of different participants quickly and easily. Further, they should be able to classify ranked features in such a way that facilitates investigation of compromise and consensus sites and helps to visualise the impacts of particular criteria weighting schemes. Jankowski et al (1997), for example, depict the degree of consensus regarding the suitability of a site in terms of graduated circles.

This core level of reporting and map display can be extended in several ways should design resources permit. All discussions of mapping to this point have focused on representing spatial features in two-dimensions. Three dimensional map display could be of considerable value in SIS with extreme topography (e.g. volcanic islands such as Montserrat) but would require substantial programming effort in terms of spatial processing capabilities as well as the navigational aids that would be required to guide non-experts. On another front, Shiffer (1995) explores the potential of enhancing communication by augmenting conventional map and tabular report output with different forms of media, such as photos, video and sound. The ability to graph various data is also desirable. Here, the design choice centres on whether to duplicate capabilities already found in other commonly available software (e.g. spreadsheets, presentation software) or to rely on the interoperability afforded by DBMS data export.

3.3 Data Requirements

Data are the critical element in decision-making that ultimately bound both the type of issues that can be addressed with a DSS and the type of answers that can be developed with the system. In addition, since data are constructed often with reference to specific regulatory, administrative or scientific standards or practices, they are a tangible and legitimising product of these procedures and the individuals or groups who advocate the procedures.

The constraints that local conditions in SIS impose on data availability, accuracy, and currency dictate that the MP-SDSS must be capable of providing meaningful decision support using a relatively small complement of digital data. The actual supply of data will vary not only between SIS but also among decision-making contexts. Typically, a common pool of base data can be identified that is shared by most if not all participants involved with land use and tourism planning issues. The interpretation, perceived relevance, and subsequent use of these data as decision-making information vary according to a participant's role in the decision-making process and the position that he/she is advocating. Over and above this core set of data, different homogeneous group contexts have additional data often that are pertinent to their specific domain of expertise. Concerns over interpretation, confidentiality, or liability associated with data that may contain known, but not easily explained, shortcomings usually preclude the use of these data in heterogeneous or multi-group settings. Examples of such data include: hotel occupancy rates, marine habitat surveys, and proposed development projects that have not entered the public evaluation process.

For the purposes of site selection for locating tourism facilities, such as hotels, condominiums, and guest houses, a minimum of three spatial data layers is required: 1) a census-based small area polygon layer to which tabular census and/or survey data concerning the host population can be linked, 2) a point or polygon layer that describes the location and pertinent attributes of existing tourism land uses as well as the properties they are situated on, and 3) a land use layer. Notwithstanding the benefits of a broader data set, at least a rudimentary level of site selection and evaluation analyses can be conducted using these layers. The census layer allows spatially-disaggregated socio-demographic information such as population counts, housing conditions, employment structure, and income levels to be visualised, contextualises planning decisions, and leverages the investment that most SIS make in costly censuses. While a census is usually only conducted every decade, more limited annual surveys are often conducted using census enumeration areas. In turn, the tourism facility location layer permits new tourism facility locations to be identified relative to the pattern of existing tourism facilities and attractions, thereby permitting aspects of agglomeration economies and diseconomies to be addressed. The presence of the third layer recognises the property-oriented focus of most land use planning decisions. Development projects, for example, are proposed for specific land parcels, environmental interest groups lobby Government to purchase parcels that encompass fragile habitats, and conflict erupts between property owners because of the externalities associated with one individual's current or planned future activities.

More complete analyses can be conducted if other data are available. Legal and administrative data, such as map layers that depict zoning designations for properties and parcel fabric changes associated with proposed developments, would be valuable in a variety of decision-making contexts. Where confidentiality concerns are not of issue, such as within internal Planning agency discussions, land registry database tables that link to parcel map layers would also be of assistance as they describe property ownership, assessed value, and development status, among other details.

Key elements of the human-built landscape that would also be valuable in various decision-making settings include: a) a transportation layer that can be associated with database tables containing traffic counts and road condition, b) pedestrian trails and pathways, c) building points or polygon footprints that are coded for structure type, age, condition, etc., and d) hard service layers that indicate the location and characteristics of electrical, sewerage, and water networks.

The natural landscape is a critical factor in determining how attractive a site is to tourists and hence operators, the potential ecological impacts of development, and the types of physical constraints that are imposed on development. Topography represented by contour lines and slope polygons is of particular relevance in islands with substantial relief, while map layers that symbolise soils, stream and river networks, and vegetation cover are more universally applicable across the Caribbean. Areas with fragile flora and fauna may be recognised in terms of parcel-level designations or as separate polygons. Equally important for assessing coastal development in SIS are aquatic features such as reefs, coastal ecosystems, and marine parks and sensitive habitats such as mangrove swamps (Pieters and Gevers, 1995; Ebanks, 1988; Salm, 1984).

A substantial portion of the digital map data required for the tourism sector will be present as elements of these legal-administrative, human-built, and natural environment spatial map layers. The building footprints that pertain to hotels and condominiums and human-built attractions (e.g. historic structures, restaurants, museums, casinos, etc.), for example, can either be extracted into a separate map layer or simply coded accordingly if one layer is desired for all structure types. A similar approach can be applied to attractions relating to natural features, such as dive sites, national parks, public beaches, scenic lookout points, and so on. Competitive pressures will generally restrict access to detailed attribute information concerning private sector elements of the tourism sector. For instance, it is probable that only a few individuals in the Government tourism ministry will have access to disaggregated hotel-by-hotel occupancy rates.

To summarise, the emphasis in this discussion on the digital data that can be read by MP-SDSS software does not imply that other data sources are unimportant to land use and tourism planning. Some geo-referenced data may only be available in hardcopy format since staff shortages, inadequate base maps, or the sheer complexity of representing the phenomena within a digital data model may preclude its conversion. Other data lack spatial references but are relevant as macro-level contextual information or as guidelines from which spatial decisions are based. Visitor surveys that profile tourist satisfaction, spending and often provide limited indications of visitor activities, and development regulations that dictate lot size, densities, and setbacks are two such examples.

The next section describes the operational design of *Tour*Plan – a MP-SDSS that was developed specifically to provide the functionality discussed above for tourism-based land development planning in SIS.

3.4 *Tour*Plan - A MP-SDSS for Tourism and Land Use Planning in SIS

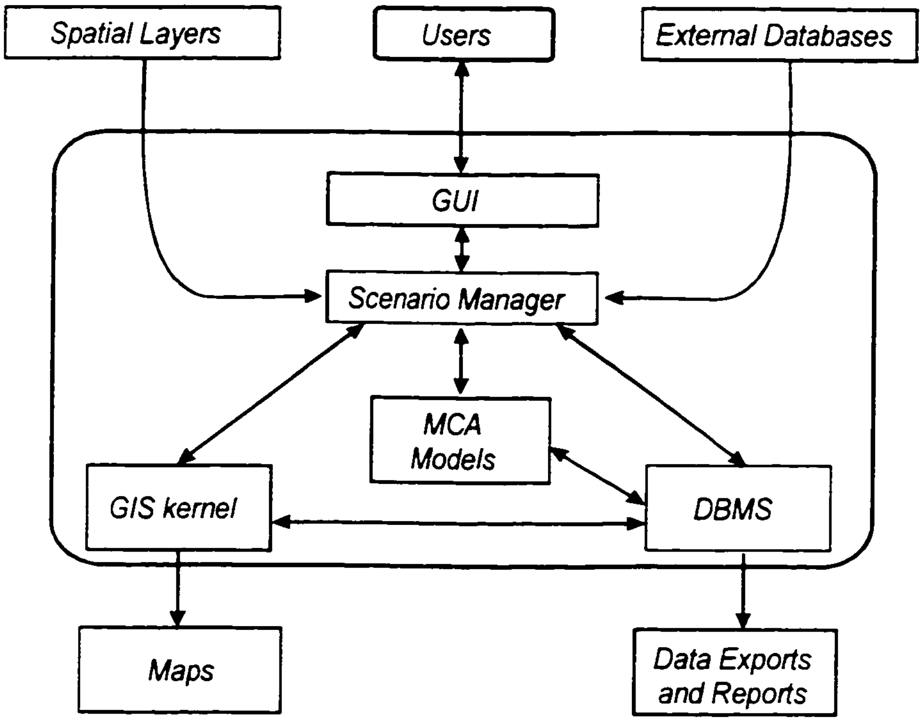
3.4.1 Development Context

*Tour*Plan is a MP-SDSS that was developed by the author as part of a research grant awarded by the International Development Research Centre (IDRC) of Ottawa, Canada to Drs. Brent Hall of the University of Waterloo, Waterloo, Canada and Arthur Conning of the United Nations Demographic Centre (CELADE) of Santiago, Chile. The overall purpose of the grant was to develop a suite of spatial decision support tools to address practical and domain-specific planning issues common to Latin American and Caribbean nations.

These tools were to be designed with the intention of fostering decentralised information use and, correspondingly, decision-making in order to broaden planning capabilities and participation wherever possible. *Tour*Plan was developed to assist land-related planning with a particular emphasis on land use change associated with tourism in SIS. The original problem investigation for *Tour*Plan and initial data collection took place in the Caribbean windward island of St. Lucia. Further development and prototyping were conducted on Grand Cayman of The Cayman Islands, British West Indies. Three other tools were developed as part of the project: *Access*Plan, to help optimise primary health care facility systems (prototyped in Costa Rica), *Edu*Plan, to support education planning needs (prototyped in Santiago, Chile), and *Zon*Plan, to present socio-demographic analyses in map form for small area census and survey data.

3.4.2 High-level design

The high-level architecture of *Tour*Plan consists of five main modules as illustrated in Figure 3.2. All modules except the GIS kernel and aspects of the optimisation functions of *Access*Plan were programmed in Microsoft Visual Basic 4.0. The advantages that this development environment offered were: a) a visual design toolbox for creating easy-to-navigate GUI, b) complete compatibility with the industry-standard Microsoft Windows 3.1, Windows 95, and Windows NT operating systems, c) built-in DBMS functionality through Data Access Objects (DAO) which supports a range of common database formats including Borland Dbase and Paradox, Microsoft Access and FoxPro and ODBC (Open Database Connectivity) protocols, d) wide user community making further customisation and extension of the resultant program possible by third party developers. However, relative to a lower-level programming language like C++, Visual Basic has comparatively poor memory management and numerical processing capabilities, which can result in slower operation. To alleviate this problem, the GIS kernel was programmed in Microsoft Visual C++ to provide a library of functions for computationally-intensive operations related to map display, distance calculations, data classification, etc. Programming of the GIS kernel was conducted by Dr. Robert Bowerman, who also developed the *Access*Plan SDSS (Bowerman, 1997).



Source: adapted from Hall et al (1997a, 75)

FIGURE 3.2 *TOUR*PLAN ARCHITECTURE

As Figure 3.2 illustrates, all user interaction with the software is channelled through the GUI. The Scenario Manager operates in a task-dependent mode to log selected decision-processing activities automatically in scenario files for subsequent reuse and recall. At the users' discretion, descriptive comments concerning a scenario or for particular steps in a site selection or evaluation process can be recorded as well. Interaction between the user and the GIS kernel (GISK), MCA, and DBMS modules is co-ordinated through the Scenario Manager. For instance, required desktop mapping functionality, such as spatial display, query and data classification, is provided by the GISK in conjunction with the DBMS. Similarly, all data storage and manipulation required by the routines in the MCA module is managed by the DBMS. The DBMS also allows for descriptive statistics to be reported, linkages to be made to external database tables, and the exporting of analytical results.

On system start-up, *Tara*Plan presents a data-oriented structure that includes simple spatial and tabular data browsing and query capabilities to a single-user for general problem exploration and use in day-to-day operational duties. It is anticipated that if the software proves to be useful for routine functions, users will be more comfortable applying it to tactical and strategic decision problems that are encountered less frequently. The software takes on a more task-oriented focus once the multi-user site selection or MCA assistants are invoked.

ESRI's (Environmental System Research Institute) public domain "shapefile" standard is the main external spatial data format that is supported by the GISK. Each shapefile is composed of three separate files which contain locational (.shp), attribute (.dbf), and spatial index (.shx) data. Vector-to-raster data conversion is built into the GISK as well. This functionality allows raster, or grid cell, data layers to be created from polygonal, vector-based shapefiles. The user can control the grid cell size in the output raster layer and whether all or selected input features are to be replicated. The allocation of attribute data from shapefiles to grids is achieved using a variant of the moving window method described in Bracken (1989). See Bowerman (1997) for technical details.

The tabular attribute data associated with shapefiles is maintained in Borland's industry standard Dbase format. *Tara*Plan supports this external database format as well as output files from *Win* R+, a companion piece of census processing software, that was also developed under the auspices of the IDRC research grant which supported the development of *Tara*Plan. *Win* R+ and its predecessor REDATAM + developed by counterparts at CELADE are ubiquitous in national census bureaus and other agencies throughout the Caribbean and Latin America. While no capabilities are provided in *Tara*Plan to change the geometry of shapefiles, users are able to edit database tables, change their structure by adding and deleting fields, and perform relational joins between tables as required.

With this broad overview in mind, the site selection, evaluation, and multi-participant functionality that is programmed into *Tara*Plan is now outlined.

*3.4.3 Tara*Plan *Low-level design*

3.4.3.1 Graphical User Interface

In order to minimise training requirements, enhance interoperability with other Windows-based applications, and contribute to user familiarity with the software, *Tara*Plan's GUI conforms to industry-wide conventions concerning point-and-click pull-down menu structure, toolbar layout, and overall visual design. The basic menu design is shown in Figure 3.3.

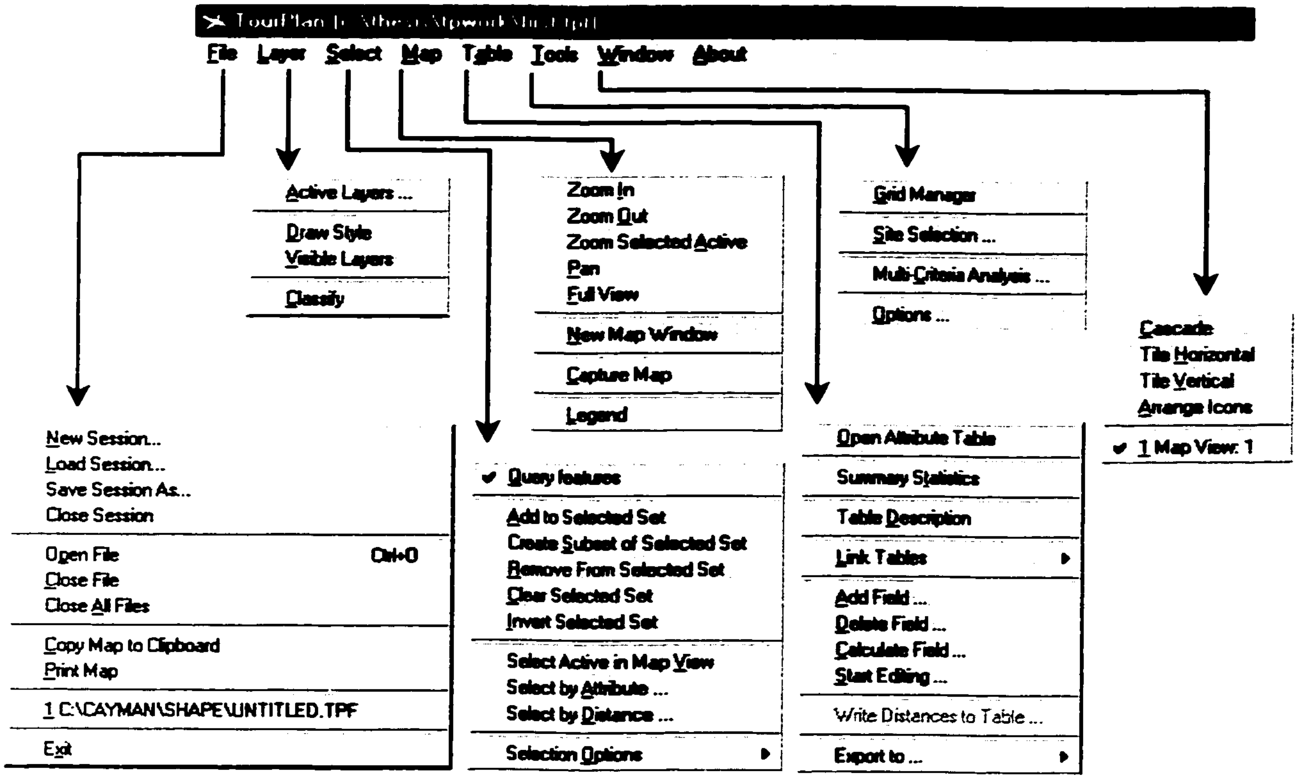


FIGURE 3.3 *TOURPLAN* MENU STRUCTURE

The menu layout is maintained with relatively few exceptions throughout the operation of the software. Menu options that are not valid due to the current state of conditions are made unavailable to the user or "greyed out". For instance, the File | Close File menu choice is not selectable unless at least one map layer or database table is open. The GUI as a whole is a blend of the data-oriented and task-oriented approaches to interface design. The menu tree component has a predominately data-oriented focus that is directed at opening and closing of data sets (map layers and database tables), selecting and displaying spatial entities and/or tabular records in multiple map or browser windows, editing database tables, and so on.

Redundant paths to data-oriented functionality are built into the menu structure by way of shortcut keys (e.g. Ctrl O initiates the File | Open dialogue), the duplication of commonly-used functions on the toolbar shown in Figure 3.4, and through a pop-up menu associated with the map legend (Figure 3.4). A limited amount of informative decision guidance is provided to users through the "tool tip" explanatory notes that appear when the mouse is paused over toolbar buttons and certain areas of some dialogues.

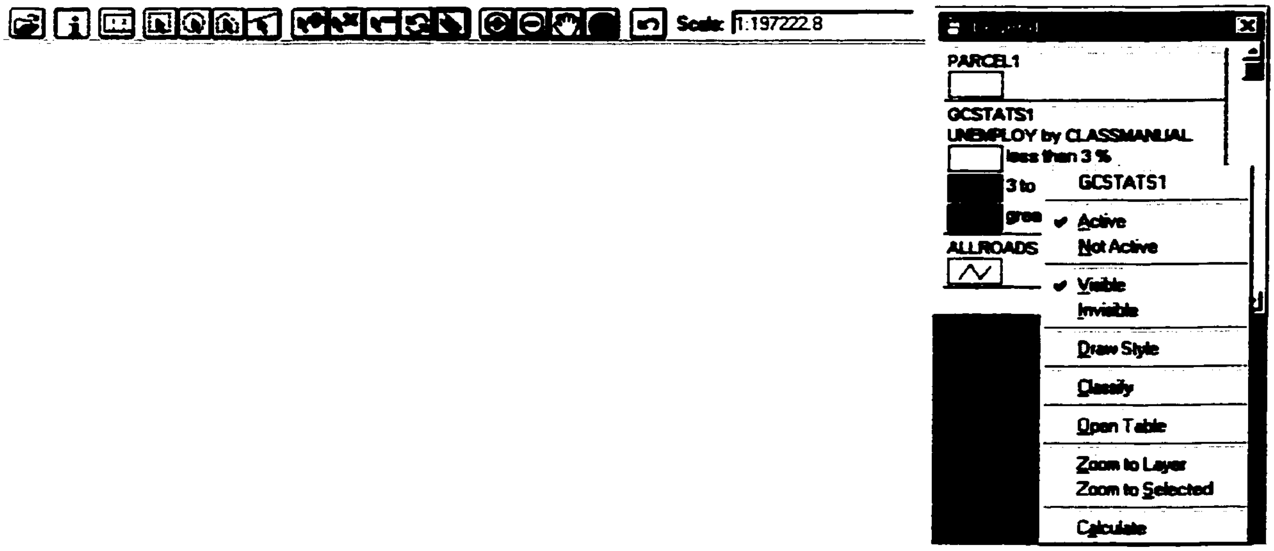


FIGURE 3.4 TOURPLAN TOOLBAR AND POP-UP MAP LEGEND MENU

The task-based orientation of the GUI is represented through four navigational aids that are termed "assistants" in *Tour*Plan and are similar in structure to the "wizards" found in many commercial software products. For example, the Map Classification assistant aids the data visualisation process by allowing the attribute data associated with a map layer to be classified according to user-defined or pre-defined classification schemes. The GISK then uses the resultant data classification as the basis for displaying the layer in map windows. The Grid Manager assistant guides users through the procedure of creating raster layers from polygonal vector shapefiles and allocating attribute data to the grid cells. Two further assistants were developed specifically to guide users through site selection and MCA processes required for generating tourism-based land development scenarios. Their operation is discussed in detail in Sections 3.4.3.2 and 3.4.3.3 below.

3.4.3.2 Site Selection Assistant

Webster (1993, 712) describes the process of generating land use plans as "more of an art than a science because it is rare that the full solution space of a problem is ever explored or that a rigorous procedure is adopted for traversing it." This assertion applies equally well to the problem of selecting sites for given purposes since determining which sites are suitable for particular types of land use activities is, in many respects, the atomic process upon which comprehensive plans are built. Several factors contribute to this situation. Openshaw et al (1989, 174) note that many site selection processes are dominated by "non-scientific methods" and hindered further by a general lack of regulations or numerical criteria that can guide important aspects of siting decisions. The presence of multiple actors with incompatible objectives and varying levels of power and the inability of many key decision factors to be translated into tangible, quantifiable, and/or digital formats were discussed in Chapter Two and in the first sections of this Chapter.

In addition, land use planning issues focus predominately on incremental changes to a dynamic land use system and rarely deal with an empty or static canvas on which optimal configurations can be developed and/or maintained. Consequently, assessing the accountability, transparency, and rigour of the site selection process the subsequent site evaluation processes is problematic to say the least.

Where development control regulations are restrictive, the site selection process for a given land use may be constrained to a small universe of potential locations and the task of identifying and evaluating candidate sites is relatively straightforward and well understood. This has generally not been the case in Caribbean SIS to date, given the lack of comprehensive frameworks for managing land use in some territories and the influence of political factors on the application of both documented and undocumented planning practices and policies (Pattullo, 1996, 113; Conway, 1989, 71; Potter and Wilson, 1989, 127).

With the above considerations in mind, the role of the site selection assistant in *Tarr*Plan is not to determine the "best" or optimal locations for specific land use activities. Instead, its role is to provide what Webster (1993, 712) terms "appropriate scientific support" for the creation and modification of land use scenarios, or alternative views of the future, in which policy problems and key assumptions are explored and alternative solution strategies are developed.

A two-stage approach embodying Etzioni's (1967) mixed scanning is common to most GIS-based site selection analyses. Large numbers of candidate sites are scanned quickly using basic thresholds of suitability to produce shortlists of feasible candidates. The objective in this first stage is to identify which candidates are acceptable in terms of their aspatial characteristics (e.g. price) and, more importantly, according to their individual and collective locations within the study area. The resultant shortlists of feasible locations are then subject to more detailed evaluation. Examples of this two-stage approach can be found in Jankowski and Richard (1994) and Carver (1991), among others. In *Tarr*Plan, these stages are facilitated by the site selection and MCA assistants respectively. Figure 3.5 illustrates the proposed interaction of these tools and the importance of the field verification element discussed in Chapter Two.

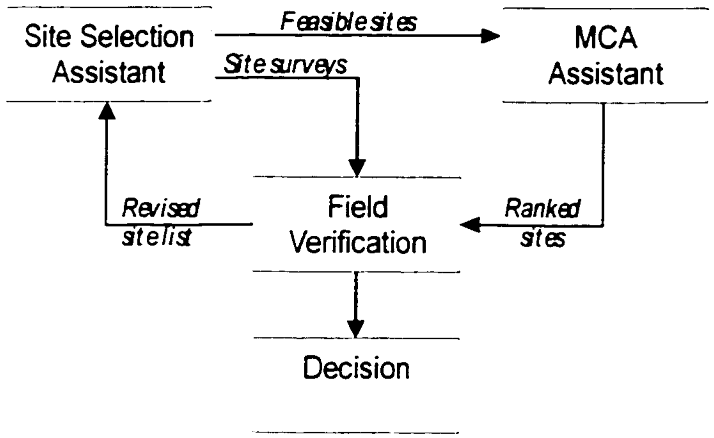


FIGURE 3.5 PROPOSED USE OF SITE SELECTION AND MCA ASSISTANTS

The site selection assistant is a multi-step navigational aid that can be used either directly by the participants in a scenario or else operated in a moderated, or "chauffeured", mode where a facilitator operates the software on behalf of the participants. The process of creating a site selection scenario involves recursion through five basic steps: 1) designate scenario participants, 2) load required spatial data layers, 3) establish a study area, 4) designate suitable land units (i.e. parcels) for particular land uses, and 5) view individual and collective selections. A scenario is initiated by entering the names of between one and ten participants each of whom may be an individual representing a particular viewpoint or a group of individuals acting together (e.g. community group). The ceiling of ten users is somewhat arbitrary but is based on what was seen to be a reasonable number of participants to interact in practice. Users can be added or deleted from a scenario at any time in accordance to the dynamic nature of the group participants.

Next, all participants in the scenario must agree on a minimal complement of data on which the scenario is based. This set of data consists of: a) a "base map" layer from which a study area or region of interest is delimited, b) a tourism facilities layer that consists of all relevant point or polygon accommodation features such as hotels, guest houses, etc., and c) a land use layer. The land use "layer" may be either a single raster layer created previously in *TourPlan*, a single vector shapefile that depicts generalised land use polygons, or several mapsheet-level shapefiles of individual land parcels. In the latter case, the user needs to interact with only one seamless parcel "layer" for convenience. Attribute data associated with these map layers are duplicated within the scenario to allow for scenario-specific modifications and thereby safeguard "master" data sets. Once the required map layers are loaded, additional spatial and non-spatial data sets can be added to, and used within, the scenario by any participant at any time.

Third, all users within a scenario must agree on the extent of the study area, or geographic solution space, from which feasible tourism facility sites (such as locations for resort or accommodation development) are identified. The study area may be designated arbitrarily on the screen through one of several possible graphical methods or with reference to the attributes of the base map features. Hence, the study area may be set according to socio-demographic indicators if a census Enumeration Area (EA) base map is used or alternatively it may be set in accordance other pertinent human, physical or environmental data sets such as administrative areas or watersheds. This stage of the site selection process determines which cadastral, or land parcel, mapsheets are loaded to form the land use layer and recognises, to a limited extent, the hierarchical dimension inherent to many land use issues where different criteria are relevant at different scales of analysis (Lin et al, 1997, 404; Arentze et al, 1996b, 128).

The process of designating land parcels for tourism development proceeds as follows. First, only one participant is "active" or currently making selections at any given time. Each participant's selections are maintained individually and there are no constraints on when or how often the active designation switches between users. In this way, users are free to refine their selections in response to the selections of other participants or as their understanding and perception of the decision problem changes.

Three basic methods are available for narrowing the universe of candidate sites down to a short-list of feasible alternatives. Graphical selection routines built into the GISK permit the active user to include or exclude parcels through simple map-based point-and-click operations and by drawing standard graphic primitives such as lines, boxes, circles and irregular polygons around or through features of interest. In addition, an easy-to-use SQL (Structured Query Language) expression builder permits users to access DBMS functionality and select candidate sites according to their attributes. Thus, one participant may initiate their selection process by looking at serviced parcels that are between two and six acres in size, zoned for tourism/hotel uses, and have at least 250 feet of frontage on a main roadway while a user with different objectives could apply other selection criteria.

Finally, a parallel dialogue is available for selecting spatial features based on proximity. In contrast to DBMS queries that probe the attributes of a site, distance-based queries extend the site selection process to include aspects of "situation" or the spatial context the individual locations are a component of (Couclelis, 1991, 15; Pereira and Duckstein, 1993, 412). Conceptual and technical issues have limited the extent to which GIS technology has been able to accommodate situation to date. However, it can be addressed to some degree through measures of "proximal space" which encompasses common elements of human spatial cognition such as adjacency, proximity, contiguity, contains, and distance along a linear feature (Couclelis, 1991, 16). Participants can access GISK functions to construct proximity-based development exclusion zones around sensitive natural features or restrict candidate sites to those within (or beyond) a user-defined distance from particular features of interest such as points of historical or cultural significance, important marine and terrestrial habitats, scenic vistas, or land uses considered undesirable from the perspective of tourists and hence tourist operators.

Xiang and Whitley (1994, 273) distinguish between land capability, which is the physical capacity of parcel *i* to support land use *j*, and site suitability which centres on the social acceptability of land use *j* on parcel *i*. In a multi-participant context, participants are likely to intermix these concepts and reappraise both physical "facts" and their perceptions periodically when determining what is appropriate for a given location. However, in the presence of sufficient factual data and mechanisms to transform these data into useful information, it is more probable for land-related conflict to revolve around what a parcel *should* be used for rather than what it *can* be used for. To recognise this value-based aspect of the selection process and provide a means to investigate the nature of conflict, site selection participants have the option of designating specific parcels for uses other than tourism (such as commercial, open space, protected, and residential uses). While this land use classification scheme is far from comprehensive, users can define their own land uses where required.

The temporal dimension to land use change is a further source of land-related conflict given the finite capacity of human and natural systems to absorb change and the temporal nature of development impacts. Scenario participants can indicate their preferences concerning the phasing of land use change through a coarse and arbitrary three-stage classification (less than 5 years, 5 to 15 years, and greater than 15 years). In this way, a pro-development participant could designate a parcel for resort development in the short-term (less than 5 years from the present time) while another user may want to reserve that site as open space until the effects of approved construction on proximate reef eco-systems are better known. The users are responsible for ensuring that the progression of land uses assigned to a particular parcel is both possible and logical since no facilities are provided with *Tour*Plan for building Markovian rules of land use change.

The degree of commonality among the participants can be reviewed at any time in two ways. The Scenario Manager can indicate how closely the participants' approaches are aligned since it records all selection operations on a participant-by-participant basis and also allows users to add explanatory meta data pertinent to specific steps in the selection procedure or to the scenario as a whole. The degree of commonality in the participants' short-lists of feasible sites can be visualised in tabular or map format, thereby providing a limited mechanism for fostering debate over consensus or compromise sites. Group members may then decide to refine their approach or assumptions regarding the issue at hand or they may elect collectively to spawn additional scenarios to investigate alternative objectives. Should all group members be satisfied with their selections, they may want to examine the candidate locations in the field, as indicated earlier in Figure 3.5, which can conceivably initiate further refinement of selection criteria and the feasible set of candidate sites. To gauge the performance of the group's collective selections relative to the priorities of its individual members, it is necessary to use the MCA assistant.

3.4.3.3 MCA Assistant

The MCA assistant is a user-friendly navigational aid that guides one or more "evaluators" through a multi-criteria evaluation of the selected potential development sites contained within up to ten site selection scenarios. Input scenarios may represent the feasible alternatives defined by different participants for one geographic region or they may span several study areas. The steps that each MCA "session" is composed of are illustrated in Figure 3.6.

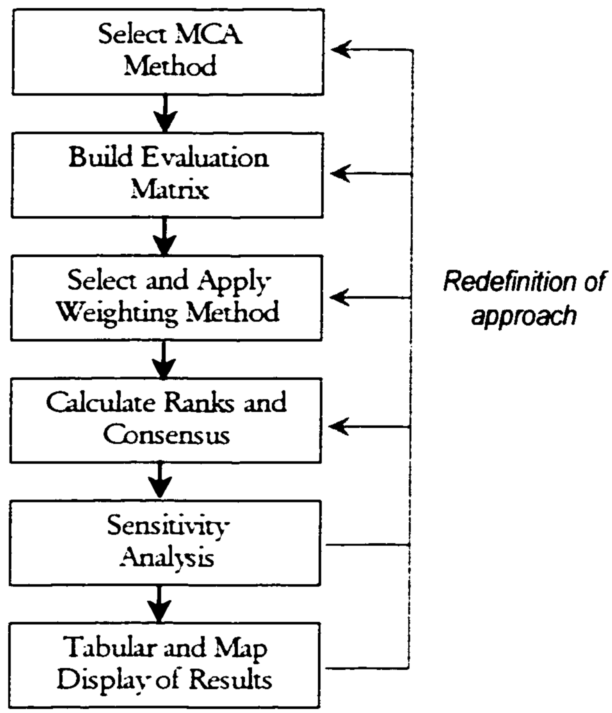


FIGURE 3.6 MCA ASSISTANT: STEPS IN EVALUATION PROCESS

All evaluators in an MCA session must agree on the input site selection scenario(s) and the evaluation method to use. *Tarn*Plan supports three techniques for determining the ranks of choice alternatives: weighted summation, net concordance-discordance dominance, and subtractive summation. Each method is appropriate potentially to different users and different choice problems given the differences in their underlying methodologies and assumptions. The weighted summation method was included in *Tarn*Plan because of its simplicity and transparency to non-expert users (Hobbs et al, 1992, 1774). The most important assumptions that the method rests upon are that the criteria are both substitutable and non-complementary – conditions that often can be difficult to satisfy and, if violated, can generate misleading results (Guimarães Pereira, 1996, 715; Pereira and Duckstein, 1993, 408; Hwang and Yoon, 1981, 102). Cardinal criteria scores and criteria weights are required as well. In order to permit aggregation across criteria that are measured typically in different units, attribute values are standardised using equation 3.3 since it has the advantage of preserving the ratio-scale properties of the raw data scores (Voogd, 1983, 77-78).

Mathematically, the weighted summation method can be depicted as follows with the alternative score (utility) being ranked first:

$$U_i = \sum_{j=1}^{J} (w_j \hat{x}_{ji}) \qquad 3.5$$

where: U_i is the total score for alternative i across all criteria,
$\hat{x}_{ji}$ is the standardised attribute score of criterion j for alternative i,
w_j is the weight assigned to criterion j

The family of concordance methods offers more robust evaluation mechanisms that establish outranking relationships through pair-wise comparison of alternatives. For a given pair of alternatives, the concordance index indicates the degree of dominance that alternative i has relative to alternative i' (Bodini and Giavelli, 1992, 640). This is calculated, assuming normalised weight values, for all criteria on which alternative i' performs better than or equal to alternative i as:

$$C_{ii'} = \sum_{j \in C_{ii'}} w_j \qquad 3.6$$

The discordance index indicates the extent to which alternative i' performs better than alternative i. Whereas the concordance index deals with differences in criteria weights, the discordance index, $d_{ii'}$, centres on criteria scores. The data values must be standardised in order for the discordance component to be calculated since it depends on inter-criteria comparisons. Specifically:

$$d_{ii'} = \max_{j \in Dii'} \left(\hat{x}_{ji'} - \hat{x}_{ji} \right) \qquad 3.7$$

In general, the most preferred alternative would have high concordance indexes relative to other alternatives and low discordance values. In analyses based on several criteria, it is not always possible to generate unique and optimal classifications of alternatives in this manner (Nijkamp, 1975, 96). Instead, the most common method of ordering alternatives is to apply user-defined threshold values, $\bar{c}$ and $\bar{d}$, to the concordance and discordance matrices in order to produce their respective dominance matrices. For alternative i to outrank alternative i', the following condition must hold:

$$c_{ii} \geq \bar{c} \quad and \quad d_{ii} \leq \bar{d} \qquad 3.8$$

Depending on the variant of CA that is used, partial or complete rankings can be produced by altering these thresholds progressively. However, the arbitrary and often ambiguous nature of these thresholds has been criticised especially in light of their importance to the final outputs of the analysis (Hwang and Yoon, 1981, 125). Jankowski and Richard (1994, 328) assert that "[t]his makes control of threshold values essentially meaningless, as a person unfamiliar with the technique is likely to choose an arbitrary value with no reasoning behind it." Hobbs et al (1992, 1773) concur and suggest that this lack of understanding undermines the confidence that users have in the output of the system. This is particularly problematic in the SIS planning environment given the diversity of the potential user community, general lack of specialised training and expertise, and the resource limitations that hinder the development of technology skills.

As a consequence, the CA technique selected for *TamPlan* is based on the method that van Delft and Nijkamp (1977, 49-51) developed for utilising the pair-wise concordance and discordance indexes to produce measures of net dominance instead of indications of outranking. The net concordance dominance value for choice candidate i, denoted here as *net* c_i, indicates the difference between the degree to which alternative i dominates all other alternatives and the extent to which they in turn dominate it. Net concordance dominance is calculated as:

$$net\ c_i = \sum_{i=1\, i' \neq 1}^{I} c_{ii'} - \sum_{i'=1\, i' \neq i}^{I} c_{i'i} \qquad 3.9$$

Similarly, the net discordance dominance value for alternative i can be calculated as:

$$net\ d_i = \sum_{i=1\, i' \neq 1}^{I} d_{ii'} - \sum_{i'=1\, i' \neq i}^{I} d_{i'i} \qquad 3.10$$

Two complementary sets of ranks can be derived from these values since high *net* c_i values and low *net* d_i values are preferred. Bodini and Giavelli (1992) use this method to provide different evaluation perspectives (i.e. how well/poorly does an alternative perform relative to others) on several development scenarios. A composite ranking can also be produced by averaging the two set of ranks, with the highest average rank being the most preferred (Yoon and Hwang, 1995, 53; van Delft and Nijkamp, 1977, 51). Participants in *TamPlan* MCA sessions are able to order candidate sites according to either their *net* c_i, *net* d_i, or average ranks.

The third evaluation method that was included in *TamPlan* is the subtractive summation technique which is one of three methods incorporated within the EVAMIX approach. It also compares alternatives in a pair-wise manner but permits ordinal scale criteria to be used in the evaluation as well as data measured on interval or ratio scales. Janssen (1992, 66) indicates that separate dominance indexes are calculated for the cardinal (Q) and ordinal (O) criteria sets respectively using:

$$\beta_{ii'} = \left[\sum_{j \in Q} \left\{ w_j \left(\hat{x}_{ji} - \hat{x}_{ji'} \right) \right\}^{p} \right]^{1\ p} \qquad 3.11$$

$$\alpha_{ii'} = \left[\sum_{j \in O} \left\{ w_j \, sign\left(x_{ji} - x_{ji'} \right) \right\}^p \right]^{1/p} \qquad 3.12$$

where: sign =+1 if xji >xjí, -1 if xji <xjí, 0 if xji = xjí

p is a scaling parameter

The scaling parameter p is typically set to 1 if there is reasonable confidence in the reliability of the criteria weights. Otherwise, larger p values can be used to decrease the effect of differences between alternatives on the less important criteria (Voogd, 1983, 176). The qualitative and quantitative dominance scores are standardised to permit overall dominance scores to be calculated as the weighted sum of their separate scores. Once the cardinal and ordinal dominance indexes are calculated, they are standardised and overall dominance scores for each alternative are produced as the weighted sum of their separate dominance scores (Bodini and Giavelli, 1992, 641).

After the evaluation method has been chosen by the user(s), the evaluation matrix is created. The first step is to specify the criteria that will be used to evaluate the choice alternatives. The list of available criteria is a function of the database fields that are common to the site selection scenario(s) and the choice of evaluation method since only the subtractive summation method supports ordinal data. Next, the evaluator(s) have the option of including all of the alternatives included in the scenario(s) or applying a filter to restrict the evaluation to a subset of alternatives (e.g. candidate sites that have been selected by all, one, or particular site selection users).

All decisions in the process to this point, such as the choice of input scenarios, the judgement criteria to use, and so on, are group-wide. The next step in the procedure is to specify the names of up to ten groups or individuals who will be evaluators. By default, all of the participants in the input site selection scenario(s) initially have evaluator status but the composition of this list can be altered by adding new evaluators and/or removing existing evaluators. This permits one or more evaluators (e.g. a government planner) to evaluate their own set of candidate sites as well as those identified by a cross-section of planning participants.

Each evaluator begins the weighting process by indicating for each criterion whether high or low data values are preferred. This may be understood universally for some criteria while in other cases there may be differences between users. If distance to the coast is a criteria, for example, hotel developers may view it as a "cost" to be minimised given the willingness of most tourists to pay premiums for waterfront accommodation. On the other hand, individuals concerned with the ecological dimension of marine and near-shore (e.g. coral reef) environments may want to limit beachfront development and consequently view higher distances to the coast as a "benefit". Once these values have been set, the criteria scores in the evaluation matrix are standardised (Malczewski, 1996, 960; Jankowski, 1989, 357).

Next, the evaluators decide collectively whether to use the seven-point scale or the eigenvector method of generating criteria weights. The former method is based on psychological scaling research that indicates individuals are generally able to distinguish reliably between seven classifications, plus or minus two (Voogd, 1983, 104). Each evaluator can generate their own set of criteria weights relatively quickly and easily by assigning a numeric value ranging from one to seven to each criterion. Semantic references, such as very low importance, low importance, and so on through to very high importance, that correspond to each numeric value are used in the weight generation process (Figure 3.7). These numeric values are then standardised to produce criteria weights within the bounds of zero to one. Examples of this method being used in spatial decision-making are illustrated by Carver (1991) and by Jankowski et al (1997) although the latter use a nine-point scale.

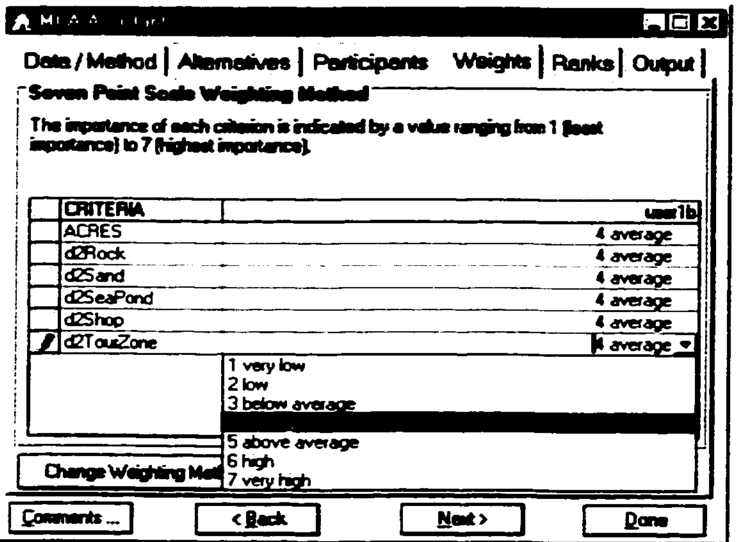


FIGURE 3.7 SEVEN POINT CRITERIA WEIGHTING METHOD

The other method for estimating criteria weights in *Tour*Plan is the eigenvector method popularised by Saaty (1980) in the Analytical Hierarchy Process (AHP). In this method, evaluators compare each pair of criteria and indicate the relative importance of criteria to each other on the following nine-point scale:

1	Criteria *i* and *j* are equally important
3	Criterion *i* is moderately more important than criterion *j*
5	Criterion *i* is strongly more important than criterion *j*
7	Criterion *i* is very strongly more important than criterion *j*
9	Criterion *i* is extremely more important than criterion *j*

Even numbers are considered intermediate points between the adjacent values. For each pair of criteria, ratios of their relative importance are entered into a positive pair-wise reciprocal matrix such that $a_{ij} = a^{-1}_{ji}$ (Van Huylenbroeck and Coppens, 1995, 396). A total of $n(n-1)/2$ comparisons are required to complete the matrix, making this method somewhat more demanding when comparatively large numbers of criteria are involved. However, Harker (1989, 35) and others have offered alternative techniques to reduce the difficult of this task. Several methods have been suggested to estimate criteria weights from this matrix including the weighted least square and the geometric mean methods (Hwang and Yoon, 1981, 48-50).

If decision-makers are completely consistent in their assessments, the same weight vector would be created simply by normalising each matrix element by its corresponding column total (Olson, 1996, 52). The eigenvector method recognises that this is usually not the case especially when larger numbers of criteria are involved (i.e. A >B, B >C, and C >A). Instead, weights are derived from the eigenvector of the matrix that has the largest eigenvalue which is denoted as λmax (Harker, 1989, 30). Since λmax is always greater than or equal to n for a positive reciprocal matrix and λmax is only equal to n if the matrix is consistent, a consistency index (C.I.) can be defined as:

$$C.I. = \frac{\lambda\ \max - n}{n - 1} \qquad 3.13$$

A consistency ratio (C.R.) can be determined next by dividing the C.I. by the appropriate random index (R.I.) which is the consistency ratio associated with a sample of purely random matrices (Banai, 1993, 320). As a general rule, C.R. values less than or equal to .10 signify that the pair-wise comparisons are reasonably consistent. It is usually recommended, although not required, that pair-wise comparisons be revised if the C.R. value exceeds a threshold of .10 (Harker, 1989, 31). See Golden and Wang (1989, 69) for an alternative method of determining consistency that is less sensitive to matrix size.

Several methods have been developed in commercial software for eliciting pair-wise criteria comparisons from users including: graphical bars (pairs of criteria or all criteria simultaneously), verbal statements, and numeric statements. Figure 3.8 illustrates the *Tour*Plan implementation of the eigenvector method of estimating criteria weights. The relative importance of each criteria pair is reflected in the height of corresponding graphical bars. This is supplemented by verbal pair-wise statements that indicate, for example, that criterion *a* is "moderately more important" than criterion *b*.

In an investigation of five different elicitation methods, Millet (1997, 47) noted that the paired graphical bars method offered a viable compromise in terms of accuracy and ease-of-use. The verbal statements method in contrast tended to provide higher degrees of accuracy but was comparatively difficult to use. In the example shown, the "planner" evaluator has chosen to designate the size of a site (acres) as "moderately to strongly more important" than the distance from the site to other tourist accommodation (d2hotel).

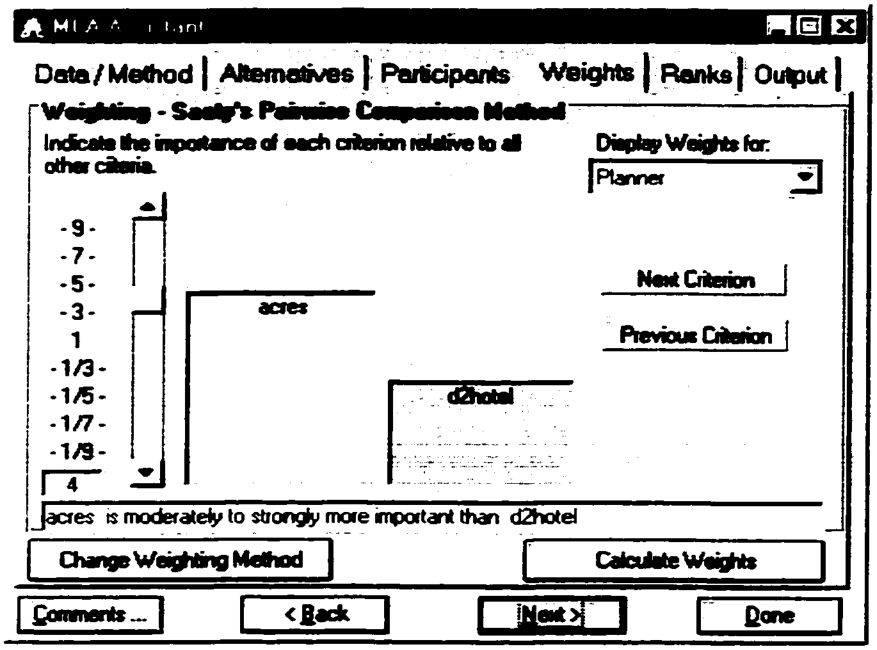


FIGURE 3.8 PAIR-WISE CRITERIA WEIGHTING METHOD

Once the criteria weights have been set and reviewed by all participants, the ranks of the alternatives represented in the evaluation matrix are calculated using the evaluation method established previously. A tabular display permits the choice alternatives to be ordered according to any evaluator's rankings and the display restricted to the user-specified top *n* ranks. In addition, the median rank across all evaluators is presented along with the frequency that a given alternative falls within the current top *n* rank setting – the latter being a measure that is most useful when larger numbers of evaluators are included in the session. Group-wide ranks that are calculated using the geometric mean of the individual evaluator's criteria weights are provided as well.

The degree of consensus can be inspected visually by loading the parcel map layers associated with the candidate sites and classifying the candidate sites according to their individual or group ranks. This allows for the evaluator(s) to examine not only the spatial configuration of different participants' evaluations but also to relate rankings to the land use designations and temporal assignments made in the site selection phase of the analysis. These investigations may result in the re-specification of criteria weights, altered criteria choices, or point to the need to consider sites that were originally excluded from the evaluation set.

3.5 Summary

The discussions in this chapter addressed the operational and design aspects of multi-participant decision support tools built for land use and tourism planning in SIS. A set of design principles, influenced by the local conditions for technology use in SIS and the roles envisioned for the software in the planning process, were established to guide the design process. Next, the functional requirements of a MP-SDSS were outlined in general terms. This discussion provided the background necessary to examine the configuration of an MP-SDSS named *Tour*Plan that was constructed specifically for the problem environment outlined in Chapter Two and to satisfy the design principles established in this chapter. Attention was focused primarily on the operational details underlying two navigational aids built into the software for the tasks of site selection and evaluation. The following chapter describes the field context in which *Tour*Plan's site selection and MCA assistants were applied by describing the data, participants, and some of the land use and tourism planning issues relevant to the West Bay District of Grand Cayman Island.

Chapter Four

CASE STUDY AND RESEARCH DESIGN

The architecture of the *TourPlan* decision support tool was examined in the previous chapter. Particular attention was given to its site selection and multi-criteria components for strategic tourism and general land use planning in SIS. This chapter builds upon Chapter Three through a discussion of the case study used to apply both the conceptual framework developed in Chapter Two and the technical structures outlined in Chapter Three.

The chapter is divided into five sections. In the first two sections, the case study context is described. In part, this is accomplished through a discussion of the relevant socio-economic and environmental characteristics of the locale where the field research was conducted - the West Bay District of Grand Cayman, Cayman Islands, BWI. Next, the relevant land use planning and development frameworks currently used in the Cayman Islands are outlined. Attention is then directed toward the selection of participants for assessing multi-party development scenarios in the West Bay District of Grand Cayman. The final section bridges to the examination of the case study results in Chapter Five, addressing the data used by the research participants in generating their development scenarios.

4.1 Land Use Change and Development on Grand Cayman and in West Bay District

4.1.1 Physical Description of Grand Cayman

The Cayman Islands (C.I.) are a British Crown Colony located in the western Caribbean. They comprise three islands, Grand Cayman, Cayman Brac and Little Cayman, that are in fact peaks of the submarine Cayman Ridge mountain range that extends north-east to become the Sierra Maestra in Cuba (Davies and Brunt, 1994; 1). Grand Cayman is the largest of the islands and is located approximately 480 miles south of Miami. The island measures approximately twenty miles long and between four and seven miles wide for a total land area of 76.4 square miles. Grand Cayman is a predominately low-lying island with the highest point of elevation being only 60 feet above sea level. Notwithstanding scattered fertile pockets, only a thin layer of soil covers its limestone base (Jacobs, 1962, 16). It has been estimated that more than 50 percent of the land mass is covered by swamps of various kinds (Brunt and Burton, 1994, 283). The central mangrove swamp located in the centre-west of the island represents the largest concentration of low-lying land. Approximately

8500 acres in size, this area is a significant habitat for native birds and aquatic life, conditions surface water, and is an important contributor to rainfall in western Grand Cayman.

In addition to the restrictions posed by the wetlands, the settlement pattern of Grand Cayman is heavily influenced by the coastal main roads which ring much of the island. Grand Cayman is divided into five administrative Districts – West Bay, George Town, Bodden Town, North Side and East End. The most densely populated area is the capital city of George Town which is the main point of entry to the country for air and sea traffic, while West Bay District is the second most heavily developed area. Comparatively less development has occurred in the remaining three Districts with linear development paralleling the main coastal road to East End and North Side. In Bodden Town this pattern has been augmented in recent years by the construction of several large residential subdivisions.

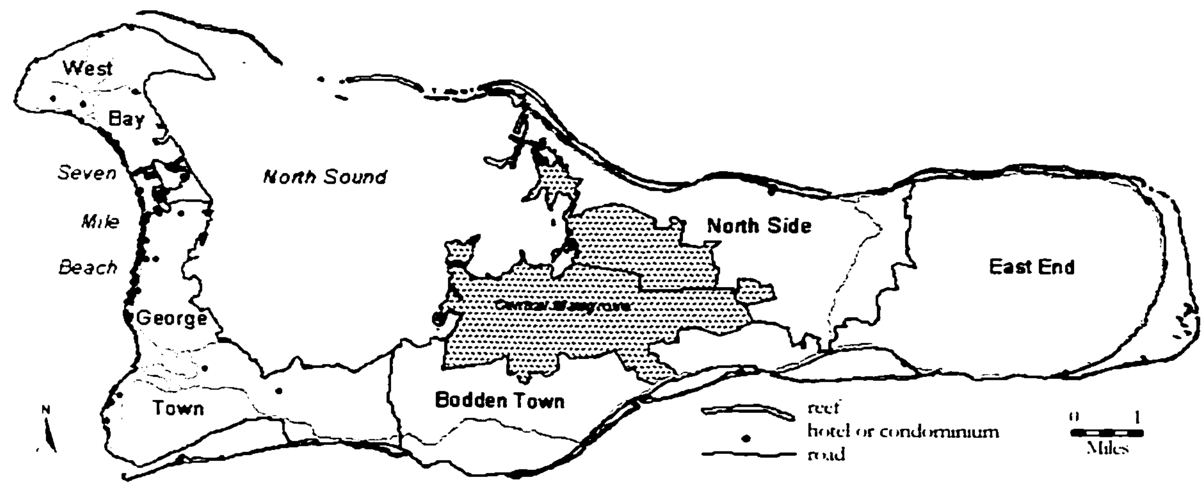


FIGURE 4.1 ADMINISTRATIVE DISTRICTS ON GRAND CAYMAN ISLAND, B.W.I.

Grand Cayman is surrounded by a series of vertical coral walls of the Cayman Ridge and fringing reefs which provide habitat for a wide variety of aquatic life and are, correspondingly, a major attraction for tourists interested in diving (Roberts and Sneider, 1982, 4). The North Sound, which is a shallow body of water enclosed on three sides by land (West Bay, George Town and North Side), is a prime environment for marine life such as conch, lobster and fin fish. Measuring about 6 miles across and 7.5 miles at its longest, it also serves as an important recreational area for tour operators and Caymanian residents.

The coastline of Grand Cayman was classified by Emery (1981, 571) into four broad classes: 1) 37 percent mangroves, 2) 33 percent sharp, irregularly shaped Ironshore and Bluff Limestone formations, 3) 24 percent sandy beaches, and 4) 6 percent beach rock or cemented beach sand/gravel. A substantial amount of mangrove coastline has been lost to tourist and residential development since the time of Emery's survey, especially along the North Sound (Ebanks-Petrie, 1997, pers. comm.). However, sections of the North

Sound coastline that have not been developed remain as ecologically significant red and white mangrove swamp habitats. The most substantial stretches of sandy beach are found behind shallow fringing reefs in George Town and West Bay Districts along Seven Mile Beach and to a much lesser extent in shorter stretches in East End and North Side Districts.

4.1.2 Socio-Demographic and Economic Characteristics

Population growth during the first half of the twentieth century remained relatively modest due to out-migration flows with approximate totals of 5,000 in 1906, 6,000 in 1940 and 7,500 in 1960 (Ebanks, 1991, 12). However, during the last three decades, fundamental socio-demographic and economic changes have spurred rapid land use change and development on Grand Cayman. By the end of 1970, the total population of the Cayman Islands was estimated at 10,652. This more than doubled by 1989 when the population reached 26,400 (Ebanks, 1991, 23). The corresponding figure for 1997 was estimated at 35,000 with approximately 33,700 persons residing on Grand Cayman, 1200 on Cayman Brac and 60 on Little Cayman (Boxill, 1995, pers. comm.). Three main sources of this population increase are: a relatively high birth rate, reduced rates of emigration and significant flows of both short-term and permanent immigration. Moreover, the structure of the population is predominately young with a high proportion being either of pre-adult or of child-bearing age.

Despite the growth in the size of the workforce, unemployment rates in C.I. dropped to low levels through this time period. In the late 1950s and early 1960's, the Caymanian economy began a process of fundamental restructuring which saw it move from dependency on fishing and remittances from merchant marine sailors to growth in the international banking and tourism sectors. This transition was initiated by the Companies Law of 1960 which established the legislative parameters permitting tax-free status for offshore companies and was further enhanced by the 1965 Banks and Trust Companies Regulation Law (Wilkinson, 1997a, 112; Jacobs, 1962, 16). The success of this legislation was made possible by the political stability following the decision of Caymanians to become a Crown Colony in 1962 when Jamaica became independent. Giglioli (1994, 509) illustrates the impact these changes had on the Caymanian economy by noting that between 1960 and 1970 white collar employment rose from 7 percent to 26 percent, skilled workers increased from 6 to 37 percent, while those classed as seamen fell from 55 percent to only 6 percent. At the end of 1997, approximately 550 banks and trust companies were registered in the country. The industry has proven to be extremely lucrative as banking accounts for more than 10 % of total employment and provides substantial licensing revenues to Treasury.

The tourism sector followed a similar path of development over this period to become a fundamental component of the C.I. economy. Ebanks (1991, 4-16), Weaver (1990, 11-14), and Wilkinson (1997a, 113-119) document the growth of tourism and visitor accommodation on Grand Cayman. Until the mid-1940s, international transportation linkages were limited largely to irregular, and as Douglas (1940, 128) notes, uncomfortable passages on bi-monthly mail ships between Grand Cayman and Jamaica. Sporadic sea-plane connections to Kingston and Miami were initiated in 1946 and to Belize City, British Honduras in 1950 (Wilkinson, 1997a, 123). Prior to the opening of the Galleon Beach Club on the western bounds of George Town in 1950, tourist accommodation was both limited and "primitive" (Ebanks, 1991, 18; Weaver, 1980, 11).

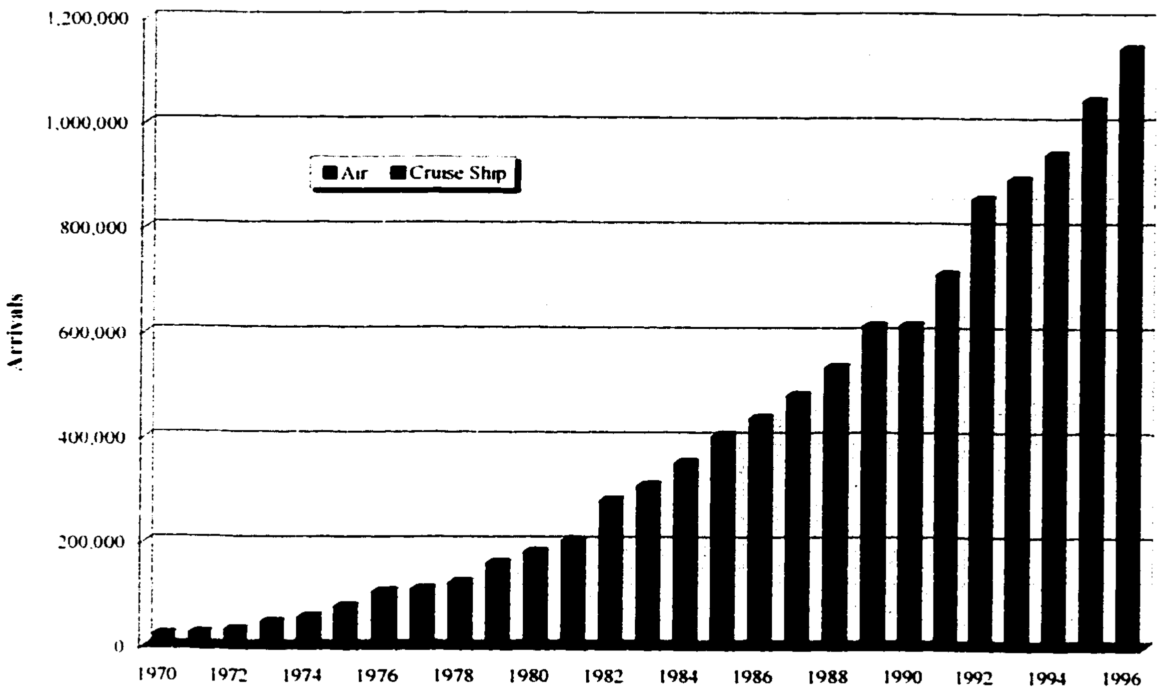
Three key developments had catalytic effects on subsequent tourism growth. First, access to Grand Cayman was enhanced greatly when Owen Roberts International airport in George Town began operating in 1952 (Weaver, 1980, 14). This factor combined with upgrades to the island's major roads in the latter part of the 1950s made tourism development more viable than it had been previously. By the late 1950s, the Seven Mile Beach area north of George Town was beginning to emerge as the leading centre of tourism activity with a total of approximately 90 hotel rooms constructed (Figure 4.1). This figure more than doubled by the end of 1969 when 227 hotel rooms and 50 condominium apartment rooms could be found along the beachfront, representing almost 60 percent of the total accommodation found across all three islands (Ebanks, 1991, 17).

Second, despite the attractiveness to hotel and condominium developers of the calm waters and sandy beaches of Seven Mile Beach, large mosquito populations from adjacent swamplands kept both building density and summer occupancy rates quite low (Ebanks, 1991, 16). Shortly after the Mosquito Research Control Unit (MRCU) was created in 1965 to alleviate this problem, the pace of tourism development increased considerably (Davies and Brunt, 1994, 2). Reclamation of swamplands, which had accounted for almost the entire Seven Mile Beach peninsula except for the sand beach, began the following year (Ebanks, 1991, 25; Ebanks, 1988, 29).

Third, Government involvement in the tourism sector increased with the formation of a Tourist Board in 1961, the passing of the Tourist Board Law in 1965 and the opening of a Tourist Board Office in Miami during the following year (Wilkinson, 1997a, 124). Budgets for promotion, the bulk of which was targeted at the United States market, rose progressively and rapidly after the Tourist Board was upgraded to Department status in 1974 (Weaver, 1990, 13).

By 1970, tourism had emerged as the second most important contributor to GDP after remittances from abroad and as a significant source of employment opportunities for Caymanians and non-national residents (Ebanks, 1991, 16). The increase in the total number of visitors from 1970 to 1996 is shown in Figure 4.2. Cruise ship arrivals increased rapidly from 1975 onward, surpassed the number of stay-over tourists by 1980, and subsequently doubled the number of land-based tourists by 1991. Using figures for 1989, de Albuquerque and McElroy (1992, 627) calculated that Cayman's ratio of cruise passengers to host population was second only to St. Martin/St. Maarten out of a sample of twenty-three Caribbean island states with populations of less than 500,000. Concerns over episodic overcrowding of portions of Seven Mile Beach, overtaxing of the infrastructure in George Town which is the sole Caymanian port-of-call, and coral damage due to improper anchorage facilities led to a ceiling of up to three cruise ships or 5,500 passengers per day being established in 1993 (Martins, 1995, pers. comm.).

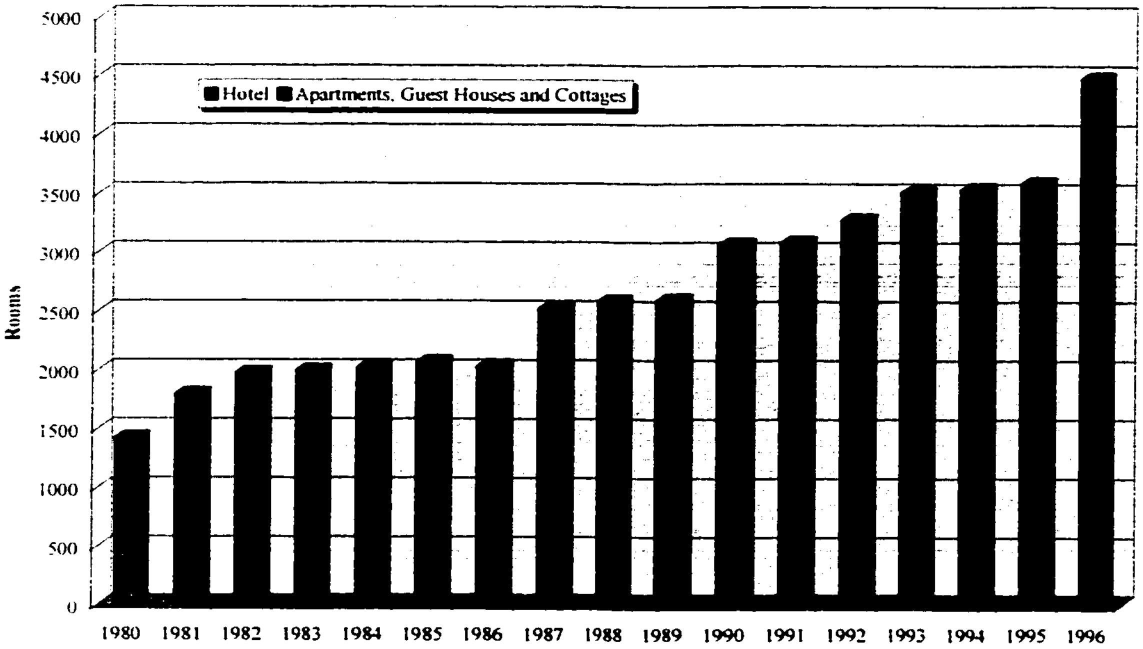
From the figure, it is evident that 1995 was a landmark year for tourism as it was the first time that more than one million total visitor arrivals were recorded in a year. According to the Department of Tourism's Tourism Management Policy (1995-1999), there is a desire to continue this pattern of increasingly high levels of growth in tourist arrivals in the range of 5 to 10% annual increase through to 1999. This is particularly significant given that tourism is responsible directly and indirectly for about 35 % of the jobs and approximately 70% of the GDP in C.I. (Weaver, 1990, 11).



Sources: 1970-1979: Cayman Islands Department of Tourism, Annual Report, 1973-1984.
1980-1996: Cayman Islands Department of Tourism (June 1997).

FIGURE 4.2 CAYMAN ISLANDS TOURIST ARRIVALS: 1970 TO 1996

The growth in tourist accommodation in the Cayman Islands is shown for the 1980 to 1996 period in Figure 4.3. More than 90 percent of current tourist accommodation is found on Grand Cayman as only a limited amount of nature- and diving-related tourism activities take place on the Sister Islands of Cayman Brac and Little Cayman. Tourist accommodation on Grand Cayman has been generally small scale and divided relatively equally between small- to medium-sized hotels and cottages, guest houses, and condominium apartments. Recent developments, discussed in the following section, suggest that a higher-density form of tourism is becoming more prevalent in Grand Cayman.

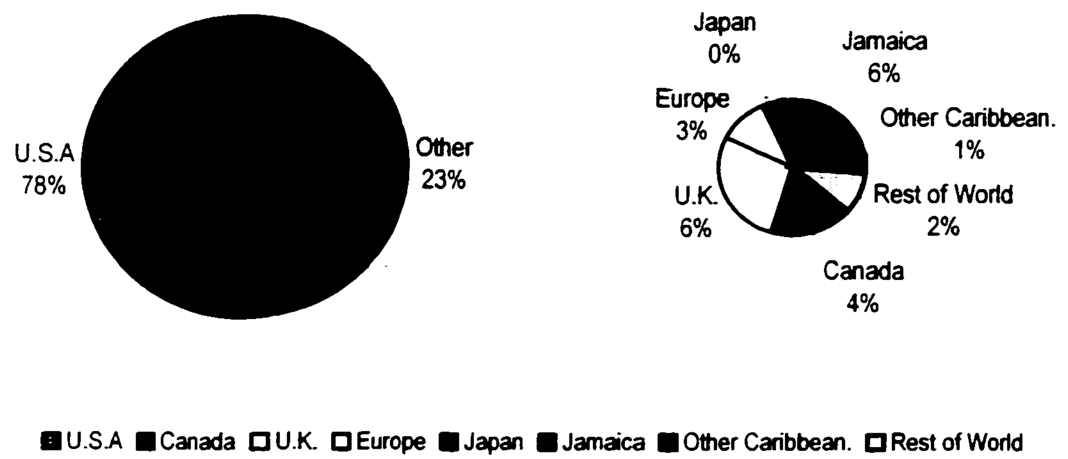


Source: Cayman Islands Department of Tourism (June 1997).

FIGURE 4.3 CAYMAN ISLANDS TOURIST ACCOMMODATION: 1980 TO 1996

Beyond the overall growth in tourist arrivals, C.I. have also been successful in attracting an increasingly high proportion of affluent travellers. For instance, in 1985 the country attracted 1.8% of all tourist arrivals to the Caribbean and received approximately 1.7% of the region's total tourist expenditures. By 1992, the arrivals figure had increased to 2.3% but tourist expenditures rose even more rapidly to 3.9% (Government of the Cayman Islands, 1994, 13). This level of expenditure can be traced, in large part, to the comparatively high room rates and the high value of the Caymanian dollar which is set at $1.20 US (Wilkinson, 1997a, 118). A particularly strong reliance is placed on the United States market, from which almost 8 out of every 10 air arrivals originate (Government of the Cayman Islands, 1994, 3). Tourist arrivals by country of origin are illustrated below in Figure 4.4.

In order to meet the demand for more residential, commercial and tourism-related development, the construction sector underwent a significant boom in the 1980s, particularly in response to higher demand for residential and commercial development. To appreciate the pace of land use change and development, it is worth noting that the number of hotel beds more than doubled from 1980 to 1990. Figure 4.3 illustrates that a further 45% increase was recorded by the end of 1996.



Source: Cayman Islands Department of Tourism, Tourism Statistics, March 1995

FIGURE 4.4 AIR ARRIVALS BY COUNTRY OF ORIGIN: 1994

Even factoring in a slowdown of economic activity in the early 1990s, the Caymanian economy has grown at an extremely brisk pace through the early 1980s to 1997. In 1997, per capita income was estimated at approximately $24,500 (U.S.), one of the highest in the Western Hemisphere (CIA World Factbook, 1999). These factors, together with the relatively small size and limited skill range within the domestic population, were responsible for substantial inflows of expatriate labour into the Caymanian labour force. Demand for unskilled and semi-skilled labour has been met largely through inflows of workers from, especially, Jamaica and Central America while British, Canadian, and American citizens are commonly found in the more highly skilled technical and managerial positions. Although most Caymanians recognise that the skills that these foreign workers bring are required, the role of these individuals in Caymanian society has been a topic of considerable social and political discussion over the last decade. As a result, most expatriate workers are reliant upon renewable "temporary" work permits.

4.1.3 Land Use Change and Development on Grand Cayman

The demographic and economic factors described above have together led to high levels of household formation and correspondingly high levels of demand for residential and commercial land on Grand Cayman. In terms of the latter, tourism accommodation has been a substantial influence on land conversion since the early 1970s. Such conversions have not been evenly distributed across the island, but have been highly localised to the area of George Town and its immediate periphery. Progressively less land use change has occurred with increasing distance from the capital. New residential construction most exemplifies this macro-level pattern with George Town gaining most of the new housing units, followed by West Bay, and, to a lesser extent, Bodden Town. Further, the financial services sector and many other commercial activities are concentrated almost exclusively in George Town.

Within George Town and West Bay Districts, tourist accommodation is concentrated spatially along the prime attraction for most tourists – the sandy extents of Seven Mile Beach. Seven Mile Beach Road is the main arterial that runs northward along the peninsular corridor from George Town and into West Bay (Figure 4.1). The road lies a short distance from the beach for most of its length and in some areas it is immediately adjacent to the beach ridge. More than 80% of all hotel beds and all rental condominiums in Grand Cayman are situated along Seven Mile Beach Road and the vast majority of this accommodation is sited on the waterfront (west) side of the road.

The general pattern of hotel and condominium development along Seven Mile Beach could be described as one of gradual ribbon expansion and intensification. The earlier hotels built up to the early 1970s were generally small, located on the waterfront near George Town, and were somewhat dispersed from each other. The exception to this pattern was the recently demolished Holiday Inn which, at the time of its construction in 1972, was considered to be relatively distant from George Town and other tourism development along the corridor. Subsequent hotel and condominium construction has progressed northward from the town along the coast to, and beyond, the Holiday Inn site into West Bay District. A hotel recently built on Seven Mile Beach (the 350 room Westin Casuarina Resort) is an example of this northward expansion of the main tourism corridor on Grand Cayman (Figure 4.5). Due to the attractions of Seven Mile Beach, development along the beachfront side of this corridor has become tightly integrated and largely uninterrupted.

As more tourist accommodation was built along the waterfront side of Seven Mile Beach Road, land on the eastern side of the road began to be developed for other commercial uses, particularly during the 1980s (Ebanks, 1991, 31). A substantial amount of this development is linked directly to tourism (dive outfitters, souvenir shops, auto rentals, etc.), while the remainder serves tourists as well as the residential population in George Town and West Bay Districts (shopping malls, restaurants, etc.). There has also been resort-style accommodation constructed to the east of Seven Mile Beach with the Hyatt Regency and the Clarion Hotel being the most prominent examples.

At the end of 1996, virtually all parcels with water frontage on Seven Mile Beach and capable of supporting a hotel or condominium complex have been developed. The demand for property on Seven Mile Beach Road has become so intense in recent years that land prices have escalated dramatically and building density has steadily increased. The absence of foreign land ownership restrictions, the largely tax-free financial environment and the positioning of the Caymans towards upper income tourists and retirees all contribute to this high level of demand. Recent price estimates for parcels with Hotel/Tourism zoning and frontage along

Seven Mile Beach have been in the range of at least C.I. $20,000 per linear foot of beach frontage (Government of Cayman Islands, 1997, 2). As a result of these price increases, the perceived opportunity costs associated with operating older, less intensively developed properties on Seven Mile Beach have risen in turn. The impact on landowners' behaviour is illustrated by the recent demolition of the existing Holiday Inn and its subsequent replacement with the 325 room Ritz Carlton hotel.

FIGURE 4.5 WESTIN CASUARINA– SEVEN MILE BEACH, GRAND CAYMAN

Not only has the pace of land use change been particularly rapid during the last 15 years, but the nature of some of this development has also raised concerns. Although the high-rise form of tourist accommodation characteristic of some other Caribbean islands (such as Cuba, for example) has been resisted along Seven Mile Beach, the scale of recent hotel projects has increased, as indicated by the 5-storey Westin Casuarina and the Holiday Inn replacement. Moreover, the continuous linear development has effectively become a physical and psychological barrier to the waterfront for tourists and residents alike. In recognition of this problem, the C.I. Planning Department requires right-of-ways to be reserved between developments to permit pedestrian access to the beachfront from the road.

More disturbing from an environmental perspective, is the amount of mangrove swampland on the North Sound interior coastline that has been "reclaimed" using the materials from dredging operations. This has been done to facilitate the development of artificial landscapes for yacht berths, canal lots, and two golf courses. A substantial number of interior wetlands have been drained and filled as well (Ebanks-Petrie, 1997, pers. comm.). To some extent, these actions were taken to reduce potential mosquito habitat, but an equally important motivation has been to provide additional land for tourism development purposes (Ebanks, 1988, 29). The alterations made to the Governor's Creek area on the Seven Mile Beach corridor are emblematic of these types of severe land use change. This once natural North Sound harbour has been reshaped extensively through the course of the Governor's Harbour, Crystal Harbour, The Cayman Yacht Club, and Safe Haven developments (Figure 4.6).

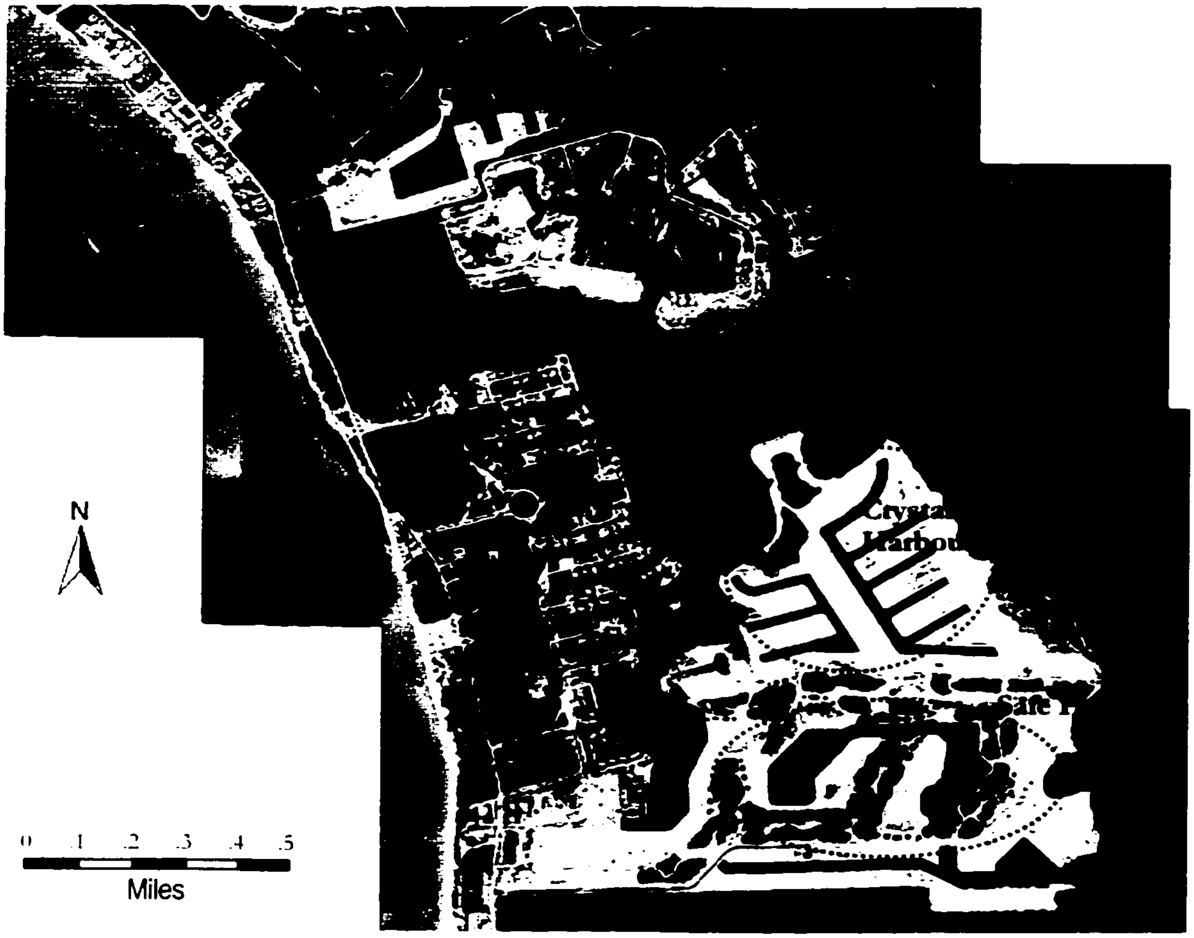


FIGURE 4.6 GOVERNOR'S HARBOUR AREA

Other examples of this type of land reclamation are residential subdivisions approved and partially constructed in the eastern extent of George Town District (Red Bay Estates and Omega Bay Estates), the north-western portion of Bodden Town District (North Sound Estates), and the area near Morgan's Harbour in West Bay District. The majority of these lots have frontage on artificial canals created through the dredging and filling process mentioned above. In the case of the North Sound Estates subdivision, the canals flow into Duck Pond Bight – an important waterfowl habitat on the North Sound on the western limit of the

Central Mangrove wetland. The discharge of sediment from dredging operations into the North Sound has negatively impacted the water clarity and has consequently reduced the growth of turtle grass, sea grass, and surrounding coral reefs as well as the survival rates of newly hatched conch, lobsters and fin fish (Burton, 1997, pers. comm.).

4.2 Case Study area of West Bay District

Several factors make the study of land use and tourism planning issues in West Bay District of particular interest. First, as was mentioned earlier, West Bay is the second most populated District on Grand Cayman. The majority of the population is of Caymanian origin, however there is a substantial population of expatriates who either work on the island or have retired to Grand Cayman. Of this expatriate population, a high proportion live in condominiums located along Seven Mile Beach Road and farther north near Dolphin Point or North West Point.

According to the last census in 1989, the official unemployment rate for West Bay District was 6.1% compared to George Town's rate of 4.5% and the island-wide value of 5.5%. Since West Bay is primarily residential in composition, limited employment opportunities are available for the resident population within the District itself. Beyond the jobs required for servicing the local community (e.g. petrol stations, local restaurants and shops), the employment opportunities in West Bay are limited largely to construction and activities related to tourism in the District. Of this latter category, employment is spread among the Cayman Islands Turtle Farm, several small to medium-sized guest-houses and hotels, dive-related operations, boat charters out of Morgan's Harbour to the North Sound's Sand Bar and Stingray City and maintenance related jobs at condominium complexes located along Seven Mile Beach. The majority of West Bay residents, however, travel daily into George Town for work.

Residential construction in West Bay has been fuelled in the last 10 to 15 years by both natural population increase and by lower land prices relative to the George Town / Seven Mile Beach area. A high proportion of the residential development along the coastline is in the form of owner-occupied and long-term rental condominiums, while inland construction is mostly single family detached and, to a lesser extent, semi-detached housing. This population growth ,combined with the lack of job opportunities in West Bay, has led to serious problems of road congestion along Seven Mile Beach Road as people commute to and from work in George Town. Efforts to construct a second roadway parallel to the existing Seven Mile Beach Road have been severely constrained by both existing commercial and tourist resort developments and the need for extensive filling of low-lying wetlands.

One approach suggested for alleviating the problems of unemployment and road congestion has been to create more tourism-related employment opportunities in West Bay District itself. This alternative is aligned with the Ministry of Tourism's stated objectives of maintaining high levels of growth in tourist receipts and arrivals on Grand Cayman (Government of the Cayman Islands, 1994, 25). From a locational perspective, West Bay has several advantages as an area for additional tourism development, particularly tourist accommodation. First, the northernmost one-third of Seven Mile Beach lies within West Bay District thereby providing tourists staying elsewhere in West Bay reasonable access to the main beachfront on Grand Cayman and the nearby restaurant, shops and dive operations. Similarly, its relative proximity to the airport, built attractions and service infrastructure of George Town is a considerable advantage.

Other factors contribute to the viability of tourism-related development in West Bay. For instance, due to the size of its population base, the availability of domestic services such as water, sewage and electricity is not as problematic as would be the case in the more sparsely populated areas to the east of George Town. Moreover the reefs surrounding much of West Bay and its direct access to the North Sound contribute to its ability to support enterprises such as the existing Spanish Bay Reef Resort which caters largely to divers. Finally, relatively large tracts of undeveloped land are present in West Bay District. Some of these properties are now used for livestock grazing while the largest tracts in the north-east of the District (Barkers) and between Morgan's Harbour, Salt Creek and Seven Mile Beach Road are wetlands. Development of the former may be unacceptable to members of the community, while construction on the wetlands would have significant environmental impacts. Barkers has substantial stretches of undeveloped sandy beach and thus has some potential for waterfront tourism development. However, the nature of any such development would likely differ in form from that found on Seven Mile Beach since the beach ridge in Barkers is relatively steep and the offshore surface varies between sand, turtle grass and cemented beach rock (Roberts, 1977, 29-30).

4.3 Planning and Regulatory Framework for Land Use Change

4.3.1 The Evolving Land Use Planning Context in The Cayman Islands

The onset of rapid growth in the 1960s made the inadequacies of the 1948 Regional Planning Law to control indiscriminate land use change very apparent. A series of legal, regulatory, and associated institutional changes were initiated with the implementation of the Land Development (Interim Control) Law in 1969 and accompanying regulations in 1970 (Ebanks, 1988, 47). At this time, land use planning functions were separated from the Public Works Department (PWD) to create a distinct, three-member Town and Country Planning Department (Ebanks, 1991, 23). The foundation for the current land use planning and management structures was laid in the following year with the passing of the Development and Planning Law (1971) which established the Central Planning Authority (CPA), a 13-member body appointed by the Cayman Islands Government with authority to rule on proposals for land use change and development.

The difficulties associated with constructing long-range land use and management plans in Caribbean SIS were discussed in Chapter Two. The first attempt at implementing a C.I. Development Plan in 1975 was withdrawn due to opposition from property owners who were concerned that environmental measures in the plan, such as restrictions on dredging and land reclamation, infringed excessively on the use and/or market value of their properties (Ebanks, 1988, 47). Once these restrictions were largely eliminated, the C.I. Government passed a set of zoning and building standards in 1977 known collectively as the 1977 Development Plan. In conjunction with the previously existing and periodically revised Development and Planning Law, this document became the central mechanism for guiding land use change decision making. For each of the eleven land use zones that are designated in the 1977 Development Plan (see Table 4.1), physical requirements and restrictions, such as minimum lot size, site coverage, parking needs, and maximum building height, are specified.

Zone	Sub Type	Maximum Density	Minimum Lot Size	Maximum Site Coverage
Residential *	Low density	3 homes / acre	12,500 sq. ft	25% of lot area
	Medium density	4 homes / acre	10,000 sq. ft	25%of lot area
	High density	6 homes / acre	6,500 sq. ft	40% of lot area
Commercial		None	none	75%-90% of lot area
Hotel and tourist-related development	Hotels	65 rooms / acre	½ acre, 100 ft minimum width	40% of lot area
	Apartments	25 rooms or 35 rooms / acre	½ acre, 100 ft minimum width	40% of lot area
Agricultural / residential	N/A	N/A	N/A	N/A
Scenic shoreline	N/A	N/A	N/A	N/A
Industrial	N/A	N/A	N/A	N/A
Public access	N/A	N/A	N/A	N/A
Public open space	N/A	N/A	N/A	N/A
Storm belt	N/A	N/A	N/A	N/A

Source: The Development Plan 1977, Cayman Islands, BWI

* Only detached and semi-detached residential are listed here. Different standards are applied to other types of residential land use.

TABLE 4.1 1977 DEVELOPMENT PLAN ZONING CATEGORIES AND SELECTED REQUIREMENTS

The importance of "free enterprise and land ownership interests" to many Caymanians is noted in the introduction of the 1977 Development Plan and, it can be argued, has contributed to the dramatic economic growth over the last 20 years. However, difficulties with this laissez faire attitude have been voiced more frequently in recent years as the impacts of sustained levels of high growth were made more visible. Davies (1994, 538), for example, notes at one point that while "the importance of mangrove, stormbelt, reefs, beaches, and national parks (both marine and terrestrial) are stressed" in the plan, "... little notice has ever been taken of this document." This comment is moderated somewhat by an acknowledgement that the Planning Department and the CPA directed more attention to consideration of the environmental impacts of development proposals (Davies, 1994, 526). The lack of linkages in the 1977 plan between offshore ecosystem damage and onshore development and land uses was addressed in part in 1978 with the enactment of the Marine Conservation Law which provides protection to specific species of aquatic life, bans marine effluent dumping and requires licenses for coral harvesting. This legislation was augmented in 1986 by the Marine Parks Law which establishes a three-tier (Marine Park, Replenishment Zone and an Environmental Zone) framework demarcating specific aquatic areas with varying restrictions on fishing, anchoring and marine activities.

Despite attempts to review and update the 1977 Development Plan in 1982 and 1986, it remained in effect until November 1997 when a revised Development Plan was accepted by the C.I. Legislative Assembly following a five year period of policy planning, reviews, and appeals. The 1997 Development Plan is a more comprehensive document than its predecessor, especially in terms of the range of land use and development issues that it considers. For instance, the introduction of a new "beach resort/residential development" zoning category is intended to provide a transition between the Low Density Residential zone and the Hotel/Tourism zone. In terms of the Hotel/Tourism zone, recognition of the impacts of existing tourism development and the need for careful planning are reflected explicitly in new concerns for "orderly development, expansion and upgrading of facilities", ensuring "that all development enhances the quality and character of the Cayman Islands' hotels and cottage colonies", "prevent[ing] the over-development of sites", and "public access to the sea" (Government of The Cayman Islands, 1997, 10).

It is beyond the scope of this chapter to detail the 1997 Development Plan. However, it is important to note, even in a general sense, that important aspects of the decision making processes used in the creation of the new Plan did resemble closely some of the structures discussed in Chapter Two. In particular, the difficulties associated with ameliorating conflict between multiple, and at times conflicting, interests were evident with respect to a number of development-related issues. Trade-offs concerning environment and development proved again to be a source of conflict. In 1994, the Planning Department with the support of the National Trust, among others, advocated for the new Development Plan to include "environmentally sensitive" and "environmentally protected" zoning categories which would restrict land use change in areas of significant habitat such as the Central Mangrove (Government of The Cayman Islands, Development Plan 1997, 2). Land owners and members of the construction industry objected to this provision on the grounds that it violated land ownership rights and could slow down the pace of development.

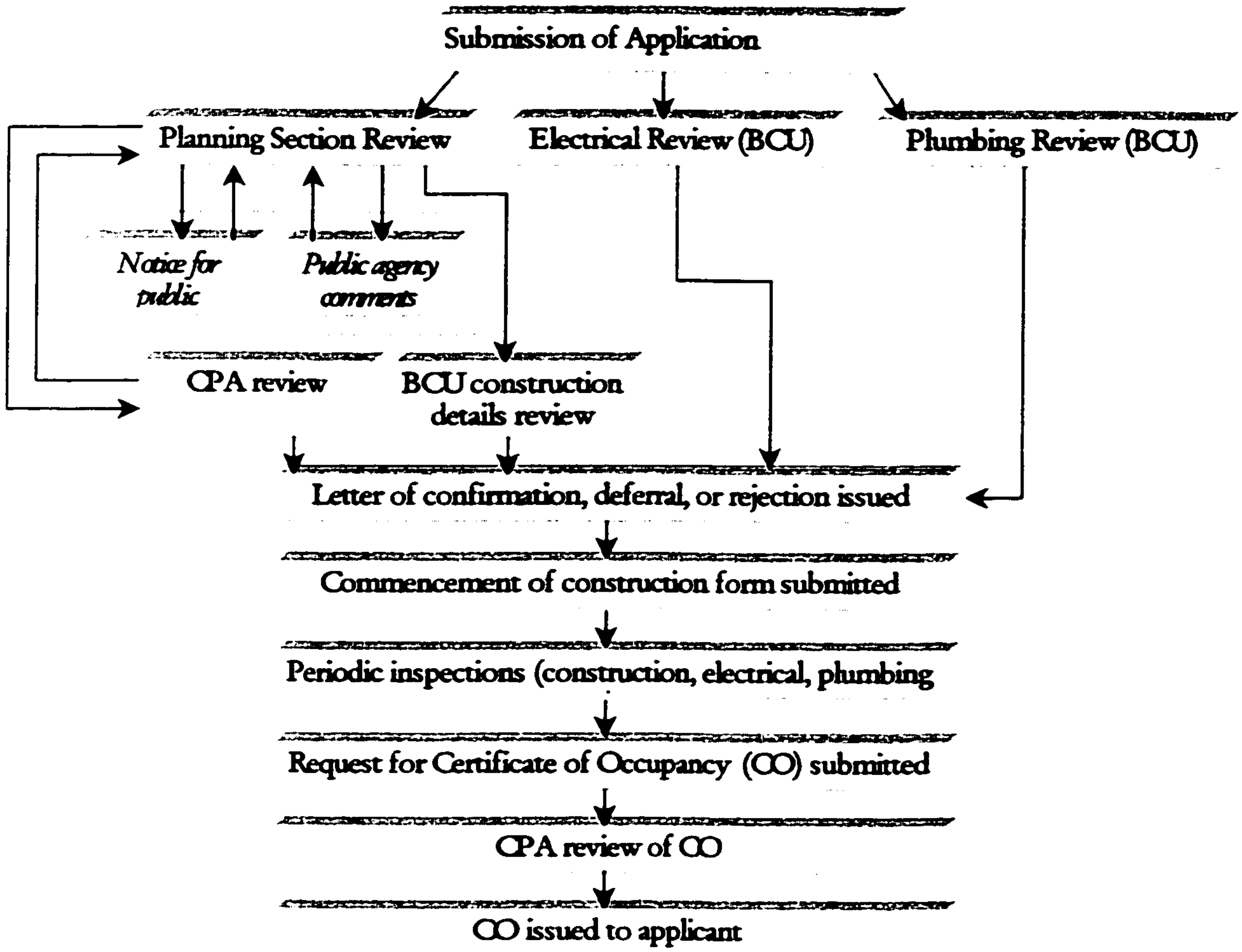
4.3.2 *Strategic and Operational Planning Practices in The Cayman Islands*

Strategic-level planning was described in Chapter Two as being concerned with establishing the nature or direction of future land use change according to a set of underlying goals, objectives, and values derived through participation and debate involving multiple stakeholders. This process of exploring alternative "visions" of the future, reconciling conflicts, and crafting a strategically-appropriate development path must be balanced against the more immediate and tangible concerns of co-ordinative and operational planning. Achieving such a balance is difficult because strategic planning efforts are necessarily selective in nature and it is not always clear what aspects of development are truly strategic (Diamond, 1995, 136-137).

It is argued in this thesis that tourist accommodation siting decisions are necessarily strategic given their potential to influence substantially the direction of land use change in SIS. However, as described in section 2.1.2, this type of pluralistic and strategic visioning is encountered infrequently at best in most SIS as the bulk of land-related planning efforts are concentrated on processing development applications. An increasingly well-developed planning capacity has been constructed in the Cayman Islands Government in recent years that exceeds the capabilities of many other Caribbean SIS. However, this strategic goal-setting and visioning aspects of reviewing the national development plan is often subsumed by parcel-specific objections to zoning designations. Given the interdependencies between operational and strategic land planning activities, it is necessary to examine the application review process in the Cayman Islands.

The current Development Plan and its associated laws and regulations guide decision making concerning land use change and management a manner that is similar to many other Caribbean countries, national and sub-national jurisdictions elsewhere and to the generic planning process described in Chapter Two. Applications for all types of land use change and development, the bulk of which are made by private interests, are submitted to the Department of Planning (DP). The nature of these applications range from small additions to individual homes through to large residential subdivision, hotel, condominium, resort and commercial projects. Figure 4.7 illustrates in general the steps involved in reviewing an application for a new hotel in The Cayman Islands.

As a first step in the review process, an application is categorised by the DP according to the nature of the submission and/or the scale of the development proposal. For submissions that are relatively minor in nature, such as a small addition to a private home, the review process is straight-forward. In this case, the DP ascertains, in conjunction with its Building Control Unit (BCU), whether applicable guidelines and regulations are met and then forwards a recommendation for the CPA's consideration based upon this examination. These frequently-occurring, rule-based reviews are characteristic of the operational mode of decision making discussed in Chapter Two.



Notes: CPA = Central Planning Authority, BCU = Building Control Unit of the Planning Department
Source: Adapted from Guide to Submitting Applications for Hotels, Cayman Islands Central Planning Authority (undated)

FIGURE 4.7 CAYMAN ISLANDS PLANNING APPLICATION REVIEW PROCESS

As the scale of a development proposal or the magnitude of its potential impacts increase, the review process becomes more comprehensive and less deterministic, while decision making procedures take on tactical and strategic elements, as described in Chapter Two. For the more "significant" proposals, the rule-checking procedures at the operational level of decision making are supplemented by more detailed, and often more subjective, examinations of the short and long-term consequences of the land use change. For example, consider an application for an extensive seaside condominium project that is proposed for a sparsely populated area of a SIS. Beyond easily defined issues of zoning, soil load bearing capacity, building standards, etc., other, multi-facetted questions relating to labour availability, social impact on nearby communities, ecological disturbance and hard servicing costs present themselves.

Since the potential impacts of these proposals are complex and multi-dimensional, evaluation and decision making must occur across a broader spectrum of decision factors and involve numerous participants with relevant specialised expertise. Development applications are circulated for comment to relevant Government departments and agencies such as the Departments of Environment, Tourism, and Public Works, Environmental Health, Education, the Water Authority Commission, and the Mosquito Research Control Unit, among others (Ebanks, 1998, pers. comm.). Typically, input is sought also from the public and other associations, groups and NGOs, such as the Chamber of Commerce and The Cayman Islands National Trust, when either the scale of a development proposal or the magnitude of its potential impacts is large.

The comments submitted by the various departments, ministries and external parties are presented with recommendations by the DP to the CPA. Given the breadth of mandates and interests represented, consensus, even within the government as a whole, is not easily found as each participant in the approval process will consider more contentious development issues from their own specialised perspective. Based upon the submitted recommendations, the CPA either rejects the proposal outright or may approve it with or without certain conditions. For more contentious proposals, this procedure can be somewhat iterative as different groups negotiate both internally and with each other in the manner described in Chapter Two.

In the absence of well-established and broadly-supported strategic planning frameworks, these negotiation processes can be especially difficult since participants must debate the merits of both specific development alternatives and competing strategic-level goals and objectives. The *Tour*Plan MP-SDSS is designed to alleviate this problem by strengthening the strategic dimension of SIS land planning.

4.4 Field Research

In order to operationalise the multi-participant, multi-criteria strategic-level approach to tourism land use development proposed in this thesis, *Tour*Plan was used to examine the degree of development consensus among a small, yet purposively selected sample of stakeholders. The selection of participants and spatial database used are now discussed.

4.4.1 Selection of Participants

For organisational purposes, the set of potential participants in SIS is divided into two deliberately overlapping subsets – one relating primarily to individuals or groups involved in land development and planning and the other concentrating specifically on the tourism sector. The discussions in Chapter Two highlighted the multi-faceted character of these two sectors and the interactions within and between their various components (e.g. private firms, public agencies, non-governmental organisations (NGOs), community groups, individual citizens). Particular attention was given to the interdependencies and the localised effects of land development and, specifically, tourism development and the need to recognise these linkages in strategic-level decision making.

Since this thesis concentrates on the use of strategic information tools for strategic land use and tourism planning, individuals or groups were only considered to be a potential candidate if they have a direct interest in the nature, location, and timing development (what should be developed?, where should it be developed? and, when should it be developed?). On this basis, for instance, representatives from the national Ministry of Finance were not considered to be appropriate as their perspective would tend to be attuned only to the aggregate impact of development rather than the locational specifics of a development scenario.

A list of the key agencies, groups and individuals typically involved with the land development planning process in SIS is shown in Table 4.2. The rows in this Table are organised into four basic sectoral categories: government, non-government, private sector (including public-private organisations), and the general public. Each category is subdivided further using organisational or functional criteria to produce one or more potential study participants. It should be noted that these categories are not completely exclusive since an individual may be associated with more than one group or organisation within a specific "sector" (e.g. private business owner and member of private-public organisation) or across different sectors (e.g. member of government agency and NGO).

The general nature of each candidate's role in the tourism sector and the land use planning and development process is noted briefly in Table 4.2 although it is recognised that the details of these roles may vary somewhat according to local conditions. In some instances, the roles are identical while in other cases, substantial differences are apparent in the scope and the nature of involvement. For example, government land use planners can be expected to apply similar procedural, professional, and analytical approaches to the task of assessing how suitable different land use proposals are for a particular location, notwithstanding differences in the regulatory parameters and potential impacts that are associated with specific development types. In contrast, Tourism Ministry officials may have direct involvement in many aspects of planning tourism-related development initiatives (e.g. scale, target market, site design, etc.) but have substantially less interest or recognised authority to register substantive concerns about "non-tourism" types of land use change proposals.

Sector	Participants	Role in land use planning and development	Role in planning tourism land uses
Government	Elected or appointed Planning Board (e.g. Cayman Islands CPA)	Decision makers who approve, reject or modify land use change proposals given input from other agencies, groups and individuals	Same as land use and development planning role
	Ministry / Dept. of Planning	Advise decision makers on the suitability of proposed land use changes, co-ordinate responses of other participants to development proposals, ensure regulatory compliance of ongoing development, stabilise land market through conflict mediation and long range planning	Similar roles as planning role but with focus on tourism specific development proposals such as new hotel construction
	Ministry / Dept. of Tourism	Comment on proposals for new tourism-related facilities, may comment on the impacts of 'non-tourism' development on image and visitor satisfaction, provide input to long-range plans re: future tourism-related land uses	Contribute to demand for tourism land uses through promotion, establish aesthetic and functional standards for tourism development, create long-range tourism sector strategies, encourage public investment in tourism facilities (e.g. cruise ship piers)
	Ministry / Dept. of Environment	Determine impacts of development on human, aquatic and terrestrial ecosystems and devise mitigation strategies, enforce regulations for species and habitat preservation, establish and maintain reserves for specific species and habitat	Similar to planning role but likely to focus on site-specific impacts of shoreline changes, vegetation and habitat disruption, work with other public, private, and NGO interests to adjust usage of sensitive sites or features
	Ministry / Dept. of Public Works	Provide and maintain roadway, sewerage, water facilities which in turn either catalyse or dampen localised development potential	Same as land use and development planning role
	Ministry / Dept. of Culture and Heritage	Identify, restore and maintain human, natural and historical-cultural features	Manage and promote heritage sites suitable as attractions for tourists
Non government organisations (NGOs)	Environmental, social, historical / cultural	Identify and maintain important socio-cultural features and natural habitats, buy land and structures for preservation	Manage and promote heritage sites as attractions for tourists
Private sector	Land developers and construction firms	Initiate small- and large-scale land use change, lobby for favourable regulatory and infrastructure environments	Same as land use and development planning role
	Commercial sector: hotel managers, tour operators, rental agencies, retailers	May comment on an infrequent and ad hoc basis re: local land development proposals thought to impact their business	Lobby for development policies favourable to their specific business/sector
	Private and private-public sector groups (Chamber of Commerce, real estate assoc.)	Comment on development proposals, lobby political elites to encourage or discourage specific types of development and/or infrastructure	Develop suggested standards for future tourism development
General public and citizens	Individuals, community groups	Initiate small-scale land use change, respond to land use change proposals via formal opportunities in planning process	Same as land use and development planning role

TABLE 4.2 POTENTIAL MPDM PARTICIPANTS FOR LAND USE AND TOURISM PLANNING

The discussion in Chapter Two outlined the manner in which a particular agency, group or individual participates in land use planning and decision making. Three generic types of group decision making contexts (homogeneous, heterogeneous, multi-group) were introduced in this discussion. Their involvement in the planning process can be described through three key dimensions: 1) participation (formal versus informal), 2) scope (broad, process-bound involvement or clearly defined topic-bound) and, 3) power (influential versus non-influential). For the thesis objectives to be realised, it was desirable to have participants representative of the diversity of perspectives on each of these spectrums and also across the generic group decision making contexts. This diversity is recognised by including participants who are decision makers (e.g. CPA members), advisors to decision makers, both advisors and decision makers (e.g. senior Government planners), and decision-takers (e.g. business owners, members of the public) within the broader land use planning context.

The *TamPlan* software described in Chapter Three and its approach to strategic land use and tourism planning can be applied to the West Bay case study area in a number of ways. One alternative is to examine the development of collective positions within a number of group contexts, such as the CPA or individual Government Departments. A second approach could focus on tracing how initial group positions that were developed by single group representatives evolve in a multi-group decision making context. In both of these instances, a significant number of participants would be required.

While these approaches are of interest and applicable to the land use and tourism planning in SIS, they were logistically prohibitive within the bounds of the thesis. The two most significant logistical constraints concerning participant selection encountered were: a) a limited amount of 'on-island' time to conduct the fieldwork and gather required data and, b) difficulties inherent in co-ordinating the availability of large numbers of people. The first constraint was attributable primarily to financial restrictions on in-field research. Consequently, the data collection had to be structured to permit interaction with all participants over a reasonably short (two week) period. Unfortunately, this first constraint made the task of co-ordinating the availability of participants more problematic.

Despite these difficulties, individuals from almost all of the major participant categories identified in Table 4.2 were able to participate in the field research. The actual participants and the perspectives that they represented are listed in Table 4.3. This table demonstrates that it was not uncommon for a person to be engaged in more than one facet of the broad land use and tourism planning problem. This 'dual role' phenomenon is not surprising given the relatively small population of Grand Cayman and is most likely characteristic of other SIS of similar size.

It should be noted that prior to the fieldwork taking place, input was received from other key individuals on the software design and its application to tourism and land use planning. For example, discussions were held with the Cayman Islands Director of Tourism, Director of the Department of Statistics and Senior Executive

Draughtsman (Lands and Survey Dept.) during preceding data gathering and software prototyping trips. Further, a workshop for twenty participants from SIS throughout the Caribbean was held in George Town during July 1996 to introduce a pre-release version of the software. A wide array of professions (e.g. land surveyors, planners, statisticians) and areas of interest/expertise (e.g. tourism information systems, environment) were represented at the workshop. This workshop enabled the software to be rigorously tested by a broad cross-section of potential users and numerous design improvements to be made prior to conducting the fieldwork.

Participant	Perspective(s) Represented
CPA Member	Government decision maker in planning process, private sector business owner and West Bay resident
Deputy Director of Planning	Government Planning Department – decision maker, advisor to CPA and West Bay resident
Planner	Government Planner
Director of Environment	Government Environment Department- decision maker, researcher, advisor to government decision makers
National Trust – Scientific Programs Manager	NGO researcher and program developer for preservation (ecological and cultural) and education
Hotel Manager & Land Developer	Private sector: land development and tourism sectors
Real Estate & Land Developer	Private sector: land development and real estate association
Local Business Person	Private sector: commercial sector and West Bay resident

TABLE 4.3 PARTICIPANTS IN FIELD RESEARCH EXERCISES

4.4.2 Data Sets

Some of the difficulties associated with data accuracy, recency, and completeness in SIS and the tourism sector were discussed in the previous chapters. These factors are not repeated here but instead attention is directed first to a generic view of the spatially-referenced digital data that could be applied to land use and tourism planning through *Tour*Plan. Five broad thematic classes of data area shown in Table 4.4 – socio-demographic, environmental, legal-administrative, natural landscape, and the built landscape. The tourism category in the table should not be interpreted as a distinct data class but instead, like the tourism sector itself, is a composite made up of selected elements found in the five classes. Within each of these groupings, individual data sets representing significant features or areas of concern are listed. In addition, notations are provided concerning the data format of each and the participants in Table 4.2 who would be likely to require or reference these data sets in the decision making process.

	Feature Type	Data Format	Purpose	Used By
Socio-demographic	Census districts	Polygon map layer	Spatial view of population and socio-economic variables	Most participants as reference for strategies
	National or small area censuses	Geo-referenced database tables	List attributes of resident population (e.g. counts, employment structure, income, etc.)	Planning, statistical offices primarily; others use as reference for strategies
	Surveys	Census area related database tables	Canvas resident population for concerns regarding development, environment, employment, etc.	As above plus may be done by NGOs or private sector groups on well-defined issues
Legal-administrative	Land parcels	Polygon map layer	Fundamental unit of land used in development proposals; coded for land use; linked to land registry records	Regular participants in planning process (Planning Board, developers, real estate, etc.); public interested in nearby land
	Land registry records	Database tables	Provide parcel ownership, value, development status	As above
	Development proposals	Polygon map layer	Proposed parcel fabric changes	Planning Board, developers, planners; others in application circulation process
		Database tables	Details of proposed land uses	As above
	Zoning plans	Polygon map layer	Zoning designations – not always coincident with parcels	Real estate, developers, planners, Planning Board
Human-built landscape	Building footprints	Point or polygon map layer	Indicates lot coverage, building density and structure; coded for building function (e.g. hotel, retail, etc.)	Primarily used by real estate, developers, planners and engineers
	Transportation	Line map layer	Determines accessibility of different features/areas; coded for road class and traffic volume	Public works, developers, real estate, planners, environmental agencies, public
	Trails / pathways	Line map layer	Shows pedestrian travel patterns in built and natural settings	Planners, environmental agencies, public
	Hard services	Line map layers	Indicates sewage, electrical, and water networks and capacities	Planners, public works, developers
Natural landscape	Topography	Line map layer (contours), DEM	Permits slope, aspect and visibility of development proposals to be examined	Planners, developers, environmental agencies
	Soils	Polygon map layer	Determines capacity of land to support specific land uses	Developers, planners
	Drainage	Line / polygon layers	Location of surface and subsurface water	Planners, developers, environmental agencies
	Vegetation	Polygon map layer or remote imagery	Classification of natural and semi-natural vegetation cover	Environmental agencies, planners
	Aquatic features	Polygon (reefs), line (coast), point map layers (bathemetry)	Determine capability of nearshore and offshore ecosystems to support land-based development	Environmental agencies, planners, developers, tourism agencies and operators
Environment	Habitats (aquatic and terrestrial)	Polygon and point map layers	Locations and characteristics of significant flora and fauna habitats	Environmental agencies, planners, public
	Protected areas / parks	Polygon and point map layers	Areas or features with protected or restricted use status	Environmental agencies, planners, public
Tourism	Accommodation	subset of building & parcels map layers	Hotel, condominium, guest house points or site parcels coded for price, rooms, structure type, amenities, etc.	Public and private tourism agencies or boards, planners, developers, public to a limited extent
	Attractions	Point, line and map polygon layers	Human-built and natural attractions coded for attraction type, ownership, visitation statistics	Public and private tourism agencies or boards, planners, developers, public to some extent

TABLE 4.4 DIGITAL DATA FOR MPDM LAND USE AND TOURISM PLANNING

In addition to these spatial map layers and linked database tables, other data are of value in the decision making process. These data are typically not in digital format or are not geographically referenced but are important nonetheless as reference material to describe the overall planning context or some aspect of it. Examples of these data include visitor surveys which profile tourist satisfaction, spending habits, and may give limited indications of visitor activities, and development regulations and laws which specify requirements such as lot sizes, densities, and setbacks for new development.

Compared to the desired data set in Table 4.4, the case study depends on a considerably smaller data set (Table 4.5). It is not uncommon for there to be substantial differences between the desired and actual data that are available for planning and decision making, especially with respect to spatial data. These differences can limit the real or perceived effectiveness of spatial information technology to practical planning problems. However, they did not prove to be a serious impediment for the field research activities in West Bay since the purpose of the fieldwork was not to produce a finished plan *per se*, but rather to apply the methodology developed in Chapters Two and Three and to gather data, in the form of the participants' scenarios, for *post facto* analysis.

The majority of the digital data listed in Table 4.5 were provided by Departments and Ministries of the Government of the Cayman Islands. The Department of Statistics supplied the most recent census database (1989) in REDATAM + format[1]. Output files containing relevant demographic (e.g. population by sex) and socio-economic (e.g. number of unemployed) variables at the Enumeration Area (EA) level were created and appended to a corresponding digital EA map layer maintained by the C.I. Government's Lands and Survey Department. The Lands and Survey Department has pioneered GIS use in the Caymans and has constructed an impressive spatial data foundation that is, in accordance with their mandate, focused primarily on the maintenance and mapping of the islands' cadastral, or land parcel, fabric. As the stewards of digital spatial data in the C.I. Government, the Department also produces spatial data layers and hardcopy output for other Departments (e.g. Planning, Statistics, Environment, and Public Works) as well as the National Trust whenever their resources permit. Unfortunately, the limited number of end-users have both access to the LIS and the requisite GIS skills to apply it successfully to complex analytical problems are concentrated almost entirely within the Lands and Survey Department. As mentioned in Chapter Two, this problem is common to the early stages of GIS implementation in larger organisations, in developed and developing countries alike, and usually becomes less problematic as the technology becomes institutionalised.

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[1] REDATAM + is a census processing software package that is used widely in Latin America, South America, and the Caribbean. Its successor, *WinR+*, was developed through the course of the same IDRC-funded project that *TourPlan* was developed.

Theme	Item	Format	Scale	Date	Description
Socio-demographic	Census Enumeration Areas (EA)	Polygon map layer	1:25,000	1993	Contains EAs for all of Grand Cayman; linked to census database table below
	Most recent national census (1989)	Geo-referenced database table		1989	Extract of 1989 RETADAM + census database containing EA level population counts disaggregated by age and sex, unemployment rates
Legal-administrative	Land parcels	Polygon map layers	1:2,500	1995	17 cadastral map sheets containing 3547 individual parcels coded for acreage, vacancy status, zoning (using then proposed (1997) scheme), length of water frontage
	1977 and 1997 land use zones	Polygon map layers	1:25,000	1993, 1996	2 map layers extracted from 1977 Development Plan and the (then) proposed 1997 Development Plan
Built landscape	Building footprints	Polygon map layer	1:2,500	1997 (1994 source data)	Extracted from digital air photographs for West Bay and George Town districts with major commercial and tourist-related structures coded
	Roads	Line map layer	1:2,500	1997	Extracted from cadastral layers, coded for road class (main, secondary, dirt surface)
	Historic structures (National Trust)	Polygon map layer	1:2,500	1995	Historic and culturally-significant structures managed by The National Trust coded for block, parcel, description, acreage
Natural landscape	Protected Areas (National Trust)	Polygon map layer	1:2,500	1995	Environmentally-significant features/areas managed by The National Trust coded for block, parcel, description, acreage
	Marine Parks	Polygon map layer	1:25,000	1995	Location and extent of marine parks and replenishment zones surrounding Grand Cayman
	Wetlands	Polygon map layer	1:25,000	1995	Location and extent of main wetlands on Grand Cayman
	Aquatic features	Line map layer	1:25,000	1991	Location of lakes, reefs, coastal type (mangrove, sand, rock)
Tourism	Accommodation	Point map layer	1:2,500	1995	Hotel, condominium, guest house points extracted from cadastral layers and coded for name, number of rooms, structure type, estimated minimum and maximum tourist populations (based on aggregate occupancy rates and individual room counts)

TABLE 4.5 DIGITAL DATA SETS USED IN WEST BAY PLANNING SCENARIOS

The map layers in Table 4.5 were provided by the Lands and Survey Department in ARC/INFO export format and were subsequently imported into *Tan*Plan in the public domain shapefile format (see section 3.4.2). One exception is the tourism facilities layer that was created by the author and the Deputy Director of the Planning Department with some of the associated tabular data (e.g. number of rooms) being provided by the Ministry of Tourism. In addition, the Scientific Officer of the National Trust provided the layer detailing most of the historical, cultural, and environmental properties or structures that the Trust owned or administered. For most of the other shapefiles, attribute data were modified by the author and supplemented where necessary. For example, coding of the extent of mangroves along the North Sound shoreline was updated with the assistance of the Director of the Department of Environment. Zoning designations were transferred from an island-wide map layer to the cadastral shapefiles pertaining to West Bay in order to simplify the process of creating scenarios for the participants. Although the 1977 Development Plan was still in effect at the time of the fieldwork, the zoning scheme that would subsequently become the 1997 was used given its more comprehensive nature relative to the 1977 plan.

A 1:25,000 scale contours layer was available from the Lands and Survey Department but was not used given the lack of significant elevation in West Bay District. A composite map layer that demarcated an area of historic homes, environmentally-sensitive areas, and proposed environmentally-protected areas was also excluded from the fieldwork. Public debate concerning the issue of environmental designations was heated at the time and this information was requested not to be used, given those circumstances.

Resource shortages, particularly in terms of personnel, affect the available stock of available spatial data in another more basic manner by reducing the ability of organisations to collect non-spatial and even non-digital sources of information. Several participants in Grand Cayman expressed a desire to use GIS for purposes such as examining land use, classifying vegetation cover, and demarcating habitat boundaries (Burton, 1997, personal communication; Ebanks-Petrie, 1997, pers. comm.). However, personnel shortfalls did not permit them either to maintain paper records which they deemed to be of sufficient recency, completeness, or accuracy for inclusion in a multi-user GIS or to convert existing records to an appropriate digital format.

Confidentiality concerns reduced the available spatial and associated attribute data further. Two aspects of confidentiality need to be distinguished here. First, as was suggested in the previous paragraph, some individuals or organisations may rely a great deal upon "working" quality data which is adequate for their needs. The distribution of these data to others may be precluded by liability concerns arising from the complexities or known limitations of these data. While these shortcomings are most often related to data accuracy or precision, occasionally data distribution may be curtailed more by political sensitivity of the data as the map layer depicting environmental areas mentioned above illustrates. Second, the more traditional aspect of confidentiality centres upon the need to ensure either personal privacy or fair marketplace competition. Land registry records, for example, could not be divulged since they contain details of parcel ownership, the most recent sale price of the property, and outstanding mortgages. Similarly, occupancy rates could not be obtained for individual hotels and condominiums due to commitments that the Ministry of Tourism had made to individual hotel, condominium, or guest home operators.

Data constraints relating to the factors outlined above are, and likely will continue to be, a reality of both multi-participant work and the use of spatial information technologies in practice. Since the data sets listed in Table 4.5 represent, to some degree, the thematic data classes (e.g. socio-demographic, built environment, etc.) identified as important to land use and tourism planning in SIS, it can be argued that the field research was based on a viable and sufficiently complete data foundation. It was noted in Chapter Three that the land parcel is the fundamental spatial unit around which many land-related planning and investment decisions are made. Consequently, although cadastral data of the quality found in C.I. are not yet ubiquitous across

Caribbean SIS, the use of these data added a valuable level of realism to the case study research discussed in the following two chapters.

4.5 Summary

This chapter has described the contextual setting for the fieldwork in which the *Tour*Plan MP-SDSS software is applied to tourism-related strategic land use decision making. Following a review of the physical and socio-demographic characteristics of Grand Cayman, particular attention was directed at the emergence of tourism as a central pillar of the Caymanian economy. The impacts of recent population and tourism growth were described next with specific reference to the case study area of West Bay District.

The increasing density of tourism-related development along the Seven Mile Beach Peninsula and its progressive dispersion towards and into the southern extents of West Bay District was then profiled. High levels of demand for beachfront properties have resulted in an almost continuous urban form, dominated by small- to medium-size hotels and condominiums, being constructed along Seven Mile Beach. The lack of development opportunities and the resultant high land costs have had two main effects on tourism-related land use. First, selected properties are being redeveloped at higher densities, as illustrated by recent construction at the Holiday Inn and the Hyatt Regency hotel sites – an indication that tourism development on the Seven Mile Beach Peninsula is moving toward the consolidation phase of Butler's (1980) model. Second, increasing interest is being expressed in exploring the potential for further tourism-related construction in West Bay (as well as other areas more distant from Seven Mile Beach and the international airport in George Town) that are at comparatively earlier stages of tourism development.

*Tour*Plan was designed to assist multiple participants involved in land use change to explore and work toward a compromise- or consensus-based resolution of contentious land use change issues, such as tourism-related development in SIS. The difficulties inherent in achieving compromise among parties with diverse interests were illustrated through discussions concerning the evolution of the Development Plan from the early 1970s through to 1997. The discussion of the application review and strategic-level planning processes in C.I. provide the background necessary to understand the decision making context within which the case study fieldwork in Chapter Five and Chapter Six is conducted.

The issue of selecting participants for assessing multi-party development scenarios in West Bay District was addressed next by first describing the potential groups or individuals that could have an interest in applying the software to land use or tourism planning (Table 4.2). Time and resource constraints limited the set of participants available for the field exercises to a smaller, but representative sample (Table 4.3). The discussion concerning the possible digital data for use in the fieldwork followed a similar pattern. The potential complement of digital data (Table 4.4) was contrasted with the more modest data set that was available and selected for use (Table 4.5). The influence of common data-related problems mentioned in Chapters Two and Three, such as confidentiality, accuracy, timeliness, and relevance, were noted as well.

The following chapters examine how the study participants used these data with *Tour*Plan to produce scenarios of future tourism land use in the case study area. The potential contributions that the software and, more importantly, the approach embodied within it can make to multi-participant compromise- and consensus-building in land-related decision making are therefore discussed in Chapter Five and Chapter Six.

Chapter Five

MULTI-CRITERIA, MULTI-PARTICIPANT TOURISM PLANNING: PART I - SITE SELECTION

This Chapter applies the *Tour*Plan decision support tool to the first component of a two-stage tourism land use planning case study. It is important to note that the purpose of the case study is not, in the first instance, to evaluate the usefulness of *Tour*Plan, but rather to evaluate the applicability of the approach used by the tool to address multi-participant/multi-criteria tourism land use planning problems in SIS. Implicitly, however, in evaluating the approach used by the tool, the software itself is also brought under scrutiny.

The overall approach used in the case study is presented in the first section of the Chapter with reference to the discussion in Chapter Two concerning the potential for the use of multi-participant SDSS in SIS planning. The processes by which participants constructed their site selection scenarios are discussed in the next section with particular attention being directed to the degree of commonality in their *a priori* objectives, approaches to the case study planning task, and selection criteria choices. The spatial locations of the participants' candidate tourism accommodation sites and optional land use designations are then described along with their supporting rationale. The chapter concludes by examining the extent of consensus among the participants as well as the degree and distribution of development versus non-development conflict.

5.1 Methodological Overview

Three interrelated roles were identified in Chapter Two for multi-participant or group-oriented SDSS in strategic-level SIS land use development and tourism planning, namely: a) consensus-building in multi-group decision contexts (e.g. brainstorming sessions involving representatives from several agencies or groups), b) consensus-building in homogeneous and heterogeneous group decision settings (e.g. National Trust members prioritising land to purchase for protection against development), and c) operationalising the "mixed scanning" approach to strategic-level planning and development decision making. The latter role, which is examined in this Chapter, centres on: a) general decision problem definition across multiple groups (e.g. intelligence gathering concerning likely data requirements, planning participants, issues of conflict or common concern, etc.), b) the design of several viable development strategies or alternatives, c) the evaluation of these alternatives according to the preferences of the participants, and d) indicating the thematic or geographic areas that require in-depth analysis. The results of these preliminary outputs may then become the subject of further field analysis, as was indicated in Chapter Three, or may be incorporated subsequently into further rounds of analysis and negotiation.

The case study analysis is structured to illustrate how a MP-SDSS, such as *Tour*Plan, can assist in the development of a land use development strategy in a SIS where tourism activities are an important source of national income and where there is both a limited and fragile land base to develop. The study participants identified in Chapter Four were required to select *potential* locations that they deemed to be both feasible and desirable for future tourist accommodation in West Bay District of Grand Cayman. The rationale for examining West Bay District was discussed in Chapter Four and is not elaborated upon further. Discussion in preceding Chapters referred to land-related conflict arising from the diversity of objectives and priorities among the individuals and groups that are involved to varying degrees in land use decision making. One aim of the case study is therefore to determine the extent to which this assertion is valid for West Bay District and the subset of participants involved in the case study. A corresponding and higher-order objective is to determine the extent to which MP-SDSS can assist in, first, uncovering the degree of commonality and conflict among participants and, second, facilitating the identification of compromise- or consensus-based strategic planning outcomes.

The use of a two-stage approach to the case study, consisting of separate but related site selection and site evaluation stages, is supported by several factors. First, logistical constraints limited the time participants could commit and work in one place at one time. Second, and more importantly, there was a desire to have each participant conduct the site selection and evaluation phases of the study independently of all other participants. Discussion in Chapter Two suggested that land use decision making can be decomposed into a number of semi-autonomous decision making contexts and, consequently, the design principles in Chapter Three specified that a MP-SDSS should be useful across these different decision environments. By structuring the study so that participants identified and evaluated candidate sites independently, an opportunity was presented to assess how participants of varying backgrounds undertook the planning task, independent of influences from other participants. This approach has the disadvantage of precluding analysis of the interactional and synergy aspects of mutual learning effects between participants that most GDSS and SDSS-G research has concentrated on to date. However, it also avoids the many group "process losses" related to problems of some individuals dominating or excessively influencing other group members as well as the inability and/or unwillingness of some participants to engage in formal face-to-face decision making processes (Silver, 1991, 23). It provides a common base of analytical capabilities and data to all participants, experts and non-experts alike, and it equips Government planners with an important mechanism to uncover and explore issues of conflict and agreement. This foundation allows planners and decision makers to concentrate their efforts appropriately with the aim of producing better considered and more widely *supported* initial plans and/or development proposals. In this sense, the independent scenario generation approach offers several advantages over conventional GDSS and SDSS-G approaches.

Few constraints were placed on the study participants concerning their site selection scenarios or during the subsequent evaluation of selected sites. Beyond the limitations of the *TourPlan* software and the available data, the main requirements that all participants had to satisfy were: a) the study area was restricted to West Bay District, b) they had to designate sufficient lands to fulfil future tourist accommodation needs for an arbitrary minimum number of new rooms, and c) they could not violate practical guidelines concerning site acreage, coverage, and building height restrictions specified in the 1997 Cayman Islands Development Plan. Candidate sites for new tourist accommodation could be undeveloped or already developed to allow the participants to explore the potential of redevelopment of the existing built form – a common practice in maturing tourist destinations as discussed in Chapter Two. The approximately 4268 acre study area consisted of a total of 4025 surveyed land parcels. "Vacant" or undeveloped parcels, as indicated by the building footprints map layer derived from the 1994 aerial photography, accounted for 2302 parcels and some 3080 acres of the total land area.

While the first two restrictions are arbitrary in nature, they can be justified as being consistent with the common practices of developing regional or secondary plans based on existing administrative areas. Moreover, they are consistent with the practice for macro-level goals and planning objectives, such as projected island-wide growth of tourist accommodation, to be apportioned in some fashion to the general process of plan development. The third constraint was included to eliminate development options that were infeasible for physical, regulatory, or social reasons, such as siting a 350 room resort on a one acre parcel of land.

As mentioned earlier, it is desirable for the outputs of this two-stage case study to be filtered for consensus sites and priorities, augmented by accompanying field investigations, and repeated as often as is required to craft a widely-supported development strategy. Since this was not feasible for reasons outlined earlier, the discussions in this chapter and in Chapter Six address both the results obtained during the field research period as well as several *post hoc* extensions and refinements to the results.

5.2 Scenario Building Process

5.21 Task Description

The main purpose of the site selection component of the case study was for each participant to produce a land use scenario for West Bay District that, at a minimum, designated one or more parcel of land suitable for and, according to personal selection criteria, capable of supporting at least one hundred new rooms of tourist accommodation. No upper limit was imposed on the total number of rooms that a participant could designate, nor were any restrictions placed on the form of the proposed development (e.g. a single coastal resort, inland hotel, condominiums, a series of smaller 20 – 40 room hotels, dispersed accommodation units, etc.).

The tasks of specifying the amount and type of new tourist accommodation and selecting appropriate sites were the minimum requirements that each participant had to satisfy in their scenario. Optionally, each participant could construct a more elaborate and complete land development scenario by assigning one of a set of possible land uses (e.g. residential, commercial, protected, open space) to specific parcels of interest. This aspect of the case study provides one means of assessing the nature and spatial extent of land use conflict once all of the individual scenarios are combined in the subsequent evaluation phase. The participants were instructed that if they did not assign a land use to a parcel, it was to be assumed that he or she was not greatly concerned with the uses that other study participants may or may not assign to that location.

Separate *Tour*Plan site selection sessions were held for each participant. Prior to starting the scenario-building process, the author provided participants with written and verbal explanations of the purpose of the study and the general procedures involved in the site selection phase. Next, the available data sets listed in Table 4.6 were described and any known limitations or assumptions that may affect their use or interpretation by participants were noted. The general operation of the *Tour*Plan SDS tool was then demonstrated and explained in conjunction with the data familiarisation process. Participants had the option of using the software themselves or directing the author to operate it on their behalf. No time limits were imposed explicitly on the scenario creation process, although logistical factors constrained site selections to three to four hours for most participants.

The following sections detail the scenario-building process for the study participants by examining the range of land use futures proposed for West Bay District, the different ways that *Tour*Plan was used to create the scenarios, the rationale that was used to guide the site selection procedure, and the results that were obtained.

5.2.1 Specification of Scenarios

To provide an initial indication of the degree of commonality among development futures envisioned for West Bay and the manner in which the participants approached the scenario-building process, each individual was asked to consider, first, the amount and, second, the type(s) of new tourist accommodation that would be appropriate for the District. The first component of this task proved to be difficult for more than half of the participants to establish *a priori*, with five of the eight participants able to indicate only approximate values during their subsequent site selection activities.

The Director of the Environment Department and the National Trust Scientist based their scenarios on the one hundred room minimum with the latter expressing concern that even this amount of accommodation was excessive, given the current levels of development in West Bay. In contrast, the Real Estate Developer stated that an additional five hundred rooms of accommodation would be a "conservative estimate" of the District's long-range development potential. The CPA Member, the Business Owner, and the Hotel Operator were less comfortable defining a total desired room count and instead approached the task by indicating, respectively, that they were interested in siting "a 250 room hotel", "40 to 60 room hotels", and "hotels with a minimum of 60 rooms". A summary of the initial scenario specifications is presented for each participant in Table 5.1.

Participant	*A priori* room objective	Preferred type of accommodation	Rationale
Director of Environment	Minimum permitted (100)	2, 25-room hotels and 1 50-room cottage development	i) small-scale forms of tourism (e.g. nature tourism) are more compatible with the ecological and social capacity of West Bay; ii) Barkers area is not ecologically pristine but important for the bird, marine, and mangrove life it supports; iii) concern with high density of Seven Mile Beach tourism and residential development.
Natural Trust Scientist	Minimum permitted (100)	Small-scale development: small hotels, cottages	i) similar concerns as listed for Director of Environment with particular concern over the sustainability of recent development trends of Grand Cayman over the last 15 to 20 years.
Real Estate Developer	500	Smaller hotels (size undefined)	i) congested roads from Seven Mile Beach to undeveloped land in the north of West Bay; ii) lack of opportunities for waterfront tourism development on Seven Mile Beach; iii) more managerial employment for young Caymanians likely in smaller hotels.
Hotel Operator Developer	Uncertain	60-room hotel is minimum feasible size	i) hotels provide more employment and ongoing revenues to government; ii) difficult to support larger developments in West Bay beyond Seven Mile Beach area because of road capacity limitations; iii) small (sub 60 room) hotels are not economically feasible.
Business Owner	Uncertain	Medium-sized hotels with 40 to 80 rooms	i) very concerned about providing local employment opportunities for younger West Bay residents – sees hotel operation and construction as key vehicles for meeting this need; ii) 40 to 80 room hotels appropriate in scale to West Bay context
CPA Member	Uncertain	Larger hotels (250 room – in Seven Mile Beach area)	i) land costs along Seven Mile Beach require a minimum of 250 room developments; ii) wide sandy beaches of Seven Mile Beach are of high importance for international tourists to the Caribbean
Planner	Not specified	No preference provided planning regulations are met	i) not specified
Deputy Director of Planning	Minimum permitted (100)	50-room hotel on coastal areas; some Bed and Breakfast units inland	i) concern for all development, including tourism, to be appropriate in scale and type to West Bay's natural and social context; ii) smaller accommodation facilities lead to a lower tourist-to-guest ratio – ratios periodically excessive in Seven Mile Beach area

Notes: a) *a priori* room count objective represents the number of new rooms of tourist accommodation that each participant stated that they would seek to locate prior to starting the site selection process (subject to the 100 room minimum), b) "Uncertain" signifies that the participant was not able to quantify precisely the room count objective.

TABLE 5.1 INITIAL SCENARIO SPECIFICATIONS

There was more agreement concerning the general form of tourism development that would be suitable for the study area, with six of the eight participants favouring small hotels and/or guest homes to condominiums. Table 5.1 shows that these preferences are based largely on an understanding that condominiums generate less local employment on a per room basis and the fact that they do not provide the Government with on-going room tax revenues. Beyond some suggestions for further intensive development on the few remaining lots on the Seven Mile Beach peninsula, almost all of the participants stated a preference for low density and small scale forms of tourist accommodation. This form of development was perceived to: a) be in character with the District's existing small hotels, guest houses and residential neighbourhoods, b) offer more potential for Caymanians in management-level positions, c) place less strain on the District's internal road network and the main road leading into George Town, d) allow better protection of the marine and terrestrial habitats, and e) provide better opportunities for managing tourism development in general and maintaining an acceptable guest-host ratio.

With this broad overview of the development preferences of the participants in mind, the next two sections describe the scenario-building process and detail the selection criteria and rationale that were used by the participants to create their tourism development scenarios.

5.2.2 *Task Approach, Criteria and Rationale*

Several aspects of commonality were observed across three aspects of the participants' scenario-building efforts, namely:

1. their interpretation of, and approach to, the case study planning task (objectives, beliefs);
2. the operationalisation of these approaches through specific selection criteria and the rationale provided to support their criteria choices (translation of general goals to identifiable standards, measures, and decision rules); and,
3. the functionality that each individual used in *Tour*Plan to complete the planning task (means to achieve objectives using the decision support tool).

At the broadest level, two distinct approaches to tourism accommodation siting were used in the participants' scenario-building efforts. The personal interests, experience, and professional background of the Deputy Directory of Planning and the representatives from the National Trust and the Department of Environment caused them to be concerned about the impacts of development on surrounding residents and ecosystems. Consequently, they adopted a site selection approach first based on designating lands appropriate for protected or open space status and then subsequently locating potential tourism development sites from the remaining subset of parcels (*selection by exclusion*). The Deputy Director of Planning in particular excluded numerous potential sites because of their proximity to important historical-cultural features such as early schoolhouses, homes of pioneering Caymanians, churches, and so on. In contrast to this approach, the other study participants focused primarily on the tourism siting issue (*selection by inclusion*) and then subsequently designated lands for the optional non-tourism uses later. This latter approach may be traced to: a) a participant's desire to minimise the time required for the site selection process, b) their lack of concern with non-tourism land issues, c) a perception that sector-specific planning, including tourism planning, comprises largely self-contained activities or, d) the influence of a bias built into the study design.

Table 5.2 shows that the scenarios based on exclusionary approaches are more comprehensive in terms of the breadth of land uses considered in the scenario and more extensive with respect to land area. Generally, the comprehensiveness of the scenarios corresponded to *a priori* expectations based on the participants' divergent training, vested interests, and roles in strategic-level tourism or planning decision making outlined in Chapter Four. For instance, the two participants with direct interests in land development did not allocate any land to protected or open space use, while these land use categories were of high importance to the two participants with direct responsibility for environmental matters (e.g. Director of Environment Dept. and National Trust Scientist). Similarly, the two planning representatives recorded explicitly the broadest range of land use activities in their scenarios. The substantial differences in the complexity of the two scenarios is most likely attributable to the Deputy Director being more knowledgeable of strategic and long-range planning issues and their linkages to operational planning decisions.

Participant	Tourism siting approach	Land Use Designation											
		Tourism		Commercial		Residential		Open space		Protected		Unassigned	
		#	Acres	#	Acres	#	Acres	#	Acres	#	Acres	#	Acres
Director of Environment	Exclusion	6/6	17/17	2/2	3/3	0	0	14/16	10/12	93/94	448/449	2187/3907	2601/3788
Natural Trust Scientist	Exclusion	65/65	382/382	0	0	0	0	38/40	56/62	68/68	476/476	2131/3852	2166/3349
Real Estate/ Developer	Inclusion	41/41	81/81	0	0	0	0	0	0	0	0	2261/3984	2999/4187
Hotel Operator/ Developer	Inclusion	46/46	123/123	18/18	42/42	49/50	350/356	0	0	0	0	2189/3911	2566/3748
Business Owner	Inclusion	192/206	448/472	50/50	47/47	0	0	0	0	7/8	167/195	2053/3761	2418/3355
CPA Member	Inclusion	11/11	29/29	0	0	0	0	1/1	5/5	9/9	124/124	2281/4004	2922/4111
Planner	Inclusion	9/10	69/347	1/1	2/2	18/18	19/19	0	0	77/77	408/408	2197/3919	2582/3492
Deputy Dir. of Planning	Exclusion	175/215	356/694	79/144	40/71	0	0	717/719	626/630	111/137	907/967	1220/2810	1150/1907

Notes: a) tourism siting approach represents the primary method by which a participant identified tourist accommodation sites, b) "#" = the number of undeveloped or "vacant" parcels that were designated for a specific land use followed by the total number of parcels that were designated for that land use, c) vacant parcel acreage precedes the total number of acres that were dedicated to a land use, d) acreage values are rounded.

TABLE 5.2 SUMMARY OF PARTICIPANT LAND USE DESIGNATIONS

Examination of Table 5.2 in the context of Table 5.1 shows that some individuals identified relatively few "feasible" sites from which they could satisfy their tourist accommodation objectives, while others adopted a more flexible approach to selecting candidate sites. The Real Estate Developer and the Deputy Director of Planning provide the greatest contrast among the participants that were expected to have different interests and roles in the land development process. However, the pro-conservation subgroup illustrates that this can occur even among individuals with similar professional interests and objectives. For example, while both participants shared an objective of locating 100 new rooms of small-scale tourist accommodation (Table 5.1), the National Trust Scientist identified 65 potential sites (381 acres), from which a smaller subset would be selected, while the Director of Environment designated only 6 candidate sites (17 acres). Further, by comparing the acreage and number of "vacant" parcels selected for tourist accommodation with the corresponding totals, it is apparent that most of the participants approached the site selection problem as a conventional search for appropriate "undeveloped" land. The most notable exception was the Deputy Director of Planning who identified more than 300 acres of non-vacant land as having potential for tourist accommodation. Also, to a lesser extent, the Business Owner, who indicated expressly the desire to redevelop a larger existing hotel site in concert with surrounding properties, focused a great deal of this redevelopment on the subdivision of a few large parcels of land which were primarily unoccupied by any type of structure.

Differences in participants' objectives and approaches to the planning task are made more apparent when the criteria that were used in the construction of the selection scenarios are considered in relation to the resulting land use patterns. Prior to discussing the participant's site selection scenarios collectively, it is necessary first to review their individual scenarios. Figures 5.1 through 5.8 and their accompanying discussion outline the land allocations each participant made in their scenario. Note that it is important to recall that land parcels designated for tourist accommodation should be interpreted as potential or candidate sites while parcels designated for the other land uses (e.g. open space, protected, commercial, residential) represent explicit allocations.

5.2.3.1 Director of Environment

The overriding objective of the Director of Environment was to ensure that future tourism development in West Bay would have as few negative impacts as possible on the District's marine and terrestrial ecosystems. The land use allocation in Figure 5.1 was based on an eco-tourism theme that was centred, first, on the protection of the semi-natural swampland of the Barkers peninsula for birding and to maintain the integrity of 'Sea Pond' which provides a unique aquatic environment based on its subterranean water source from the sea. Equally important was the need to exclude all types of shoreline development adjacent to the marine park and replenishment zones off of the north of Barkers in order to encourage aquatic species preservation and regeneration. Protected parcels are shaded dark green in Figure 5.1 and Sea Pond is visible as the largest lake (blue outline) within the protected area.

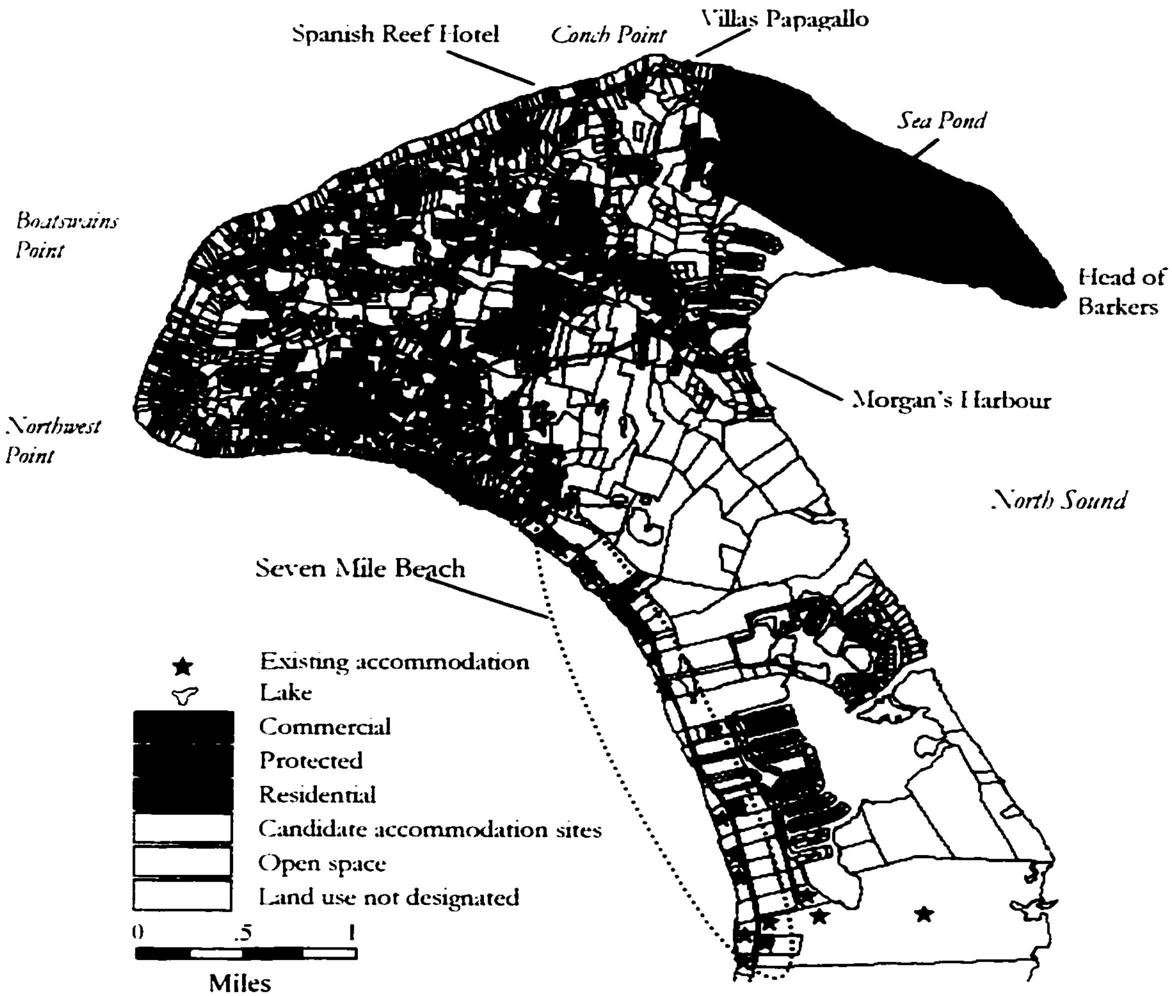

FIGURE 5.1 SITE SELECTION SCENARIO – DIRECTOR OF ENVIRONMENT

The Director of Environment concentrated on locating sites (shaded yellow in Figure 5.1) that would support two 25 room hotels and one 50 room cottage type development in close proximity to these two natural attractions. The main selection criteria used to identify the six candidate sites (with the selection method used in parentheses) were: 1) include parcels with sandy beachfronts between the existing Spanish Reef Hotel and the Villas Papagallo (*mouse select*); 2) add all parcels in West Bay zoned for hotel/tourism (*SQL query*); 3) exclude any parcels in the Barkers swampland protected previously and any parcels in the overdeveloped Seven Mile Beach area (*distance-based query, SQL query*); 4) exclude all parcels that were not vacant (*SQL query*);

and 5) exclude parcels under 2 acres in size to maintain a low-density design compatible with the physical, economic, and social capacities of the local community (*SQL query*).

Other land designations included in this scenario included sea-side parcels reserved for open space community use and a small amount of commercial development intended to support the new tourism facilities near Barkers. The potential for additional commercial development related to tourism (e.g. fishing charters, snorkel and scuba operations) in the vicinity of Morgan's Harbour were mentioned but were not investigated fully due to time limitations.

5.2.3.2 *National Trust Scientist*

The other pro-conservation participant, the National Trust Scientist, was also concerned about the impacts that additional tourist accommodation or any other type of development would have on local environments, the West Bay community, and life on Grand Cayman as a whole. Again, the selection of candidate sites for tourist accommodation was driven primarily by the desire to identify where development should be excluded from, although the undeveloped areas of West Bay District were judged to be of diminished quality already due to dredging, population pressures, and overuse (e.g. popular reef dive sites). Remaining areas of significant white and red mangroves along the North Sound and in the entrance to Governor's Harbour were highlighted for protection. Similarly, protected status was applied to a substantial portion of the swampland in the Barkers peninsula, in part due to the ecological significance of Sea Pond. Less land in Barkers was designated for protection by the National Trust Scientist than by Environment Director as the former reserved the north shore of the peninsula for open space to permit the continuance of informal community recreational activities (e.g. fishing, beachcombing). Several smaller parcels in the District were assigned either protected (Blue Hole) or open space status (rock formations at Hell, community pasture land).

A two-pronged approach was followed in the selection of candidate sites for tourist accommodation. The potential for shoreline-based tourism development in Barkers was precluded by the steep beach ridge along its north shore, the marine park and replenishment zones, the shallowness of the water inside of the fringing reef, and the conditions of the seabed immediately offshore of the beachfront (i.e. coral, broken conch shells, turtle grass). However, two large parcels in the area were identified as candidates for a small number of low-density tourist facilities suitable for interpretative nature tourism focused on birding, hiking and kayaking on the Mosquito Research Control Unit canals. In addition, most of the parcels between Spanish Reef Hotel and Villas Papagallo were identified as being suitable for smaller cottage developments (approximately 20 rooms) based on their sandy beach frontage, distance beyond the marine park and replenishment zones, and the relatively low-impact nature of this form of tourism. Due to the highly developed nature of the Seven Mile Beach corridor, much less concern was expressed about the impacts of additional tourism accommodation if infill development on the beach and North Sound sides of the road were to occur.

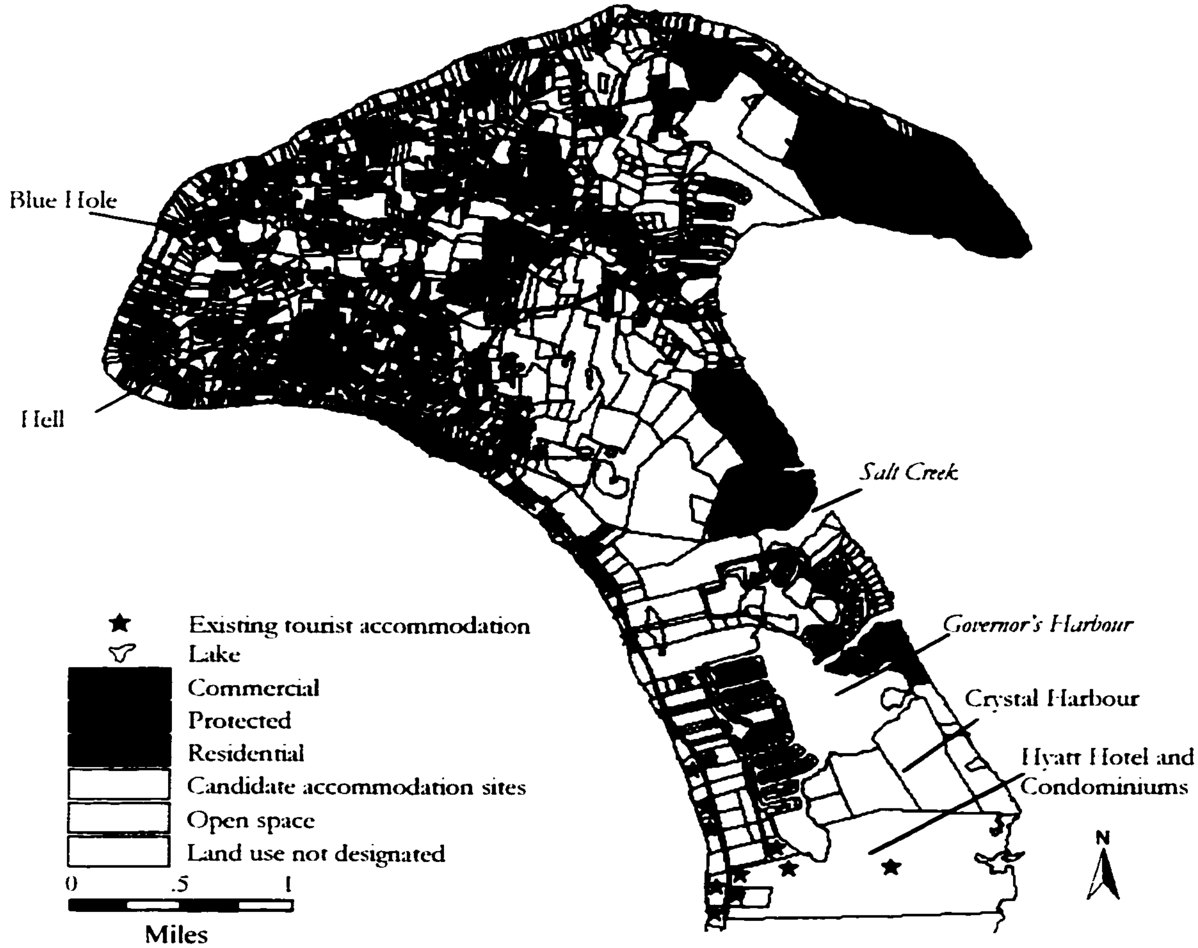

FIGURE 5.2 SITE SELECTION SCENARIO – NATIONAL TRUST SCIENTIST

Unlike the Director of Environment, all selections were *mouse-based* guided by local knowledge of West Bay and reference to a copy of the swamps and shallow marine substrates map for Grand Cayman (Overseas Development Natural Resources Institute, 1987). The main selection criteria for tourism land uses were: 1) a multi-step process of excluding the protected and open space properties described above, 2) exclude all tourism development along the ironshore since shoreline modifications contribute to sediment loading of downstream reefs, 3) exclude all interior sites as they are usually less attractive to tourists than coastal locations, and 4) focus on vacant properties with, or in close proximity to, sandy beachfront.

5.2.3.3 Real Estate /Land Developer

In contrast to the scenarios prepared by the two pro-conservation participants, the Real Estate Developer chose to address the site selection task without explicitly recording any preferences for optional land use types. Again, the area between Spanish Reef Hotel and Villas Papagallo was highlighted as a potential development zone, as were a number of parcels on the north shore of Barkers and three other parcels toward the southern extremities of the District (Figure 5.3).

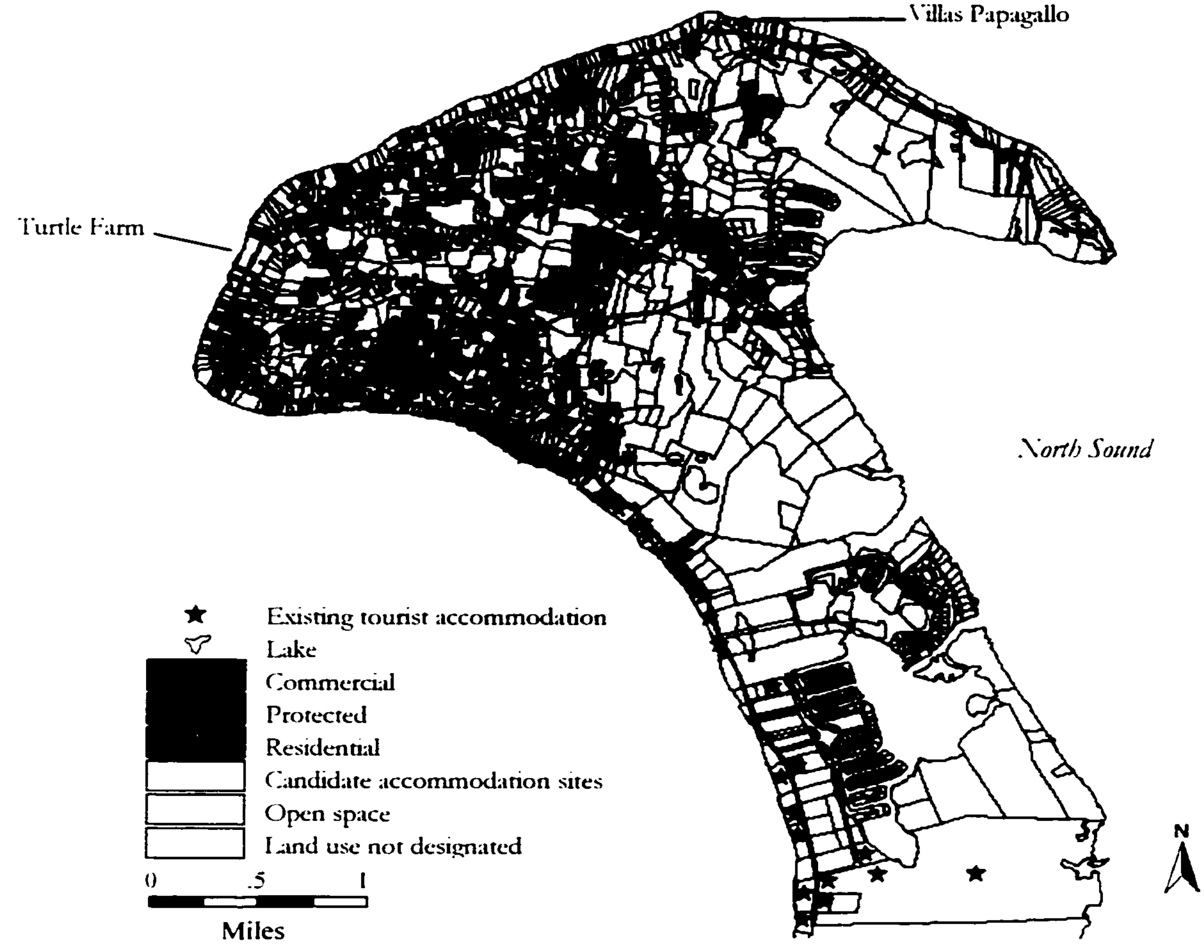

FIGURE 5.3 SITE SELECTION SCENARIO – REAL ESTATE DEVELOPER

The selection criteria that produced this pattern of sites were: 1) include only vacant parcels (*SQL query*); 2) remove all parcels that do not have sandy beachfront (*SQL query*); 3) include only parcels zoned for hotel/tourism in the 1997 Development Plan (*SQL query*); 4) remove all parcels along Seven Mile Beach that are not deep enough (from the beach to the road) to support hotel development or have unsuitable beach conditions (*mouse-driven query*); 5) *remove by mouse* four larger parcels comprising the undeveloped Crystal Harbour plan of subdivision on the south of Governor's Harbour.

5.2.3.4 Hotel Operator /Developer

The Hotel Operator/Developer also followed an inclusionary approach to site selection, although in this case both mouse-driven and SQL query methods were employed to identify candidate sites. The importance of the Barkers area to future land use decision making in West Bay is illustrated once again in Figure 5.4 as the lack of building opportunities and high land costs in the Seven Mile Beach corridor make that area less attractive for new tourist accommodation. The main constraint that was identified to development in this area is the lack of easy and quick access for tourists to the airport in George Town and the attractions along Seven Mile Beach.

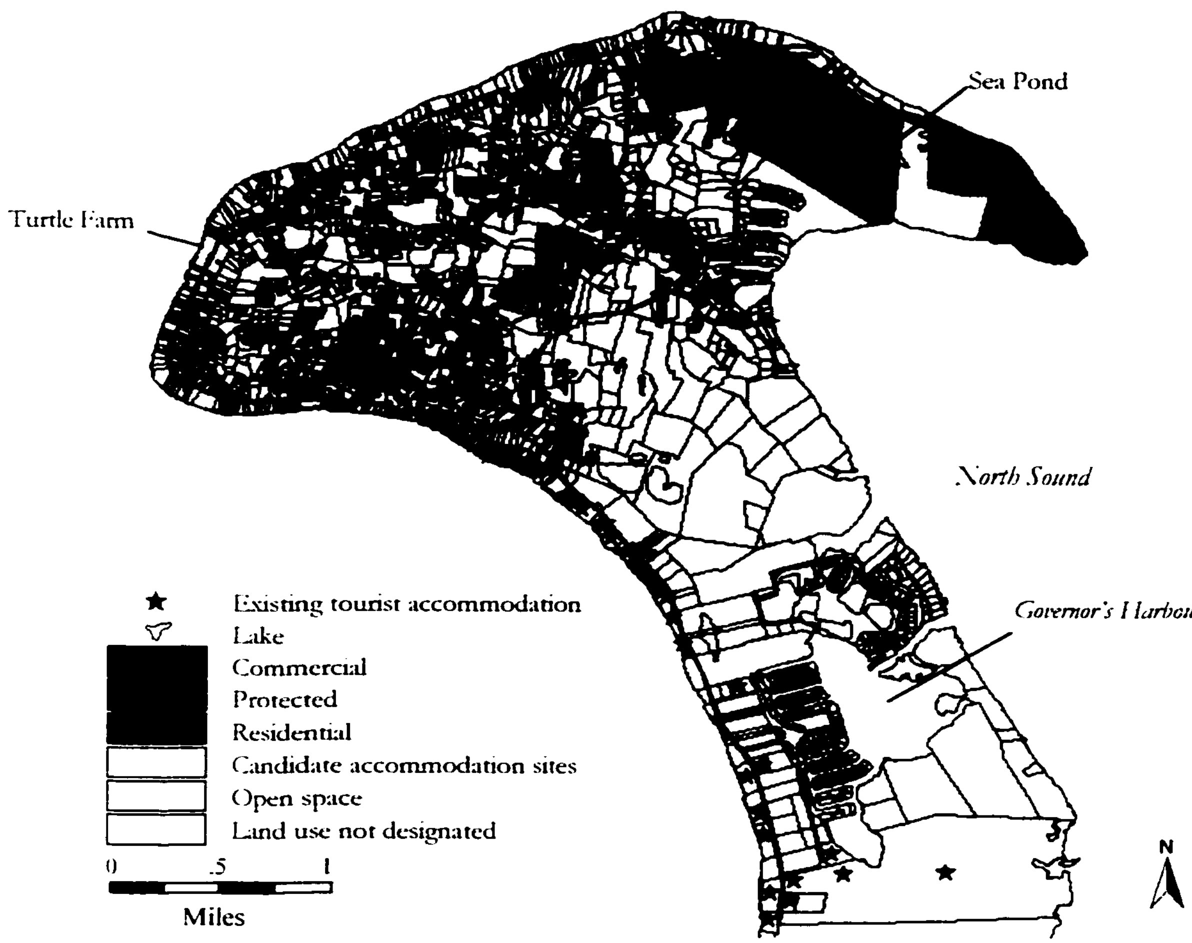

FIGURE 5.4 SITE SELECTION SCENARIO – HOTEL OPERATOR/DEVELOPER

The following selection criteria were used to identify the candidate sites for hotels of at least 60 rooms in size: 1) include only vacant parcels (*SQL query*); 2) exclude all parcels zoned for high density residential or low density residential uses (*SQL query*); 3) exclude all parcels except those in Barkers/Villas Papagallo vicinity (*mouse select*); 4) include only parcels fronting onto a sandy beach or with North Sound access. In addition to these sites, the potential for more dive-related hotels between the Spanish Reef Hotel and the Cayman Islands Turtle Farm (Figure 5.4) were discussed but not included within the scenario itself. Once the tourism component of the planning task was addressed, supporting commercial uses (e.g. restaurants, shops, etc.) were designated for an adjacent linear series of parcels and the remainder of the vacant lands in the Barkers area was earmarked by the participant for residential uses.

5.2.3.5 *West Bay Business Owner*

Of the three participants in the pro-development group, the West Bay Business Owner assembled the most comprehensive selection scenario. The tourist accommodation component of the planning task was anchored by the siting of one 40-60 room hotel at the head of Barkers and another of similar size adjacent to Villas Papagallo. Sites for smaller hotels of 15 rooms in size were then identified between these two points. Potential locations for dive-related hotels were selected along the north shore of the West Bay peninsula and south of the Turtle Farm.

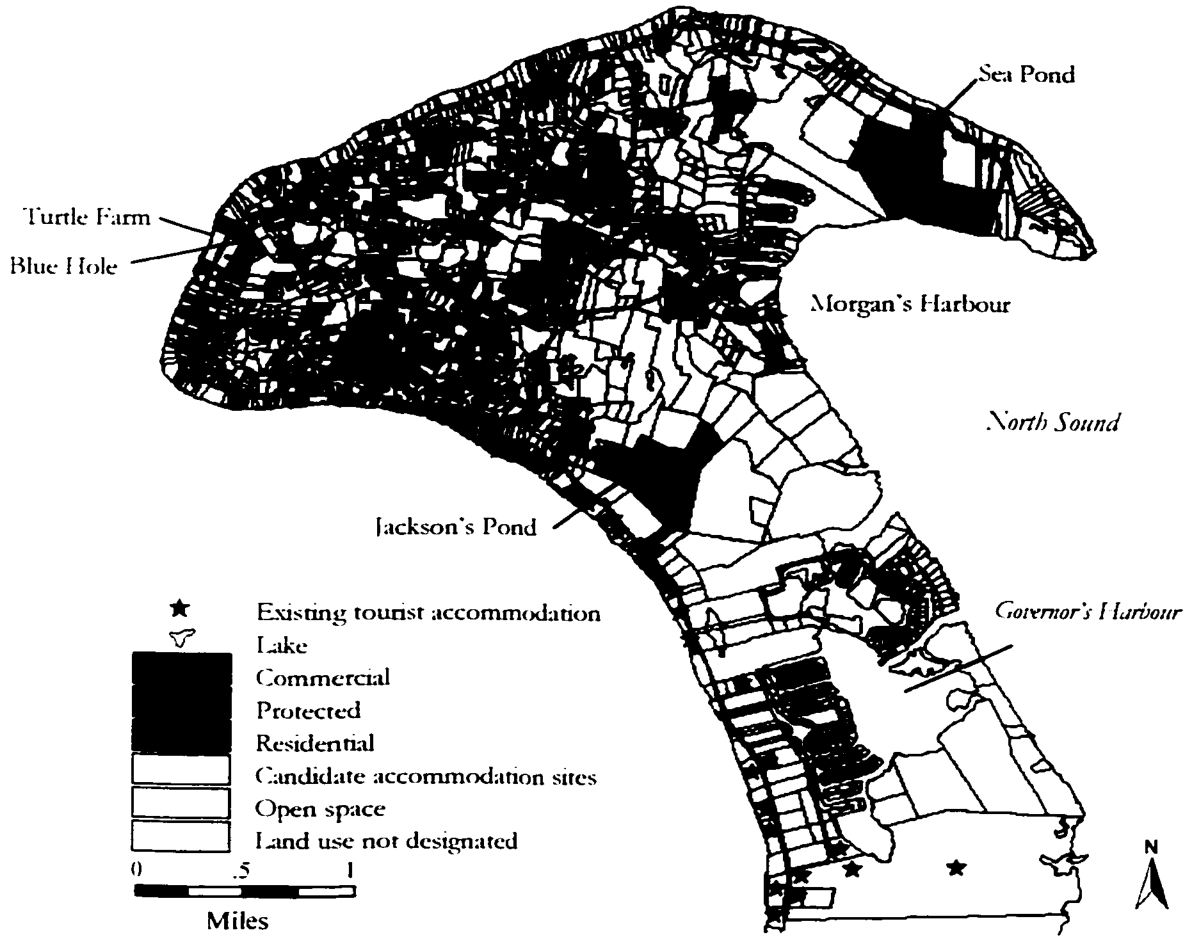

FIGURE 5.5 SITE SELECTION SCENARIO – WEST BAY BUSINESS OWNER

This participant also supported the intensification of the existing tourist development in the Seven Mile Beach corridor with the addition of larger hotel sites (200 to 300 rooms) on the North Sound side of the road and on the southern end of Governor's Harbour. Three natural features were reserved for protected status in the scenario: Sea Pond in the Barkers peninsula, the Blue Hole near the Turtle Farm, and Jackson's Pond located approximately in the centre of West Bay District. Finally, commercial activities were targeted at appropriately zoned and vacant parcels with additional new commercial centres being sited behind the Turtle Farm and in the vicinity of Morgan's Harbour.

The Business Owner used a mixture of SQL, distance-based, and mouse-driven query methods to produce his scenario. The primary selection criteria that were employed to identify the tourism development sites were: 1) include only vacant parcels (*SQL query*); 2) exclude any parcels within 150 feet of a lake (*distance query*); 3) exclude parcels *with mouse* zoned for low-density or high-density residential uses due to a shortage of residential properties in West Bay; 4) add parcels *with mouse* on the head of Barkers (mouse); 5) remove all inland properties suitable for residential development (*mouse*); 6) add *with mouse* a 9.4 acre parcel at Morgan's Harbour now zoned for marine commercial as a location for a larger hotel in the long-term; 7) exclude parcels in Seven Mile Beach corridor that were judged to have unsatisfactory dimensions to support a larger hotel or would be allocated better to commercial uses (*mouse*), 8) add *with mouse* the four larger parcels comprising the Crystal Harbour area on the south of Governor's Harbour.

5.2.3.6 *Central Planning Authority (CPA) Member*

The site selection scenario prepared by the CPA Member is shown in Figure 5.6. Compared to the other scenarios reviewed to this point, relatively modest amounts of land were designated for specific land uses. Candidate sites for additional tourist accommodation in the Seven Mile Beach area were limited to parcels that would be capable of supporting at least 250 rooms due to the high land costs. Beyond the Seven Mile Beach corridor, low-density tourism development was supported given the constraints of the existing narrow and circuitous road network in West Bay and a concern that the provision of a straight and wide roadway would be out of character for the island. Similar to many of the other participants, the land parcels surrounding Sea Pond were designated for protection, as were the lakes adjacent to Villas Papagallo.

The CPA member used the following selection criteria to identify the candidate tourist accommodation sites: 1) exclude parcels without a sandy beachfront (*SQL*); 2) include only vacant parcels (*SQL*); 3) remove parcels on Seven Mile Beach that have unsuitable offshore conditions for swimming and wading (*mouse*); 4) remove residential-zoned parcels in Governor's Harbour area (*mouse*); 5) exclude parcels fronting onto the North Sound because prevailing currents cause turtle grass and debris to drift onshore (*mouse*); 6) exclude parcels near the Spanish Reef Hotel because the shoreline is too rocky and too shallow offshore (*mouse*); 7) exclude protected parcels around Sea Pond (*SQL*), 8); exclude parcels on the head of Barkers because of mangroves, North Sound currents, and land is too swampy (*mouse*).

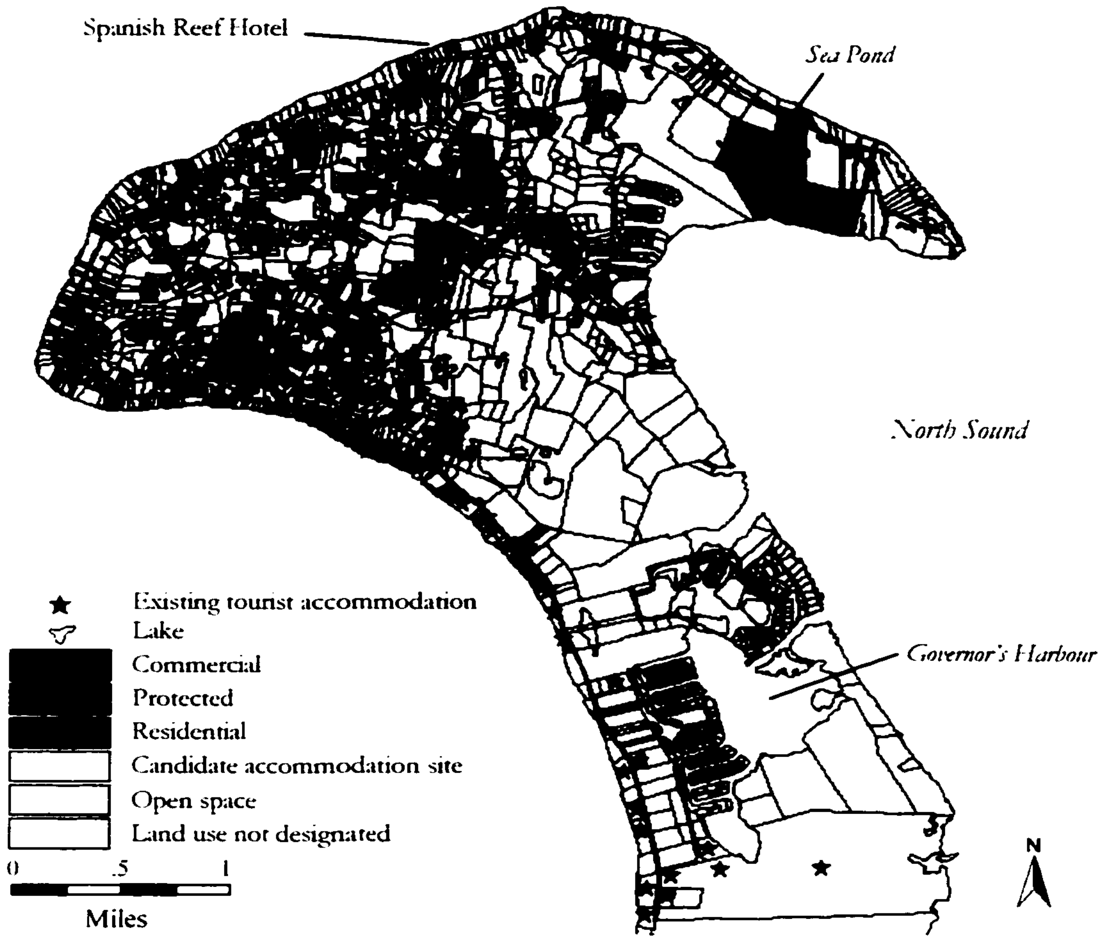

FIGURE 5.6 SITE SELECTION SCENARIO – CPA MEMBER

5.2.3.7 *Land Use Planner*

The Land Use Planner was also able to draw upon his knowledge of planning regulations, current and submitted development proposals, and the capabilities of specific areas to support different types of development. Candidate sites were located primarily in the Seven Mile Beach corridor. The Barkers peninsula was designated as protected in order to maintain both terrestrial habitat and the vitality of the adjacent marine park and replenishment zones. Similarly, vacant parcels near Villas Papagallo were designated for residential uses as they tend to have less impact on offshore ecosystems than tourism uses.

The balancing of the pro-development and pro-conservation perspectives are evident in the selection criteria the Planner used to identify candidate sites. These criteria were: 1) include only vacant parcels (*SQL*); 2) exclude all parcels within 450 feet of a replenishment zone since shoreline development can disturb these sources of future marine life significantly (*distance*); 3) exclude parcels less than 2.4 acres in size (*SQL*); 4) exclude parcels located more than 1000 feet from the coast (*distance*); 5) exclude parcels within 350 feet of any lake (*distance*); 6) include only parcels zoned for hotel/tourism (*SQL*), 7); add *by mouse* the large Hyatt Regency parcel south of Governor's Harbour to account for intensification of development on that property; and 8) remove *by mouse* the four parcels comprising the Crystal Harbour project.

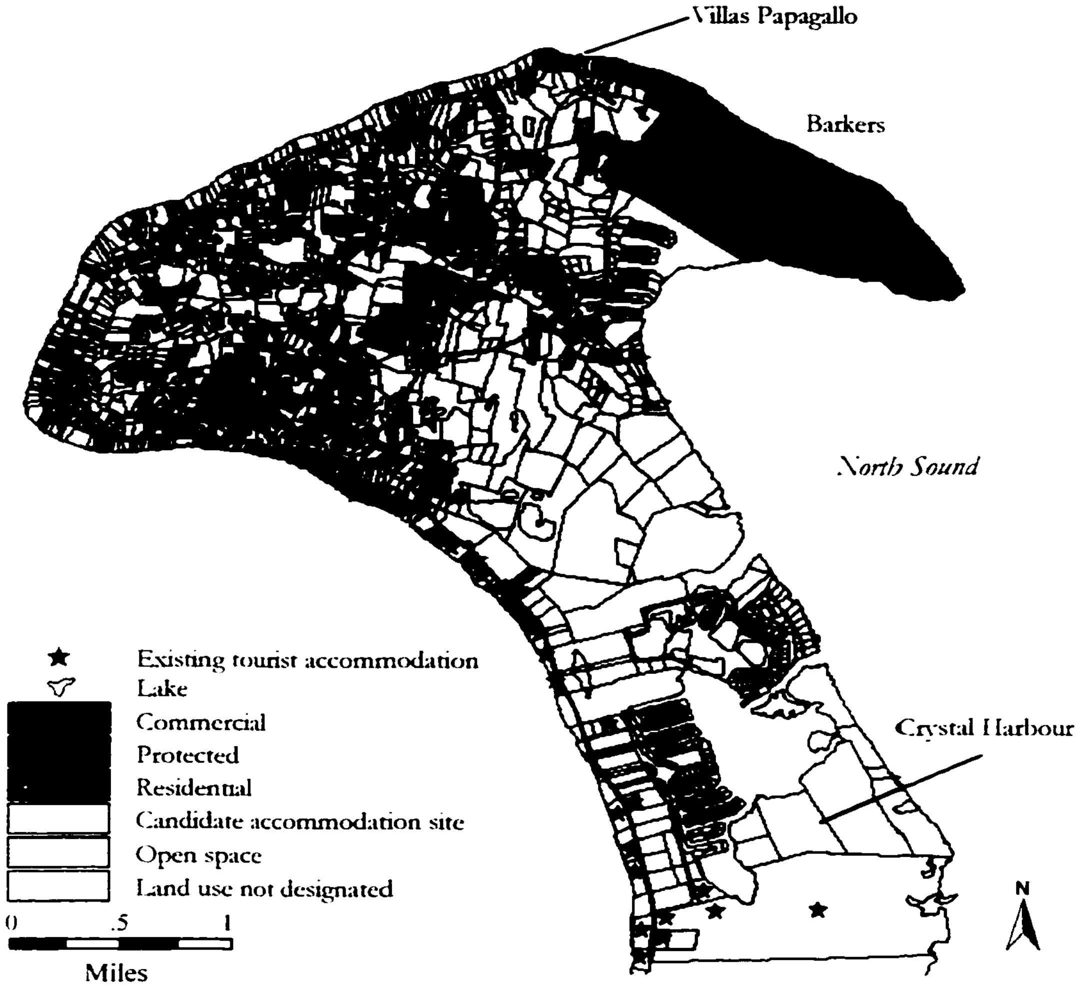

FIGURE 5.7 SITE SELECTION SCENARIO – PLANNER

5.2.3.8 *Deputy Director of Planning*

Prior to starting the scenario-building processes, it was anticipated that the Deputy Director of Planning would produce a scenario that balanced the other participants' desires for development and conservation relatively equally. The scenario that resulted, however, placed considerably more emphasis on the social needs of the West Bay community through the preservation of historical structures and properties, the maintenance of common open space for recreation or pasture, and the preservation of ecosystems important to the heritage of West Bay residents and Caymanians in general.

The exclusionary approach to identifying candidate tourist accommodation sites was initiated by the designation of almost all of the Barkers peninsula for protection in order to safeguard mangroves, Sea Pond, and the wetland environments. Protected status was assigned to properties with specific natural features such as mangroves along the North Sound coast, a substantial "green belt" stretching from the Seven Mile Beach Road through to the North Sound that encompassed several important lakes (e.g. Johnson's Pond) and swamplands and served as a barrier to expansion of West Bay and George Town development, and a number of smaller interior wetlands that served as both bird habitat and natural storm water management basins. Historical-cultural considerations, such as buildings with significant architecture features, former schools, long-established commercial structures, and homes of pioneering nurses, educators and seamen, led to a larger number of small parcels being designated for protection as well.

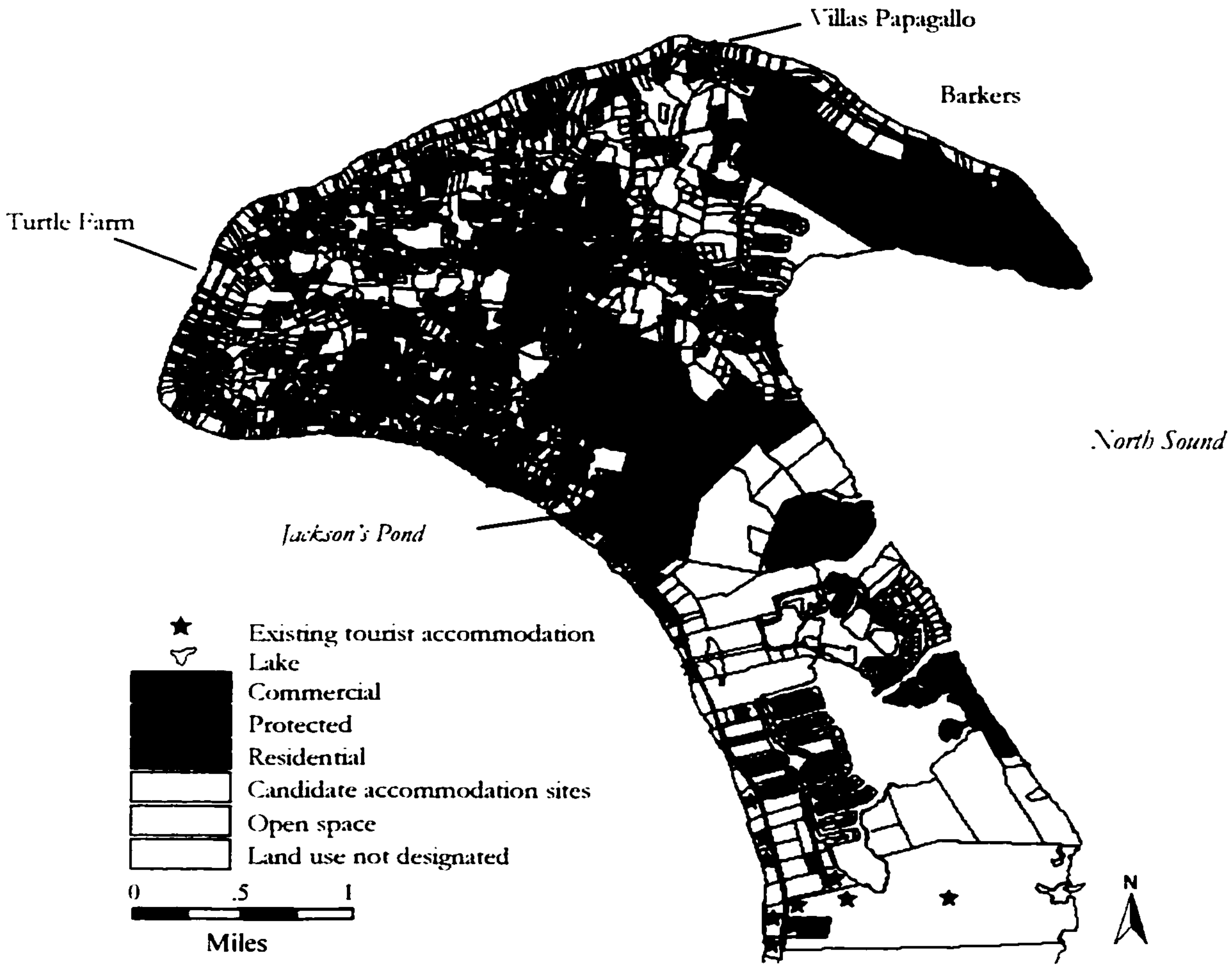

FIGURE 5.8 SITE SELECTION SCENARIO – DEPUTY DIRECTOR OF PLANNING

Smaller scale tourism development was judged to be most appropriate to the social and environmental context of West Bay. On coastal properties, hotels of approximately 50 rooms in size were preferred while the inland sites would be targeted for smaller 10 to 15 room hotels or bed and breakfast establishments.

After excluding all of the properties designated for protected and open space uses from the available candidate sites, the Deputy Director of Planning used the following criteria to identify potential sites for tourism development: 1) include coastal parcels from Villas Papagallo to the open space properties on the north shore of Barkers (*mase*); 2) add parcels south of the open space area on Barkers (*mase*); 3) add coastal properties from Villas Papagallo west to the Turtle Farm as potential dive related hotels (*mase*); 4) add inland sites with sufficient area to support either a bed and breakfast establishment or a smaller hotel (*mase*).

The next section explores instances of agreement and disagreement among the participant's site selections and between the three participant sub-groups identified in Chapter Four.

5.3 First-Order Consensus and Conflict in the Site Selection Scenarios

When the eight site selection scenarios described above are examined together, initial indications of conflict and consensus among the participants are revealed. At least four different aspects of commonality can be explored at this stage: 1) commonality in the participants' stated planning objectives, 2) commonality in the translation of these planning objectives into selection criteria pertinent to the SDSS problem-solving environment and within the bounds of available data, 3) commonality in the manner of use of the software to actualise the selection criteria, and 4) commonality in scenario outcomes. The first dimension of commonality was discussed earlier (Table 5.1). This section focuses primarily on scenario outputs but, in doing so, also touches upon the second and third elements of commonality as well.

Agreement on the set of candidate locations for a particular land use activity can be considered to be one of the most basic indications of consensus in a multi-participant planning environment. For example, Table 5.2 lists a total of 600 parcels that were designated as potential tourist accommodation sites from the set of over 2,300 undeveloped parcels and the universe of more than 4,000 total parcels. However, since many of the 600 candidate sites were selected by more than one participant, the number of unique sites is 361. This figure is influenced highly by the open-ended nature of the case study planning task which, in the spirit of intelligence gathering and preliminary strategizing outlined in Chapter Three, did not limit the amount of land that participants could designate as possible locations for tourism development. It was also possible for participants to inadvertently include very small parcels in their selection sets if they used certain graphical selection methods (e.g. select parcels bisected by a user-defined line, box, or circle) and did not subsequently filter the results for parcel size. These factors can account, to some degree, for the large number of sites selected by the Deputy Director of Planning (215 candidates) and the Business Owner (209 sites) who each identified more potential sites than the remaining six participants combined, despite having substantively different planning objectives, task interpretations, and problem-solving approaches.

When the 361 unique candidate sites are mapped in Figure 5.9, a preference among the group for sites on or near the primary attraction of the shoreline is apparent. At some stage in each participant's scenario, coastal proximity was used explicitly as a selection criterion although the manner of operationalising that criterion varied between direct mouse-driven selection, attribute selection (e.g. length of waterfront > 0), and distance-based methods (e.g. distance from sandy beach < 50 feet). In light of the discussion of Caribbean tourism morphology in Chapter Two, this result is not surprising, even given the heterogeneous interests represented in the participant group.

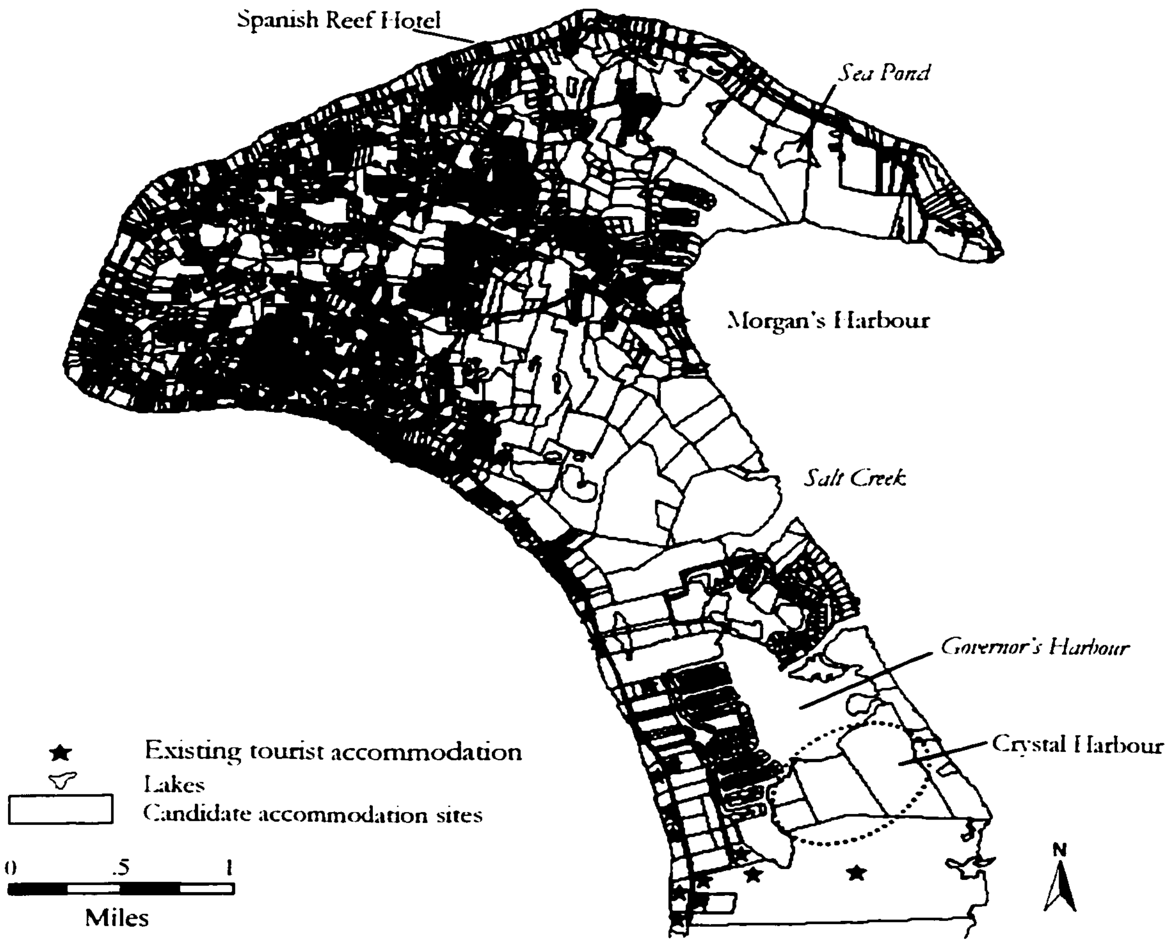

FIGURE 5.9 CANDIDATE TOURIST ACCOMMODATION SITES – ALL PARTICIPANTS

Beyond the emphasis on coastal properties, three other aspects of the group's aggregate selection set should be noted. First, the potential for further intensification of tourism development in the Seven Mile Beach and Governor's Harbour areas is evident through redevelopment of existing properties, expansion of development into wetlands on the west (North Sound) side of the Seven Mile Beach road, and through development proposals like the Crystal Harbour development. Second, even though the bulk of the undeveloped Barkers peninsula was designated by at least one participant as having potential for tourism development, all participants excluded the parcel on which the bulk of Sea Pond is found and only one included the large "L-shaped" parcel at the east end of Sea Pond. Third, there was complete agreement on the set of parcels to exclude from consideration for tourist accommodation, in particular almost all of the wetlands lying between Salt Creek to the north of Governor's Harbour, the Seven Mile Beach road, and Morgan's Harbour on the North Sound.

The number of times that the participants collectively selected each of the candidate sites provides an initial indication of the degree of consensus concerning potential tourism development. Within the sample problem environment, this value ranged from 1 to 8 with complete unanimity being limited to a single parcel at the northern extremity of West Bay District. To illustrate better the extent and distribution of agreement, the set of 361 candidate sites were divided into the following classes:

1. no consensus – all parcels selected by less than two participants
2. weak consensus – parcels selected for tourism by two or three individuals
3. moderate consensus – parcels identified as candidates by four or five participants
4. strong consensus – parcels selected by six or more participants

Eliminating the parcels that were selected by only one participant reduced the set of potential accommodation sites by almost two-thirds to 135 in total. Figure 5.10 illustrates that the highest concentration of moderate and strong consensus within this reduced set of sites is found along the north shore of West Bay stretching east from the Spanish Reef Hotel, past the Villas Papagallo, and on into the undeveloped Barkers area. The other two parcels on which the participants agreed to a moderate to strong extent as being suitable for tourist accommodation are on the waterfront side of the Seven Mile Beach road near the Harbour Heights condominiums and the Westin Casuarina Hotel. Interestingly, while only three participants (Director of Environment, Planner, and Real Estate Developer) made reference to parcel zoning in the construction of their scenarios, all of these parcels with moderate to strong support in the group scenario were designated for Hotel/Tourism zoning in the new Development Plan. In fact, only 6 of the 103 parcels with weak consensus were not zoned for Hotel/Tourism in the 1997 Development Plan. This suggests that: a) the high profile of the debates concerning the Development Plan in Grand Cayman over the preceding two years raised awareness of the tourism siting issue, b) the direct vocational interest of some participants (e.g. Deputy Director of Planning, Planner, CPA member, Real Estate/Developer, Hotel Operator/Developer) with the proposed zoning patterns influenced their own tourism selections, or c) the Development Plan zoning reflects the diverse viewpoints of the study's participants quite accurately.

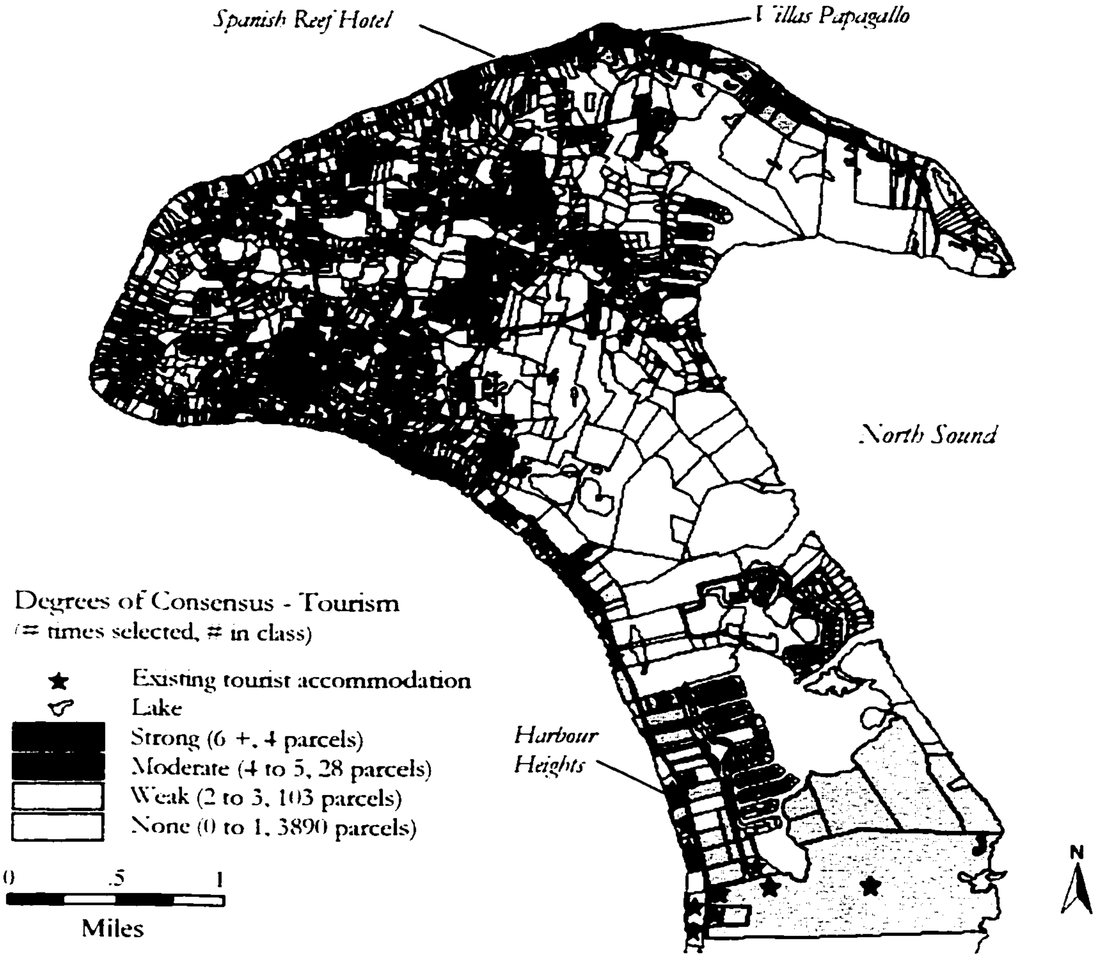

FIGURE 5.10 FIRST ORDER CONSENSUS ON CANDIDATE TOURISM SITES

Beyond the required land allocations for tourist accommodation, Table 5.2 indicates that participants were most interested in the optional land uses of Commercial, Open Space, and Protected. Compared to the case of tourism discussed above, there was a considerably less spatial consensus on Commercial land uses since no parcels were selected more than twice for this designation. Open Space was limited similarly with the exception of one parcel on the north shore of the Barkers peninsula which was assigned this land use by a total of three participants.

Much more interest was expressed in the assignment of Protected status to a diverse collection of ecological and historical-cultural phenomena. Figure 5.11 illustrates the varying degrees of consensus that emerged from the individual scenario-building sessions with respect to the need to safeguard these features. Similar to the consensus mapping approach employed in the previous figure, the emphasis is placed on parcels designated for Protected status by two or more participants. Not surprisingly, given the discussion in the preceding section, interest in assigning Protected status to parcels was the greatest in the Barkers area. Consensus on protection of much of the north shoreline was relatively weak given the development potential.

However, as one moves south or east to the head of the peninsula, a heightened desire to maintain the quality of existing mangroves and lakes for the purposes of habitat preservation and/or as an ecologically-based tourist attraction is evident. The environmental and cultural importance of Sea Pond in particular to the West Bay community is readily apparent since all six of the participants that considered the Protected land designation explicitly in their scenarios ensured that it was applied to the two parcels on which Sea Pond rests. Beyond the Barkers peninsula, weak consensus was found on the need to protect Jackson's Pond and three other areas with significant remnants of North Sound mangroves.

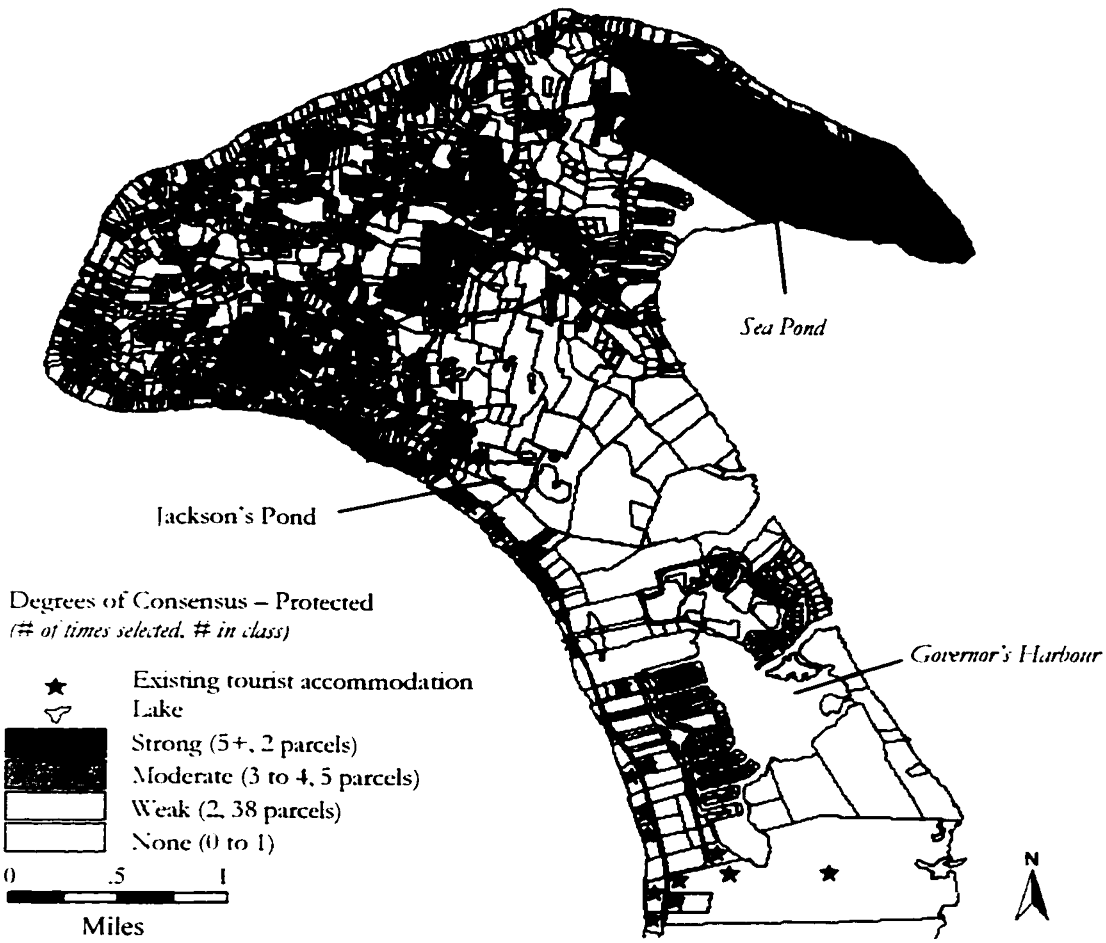

FIGURE 5.11 FIRST ORDER CONSENSUS ON PROTECTED STATUS

To this point, emphasis has been on uncovering the patterns and intensities of consensus among the participant's individual scenarios. However, the main challenges facing decision makers when confronted with an ill-structured problem environment is to devise compromise alternatives that reduce, if not eliminate, instances of conflict. The process of crafting compromise alternatives that, to varying degrees, trade-off elements of different party's interests and objectives is addressed using MCA methods in the following site evaluation section. Prior to this, a preliminary analysis of conflict in site selection can be obtained by examining the compatibility and frequency of the designations assigned to each land parcel. To illustrate, a parcel that has been designated for Protected Status by three individuals and for Open Space by another four participants could be expected to generate low levels of intra-group conflict given that both leave the land in a more or less unaltered state. On the other hand, more intense levels of conflict would result in the case of a debate centred on Protected versus Tourism assignments.

A more fundamental element of conflict in land use planning decision problems revolves around the question of whether a property should, or should not, be developed. This basic element of conflict is examined within the case study by grouping the land uses classes available to the participants into the dichotomous "development" (Tourism, Commercial, Residential) and "non-development" (Open Space and Protected) categories. In the absence of any information concerning the influence of different groups or individuals in the decision making process, the intensity of conflict for a given property can be seen as a function of both the number of participants involved (i.e. assigned a particular land use for the parcel) and the distribution of participants between the development and non-development land use classes. More specifically, conflict could be expected to be higher for locations that: a) interest larger numbers of participants, and b) have a relatively equal number of individuals or groups on each side of the debate. As the numbers of involved parties decreases and/or their distribution between, in this case, the two positions become less balanced, the polarity of the conflict should decline.

Figure 5.12 demonstrates how this interpretation of simple dual polarity conflict can be applied in a spatial context. A multiplicative conflict index, C, was calculated for each parcel in West Bay District by multiplying the total number of participants (development + non-development groups) interested in a specific parcel by the minimum number of participants in either of the two groups.

$$C = n^p * m^k$$

where: n is the number of participants involved (development + non-development groups)

p, k are scaling parameters

m is the minimum number of participants representing either position

With p and k set to 1 and m = eight participants, the conflict index ranges from 0 (e.g. all participants agree on a land use designation or left it unassigned) to a maximum value of 32 (e.g. 4 participants representing each viewpoint). The class breaks that are employed in Figure 5.12 are based on the minimum and maximum index values that could be attained by different sized participant sets within the case study environment. The lowest class (grey) contains all parcels that registered no conflict (i.e. all participants agreed on a designation) or a conflict index of 2 (i.e. 1 pro-development participant and 1 anti-development participant). The next class, shaded light red, was bounded by the minimum index score for 3 participants and the maximum score for four participants. Similarly, the medium red class represents the minimum index value for five participants and the maximum possible with 6 participants while the last class (dark red) accounts for all parcels where seven or eight participants were involved.

The structure of the case study planning task clearly influenced this conflict index as tourism was the only required land use and, unlike the optional land uses, the participants were instructed specifically to identify candidate accommodation sites. Notwithstanding this bias which may even contribute to underestimating potential conflict, an index of this type does provide a relatively simple means of encapsulating the core development versus non-development decisions made collectively by the participant group.

The intensity of disagreement among the participants concerning the future development of the Barkers peninsula is evident in Figure 5.12. The most intense conflict occurs along the northern shoreline that several participants had designated as suitable for tourist accommodation based largely on the sandy beachfront, the relative isolation of the area, and the low land costs relative to Seven Mile Beach. Other participants had expressed concerns about the fragility of the on- and off-shore ecosystems in this area and also the importance of the Barkers beachfront as open space for informal community recreation. As one moves away from this stretch of sandy shoreline, conflict over development declines largely because fewer pro-development votes were cast for these parcels. This is especially so in the case of the two parcels on which Sea Pond rests given the desire of most participants to protect this feature.

Mapping conflict scores or the number of selections that parcels receive for specific land uses like tourist accommodation or protected status provides some insight into the range of development futures that could be supported within a multi-participant planning context. The contributions that conventional GIS analyses can offer to complex planning problems such as site selection are, as discussed in Chapter Two, limited largely to producing short-lists of feasible locations based on deterministic overlay and logical selection methods. Candidate sites within these shortlists are typically subjected to more in-depth examination before the most promising site(s) are chosen for the activity in question.

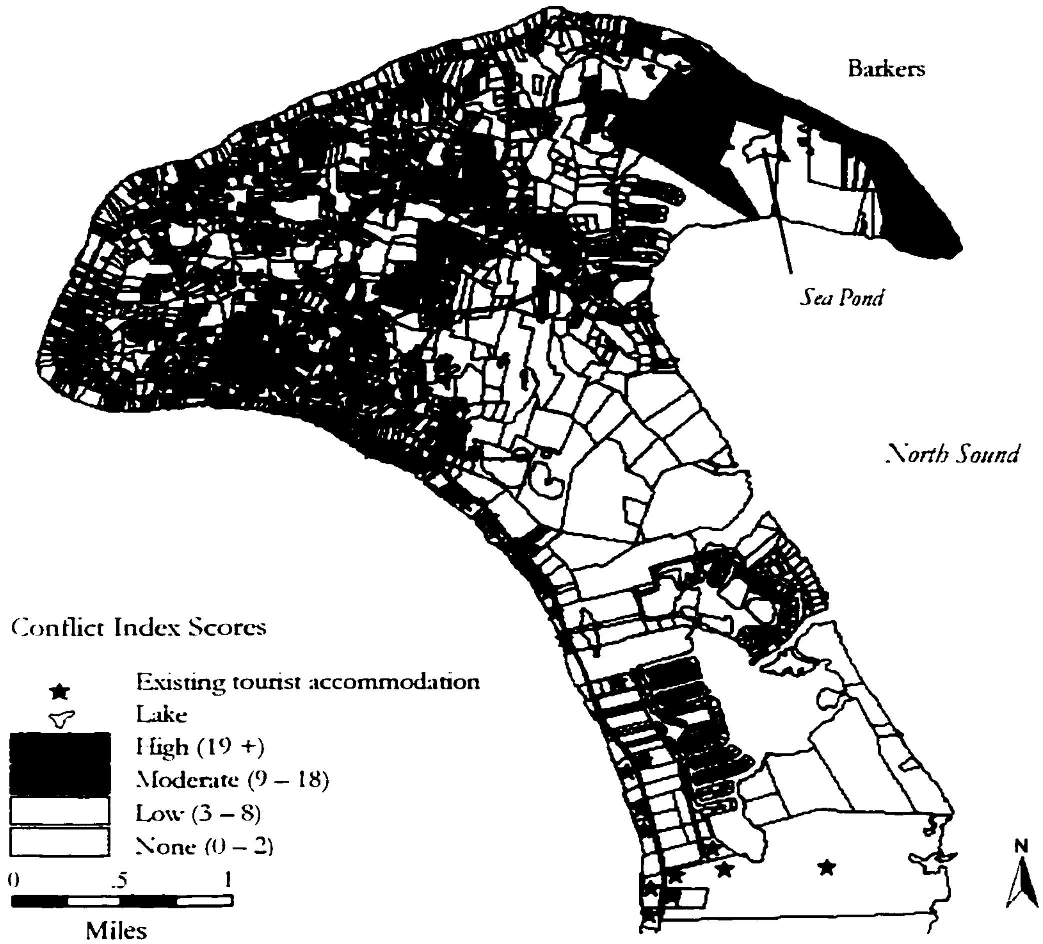

FIGURE 5.12 CONFLICT INDEX – DEVELOPMENT VERSUS NON-DEVELOPMENT

Even when customised GIS or SDSS provide mechanisms for integrating the outputs of multiple participants, at least two fundamental problems remain concerning their capacity to capture the intangible and value-based aspects of problem-solving. First, as discussed in Chapter Three, it is possible for these key elements of strategic-level decision making to be disregarded if "reverse adaptation" results in decision processes being altered to correspond to the capabilities of the available decision aids (Veregin, 1995, 97). Second, since the screening procedure used to produce short-lists of candidate sites is conjunctive and non-compensatory in nature, it is necessary to balance the costs of evaluating in detail a larger list of choice alternatives sites versus the risk of excluding viable alternatives (Arentze et al, 1996a, 127).

The implications of these shortcomings are particularly significant in light of the objective to produce compromise or consensual multi-party decisions. Massam (1993, 190) reviews four elements of the term consensus that are pertinent in the context examined in this thesis. First, it can indicate that the legitimacy of decision makers' actions are dependent upon their authority being accepted by the majority. Second, and of more direct relevant to the case study, consensus can be interpreted as agreement by a "sufficient number" of involved parties on the suitability of a location for a specific activity. This supports the use of the consensus and conflict mapping methods shown in Figures 5.11 and 5.12. Third, consensus can be viewed as agreement that the decision making process is both just and appropriate. Finally, consensus implies that the involved parties collectively accept and take responsibility for the outcomes of the decision process.

For the latter two aspects of consensus to be realised, the decision process must extend beyond the simple aggregation and manipulation of individuals' inputs, especially when these inputs are based almost solely on narrowly-defined technical criteria. Rather, opportunities must be provided for divergent planning objectives and priorities to be both included and debated if negotiated solutions are to be facilitated through technological means. The next chapter demonstrates how some of the MCA methods presented in Chapter Three can provide a mechanism for accommodating these needs into the multi-participant decision making process.

5.4 Summary

This chapter documented the processes that the case study participants employed to identify potential locations for additional tourist accommodation in West Bay District and, optionally, to designate areas for a limited number of other land uses. The scenario-building process was described with reference to three key facets of human-computer interaction and SDSS that are of particular relevance to decision contexts, such as SIS tourism and land use planning. These facets are: the participants' overall planning objectives and concerns, the translation of these objectives and concerns into informal decision rules compatible with available data and technological capabilities, and the software functionality that was used to operationalise their objectives.

Three broad areas of concern were identified by the participants in their stated objectives and in their land use designations: a) the feasibility of developing and operating specific land parcels for tourist accommodation, b) environmental protection, and c) community impacts. Participants that emphasised development feasibility adopted an inclusionary approach to the planning task generally, while those that were concerned primarily, or also, with environmental and community impacts used exclusionary methods to identify potential accommodation sites.

Next, the individual land use scenarios were aggregated to facilitate investigation of consensus and conflict across the participants' individual land use scenarios. Consensus on the suitability of individual land parcels for tourism was found to be highest along the western half of the north shore of West Bay District and into the Barkers peninsula and, to a lesser extent, on in the Seven Mile Beach area. The intensity and distribution of land use conflict was focused almost exclusively in the Barkers area as well. The degree of conflict was established by means of an index that related the number of times that the participants voted for development and non-development land uses on the study area land parcels.

Taken singularly or collectively, the analyses of intra-group consensus and conflict presented in this chapter provide instruments for concentrating evaluation efforts on those candidate sites that have the greatest potential for multi-participant support. The next chapter details the second stage of the case study research in which the participants apply selected MCA methods incorporated into *Tam*Plan to the task of ranking the suitability of a subset of candidate accommodation sites according to differentially weighted evaluation criteria.

Chapter Six

MULTI-CRITERIA, MULTI-PARTICIPANT TOURISM PLANNING: PART II - SITE EVALUATION

The preceding chapter examined the degree of commonality between participants in the objectives, selection criteria, and land use designations that defined their tourism site selection scenarios. This chapter applies the MCA component of *Tour*Plan to the subjective and intangible aspects of participants' selections. The analysis is focused on a subset of selected sites that represent development versus non-development conflict and the degree of selection consensus among participants.

The chapter comprises five sections. First, the methodology of the evaluation stage of the case study is described. Next, participants' individual and collective evaluation criteria, the weights assigned to each criterion, and the MCA method used are presented. The criteria sets are then applied to two sub-groups of candidate tourist accommodation sites that were identified in Chapter Five and the degree of similarity in each participant's rankings of the candidate sites is examined. The penultimate section of the chapter discusses the types of uncertainties that are most pertinent to the case study and investigates directly the influence of uncertainty in criteria weighting and MCA method choice. The chapter concludes with a brief discussion of the sites that would be expected to generate the least amount of intra-group conflict.

6.1 Methodology

The methodology followed in the site evaluation stage of the case study is, in many respects, similar to that of the preceding site selection discussion. For example, participant anonymity was maintained by holding separate *Tour*Plan evaluation sessions for each participant. Once again, no explicit time limits were imposed on each participant and each person was free either to operate the software themselves or direct the author to operate it on their behalf. Typically, logistical factors limited the evaluation sessions to between two to four hours in length with the extremes being one and one-half hours (Hotel Operator / Developer) and more than 5 and one-half hours (Deputy Director of Planning and the Director of Environment). The unfamiliarity of MCA methods to the study participants meant that most individuals did not elect to use the software directly themselves. Further, due to a significant family emergency, the Planner was forced to curtail his completion of the evaluation phase of the field work, rendering his results for this phase incomplete and reducing the number of site evaluations by one relative to the site selections discussed in the previous Chapter. It should be noted that the approach used for site evaluation in *Tour*Plan does allow site evaluations to be completed asynchronously. However, due to the limited time frame of the field research and the significance of the emergency, it was not possible for the planner to complete his input.

Before each remaining participant began their evaluation session, they were provided with both written and verbal explanations of the three MCA methods implemented within *TaoPlan* and the general procedures involved in the site evaluation stage of the case study. In addition, the evaluation criteria were described and any known limitations or assumptions that may have affected their use were noted. Each participant was then required to select an MCA method and to complete three main tasks: a) choose criteria from the available set to compare and evaluate candidate parcels, b) develop subjective weights that reflect the relative importance of each criterion in the evaluation process, and c) review the ranked candidate parcels. Participants could repeat the procedures as often as necessary using different criteria sets, refined criteria weights, and/or alternative MCA methods.

Logistical factors and the role proposed for MP-SDSS in the planning process had substantial impacts on the methodology used in the evaluation stage of the case study. It is important to note that during the preliminary intelligence gathering and site identification stage, the aim of the evaluation component was not to produce a final group ranking of the candidate tourist accommodation sites. Rather, the purpose of this stage was to gain insights into which sites were supported most widely and would be worthy of further investigation in subsequent rounds of analysis and debate. The intent, therefore, was to identify critical data needs, key participants or contributors to the decision making process, the degree of commonality in evaluation criteria choices and their relative importance, the appropriateness of different evaluation methods to the planning task, and a preliminary reading of potential solution strategies.

6.2 Specification of Evaluations

6.2.1 Choice of MCA Method

Each of the three MCA methods incorporated within *TaoPlan* differs in its applicability to specific decision problems and, also, to specific aspects of a particular decision problem. The discussion in Chapter Three outlined the relative advantages of these techniques as: computational simplicity and ease of learning (weighted summation or WS method), thorough pair-wise comparison of alternatives (net concordance discordance or NCD method), and support for both cardinal and ordinal data in the evaluation (subtractive summation method).

It was anticipated prior to the field research that some relevant ordinal- or interval-scaled data (e.g. marine and onshore habitat characteristics, approximate land prices, amenity values, composition of nearshore seabed, etc.) could be gathered directly from experts and agencies in the Cayman Islands and used in both stages of the case study. Unfortunately, however, this information could not be obtained due to confidentiality concerns (e.g. seasonal occupancy levels of specific resorts), a lack of spatial-referencing in some data sets, and time constraints that did not permit either the researcher or the experts in the participant group to assess factors such as scenic quality either for groups or for single land parcels in the study area. In the absence of these data types, no participants chose to use the subtractive summation method in their evaluations. Furthermore, the time limits mentioned above also did not permit the participants to apply either of the two remaining methods to their criteria set and contrast their results. This shortcoming is addressed in section 6.4.

The site evaluation method that each participant elected to use is listed in Table 6.1. In almost all cases, the participants who chose the weighted summation method stated that they found its underlying concepts easier to understand than either of the two other methods. Those that opted for the NCD method either indicated that they preferred the more comprehensive comparison of alternatives or expressed concern with the multiplicative nature of combining individual criterion weights and scores with the WS technique.

Participant	Evaluation Method
Director of Environment	Net Concordance - Discordance (NCD)
Natural Trust Scientist	Net Concordance - Discordance (NCD)
Real Estate Developer	Weighted summation (WS)
Hotel Operator/ Developer	Weighted summation (WS)
Business Owner	Weighted summation (WS)
CPA Member	Weighted summation (WS)
Deputy Director of Planning	Net Concordance - Discordance (NCD)

TABLE 6.1 CHOICE OF MCA METHOD

6.2.2 Evaluation Criteria

The previous section noted why some potentially useful evaluation criteria that are typically measured on ordinal or interval scales were not available for the case study. These factors, which were discussed for the general Caribbean SIS context in Chapter Two and specifically for the Cayman Island context in Chapter Four, also had a substantial impact on the stock of ratio-scaled data that could be used to judge the relative suitability of the candidate sites. Consequently, most of the criteria that the participants employed in their evaluations were generated directly by the researcher. Table 6.2 lists abbreviated criterion names, brief descriptions, and data sources for the each evaluation criterion available to the case study participants.

Criterion Name	Description	Data source
Acres	Size of parcel in acres	Cadastral map layers
D2Hotel	Distance from parcel to nearest hotel, condominium, or guest house	Calculated using accommodation map layer
D2Mangrove	Distance from parcel to nearest mangroves	Calculated using coastline map layer
D2Marine	Distance from parcel to nearest marine park	Calculated using marine parks map layer
D2PrimRd	Distance from parcel to nearest primary road	Calculated using road network map layer
D2Reef	Distance from parcel to nearest reef	Calculated using coastline map layer
D2Replent	Distance from parcel to nearest replenishment zone	Calculated using marine parks map layer
D2Rock	Distance from parcel to nearest ironshore coastline	Calculated using coastline map layer
D2Sand	Distance from parcel to nearest sand coastline	Calculated using coastline map layer
D2SeaPond	Distance from parcel to Sea Pond	Calculated using coastline map layer
D2SecRd	Distance from parcel to nearest secondary road	Calculated using road network map layer
D2Shop	Distance from parcel to nearest commercial zone (shops, restaurants, services)	Calculated from 1995 zoning map layer
D2Tourzone	Distance from parcel to nearest parcel zoned for Hotel/Tourism	Calculated from 1995 zoning map layer
D2Wetland	Distance from parcel to nearest wetland	Calculated using wetlands map layer
NumSelect	Number of participants that designated the parcel as a potential accommodation site	Aggregated from the individual site selection scenarios
Vacant	Indicator if any structures were found on parcel	Based on 1994 air photographs
Waterfront	Length of water frontage	Cadastral map layers

TABLE 6.2 AVAILABLE CASE STUDY EVALUATION CRITERIA

All of the proximity-related criteria listed in Table 6.2 were calculated within the *Tan*Plan tool and represent the shortest straight-line distance in feet between any point on the perimeter of a given candidate parcel and any feature in a second map layer of interest. Different subsets of features from a single map layer (e.g. road network) were used in several cases to determine the values for several individual criteria (e.g. D2PrimRd, D2SecRd). With the exception of the D2Reef criterion, the minimum criterion value of zero was assigned if the parcel in question either contained or was adjacent to a feature in the second map layer. Hence, a candidate site that fronted directly onto a sandy beach and was zoned for Hotel/Tourism in the Development Plan would have a value of zero recorded for both the D2Sand and D2TourZone criteria.

When Table 6.2 is viewed in light of a distinction between site and situation (Couclelis, 1991, 15), it is apparent that the case study criteria set represents the latter to a greater extent than the former. Clearly, this list of criteria is not exhaustive nor is it claimed that these are necessarily the most appropriate criteria to include in other multi-participant planning studies that involve site selection and evaluation. However, in the context of this case study, these criteria do provide useful proxies for several key aspects of a land parcel's suitability as a site for tourist accommodation. Development potential, for example, is influenced by parcel size (Acres), the parcel's zoning and the zoning of surrounding parcels (D2TourZone), proximity to major roads (D2PriRd), whether the site is undeveloped (Vacant), how widely supported development is for that parcel (NumSelect), and so on. The attractiveness of a location to tourists and, hence, its economic viability as a hotel or condominium site is affected by factors such as proximity to the shops, restaurants, and services demanded by tourists (D2Shop), how close the site is to a sandy beach (D2Sand), and if the site is located near other accommodation or is more secluded (D2Hotel). Finally, some sense of development impacts can be inferred from parcel size (Acres) and its proximity to sensitive onshore, nearshore, and offshore environments (D2Mangrove, D2SeaPond, D2Wetland, D2Replent, D2Marine, D2Reef).

The case study participants were required to select at least two of the criteria listed in Table 6.2 for use in their evaluations. Criteria that were not selected were assumed explicitly to be of no significance in the participant's decision making processes and were assigned a value of zero in the subsequent criteria weighting procedures. The participants were also required to complete two other tasks to facilitate the data normalisation process that scales criteria data values on a common 0 to 1 range: a) designate "cost" and "benefit" criteria and, b) determine the practical bounds of data values for each criterion. The first task involved indicating for each criterion whether high data values would contribute to the relative attractiveness of a site (i.e. a maximising or 'benefit' criterion) or detract from it (i.e. a minimising or 'cost' criterion). For example, a participant interested in beachfront hotel sites would designate D2Sand as a cost criterion in order to favour candidate sites with low D2Sand values (i.e. close to a sand beach) over other sites that would not offer the same advantages. In contrast, a person concerned with the negative impacts of nearshore development would designate D2Sand as a benefit in order to favour sites that are either located inland or on ironshore. The participant's criteria selections and cost/benefit designations are listed in Table 6.3

Table 6.3 illustrates one element of consensus and conflict in multi-participant decision making that was discussed in Chapter Two, namely the extent of agreement concerning which criteria should be used to judge the suitability of alternatives. At the group level, the most frequently selected criteria were: Acres and D2Shop (6 participants each), D2Sand (5 participants), and D2TourZone and Waterfront (four participants each). There were also relatively strong levels of agreement on the criteria that would be less useful in the site evaluation process. NumSelect and D2SecRd, for instance, were chosen by only one person each while D2Reef and D2Hotel were selected by two individuals. The fact that only one participant chose the NumSelect criterion is somewhat surprising, given the case study's focus on multi-party consensus-building. The lack of interest in D2SecRd can be accounted for in terms of its overlap with the D2PrimRd criterion. Three participants (Director of Environment, National Trust Scientist, and Deputy Director of Planning) noted that the map layer available at the time from the C.I. government LIS that was used for D2Reef calculations failed to include several important, but smaller, reefs off of the north-eastern shore of the West Bay District. Due to this problem, the Director of Environment chose not to include the D2Reef criterion despite an acknowledgement of the significance of this factor in her decision making processes.

Criterion	Director of Environment	National Trust Scientist	Real Estate /Developer	Hotel Operator /Developer	Business Owner	CPA Member	Deputy Director of Planning
Acres	Benefit		Benefit	Benefit	Benefit	Benefit	Cost
D2Hotel			Benefit				Cost
D2Mangrove	Benefit	Benefit					Benefit
D2Marine	Benefit	Benefit					
D2PrimRd		Cost				Cost	Benefit
D2Reef		Benefit					Benefit
D2Replent	Benefit	Benefit					Benefit
D2Rock	Benefit	Benefit			Cost		
D2Sand	Cost		Cost	Cost	Cost	Cost	
D2SeaPond		Benefit			Benefit		
D2SecRd	Cost						
D2Shop	Cost		Cost	Cost	Cost	Cost	Cost
D2Tourzone	Cost			Cost	Cost		Cost
D2Wetland	Benefit	Benefit					
NumSelect							Benefit
Vacant	Cost		Cost				Cost
Waterfront	Cost			Benefit		Benefit	Benefit

Note: Higher data values are preferred for Benefit criteria, lower data values are preferred for criteria designated as Costs.

TABLE 6.3 EVALUATION CRITERIA CHOICES

The criteria choices shown in Table 6.3 mirror, to a large extent, the distinction between the inclusive and exclusive selection approaches observed in the first stage of the case study. The National Trust Scientist, Director of Environment and the Deputy Director of Planning all expressed concerns about the ecological and social impacts of constructing further tourism accommodation in West Bay, while at the same time recognising the employment opportunities such development could provide to local residents (Table 5.1). Of the three participants, the National Trust Scientist chose the highest proportion of criteria that can be interpreted as representing the environmental impacts of development. The Director of Environment and particularly the Deputy Director of Planning supplemented this environmental emphasis with criteria that capture elements of the potential attractiveness of a site to tourists (D2Shop), the feasibility of developing the site for tourism uses (D2TourZone, Acres, Vacant), and the impact of tourism development on the District's urban form (D2Hotel). In contrast, the four remaining participants chose fewer criteria and limited their focus almost exclusively to criteria that address a site's development potential and attractiveness to tourists. The concern of the Business Owner to buffer Sea Pond from development provided one exception to this general pattern.

The second data normalisation task required participants to determine whether criterion data values should be scaled relative to calculated minima and/or maxima or whether user-specified values should be substituted into the scaling process. Participants could adopt the latter approach for a given criterion in order to recognise that there are practical limits beyond which no further benefit or cost is realised (Massam, 1988, 34). For example, a person will walk a finite distance to reach a sand beach and all beaches beyond that threshold are considered "far away". From a technical perspective, fuzzy set membership functions provide an attractive means of incorporating these effects into the standardisation process (Lin et al, 1997, 412). However, requiring the participants to select a membership function for each criterion and then provide the necessary parameter values for that function would have demanded considerably more time than each participant could devote to the case study.

Consequently, a simpler approach was adopted whereby participants were asked to indicate practical minimum and maximum data values for each criterion that would be used in a modified normalisation process. This approach was considered necessary due to: i) the number of distance-based criteria in the case study, ii) the lack of correspondence between functional limits on the influence of these criteria in the decision process and their respective calculated range of data values, and iii) the skew for the Acres criterion created by the 279 acre Hyatt Regency property.

To illustrate, the Real Estate / Developer determined that the walking threshold of the "average" tourist with respect to a sand beach was 1000 feet instead of the calculated maximum D2Sand value of 5185 feet. Assuming that lower D2Sand values were preferred (i.e. a "cost" criterion), 1000 was substituted into the standardisation procedure in place of the actual maximum. Thus, in this case, the site closest to a sand beach would receive the highest standardised score of 1 and all candidate sites beyond the user-specified limit of 1000 would have a standardised score of 0 (Figure 6.1 A).

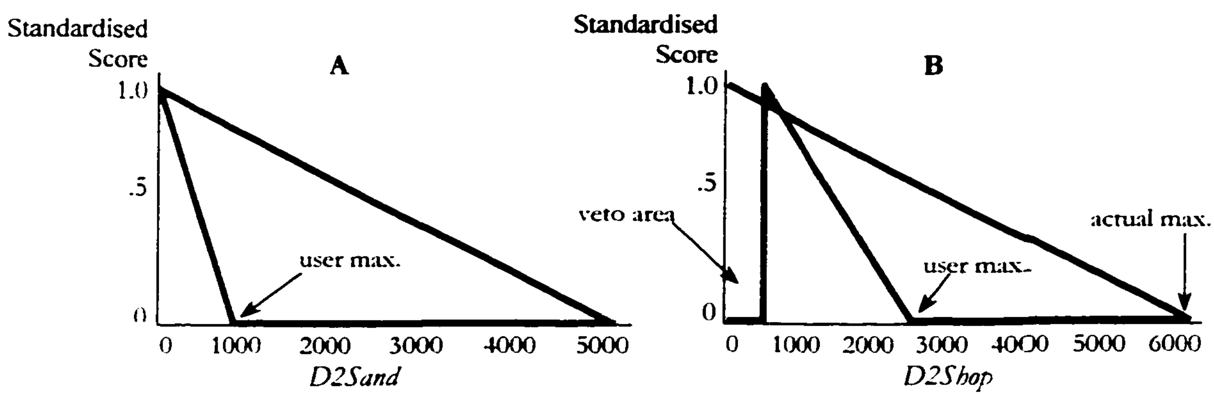

FIGURE 6.1 EXAMPLES OF USER MAXIMUMS IN DATA STANDARDISATION

Further, participants could indicate a "veto" point before which a criterion made no contribution to the attractiveness of a potential site. This was particularly relevant for criteria where the participant valued proximity to a given attraction (i.e. "cost" criterion) but also valued a minimum amount of separation to account for undesirable externalities. For example, the CPA Member preferred candidate sites that were within walking distance (½ mile) of potential shopping attractions (D2Shop), but also stipulated a minimum separation of 500 feet due to the noise, amenity, and congestion effects associated with shopping centres. Based on this input, candidate sites within 500 feet of a commercial zone received a standardised score of zero, the site closest to the 500 foot veto point was awarded the highest standardised score of 1, and all remaining D2Shop values were scaled from the veto point to the ½ mile maximum (Figure 6.1 B).

Table 6.4 lists the criteria employed for user-specified minima, maxima, and/or veto points as well as the rationale provided for these settings. All values in the table are in feet, with the exception of the Acres criterion. Any criteria that are not listed in the table for a given participant were standardised using the actual minimum and maximum data values found in the case study data sets.

Considering that all evaluations were conducted independently and the diversity of the participant's backgrounds and objectives, a fair degree of consistency is evident in the parameters and the supporting rationale supplied by the participants. Minimum site size, for example, ranged from a high of 2.5 acres to a low of .5 acres (minimum hotel site size in The Cayman Islands Development Plan) and three of five persons did not indicate an upper limit on site size. Further, four participants specified a ceiling on D2Shop values ranging from ¼ mile to 1500 feet based on what they thought that tourists would see as a reasonable walking distance to shopping attractions.

6.2.3 Criteria Weights

Once their criteria set had been established, each participant chose either the seven-point scale or pair-wise comparison method to develop their criteria preferences. From a practical perspective, the usefulness of different criteria weighting methods is determined to a large degree by the amount of time required to complete the procedure and the cognitive demands the method places on a user (Voogd, 1983, 315). In his study, which involved over 300 participants disaggregated by profession, Voogd (1983) found the seven point scale method performed better than pair-wise comparison and three other weighting methods in terms of time requirements and ease-of-use. However, divergent opinions concerning the ease-of-use and understanding of the pair-wise comparison method are evident in the literature. Some researchers, including Massam (1993, 65), note that subjects are more likely and able to compare criteria on a pair-wise basis. Other researchers report difficulties relating pair-wise criteria assessments to the wider criteria set (Voogd, 1983, 316).

Participant	Criteria	Actual Min.	User Min.	Actual Max.	User Max.	Veto Point	Rationale
Dir. of Environment	D2shop	0	0	6216	1320		¼ mile = maximum "reasonable walking limit" to shops
	D2Mangrove	53	300	13602	1000	300	300 ft. = vegetation line, no additional benefit after 1000 feet
	D2Marine	0	200	5650	300	200	No development within 200 feet, after 300 feet no added benefit
	D2Replent	0	200	9969	300	200	As above
	D2Wetland	0	200	14391	750	200	No development within 200 feet, no added benefit after 750 feet
National Trust Scientist	D2Mangrove	53	300	13602	5280	300	No development within 300 feet, no added benefit after 1 mile
	D2SeaPond	3889	300	17450	5280	300	As above
	D2Wetland	0	300	14391	5280	300	As above
Real Estate / Developer	Acres	1	2	279			Minimum of 2 acre site desired for hotel services & facilities
	D2Sand	0	0	5185	1000		1000 feet is farthest that tourists will walk to a sand beach
Hotel Oper./ Developer	Acres	1	2.5	279			2.5 acres is minimum preferred site size, no maximum size
	D2Tourzone	0	0	9022	10 *		Only considering sites that are currently zoned for tourism
	Waterfront	0	200	6217			At least 200 feet of water frontage required for aesthetics, activities
Business Owner	Acres	1	.5	279			Minimum ½ acre site satisfactory, no maximum size
	D2Sand	0	0	5185	500		Want site on a sand beach or at least across the road from one
	D2SeaPond	3889	100	13602	2000	100	No development within 100 feet, all sites >2000 feet are equally attractive
	D2shop	0	0	6216	1000		1000 feet is the maximum distance that tourists will walk to shops
CPA Member	Acres	1	.5	279	100		Min. site size of ½ acre, no additional benefit beyond 100 acres
	D2PrimRd	5.9	0	5310	5280		Want to be within 1 mile of a primary road and associated services
	D2Sand	0	0	5185	2640		If site is more ½ mile from a sand beach, tourists require transport
	D2Shop	0	0	6216	2640	500	Prefer sites close to shopping but beyond 500 veto due to undesirable externalities, tourists need transport to get to sites >½ mile distant
	Waterfront	0	100	6217	500		At least 100 feet of water frontage needed, no further benefit beyond 500 ft.
Deputy Dir. of Planning	Acres	1	.5	279	3		Preferred site size of ½ acre, maximum size of 3 acres (acres = cost)
	D2Hotel	0	0	4273	1320		Want to cluster accommodation within ¼ mile due to service concerns
	D2Mangrove	53	50	13602	1000	50	No development within 50 feet, no added benefit received beyond 1000 feet
	D2PrimRd	5.9	0	5310	660		Want to be within 1/8 mile of hard services along primary road
	D2Reef	1274	1000	20448	1500	1000	sites between 1000 and 1500 feet from reefs discourage daily use but still allow less frequent use
	D2Shop	0	0	6216	1500		1500 feet is the farthest tourists are likely to walk to shops before using a car
	D2TourZone	0	0	9022	10 *		Want all accommodation development on parcels zoned for tourism

Notes: 1. Data values are rounded. 2. * indicates a User Maximum value of 0 feet was specified. The researcher substituted a value of 10 to account for possible errors in the spatial data sets. 3. Criteria not listed in the table for a given participant were standardised using the actual minimum and maximum data values found in the case study data sets.

TABLE 6.4 USER-SPECIFIED DATA STANDARDISATION PARAMETERS

The choice of weighting method in this study supports both perspectives. Four participants (Hotel Operator / Developer, Business Owner, CPA Member, Real Estate / Developer) elected to generate their criteria weights using a seven-point scale and cited either the simplicity of the technique or its lower time demands as the basis for their choice. In contrast, the Deputy Director of Planning and the Director of Environment opted for pair-wise comparisons because of its comprehensiveness in comparing criteria and its more rigorous mathematical structures. The National Trust Scientist favoured the pair-wise comparison method for these reasons as well, but elected to use the seven-point technique due to time constraints. Participants who used the seven-point method required between twenty to forty-five minutes to generate an initial set of criteria weights and any subsequent revisions typically involved relatively quick adjustments to the relative importance of one or two criteria. No participants opted to change weighting methods during their evaluation session.

The Deputy Director of Planning and the Director of Environment both spent approximately two and one-half to three hours each for this task and directed more cognitive effort to the criteria weighting process than the other participants. Three factors contributed to the increased time requirements. First, the methodology of the technique demands that the participant make $\frac{1}{2} * (n (n-1))$ criterion-by-criterion comparisons while methods such as the seven-point scale and direct rating (e.g. distributing a budget of 100 points among the criteria) require only the relative importance of each criterion to be considered. Second, since the Deputy Director of Planning and Director of Environment chose to include substantially more criteria in their evaluation sessions than any of the other participants, the method-induced time requirements were increased. This problem is alleviated in the AHP (Analytical Hierarchy Process) family of methods by organising evaluation criteria into several thematic hierarchies – a process which can itself introduce conflict in group contexts if perceptions of the decision problem vary substantially (Saaty, 1989, 61). Third, both participants experienced difficulty and, consequently, spent more time establishing a basis for comparing some criteria pairs. Despite the technique's demands and the large number of criteria involved, the initial pair-wise comparisons made by both participants required few adjustments to satisfy Saaty's (1977) recommended .10 consistency index threshold.

The criteria weights derived by the participants are illustrated below in graphical (Figure 6.2) and tabular formats (Table 6.5). Despite the differences in the participants' selected criteria sets and metric weighting values, the ordinal criteria rankings provide some indication of which factors were considered most and least important by the participants. Proximity to a sand beach and to an area zoned for tourism were rated as the most important or second most important factors by four participants each, once tied weight values are accounted for (D2Sand: CPA Member, Real Estate / Developer, Hotel Operator / Developer, Business Owner, D2TourZone: Hotel Operator / Developer, Business Owner, Deputy Director of Planning, Director of Environment).

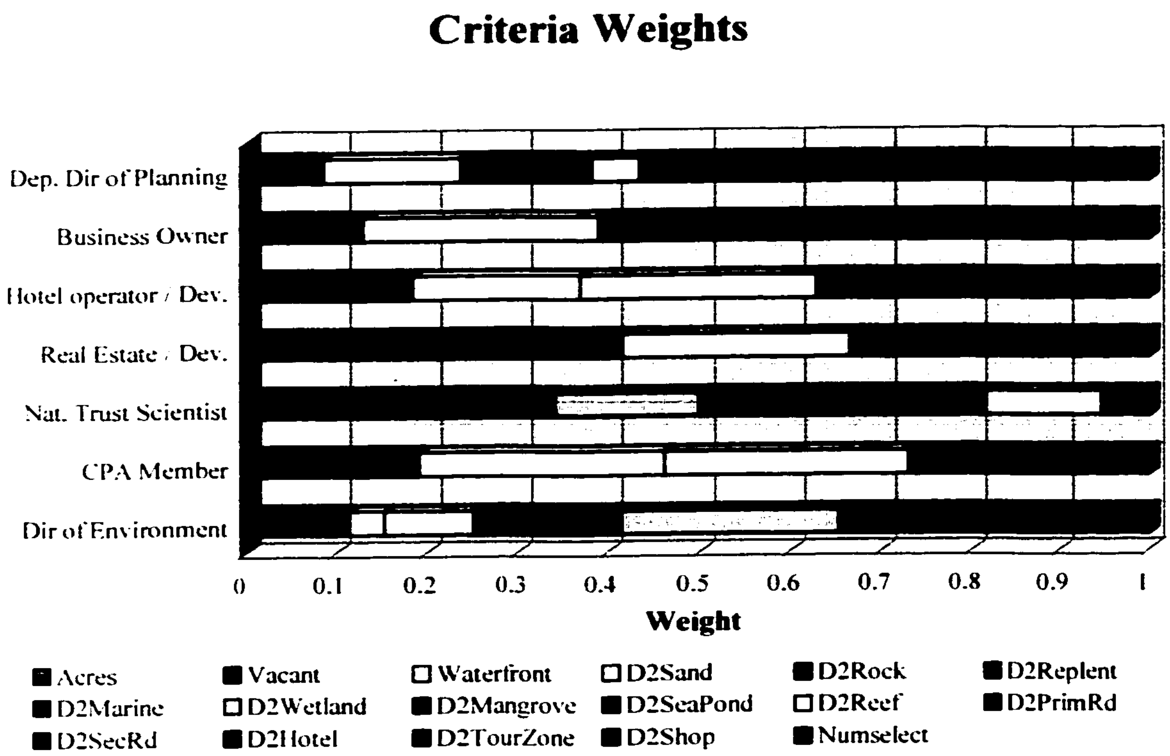

FIGURE 6.2 EVALUATION CRITERIA WEIGHTINGS

Moreover, the ordinals reflect, to a significant degree, the relative weightings that would be anticipated from the three participant subgroups identified *a priori*. The pro-conservation subgroup, for example, emphasised environmental factors most (D2Wetland, D2SeaPond) and regulatory influences for containing development within specific locales (D2TourZone) and placed less significance on factors relating to economic feasibility of development (D2Shop, D2PrimRd, D2SecRd, Acres). In contrast, the factors related to development potential and operating viability (D2Sand, D2TourZone, Acres, Vacant) were given the most weight by the pro-development group while environmental impacts lacked almost any representation in their criteria sets. Moreover, Table 6.4 illustrates that the criteria choices and weightings made by the CPA Member are quite closely aligned with the pro-development group. Consequently, given the loss of the Planner at this stage of the case study, the "neutral" viewpoint that seeks to balance pro-development and pro-conservation interests was represented only by the Deputy Director of Planning and the CPA member.

	Director of Environment	National Trust Scientist	Real Estate /Developer	Hotel Operator /Developer	Business Owner	CPA Member	Deputy Director of Planning
Acres	0.075367	0	0.166667	0.185185	0.130435	0.192308	0.051478
D2Hotel	0	0	0.166667	0	0	0	0.099735
D2Mangrove	0.143221	0.131579	0	0	0	0	0.120503
D2Marine	0.040849	0.131579	0	0	0	0	0
D2PrimRd	0	0.052632	0	0	0	0.115385	0.123595
D2Reef	0	0.131579	0	0	0	0	0.05236
D2Replent	0.044319	0.105263	0	0	0	0	0.025511
D2Rock	0.078903	0.105263	0	0	0.086957	0	0
D2Sand	0.096823	0	0.25	0.259259	0.26087	0.269231	0
D2SeaPond	0	0.184211	0	0	0.130435	0	0
D2SecRd	0.034237	0	0	0	0	0	0
D2Shop	0.019675	0	0.166667	0.111111	0.086957	0.153846	0.070991
D2Tourzone	0.148688	0	0	0.259259	0.304348	0	0.201688
D2Wetland	0.239397	0.157895	0	0	0	0	0
NumSelect	0	0	0	0	0	0	0.068527
Vacant	0.039633	0	0.25	0	0	0	0.035312
Waterfront	0.038864	0	0	0.185185	0	0.269231	0.150301

Note: Criteria weights may not sum exactly to 1.0 due to rounding

TABLE 6.5 EVALUATION CRITERIA WEIGHTINGS

Two factors influence the criteria weights shown in Table 6.5. First, the importance of a given criterion as a standard to judge the suitability of different options depends to a large extent on the range of the scores for that criterion in the choice set (Voogd, 1983, 315). For example, a criterion that would usually be assigned a high weight should have its relative importance in the decision making process reduced if it is discovered that all of the alternatives under consideration have similar scores for that indicator. A generic dialog for displaying simple descriptive-statistics on any data field is incorporated into the *Tan*Plan GUI. However, few participants took advantage of this during the weighting process since this required that they execute an additional menu step that was external to the MCA Assistant. This most likely impacted on the significance attached to the D2PrimRd, D2SecRd and Vacant criteria since there was little difference in the distance from any candidate parcel to a road and almost all of these sites were undeveloped.

Second, it is important to recall that criteria weights are only approximations of an individual's priorities and, as such, they can vary with time, the set of criteria available, and with respect to a specific set of choice alternatives (Jankowski, 1989, 354). All of these factors are acknowledged in this thesis but the last consideration in particular is set aside in the following discussion for the purposes of testing the methodology. The issue of available criteria for the case study was mentioned earlier to aid the interpretation of the weights in Table 6.5 and the forthcoming results discussion.

6.3 Discussion of Site Ranking Results

In this section, the weights and criteria choices listed in Tables 6.3 and 6.5 are applied to two sets of candidate sites and the discussion of the resultant rankings are aided by map and tabular outputs. The first set of candidate sites includes 242 sites in total and represents the complete group of land parcels for which the study participants derived their criteria selections and weight settings during the field research. The only conditions that had to be satisfied for a parcel to be included in this set were: a) an area of .5 acres or greater to recognise the minimum parcel size permitted for hotels in the 1977 and 1997 National Development Plans and, b) it had to be designated by at least one study participant as suitable for tourist accommodation (e.g. NumSelect criteria of 1 or greater). The second set of sites is a subset of the first and includes 53 candidate parcels. This subset is based on the discussion in Chapter Five concerning selection consensus and development-non-development conflict.

Given the role suggested in this thesis for MP-SDSS tools such as *Taro*Plan, the discussion of both sets of sites deals primarily with the similarities and differences in the spatial patterns of the participants' rankings. The maps that portray these patterns are based on a six category, equal interval classification scheme that is symbolised using progressively darker shades of red to signify increasing preference (higher ranks), with the exception of the highest ranked sites which are shaded dark green in order to aid the visualisation process. Approximately the same number of candidate sites are included in each class, however, tied ranks did cause some deviations from this rule. Comparatively less attention is directed to detailed examination of the rankings of individual parcels. Despite the emphasis in the following discussion on the resultant patterns of rankings, it should be noted that the task of producing "final" rankings of much smaller sets of choice alternatives (e.g. less than 12 sites) can be supported by the methods employed in this chapter as the planning generation process becomes more refined over time.

6.3.1 Initial Results – 242 Candidate Sites

The 242 unique candidate sites identified from the site selection process proved to be considerably larger than had been anticipated prior to the field research. This can be attributed to: a) the emphasis in the study design on identifying potential instead of most preferred sites, b) the range of interests and planning objectives represented in the participant group, c) the lack of constraints on the participants' site choices or on the type of tourist accommodation the participants could elect to locate, and d) the long-range time horizon of the planning task.

Generally, 242 alternatives is considered excessive for a detailed evaluation and, consequently, is atypical of land-related applications of MCA reported in the literature. For example, while Malczewski et al (1997) investigated environmental conflict in 32 regions in Mexico and Janssen and van Herwijnen (1991) examined the suitability of 118 regions in the Netherlands for agricultural and non-agricultural land uses, studies involving fewer than 20 alternatives are more common (e.g. Jankowski and Richard (1994); Massam (1991)). Hence, the secondary purpose of the field work, namely to collect data needed to support *post hoc* analysis, was elevated in importance.

However, even a cursory examination of this large subset of selected sites provides some insight into the applicability of MCA methods for classifying large numbers of alternatives into broad categories of acceptability during the early stages of intelligence gathering and plan formation. It is conceivable that such a situation could arise if: a) an inadequate number of filtering criteria are available or acceptable to the group(s) involved and this causes dominated alternatives generated at the selection stage to remain in the evaluation stage, and b) there is a desire, due to political factors or other considerations, to include the contributions of all individuals or groups from the preceding site selection stage at least for an initial round of evaluation. For example, only one participant (Deputy Director of Planning) designated any inland parcels for potential tourist accommodation sites although, as the following discussion indicates, these parcels were ranked moderately-high to high by several other participants in the case study.

It is more likely that, even during the initial stages of plan formation, the vast majority of MCA-based evaluations will be conducted on much smaller groups of alternatives. It was demonstrated in Chapter Five that simple lexicographic means can reduce large sets of alternatives easily to a number more amenable to multi-party examination. Place names and environmental features relevant to both sets of candidate sites are illustrated in the general context map below (Figure 6.3).

Both pro-environment participants share a concern to direct future development, whether tourism-related or not, away from fragile wetland, mangrove, and marine environments. The most preferred sites for the Director of Environment are found in three areas: a) along the heavily developed Seven Mile Beach road and the southern extent of Governor's Harbour, b) a small group of properties near the small sand beach that is close to the Magnificent Dive Dump (Boatswains Point), and c) the western-most interior properties originally identified by the Deputy Director of Planning in the preceding site selection stage. Properties close to mangroves (i.e. North Sound shoreline, Salt Creek and islands in Governor's Harbour) and/or the Barkers wetland comprise the least preferred group of sites (Figure 6.3).

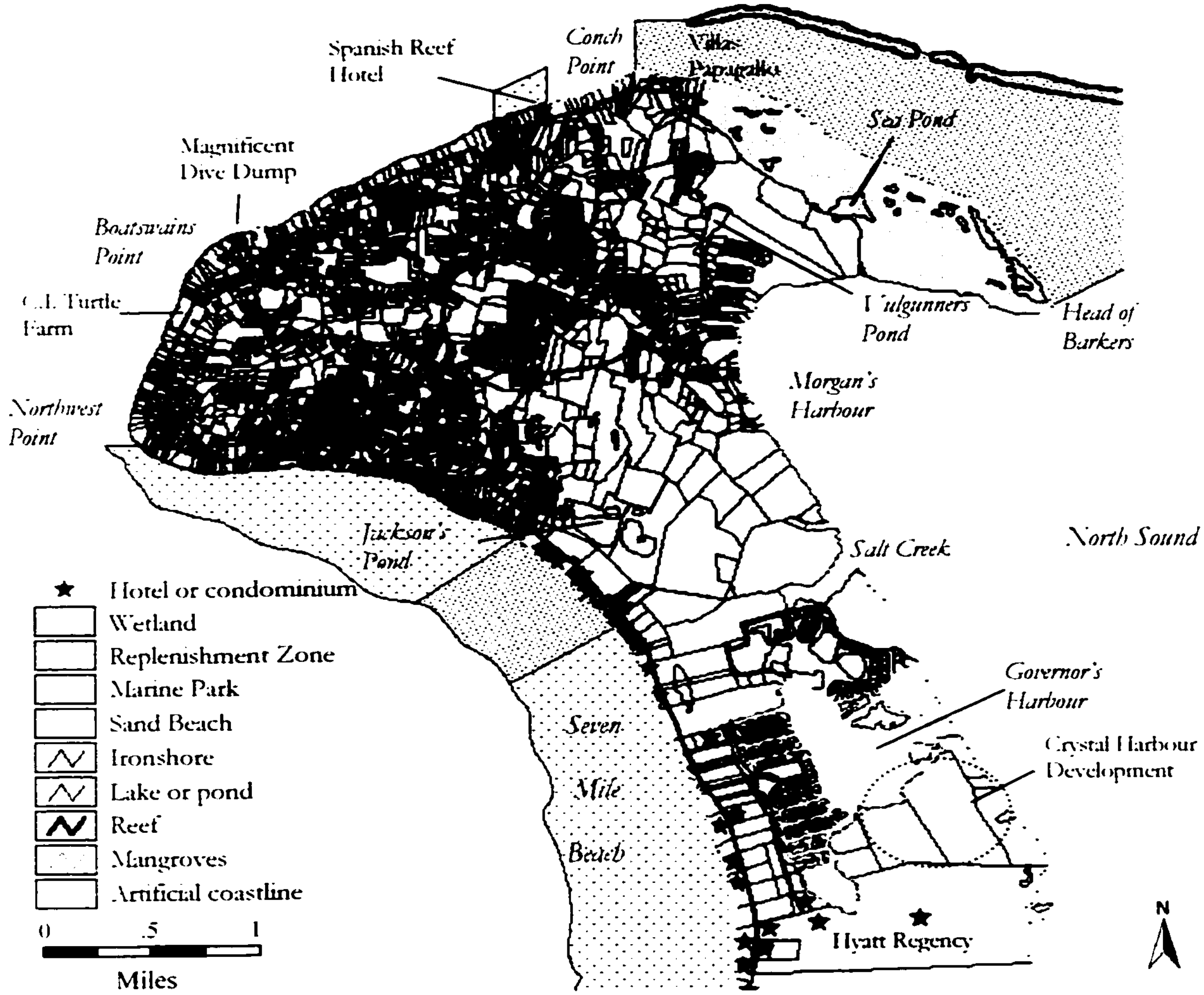

FIGURE 6.3 CONTEXT MAP FOR WEST BAY DISTRICT

6.3.1.1 Pro-Environment Group – National Trust Scientist and Director of Environment

A central objective of the National Trust Scientist was to exclude tourist development in close proximity to Sea Pond, and the Marine Park, Replenishment Zones and reefs to the north and north-east of the Villas Papagallo (see Figure 6.3). This desire was evident in the rankings, as sites in the immediate vicinity of these features were the least preferred as locations for new tourist accommodation. A gradation of preference was evident to the east, west, or south from the Sea Pond / Barkers area. The most highly ranked sites are, in turn, clustered primarily along the west coast of West Bay from North West Point to the Magnificent Dive Dump. Highly ranked sites are found in the southern extent of the Seven Mile Beach / Governor's Harbour area as well but the concentration is less pronounced than in the case of the Director of Environment. Had the small reefs offshore of the Magnificent Dive Dump been included in the reefs map layer, it is likely that the maps for the two pro-environment participants would be more closely aligned.

6.3.1.2 Pro-Development Group – Business Owner, Hotel Operator / Developer, and Real Estate / Developer

The similarities in the planning objectives, choice of criteria and criteria weightings among the members of the pro-development group were noted in Chapter Five and in the previous section of this chapter. For example, all three individuals assigned relatively high degrees of importance to Acres and D2Sand criteria but differed somewhat in the case of the common D2Shop criterion. Moreover, the Hotel Operator / Developer and the Business Owner included the D2TourZone criterion in their evaluations and associated a high weight to it while the Real Estate / Developer excluded zoning from consideration. The effects of the differences in criteria choices and weightings (see Tables 6.3 and 6.5) were evident in the site ranking patterns.

The highest degree of spatial similarity within the subgroup is found between the Business Owner and the Hotel Operator / Developer. Both assigned the highest ranks to the large parcels in the Seven Mile Beach area and also favoured properties along the northern coast of the District between Spanish Reef Hotel and the Villas Papagallo. However, their sets of most highly ranked parcels did differ noticeably with respect to the two largest candidate sites in the contentious Barkers area due to the Business Owner's concern for buffering Sea Pond from development. At the opposite end of the spectrum and in direct contrast to the rankings of the pro-environment subgroup, properties along the north-western shore between North West Point and the Magnificent Dive Dump were ranked in the lowest two classes by both the Hotel Operator / Developer and the Business Owner.

The rankings of the Real Estate / Developer deviate noticeably from the two other participants that were designated on an *a priori* basis as pro-development. In particular, the most preferred class of parcels is less concentrated spatially than that of any other case study participant. The high degree of importance that was assigned to the D2Shop and Vacant criteria and the exclusion of zoning as a factor in the evaluation can account for this pattern to a large degree. The clusters of highly ranked candidate sites near Morgan's Harbour, Boatswains Point, and Seven Mile Beach are all in close proximity to the commercial land use zones which were used as a proxy for shopping facility locations. The groupings of highly ranked parcels near the eastern extreme of Barkers and on the south-eastern limit of Governor's Harbour are generally above average in size, vacant, close to or on a sand beach and are relatively far from other hotels (D2Hotel).

6.3.1.3 Neutral Group – CPA Member and Deputy Director of Planning

The discussion in section 6.2 suggested that the two remaining members of the neutral subgroup were sufficiently dissimilar in their criteria choices and weightings that it may be questionable to consider them as comprising a subgroup at all. This supposition is verified upon review of their respective rankings. In fact, the CPA Member's criteria settings and method selections most closely resembled those of the Hotel Operator / Developer with the exception of the zoning criterion which, interestingly, the former elected not to employ despite being involved directly in zoning-related decision making on a regular basis.

The similarities between the CPA Member and the pro-development group members were particularly apparent with respect to the highest ranked class of candidate sites which is composed primarily of the larger parcels in the Seven Mile Beach / Governor's Harbour vicinity. A secondary concentration exists around Morgan's Harbour and extends northward to include a single highly-ranked parcel in Barkers as well. Sites that have little or no water frontage (Waterfront), are distant from sand beaches (D2Sand), are far from commercial zones (D2Shop), or are small in size (Acres) were ranked lower. With two exceptions, sites in the Barkers area were ranked low given their poor performance on the D2PrimRoad and D2Shop criteria.

The criteria choices and weightings employed by the Deputy Director of Planning reflected a much wider range of decision factors than the CPA Member and any other participant in the case study. Environmental concerns were represented in the criteria set through a preference for sites that were comparatively small (Acres) and were far from mangrove coastlines (D2Mangrove), offshore reefs (D2Reef), and fragile marine environments (D2Replenishment). Economic factors associated with the initial development of a site for tourist accommodation and its attractiveness to tourists were captured specifically in terms of zoning and servicing concerns (D2TourZone), proximity to waterfront, other hotels (D2Hotel), and shopping (D2Shop), and distance away from main roads (D2PrimRd). Further, in recognition of the realities of attempting to balance pro-development, pro-environment, and political interests, the Deputy Director of Planning also considered the number of times a site had been designated by any case study participant as a potential factor for determining the appropriateness of further accommodation units (NumSelect). Notably, he was the only participant to consider this factor.

Based on these considerations, two groups of highly ranked sites were evident in the Deputy Director of Planning's rankings. The first is located at the south end of Governor's Harbour and includes several of the most frequently selected candidate sites in the District that have water frontage and are zoned for Hotel/Tourism. The second group of parcels is linear in form extending along the northern coast from Spanish Reef Hotel to the Villas Papagallo and beyond midway along the Barkers peninsula. In this second group, the influences of favourable scores on more heavily weighted D2TourZone, Waterfront, D2PrimRd, NumSelect, and Acres attributes appear to have compensated for relatively poor scores on criteria with less emphasis such as D2Shop, D2Reef, D2Replent, and D2Mangrove (see Figure 6.3). The Deputy Director of Planning was the only participant whose highest class of ranks included the one site located near Conch Point for which there was complete first order selection consensus (e.g. NumSelect = 8). In contrast to the other participants, several candidate sites on the east side of Seven Mile Beach Road were assigned low to moderately low ranks. This can be attributed to the commercial zoning of the parcels, their lack of water frontage, and undesired proximity to a main roadway.

6.3.2 Consensus Measures – 242 Sites

Some of the conceptual problems associated with combining the preferences of several individuals to produce a "group" choice set were discussed in Chapter Three. Although it is widely recognised that no techniques have been developed to satisfy all five of the conditions that Arrow (1963) required of a social choice function, the need to derive indicators of collective preference does exist. Two of the more common methods for aggregating individual sets of ranks are applied in the following section to the case study participant's rankings of the 242 site subset. Following this, the similarity between the participant's individual rankings of the candidate sites and the two collective ranking schemes is investigated.

6.3.2.1 Borda and Copeland Methods of Consensus – 242 Sites

The Borda counting function calculates an aggregate ranking from a series of individual ranking vectors (Borda, 1781). This procedure is based on a simple sum of ranks rule, whereby scores of n-1, n-2, ... 0 are assigned for each individual's highest ranked (most preferred) alternative, their second highest ranked alternative, and so on (Fishburn, 1971, 539). These individual scores are summed across the group to produce a Borda score for each alternative, with the lowest Borda score being the highest ranked choice alternative for the group. It is assumed that all individual ranks have equal influence on the aggregate ranks and, given its rank-order focus, that the differences between adjacent alternatives (e.g. 3rd and 4th position) can be considered to be equal in the absence of any contrary information (Arrow, 1963, 94).

The Borda method is widely used in practice because of its computational simplicity (Bui, 1987, 58). However, its *ad hoc* nature, susceptibility to deliberate manipulation through strategic voting (i.e. deliberately promoting or demoting an alternative to skew the group rank), and the potential for a change in one alternative's ranking to affect the collective ranking of several other alternatives (i.e. independence of irrelevant alternatives) has caused it to be both criticised and subject to modification (Cox, 1997, 147; Massam, 1993, 92). For example, the Nanson function incorporates the Borda method in a sequential elimination process, while Cook and Seiford (1982, 622) suggest a modification that improves the basic Borda function with respect to tied ranks (Arrow, 1963, 95; Hwang and Lin, 1987, 40).

Figure 6.4 depicts the group ranking generated using the unmodified Borda count function for the case study participants. The same classification scheme as used in the maps of the individual rankings is applied to the aggregate ranks. All of the sites in the highest ranked class are found in the vicinity of Seven Mile Beach and the southern extent of Governor's Harbour. This pattern reflects the individual preferences of four participants in particular (Hotel Operator / Developer, Business Owner, Director of Environment, CPA

Member). With the exception of six sites in the south of Seven Mile Beach, few similarities are apparent between the rankings produced by the National Trust Scientist and the collective Borda map of rankings.

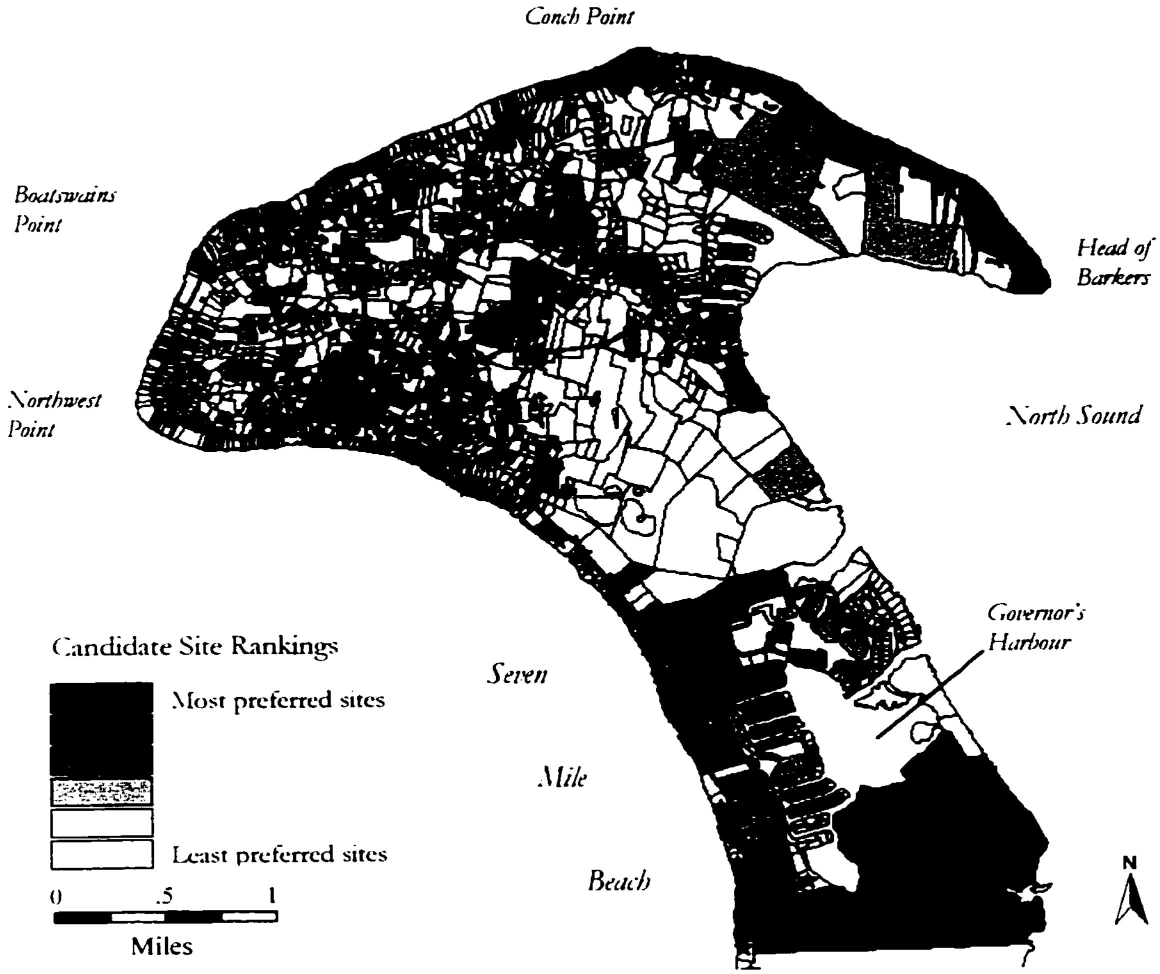

FIGURE 6.4 GROUP RANKINGS OF 242 SITES – BORDA METHOD

The Copeland method for determining aggregate ranks is based on Condorcet's (1785) assertion that the only fair way to determine which alternative is supported by the majority of all voters is to examine each pair of alternatives and select the alternative that has a simple majority over all other candidates, should such a candidate exist (Hwang and Lin, 1987, 29-30; Fishburn, 1971, 539). Whereas a Condorcet-based count can be determined for each alternative based on the number of times it is preferred to another alternative, the Copeland (1951) method produces aggregate ranks by subtracting from this sum the number of times each alternative is ranked lower than other alternatives (Fishburn, 1973, 170). Alternatives are ranked from highest net score (i.e. number of 'wins' – number of 'losses') to lowest net score. Fishburn (1971, 542-544) reported that in about 90 percent of the cases in a simulation at least one common candidate was identified by both the Copeland and Borda methods. Compared to the Borda count, the Copeland method is more likely to produce a higher number of tied ranks, particularly as the number of alternatives increases.

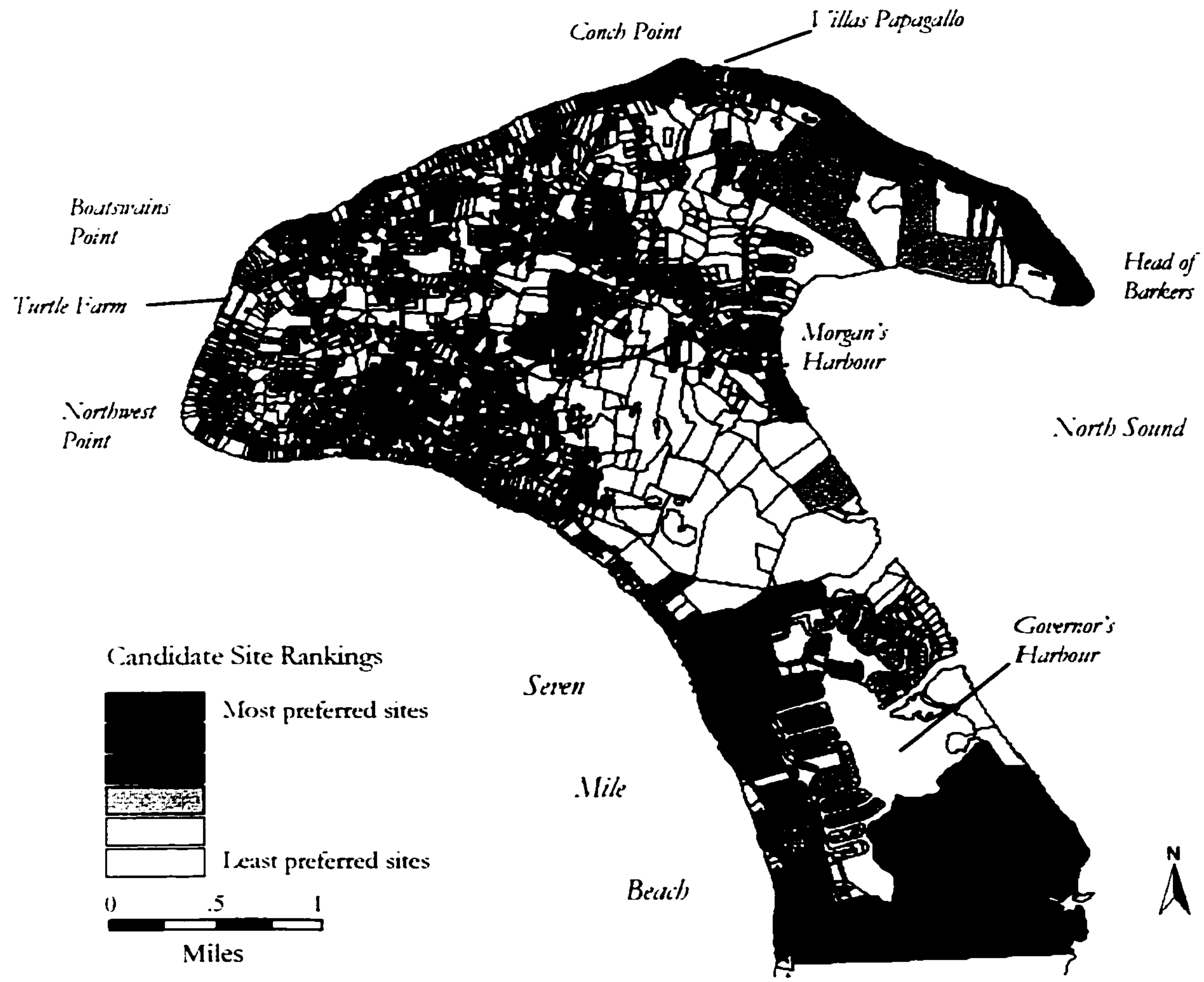

FIGURE 6.5 GROUP RANKINGS OF 242 SITES – COPELAND METHOD

Comparison of Figures 6.4 and 6.5 show few differences in the aggregated ranks produced by the Borda and Copeland methods when the ranks are viewed in a class-based map format. Inspection of Table 6.6, which lists the top 30 parcels as ranked by the Copeland method as well as the Borda and the individual ranks for these sites, confirms that the variations in two aggregate ranks are relatively minor given the number of candidate sites under consideration in the case study. The next section examines the extent to which the visually apparent similarities between individual ranks and between individual ranks and the collective ranks are statistically significant.

Block_Parcel	Director of Environment	National Trust Scientist	Real Estate / Developer	Hotel Operator / Developer	Business Owner	CPA Member	Deputy Director of Planning	Borda Rank	Copeland Rank
R17A_14	118.5	7	35	158	93	2	3.5	6	1
R1E_40	1	72.5	110	4	15	95	19	1	2
R1E_14	5.5	44	131	10	12	186	22.5	5	3
R17A_4	101	1	23	149	90	33	10	4	4
R1E_17	4	45	124	7	14	205	25.5	8	4
R1D_31	8	42	158	44	4	117	20	2	6
R2C_66	13	86.5	106	1	19	200	22.5	13	6
R1E_18	2	61.5	119	6	16	209	38	14	8
R17A_13	118.5	11	21	147	95	24	11	9	10
R1E_15	10.5	46.5	129	8	13	210	27	12	10
R1E_45	3	57	139	13	11	147	28.5	3	12
R1D_34	7	32	146	29	5	191	42	15	12
R1E_19	5.5	67.5	113	5	17	220	50.5	17	14
R1D_33	9	26	154	32	3	224	36.5	18	14
R1E_12	10.5	48	136	12	10	218	58	20	14
R17A_12	133	18.5	112	160	102	5	5	27	14
R1D_30	12	33.5	162	47	1	229	21	21	17
R1E_44	15	65.5	143	22	8	134	33	7	18
R2C_67	19	82	108	3	21	226	54	23.5	20
R1E_41	16	78.5	107	2	18	235	128	42	20
R1C_175	20	30.5	155	159	24	37	14	10	21
R11C_238	90	9.5	168	48	103	16	7	11	22
R1D_29	14	37	165	53	2	231	39.5	28	22
R1E_9	18	65.5	140	15	9	219	78	29	25
R1C_1	23.5	33.5	157	142	20	192	16	41	25
R1C_4	30	17	156	151	22	207	28.5	52	25
R1E_3	21	59	147	24	7	198	57	23.5	27
R1C_6	25	21	144	169	27	161	41	43	28
R11D_49	79.5	3.5	180	63	114	29	3.5	16	30
R1D_28	23.5	29	163	59	6	236	34	30	30

Note: Block_Parcel is a unique property identifier that is assigned by the Cayman Islands Land Registry. Each island is divided into grid-like Blocks within which properties are assigned unique parcels numbers (e.g. 11D_31 refers to parcel 31 in Block 11D). Similar systems are used elsewhere in, and beyond, the Caribbean region.

TABLE 6.6 TOP 30 CANDIDATE SITES USING COPELAND RANKS

6.3.2.2 *Correlation of Ranks – 242 Sites*

Spearman's rank correlation coefficient (r_s) and Kendall's coefficient of concordance (τ) are two of the most commonly applied nonparametric statistical techniques for determining the association between pairs of ordinal variables. Each method is equally powerful but Spearman's r_s offers advantages in terms of computational and conceptual simplicity (Norcliffe, 1982, 116). R_s varies from −1 to +1 with −1 indicating perfect negative correlation, 0 signifying an absence of correlation, and +1 indicating perfect positive correlation. The statistic assumes that at least 5 pairs of observations are present and that the observations are ranked from 1 to *n* with any tied ranks being represented by average ranks (Silk, 1979, 201). If the number of pairs of tied ranks exceeds 25 percent of *n* a corrected measure is required, otherwise the statistic has the following form (Norcliffe, 1982, 117, Siegel, 1956, 209-210):

$$r_s = 1 - \left(\frac{\sum_{i=1}^{N} d^2}{n^3 - n} \right) \qquad 6.1$$

where: d^2 is the squared difference between the two ranks
n is the number of observations

When *n* is greater than 10, the distribution of r_s approaches the *t* distribution allowing the significance of r_s to be tested as a value of *t* with $n - 2$ degrees of freedom (Siegel, 1956, 212). The transformation of r_s values to Student *t* values is calculated by:

$$t = r_s \sqrt{\frac{n-2}{1 - r_s^2}} \qquad 6.2$$

The pair-wise r_s measure can be applied in several ways to the case study site evaluation problem including:

1. Creating an index of the degree of association between the participant's rank sets by calculating all possible pair-wise correlations and averaging the result to produce the average rank correlation ($r_{s,av}$) (Yeates, 1974, 196);
2. Examining the correlation between members within each of the *a priori* designated subgroups (pro-development, neutral, pro-environment);
3. Investigating the association between the participant's rankings and the group rankings produced through the Borda and Copeland methods.

The r_s values that support examination of all three areas of interest are presented in Tables 6.7 and 6.8,. However, only a brief discussion is provided in each case in anticipation of the more complete discussions to follow pertaining to the 53 site subset.

Participant 1	Participant 2	Rs	Student's t-statistic	Significant at 95%	Significant at 99%
Deputy Director of Planning	National Trust Scientist	-0.556666017	-10.38094993	Yes	Yes
Hotel Operator / Developer	National Trust Scientist	-0.315192878	-5.145210634	Yes	Yes
Business Owner	National Trust Scientist	-0.262889385	-4.221139282	Yes	Yes
Deputy Director of Planning	Director of Environment	-0.146255717	-2.29041305	Yes	No
CPA Member	Deputy Director of Planning	-0.091206081	-1.418872338	No	No
Director of Environment	Real Estate / Developer	-0.026301619	-0.407603934	No	No
National Trust Scientist	Real Estate / Developer	0.00734005	0.113714634	No	No
Deputy Director of Planning	Real Estate / Developer	0.015268787	0.236570606	No	No
Hotel Operator / Developer	Director of Environment	0.04491264	0.696486439	No	No
Business Owner	Real Estate / Developer	0.172950849	2.720337272	Yes	Yes
Director of Environment	Business Owner	0.231617272	3.688500787	Yes	Yes
CPA Member	National Trust Scientist	0.246353254	3.937852396	Yes	Yes
Real Estate / Developer	Hotel Operator / Developer	0.349780977	5.784160293	Yes	Yes
CPA Member	Real Estate / Developer	0.364160061	6.057471322	Yes	Yes
Director of Environment	CPA Member	0.431018978	7.399977972	Yes	Yes
Hotel Operator / Developer	Deputy Director of Planning	0.564991653	10.60822798	Yes	Yes
Business Owner	CPA Member	0.59554553	11.48500451	Yes	Yes
Business Owner	Deputy Director of Planning	0.601617217	11.66799495	Yes	Yes
Hotel Operator / Developer	CPA Member	0.61082387	11.95155722	Yes	Yes
Director of Environment	National Trust Scientist	0.726844907	16.3951749	Yes	Yes
Business Owner	Hotel Operator / Developer	0.924295962	37.51640533	Yes	Yes

TABLE 6.7 SPEARMAN RANK CORRELATION– PARTICIPANT RANKS – 242 SITES

Based on the r_s values in Table 6.7 and the general observations made concerning the ranking maps, the pro-development and pro-conservation subgroups appear to be valid constructs on which to base further discussion. Almost no correlation is found, however, between the two remaining members of the neutral subgroup. Instead, Table 6.7 confirms the earlier assertion that the rankings of the CPA Member are more closely aligned with the three pro-development participants. Further, the negative correlations between the rankings of the National Trust Scientist and three other participants (Deputy Director of Planning, Hotel Operator / Developer, and Business Owner) are indicative of significant conflict. A negative correlation is also found between the Director of Environment and the Deputy Director of Planning although it is significant only at the 95 percent level. Conflict between the National Trust Scientist and the two pro-development participants (Hotel Operator / Developer and Business Owner) can be expected, given their divergent interests. However, the conflict with the Deputy Director of Planning is more surprising and is likely due to the latter's decision to include the NumSelect criterion which, because of the influence of the pro-development participants, favoured sites in the environmentally sensitive Barkers area.

Group Ranking	Participant Ranking	Rs	Student's t-statistic	Significant at 95%	Significant at 99%
Borda Rank	National Trust Scientist	0.116488241	1.816998058	No	No
Borda Rank	Deputy Director of Planning	0.352578759	5.83696397	Yes	Yes
Borda Rank	Real Estate / Developer	0.464477748	8.12531832	Yes	Yes
Borda Rank	Director of Environment	0.505441487	9.074772073	Yes	Yes
Borda Rank	Hotel Operator / Developer	0.783414662	19.52794859	Yes	Yes
Borda Rank	Business Owner	0.804500639	20.98363985	Yes	Yes
Borda Rank	CPA Member	0.809202492	21.3369773	Yes	Yes
Copeland Rank	National Trust Scientist	0.039660405	0.614900151	No	No
Copeland Rank	Deputy Director of Planning	0.376683772	6.299574517	Yes	Yes
Copeland Rank	Director of Environment	0.445082456	7.699908326	Yes	Yes
Copeland Rank	Real Estate / Developer	0.483176202	8.549555388	Yes	Yes
Copeland Rank	CPA Member	0.78507781	19.63582348	Yes	Yes
Copeland Rank	Hotel Operator / Developer	0.819203377	22.12898888	Yes	Yes
Copeland Rank	Business Owner	0.839122593	23.89891405	Yes	Yes

TABLE 6.8 SPEARMAN RANK CORRELATION – PARTICIPANT AND AGGREGATE RANKS - 242 SITES

Table 6.8 lists the r_s values between the two aggregate rank methods, Borda and Copeland, and the individual participants. Two observations concerning the values in this table should be noted. First, the r_s values calculated for the Borda method and the Copeland method are quite similar with only a slight reordering of the participants when sorted by r_s value. Second, the three participants that attempted to encapsulate environmental and social concerns within their criteria sets generally had the weakest association with either aggregate ranking. The rankings produced by the National Trust Scientist were in fact the only participant ranks that were not found to be correlated to any significant degree with those produced by the Borda and the Copeland methods. This suggests that there is a relatively strong level of consensus in the overall pattern of ranks that was produced by these methods and that the aggregate rankings may serve as a useful starting point for further debate and refinement.

6.3.3 Initial Results – 53 Sites

To provide a further illustration of how the approach advocated in the preceding chapters could be applied to the SIS planning context, the following sections concentrate on the application of the participant's choices of method, evaluation criteria, and weights to a smaller subset of sites. A "low conflict, moderate to high consensus" group consisting of 53 sites was created by filtering the selections for parcels that were selected by two or more participants, were at least one acre in size, and had a conflict index score of less than nine. These parameters correspond to weak, moderate, or strong consensus in Figure 5.10, slightly less than half of the average 1.7 acre parcel size for hotels in West Bay District, and no appreciable development versus non-development conflict in Figure 5.12. In addition, seven other parcels that met these restrictions but had excessive length-to-width ratios (e.g. 35 to 50 feet wide) were removed from the evaluation set. The net result of applying these filters to the total set of candidate sites was to exclude all parcels in the Barkers peninsula, all of the inland parcels selected originally by the Deputy Director of Planning, and most of the potential sites on the north-west coast between North West Point and the Cayman Islands Turtle Farm. Some of the candidate accommodation sites in the Seven Mile Beach area were excluded as well. However, the majority discussed in the preceding section are retained.

Time constraints did not permit the case study participants to evaluate this smaller subset of sites during the field research. Consequently, the analysis described in the following pages is purely *post hoc*. It is recognised that the participants may have altered their criteria choices and weightings from those outlined in the previous sections if they had been able to consider only the 53 candidate sites shown in Figures 6.11 to 6.19. For example, the importance of the distance to mangrove (D2Mangrove) criterion would likely be affected, since the exclusion of Barkers peninsula leaves only a few candidate sites in the smaller subset located on the east of Governor's Harbour that can be considered close to mangroves. However, while this constraint is recognised, the smaller subset of sites is deemed sufficiently representative to facilitate further, more detailed analysis.

For consistency with Chapter Five and the previous section, the discussion is organised using the pro-development, pro-conservation, and neutral subgroups, notwithstanding the questionable validity of the latter. In contrast to the previous section, maps annotated with the individual ranks of the parcels in the most preferred classes are presented for each participant. In addition, Table 6.9 provides a comparison of individual and aggregate (Borda and Copeland) rankings for a selected portion of the 53 site subset.

6.3.3.1 Pro-Environment Group – National Trust Scientist and Director of Environment

Figures 6.6 and 6.7 illustrate the ranking patterns that were obtained when the criteria sets of the two pro-environment participants were applied to the set of 53 potential sites. Overall, there is a higher degree of similarity in their rankings than was evident when the larger set of sites was evaluated. However, the choices that each participant made concerning criteria, weights, and data normalisation parameters did result in localised areas of both rank agreement and rank differences.

In general, both participants ranked waterfront sites comparatively low given the proximity of these lands to sensitive marine and land-based environmental features and habitats (e.g. Director of Environment – D2Mangrove, D2Marine, D2Replent, D2Wetland; National Trust Scientist – D2Mangrove, D2Marine, D2Reef, D2Replent, D2SeaPond, D2Wetland). The D2Marine and D2Replent criteria, in particular, were responsible for the moderately low ranks shown in Figures 6.6 and 6.7 for the beachfront properties along Seven Mile Beach (see Figure 6.3). Correspondingly, the few inland sites, and particularly those found in the south of the Seven Mile Beach / Governor's Harbour area, were ranked highly by both individuals.

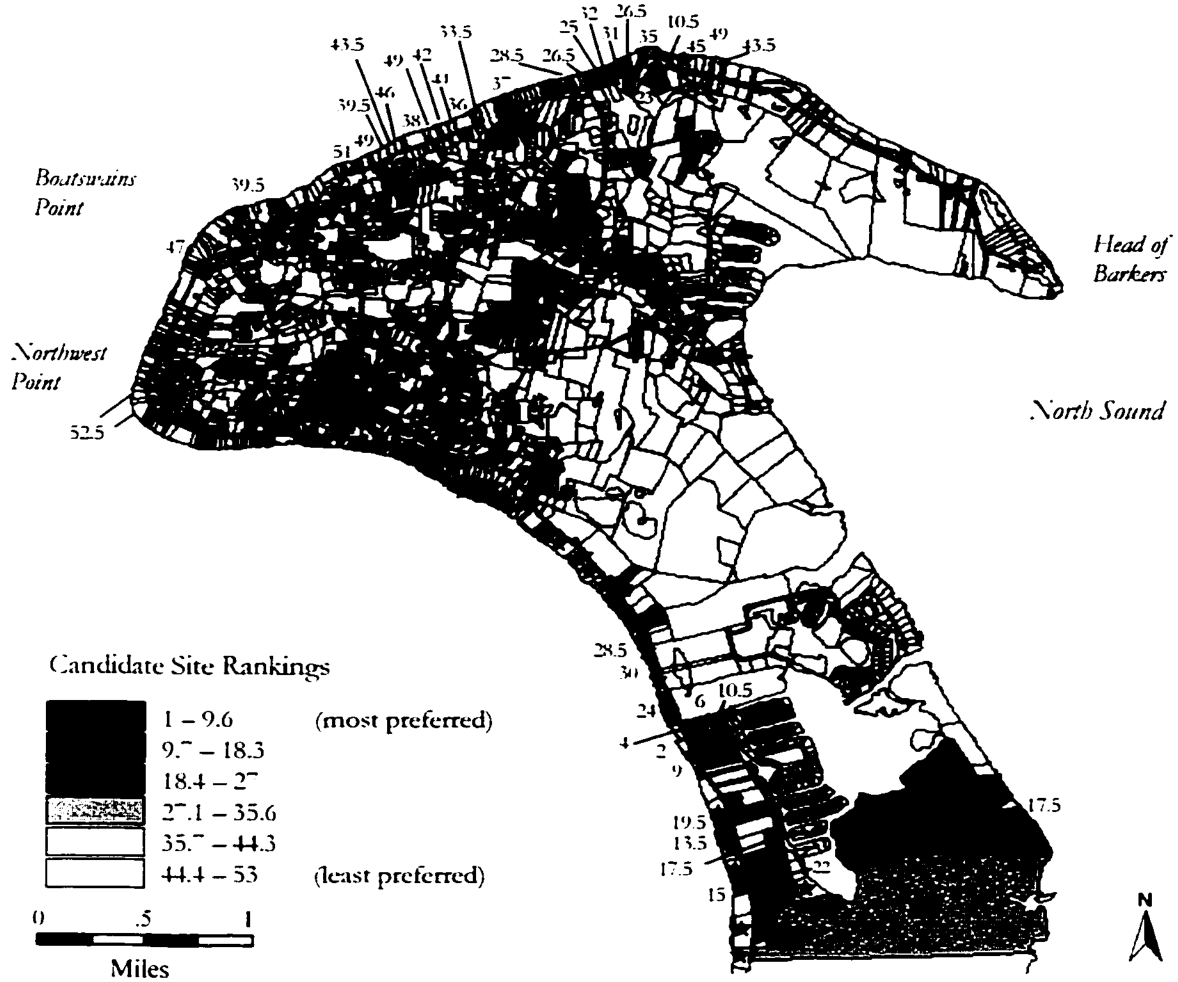

FIGURE 6.6 DIRECTOR OF ENVIRONMENT RANKINGS OF 53 SITES

Beyond these general patterns of agreement, notable differences are apparent in the pro-environment rankings that can be accounted for by the participants' criteria set choices. For instance, the Director of Environment included a broad set of criteria that addressed environmental, tourist, and economic concerns. Figure 6.6 shows that the most favoured sites according to this criteria set are located inland in the southern portion of Seven Mile Beach. These parcels offer comparative advantages in terms of construction feasibility (e.g. in or adjacent to a Hotel / Tourism zone – D2TourZone, above average in size – Acres), attractiveness to tourists (e.g. on or close to a sand beach – D2Sand), and greater distances from sensitive environmental features (D2Wetland, D2Mangrove, D2Rock, D2Replent, D2Marine). Further, these sites, along with an inland site to the south of Villas Papagallo (see Figure 6.3), are located beyond the maximum effective distances that the Director of Environment established for D2Marine, D2Replent, D2Wetland, and D2Mangrove (300, 300, 750, and 1000 feet – see Table 6.4).

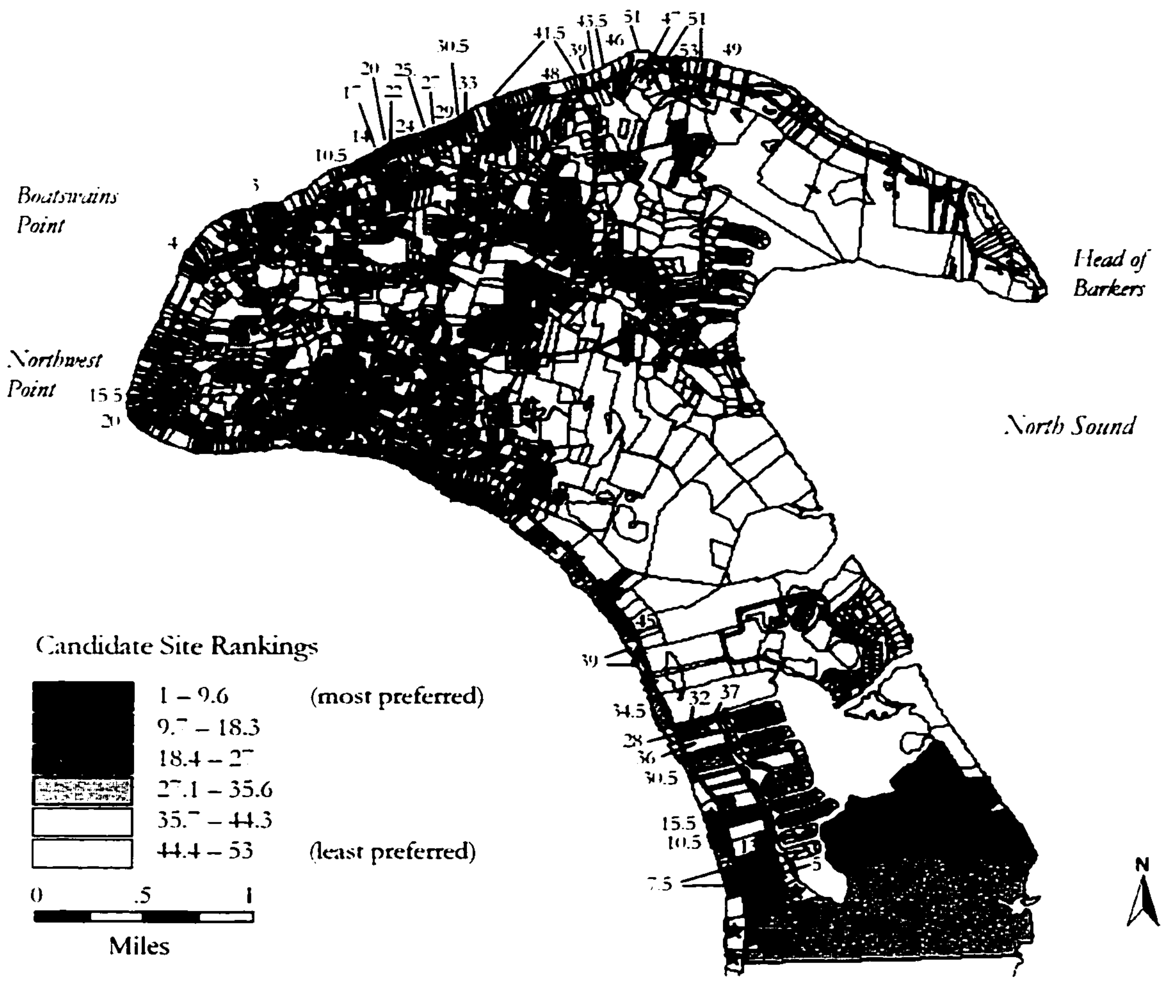

FIGURE 6.7 NATIONAL TRUST SCIENTIST RANKINGS OF 53 SITES

The National Trust Scientist, in contrast, focused primarily on identifying the sites that would have the lowest potential environmental impacts. Compared to the Director of Environment, the National Trust Scientist specified user maxima for fewer criteria and, for the criteria where data bounds were specified (e.g. D2Mangrove, D2SeaPond, D2Wetland), the limits were considerably larger (see Table 6.4). As Figure 6.3 illustrates, many of the criteria selected by the National Trust Scientist are most applicable to sites that are located near the environmentally sensitive Barkers peninsula where little development has taken place to date. The cluster of highly ranked sites in the south of the Seven Mile Beach/ Governor's Harbour are as far from wetlands, mangroves, reefs, etc. as possible within the study area and are accordingly assigned the highest ranks. While these sites are close to the Marine Park off of Seven Mile Beach, they are also far from the Replenishment Zone farther to the north.

Finally, it is important to note that the high (3rd and 4th) and moderately high (10.5, 14, 15.5) ranks near North West Point should be viewed as an artefact of an incomplete or overly generalised spatial data set. If the reefs map layer had included the fringing reef near Boatswains Point, lower D2Reef values would have been generated for the sites in the north west of the study area. These sites would have been disadvantaged since D2Reef was designated as a benefit criterion (i.e. higher data values preferred) and caused the National Trust Scientist's rankings to more closely resemble those of the Director of Environment (Figure 6.6).

6.3.3.2 *Pro-Development Group – Business Owner, Hotel Operator / Developer, and Real Estate / Developer*

The similarities between the rankings that the Business Owner and the Hotel Operator / Developer assigned to the 242 site subset are more evident when their criteria sets are applied to the 53 site group. Figures 6.8 and 6.9 illustrate that the most preferred sites are concentrated in two areas: a) on or immediately adjacent to

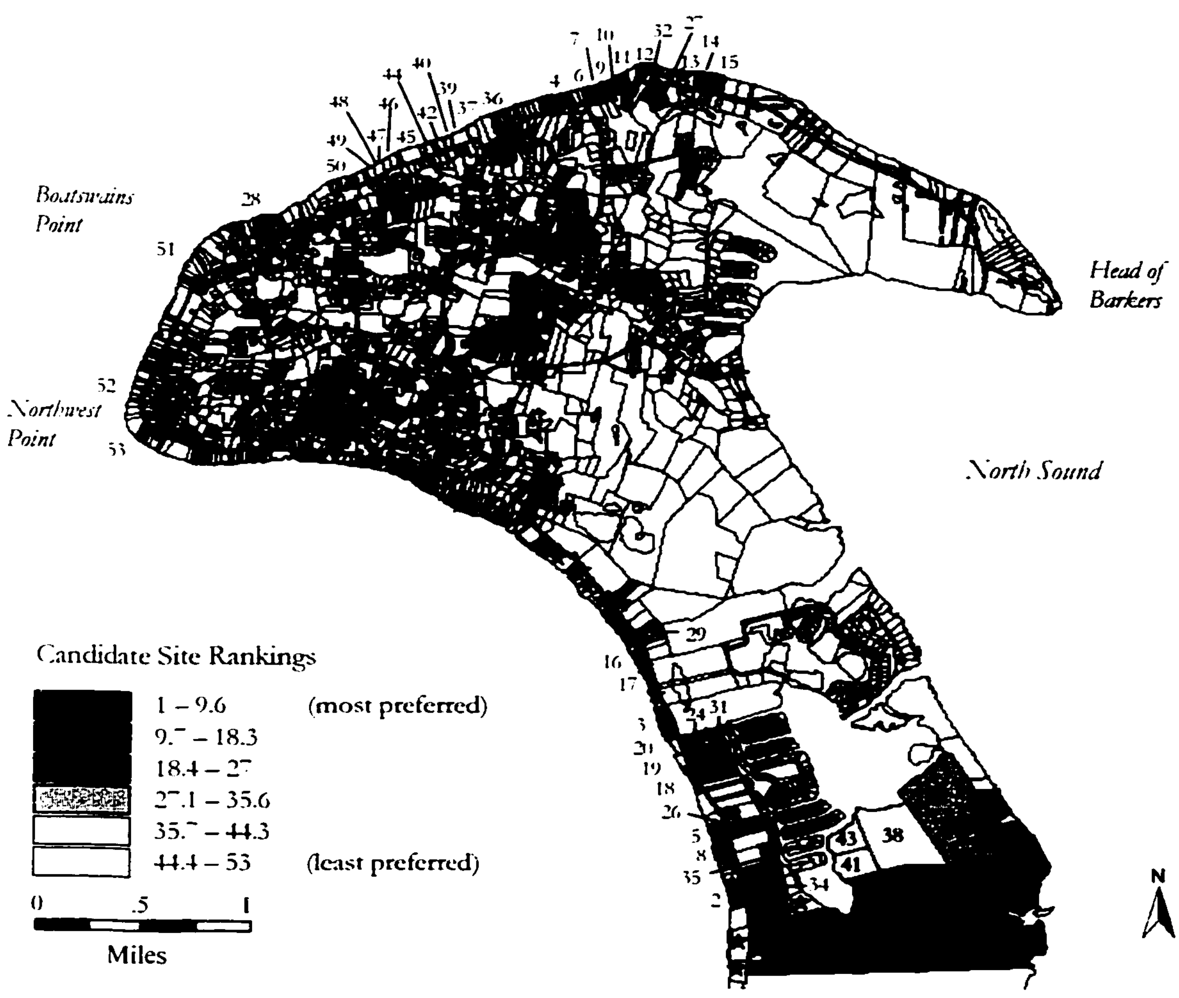

FIGURE 6.8 BUSINESS OWNER RANKINGS OF 53 SITES

Seven Mile Beach, and b) along the north coast from the Spanish Reef Hotel east past the Villas Papagallo. Sites in both of these areas have advantages in size (Acres – benefit criterion), proximity to a sand beach and a Hotel / Tourism zone (low D2Sand, D2TourZone values – cost criteria), while those on Seven Mile Beach are also close to commercial zones (low D2Shop values – cost criterion). The individual ranks that they generated for their most preferred group of sites were either identical or differed by one for the properties that were ranked 1st, 2nd, 5th, and 9th by the Hotel Operator / Developer.

A similar degree of correspondence is evident in terms of the least preferred sites as low site ranks are concentrated spatially along the coast to the west of the Spanish Reef Hotel. Unlike the sites discussed above, properties in this locale are zoned for either Beach Residential or Low Density Residential uses, are located on ironshore, are often small in size, and are distant from potential shopping attractions.

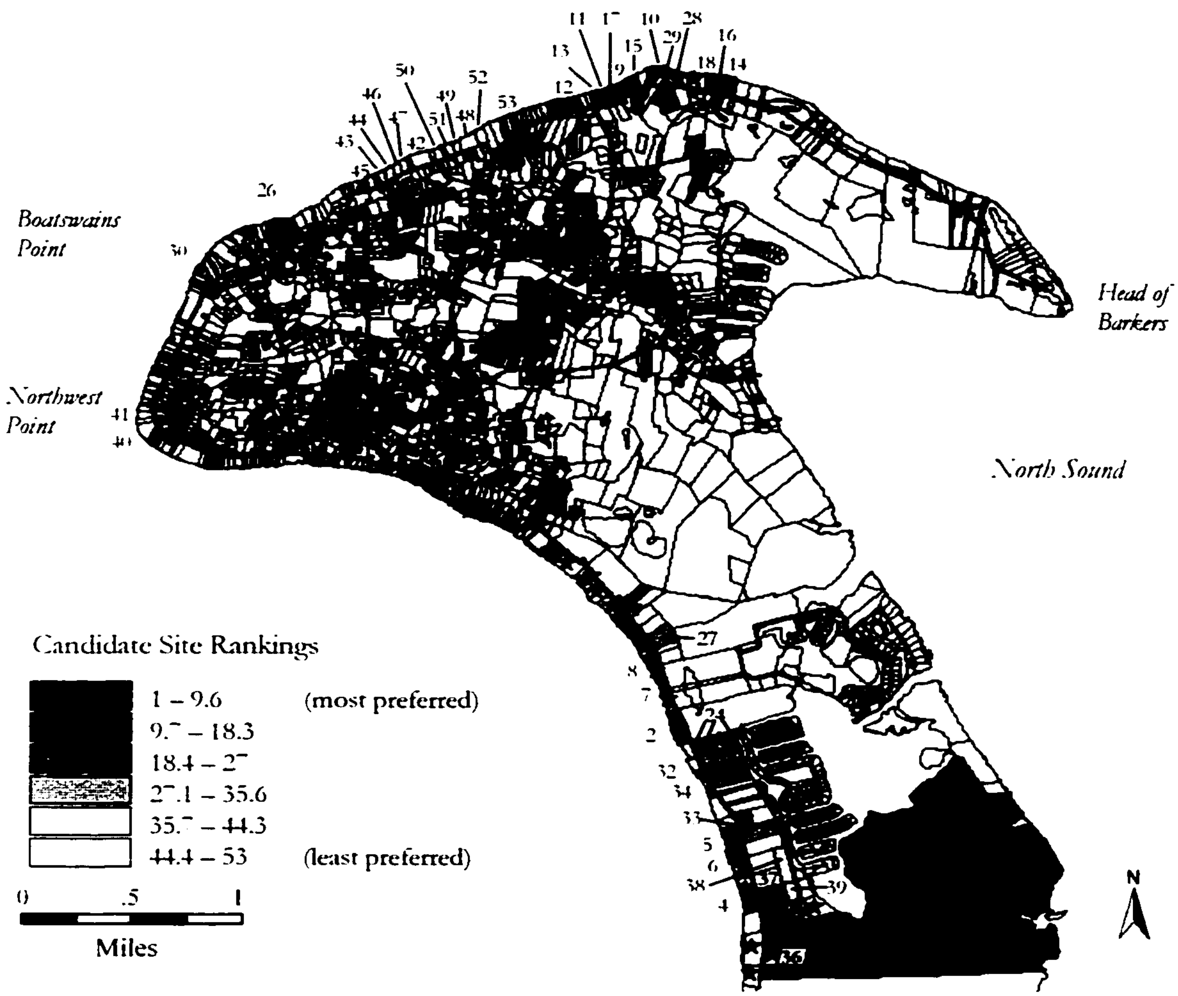

FIGURE 6.9 HOTEL OPERATOR / DEVELOPER RANKINGS OF 53 SITES

The most apparent variations from this pattern of commonality can be traced primarily to differences in how the D2TourZone criterion was applied to the decision problem. Although both participants assigned a high weight and a cost status to D2TourZone, only the Hotel Operator / Developer indicated that a property must lie within a Hotel/Tourism zone in order to avoid any potential problems associated with changing the zoning of a property (see Table 6.4). Consequently, any site that was zoned for tourism-related land uses had a substantial advantage over sites that may have been adjacent to such a zone. This effect is most apparent for inland parcels at the south of Seven Mile Beach and in the Crystal Harbour development.

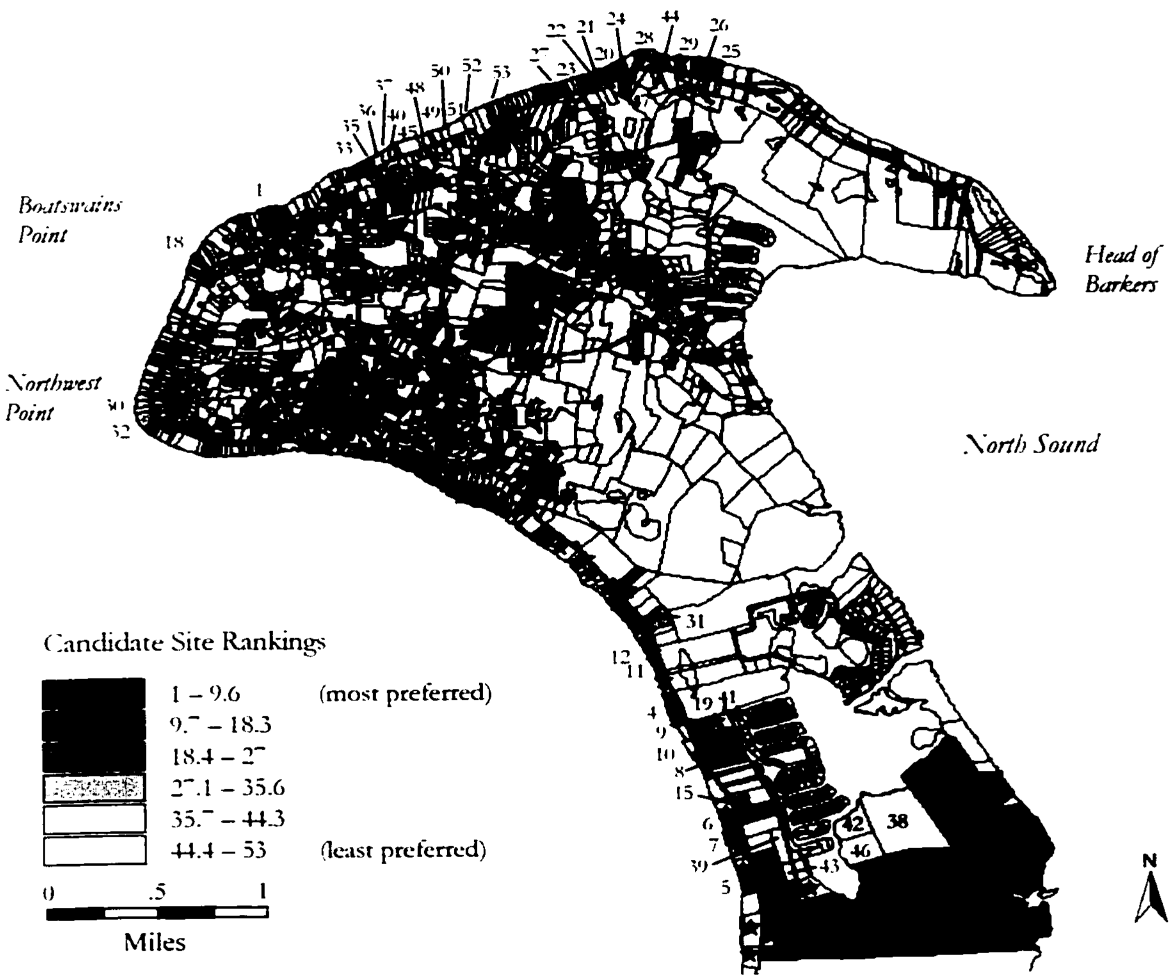

FIGURE 6.10 REAL ESTATE / DEVELOPER RANKINGS OF 53 SITES

Figure 6.10 and Table 6.6 illustrate that the rankings developed using the Real Estate / Developer's criteria set differed noticeably in some parts of the study are from those discussed above. For example, while the four of the Real Estate / Developer's top ten ranked sites (2nd, 4th, 6th, and 7th) differed at most by one position from one of the other two pro-development participants, his highest ranked site is located near Boatswains Point. Although this property was vacant as of September 1999, on a very small sand beach (low D2Sand value) and close to a commercial zone (low D2Shop value) that has tourism relevance (i.e. Cayman Islands Turtle Farm), it is questionable that the Real Estate / Developer would prefer it over all other sites.

The properties along Seven Mile Beach which are more capable of supporting the type of hotel development favoured by the Real Estate / Developer (Table 5.1) were disadvantaged somewhat by a lack of concern for current zoning designations and a preference for locations that are more secluded from existing hotels and condominiums (i.e. higher D2Hotel values). These factors, in combination with the Vacant criterion, caused the large parcel occupied by the Hyatt Regency Hotel and condominiums to be ranked 17th, in direct contrast to the 1st place designation derived from the criteria sets of the other two pro-development participants.

6.3.3.3 *Neutral Group – CPA Member and Deputy Director of Planning*

Very little association was found in the previous section between the rankings generated by the two members of the neutral group. Instead, the CPA Member's ranks were more closely aligned with those of the Hotel Operator / Developer and the Business Owner.

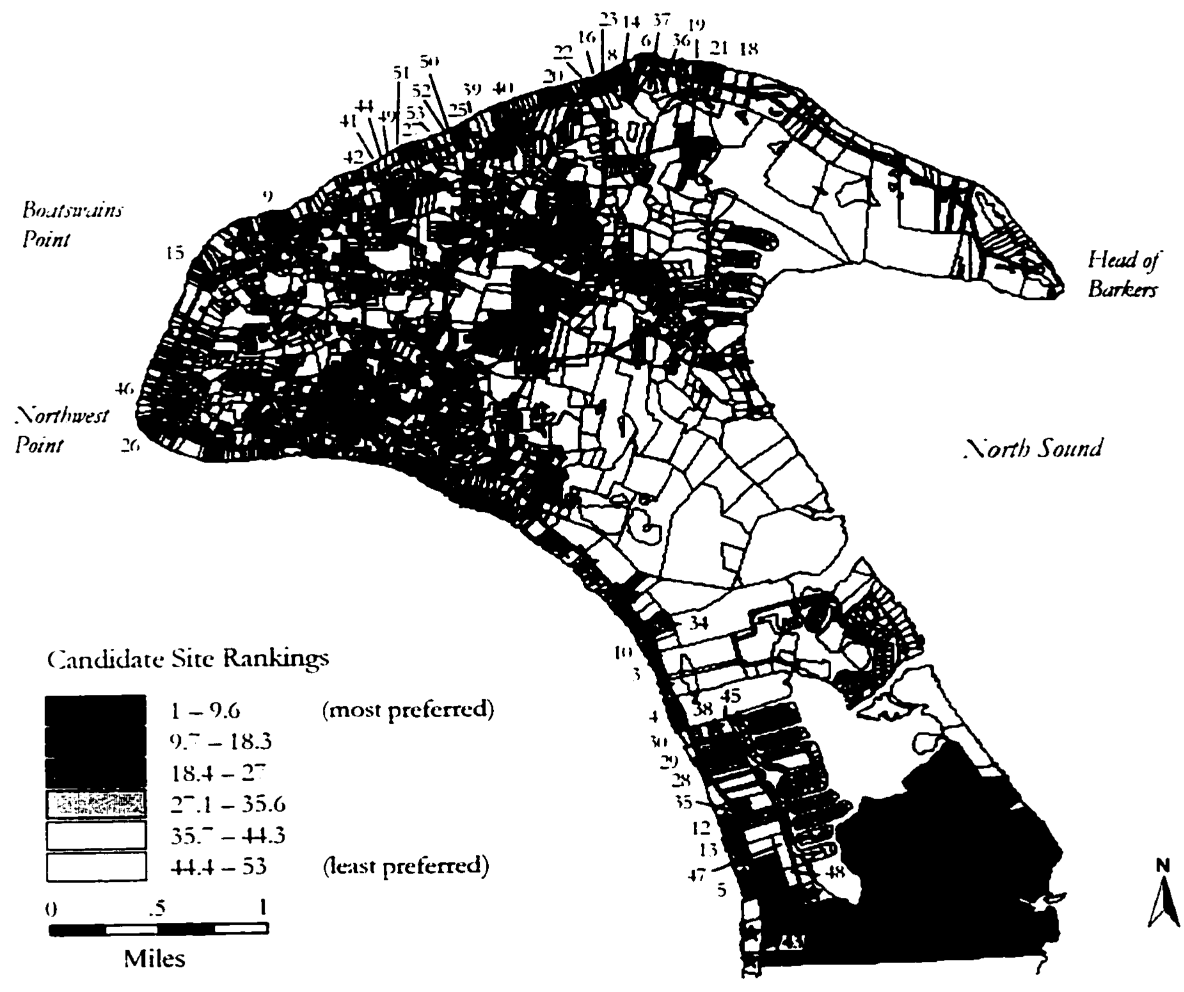

FIGURE 6.11 CPA MEMBER RANKINGS OF 53 SITES

The criteria set selected by the CPA Member favour larger coastal sites (Acres, Waterfront) that are close to shopping (D2Shop), sand beaches (D2Sand), and main roads (D2PrimRd). The properties that reflect best these attributes are found primarily near Conch Point and also along Seven Mile Beach. Like the Hotel Operator / Developer and the Business Owner, the Hyatt Regency site ranks first based on the CPA Member's criteria set. However, it should be noted that the quality of its North Sound water frontage was considered to be sufficiently unattractive to many tourists that property was purchased recently across the main road to allow their guests to have access to Seven Mile Beach. A similar problem exists with the Crystal Harbour properties that were ranked 2nd and 7th. As noted above for the Real Estate / Developer, the high ranks (9th and 15th) assigned to the two sites near the Magnificent Dive Dump at Boatswains Point should be considered an anomaly resulting from the small sand beach nearby and would not likely be supported after field verification.

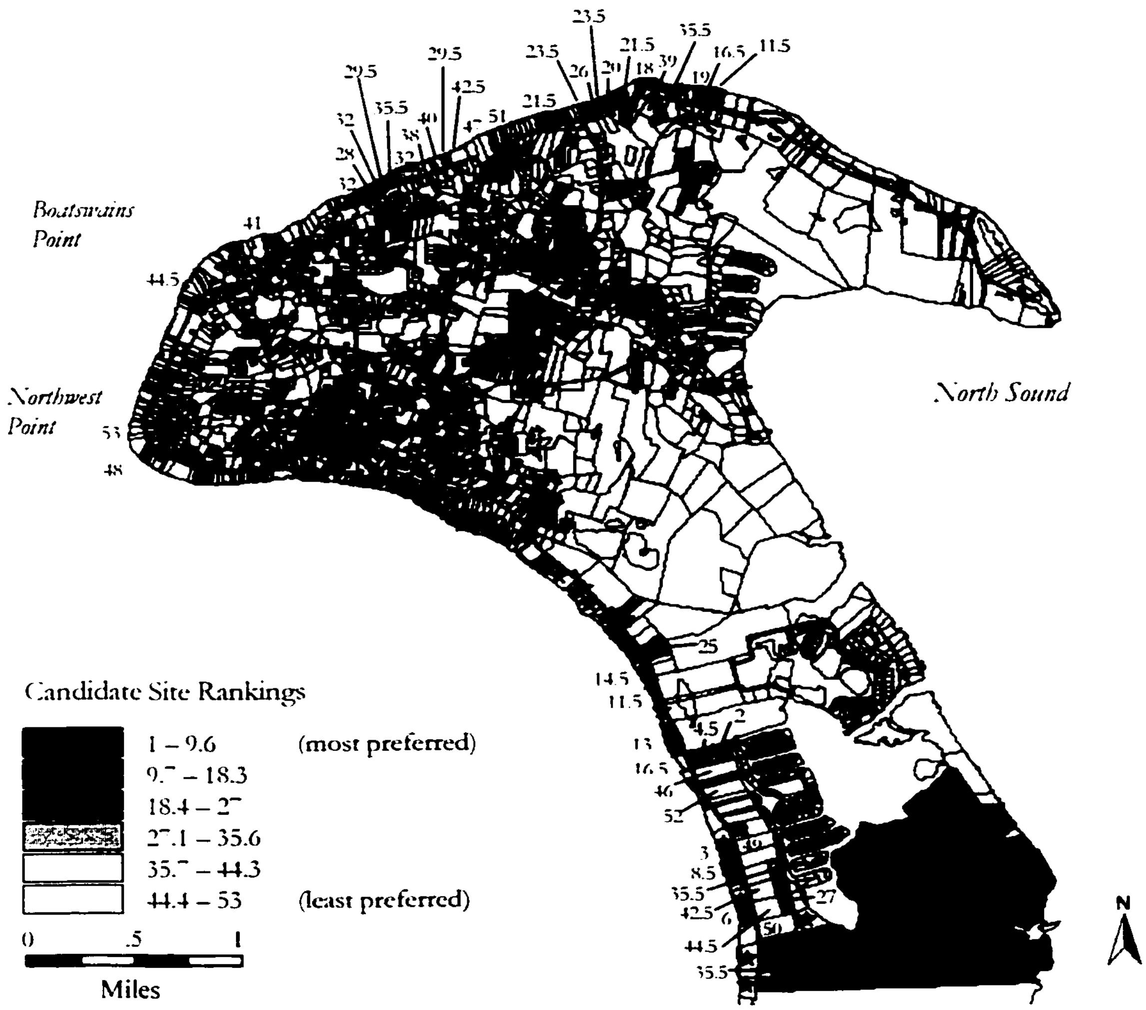

FIGURE 6.12 DEPUTY DIRECTOR OF PLANNING RANKINGS OF 53 SITES

To recognise the need to balance development and conservation interests in the planning process, the Deputy Director of Planning created a criteria set that was unique among the participant group in terms of the criteria selected and their application to the evaluation process. While the relevance of the NumSelect criterion was mentioned earlier, it is also important to note that the Deputy Director of Planning was the only person to favour sites that were comparatively far from a main road (D2PrimRd = benefit), small in size (Acres = cost), and close to existing accommodation facilities (D2Hotel = cost). In addition, several criteria that may be considered "conventional" among the participant group (e.g. D2Sand, D2TourZone, Waterfront, D2Shop, D2Mangrove, D2Wetland) were also judged to be of relatively high importance based on the weights listed in Table 6.5

The net result of applying this criteria set to the 53 candidate sites is shown in Figure 6.12. High ranks were generated for parcels that were zoned for Hotel / Tourism uses such as those along Seven Mile Beach (3rd, 6th, and 8.5), the south of Governor's Harbour and the Crystal Harbour development (1st, 4.5, 7th, and 8.5). Two other inland parcels on the Northwest of Governor's Harbour that did not have this zoning status were also ranked highly (2nd and 4.5) due to small size, proximity to shopping and other hotels, and distance from major sensitive features such as mangroves.

In contrast, the sites on the east, or North Sound, side of the Seven Mile Beach Road received generally low rankings. In this instance, their lack of water frontage, comparatively large size, and commercial zoning outweighed any advantages that these properties had in terms of closeness to shopping, other accommodation units, and a sandy beach. Similar to the Business Owner and the Hotel Operator / Developer, sites on the western coast from North West Point to Boatswains Point were ranked among the least desirable locations for new tourist accommodation.

6.3.4 Consensus Measures - 53 Sites

6.3.4.1 Borda and Copeland Methods of Consensus – 53 Sites

Figures 6.13 and 6.14 illustrate the aggregate ranks produced by the Borda and Copeland methods for the 53 sites described in the previous section. The rankings are also provided in Table 6.9 for the sites that were ranked among the top 30 according to the Copeland method. Both methods identify the southern portion of Seven Mile Beach and the southern extremities of Governor's Harbour as the most preferred potential locations for new tourist accommodation. For the most part, these sites are advantaged in terms of distance from sensitive environmental features (D2Reef, D2Wetland, D2Mangrove) and proximity to other features that contribute to their attractiveness to potential developers and tourists alike (D2Sand, D2Hotel, D2Shop). These same factors account also for the least preferred sites being concentrated in the north and north west portions of the study area.

Table 6.9 illustrates the high degree of correspondence between the Borda and Copeland rankings and also some of the idiosyncratic aspects of the results produced by each method. For instance, in addition to ranking the same parcel first, 13 of the top 15 sites based on the Copeland ranks were also ranked within the top 15 according to the Borda method. Further, although the lowest ranked sites are not included in Table 6.9, it is worth noting that 9 of the 10 least preferred sites are common between the two methods.

The greater propensity for the Copeland technique to produce tied ranks due to its "win minus loss" structure of comparing each alternative with every other alternative is evident in Table 6.9. This characteristic is not necessarily a disadvantage within a multi-party decision making context, since it can serve as a reminder to the participants that the results of both individual and aggregate ranking procedures may not provide sufficient grounds to differentiate between some choice alternatives without other supporting evidence.

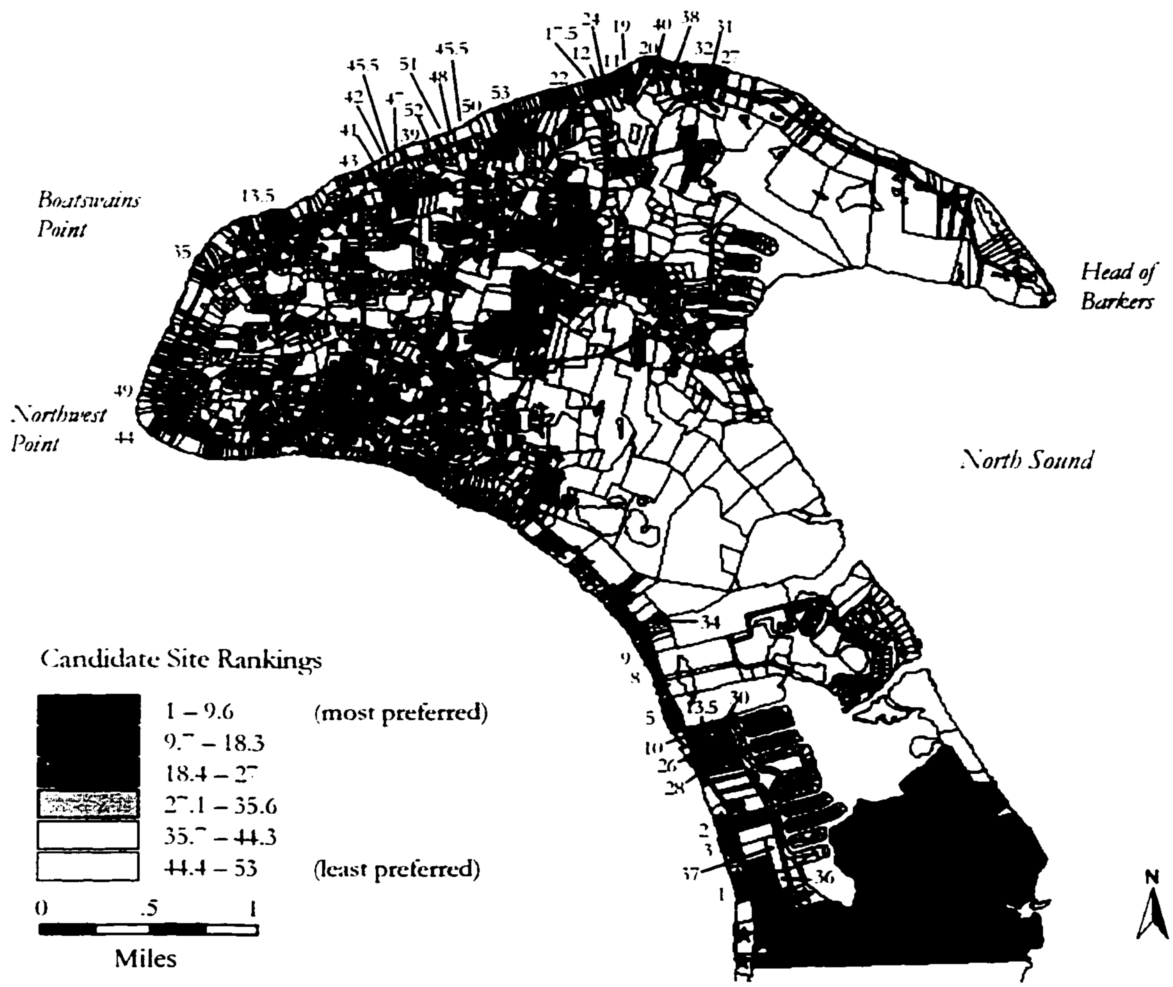

FIGURE 6.13 BORDA METHOD RANKINGS OF 53 SITES

Finally, Table 6.9 illustrates that the effectiveness of the Borda social preference function as a mechanism to develop consensus rankings is dependent upon the principles that are used to guide the evaluation process. The method is appropriate if the purpose of the evaluation procedure is to minimise conflict by promoting alternatives that are highly ranked on average over alternatives that are highly favoured by some participants but ranked very poorly by others (Jankowski et al, 1997, 589).

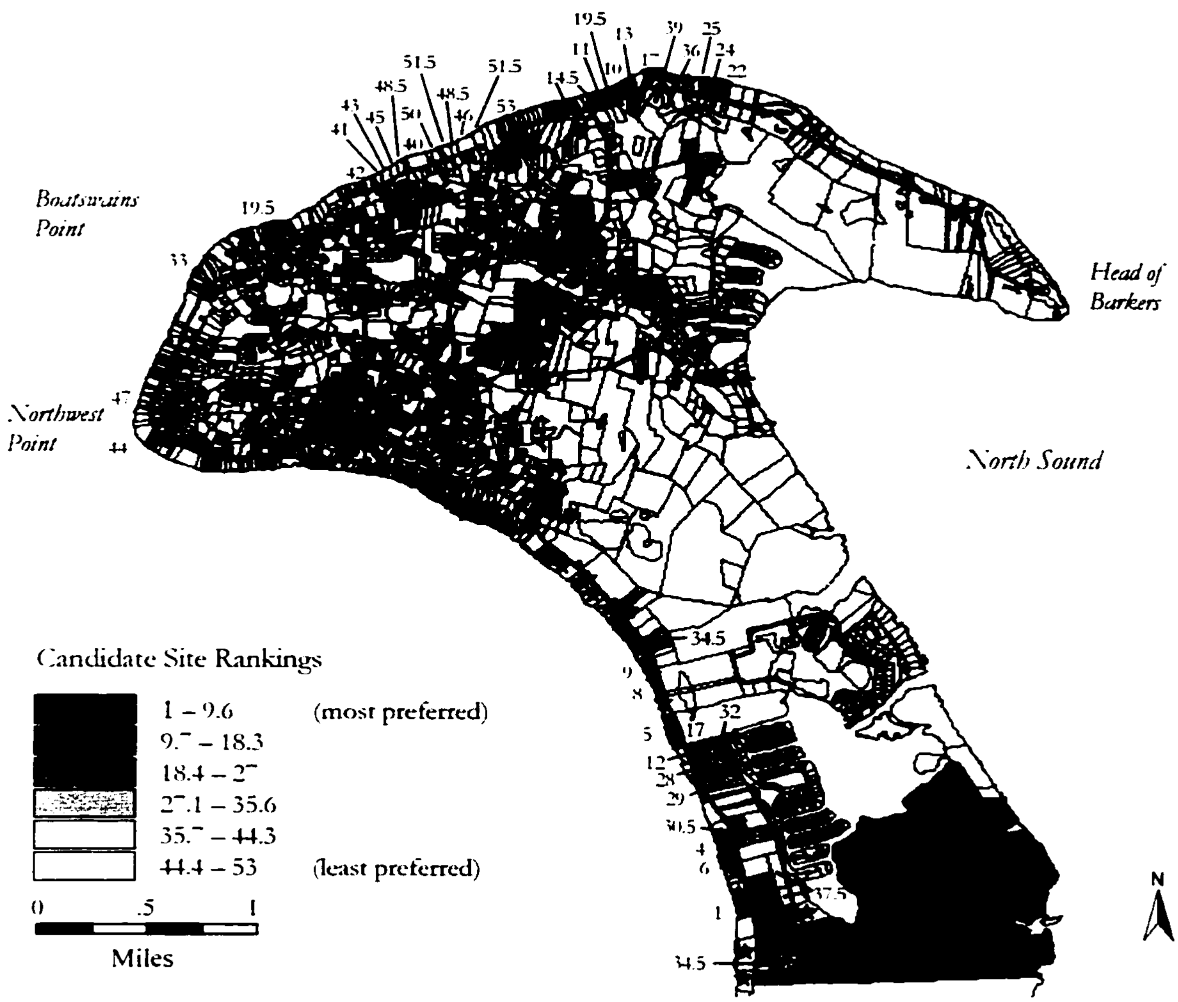

FIGURE 6.14 COPELAND METHOD RANKINGS OF 53 SITES

However, as Cox (1997, 147), among others, has noted, the Borda method can promote mediocre candidates if the participant's ranking vectors are either highly diverse or if one or more participants deliberately assigns low ranks to alternatives that may threaten their own most favoured choices. The problem of strategic voting can, however, be discounted in this thesis given the efforts that were taken to ensure participant anonymity. Despite this, the averaging effects of the Borda function can be seen in Table 6.9, where the site that tied for second Copeland rank received a sixth place Borda rank due to the influence of the National Trust Scientist and Business Owner ranks (25.5 and 30th).

Block_Parcel	Director of Environment	National Trust Scientist	Real Estate / Developer	Hotel Operator / Developer	Business Owner	CPA Member	Deputy Director of Planning	Borda Rank	Copeland Rank
11D_31	15	7.5	5	4	2	5	6	1	1
17A_14	17.5	18	2	3	21	7	10	4	2.5
17A_12	3	25.5	3	19	30	2	4.5	6	2.5
11B_67	19.5	15.5	6	5	5	12	3	2	4
11B_17	24	34.5	4	2	3	4	13	5	5
11B_76	13.5	10.5	7	6	8	13	8.5	3	6
17A_10	33.5	34.5	17	1	1	1	14.5	7	7
10E_35	30	39	11	7	17	3	11.5	8	8
10E_9	28.5	39	12	8	16	10	14.5	9	9
8A_3	31	43.5	20	9	10	8	20	11	10
8A_60	25	39	22	11	7	16	26	12	11
11B_61	4	28	9	24	20	30	16.5	10	12
8A_68	26.5	46	24	15	11	14	21.5	19	13
3D_110	26.5	41.5	23	13	6	22	23.5	17.5	14.5
3D_23	28.5	4	27	12	4	20	21.5	22	14.5
11B_62	6	32	19	24	24	38	4.5	13.5	17
17A_11	13.5	23	38	20	38	11	7	15	17
8A_7	35	51	28	10	12	6	18	20	17
1C_33	39.5	3	1	26	28	9	41	13.5	19.5
8A_2	32	43.5	21	17	9	23	23.5	24	19.5
11D_49	19.5	9	46	22	41	17	1	17.5	21
8A_16	43.5	49	25	14	15	18	11.5	27	22
11D_4/1/5	1	1	13	31	25	31	50	16	23
8A_14	49	51	26	16	14	21	16.5	31	24
8A_13	45	53	29	18	13	19	19	32	25
11D_32	7	6	14	35	22	32	44.5	21	26
11D_14	8	7.5	16	37	23	33	42.5	23	27
11B_15	2	36	10	32	19	29	46	26	28
11B_69	9	30.5	8	34	18	28	52	28	29
11C_238	21	12	42	21	43	24	8.5	25	30.5

Note: Block_Parcel refers to the system used in the Land Registry of The Cayman Islands to assign unique identifiers to every property. Each cadastral parcel is referenced by a grid-like Block number and an associated Parcel number within that specific Block. For example, 11D_31 refers to parcel 31 in Block 11D. Similar systems are in use throughout the Caribbean and other states as well.

TABLE 6.9 TOP 30 CANDIDATE SITES USING COPELAND RANKS - 53 SITES

6.3.4.2 *Correlation of Ranks – 53 Sites*

The Spearman rank correlation coefficients (r_s) calculated for the 242 site set in the previous section supported two observations that were made in the discussion of the participants' mapped rankings. First, the ranks produced by the CPA Member were more closely aligned with those of the pro-development group than with the other neutral group member (Deputy Director of Planning). Second, the conflict visible between the ranking maps of the National Trust Scientist and two other participants (the Hotel Operator / Developer and the Business Owner) is supported by significant negative r_s values in Table 6.10. The National Trust Scientist was also the only participant to generate rankings that were not significantly associated with the aggregate ranks produced by either the Borda or Copeland functions (Table 6.11).

Participant 1	Participant 2	Rs	Student's t-statistic	Significant at 95%	Significant at 99%
National Trust Scientist	Business Owner	-0.4330887	-3.431372256	Yes	Yes
Hotel Operator/Developer	National Trust Scientist	-0.2956599	-2.210246935	Yes	No
CPA Member	National Trust Scientist	-0.1929096	-1.404022386	No	No
Deputy Dir of Planning	National Trust Scientist	-0.1903599	-1.384763125	No	No
Dir of Environment	National Trust Scientist	0.1172994	0.843508296	No	No
Real Estate/Developer	National Trust Scientist	0.1240219	0.892585086	No	No
CPA Member	Dir of Environment	0.1635682	1.184057324	No	No
Dir of Environment	Deputy Dir of Planning	0.1948356	1.418590395	No	No
Real Estate/Developer	Deputy Dir of Planning	0.2524605	1.863285703	Yes	No
Hotel Operator/Developer	Dir of Environment	0.2991732	2.239076619	Yes	No
Business Owner	Dir of Environment	0.3864177	2.991979839	Yes	Yes
Real Estate/Developer	Dir of Environment	0.4048474	3.161896703	Yes	Yes
Business Owner	Deputy Dir of Planning	0.4342934	3.443131779	No	No
CPA Member	Deputy Dir of Planning	0.5240401	4.39406253	Yes	No
Business Owner	Real Estate/Developer	0.6210288	5.658462033	Yes	Yes
CPA Member	Business Owner	0.6415901	5.973382618	Yes	Yes
Real Estate/Developer	CPA Member	0.6472343	6.063533374	Yes	Yes
Hotel Operator/Developer	Real Estate/Developer	0.6592211	6.260768618	Yes	Yes
Hotel Operator/Developer	Deputy Dir of Planning	0.7181525	7.369938195	Yes	Yes
Business Owner	Hotel Operator/Developer	0.812757	9.962612529	Yes	Yes
CPA Member	Hotel Operator/Developer	0.8459802	11.33035275	Yes	Yes

TABLE 6.10 SPEARMAN RANK CORRELATION – PARTICIPANT RANKS - 53 SITES

One effect of filtering out the most contentious potential accommodation locations (e.g. conflict index >8) to create the smaller set of 53 candidate sites was to attenuate the negative r_s value evident in Table 6.7 between the National Trust Scientist and the Deputy Director of Planning. Despite this change, the National Trust Scientist still remains unique among the group as the only member whose rankings are not associated positively with those of any other participant. Altering the number of candidate sites under consideration did not, however, have an appreciable impact on the degree to which the ranks of the CPA Member were associated with the pro-development group.

The r_s values that were calculated between the participants' rankings and the two methods of producing aggregate ranks are shown in Table 6.11. The effects of the different methodologies underlying the Borda and Copeland functions are apparent in the table when the range of r_s values generated for each of the two methods is considered. In particular, the r_s values listed for the Borda function are higher for the "minority" participants who emphasised environmental factors in their criteria sets (e.g. the National Trust Scientist and the Director of Environment) and lower for the "majority" participants who focused almost exclusively on developmental or economic considerations (Real Estate / Developer, Business Owner, Hotel Operator / Developer, CPA Member). This indicates that the method is more likely to promote compromise alternatives. In contrast, the Copeland method is less susceptible to "extreme" minority positions and will produce aggregate ranks that more closely reflect the majority, if such a majority exists, as shown by the strong associations between its ranks and the four *de facto* pro-development participants.

Group Ranking	Participant Ranking	Rs	Student's t-statistic	Significant at 95%	Significant at 99%
Borda Rank	National Trust Scientist	0.1247883	0.89818721	No	No
Borda Rank	Director of Environment	0.581401	5.10317843	Yes	Yes
Borda Rank	Deputy Director of Planning	0.64722377	6.063363288	Yes	Yes
Borda Rank	Business Owner	0.6998065	6.99620761	Yes	Yes
Borda Rank	CPA Member	0.7567328	8.26671493	Yes	Yes
Borda Rank	Hotel Operator / Developer	0.8256592	10.4514504	Yes	Yes
Borda Rank	Real Estate / Developer	0.8388969	11.006851	Yes	Yes
Copeland Rank	National Trust Scientist	-0.0661354	-0.47333735	No	No
Copeland Rank	Director of Environment	0.461419	3.71422027	Yes	Yes
Copeland Rank	Deputy Director of Planning	0.6789115	6.603466578	Yes	Yes
Copeland Rank	Business Owner	0.7786226	8.86142543	Yes	Yes
Copeland Rank	Real Estate / Developer	0.8233136	10.3590068	Yes	Yes
Copeland Rank	CPA Member	0.8263387	10.4785456	Yes	Yes
Copeland Rank	Hotel Operator / Developer	0.9148263	16.1773126	Yes	Yes
Copeland Rank	Borda Rank	0.9792914	34.5435695	Yes	Yes

TABLE 6.11 SPEARMAN RANK CORRELATION – PARTICIPANT AND AGGREGATE RANKS – 53 SITES

While the two sets of aggregate rankings of candidate accommodation sites discussed in this section could be used as input to the initial stages of a plan generation process, it is not clear at this stage how susceptible these rankings are to small changes in data standardisation parameters, the MCA method that was used, criteria choices, or criteria weight settings. The following section addresses these aspects of applying MCA to practical decision making problems and presents some extensions to the site evaluation methodology used in *Tan*Plan.

6.4 Sensitivity of Evaluation Results to Uncertainties

This section focuses on the sensitivity, or susceptibility, of the rankings of candidate accommodation sites to uncertainties internal to the analysis. Sensitivity analysis methods help to determine how stable an evaluation outcome is by introducing small changes to key inputs such as criteria weights, criteria data scores, and/or altering the choice of MCA method. The discussion is divided into two main components: a) the sources of uncertainty that are relevant to the case study and, b) the application of selected sensitivity analysis techniques to the participant and collective rankings. The four-part typology of uncertainties in MCA that was proposed by Voogd (1983, 190-191) and mentioned in Chapter 3 is used to structure the discussion of the first component. It is important to note that attention is confined to investigating the possible effects that the participant's choice of MCA method, specific criteria weight settings, and criterion data values, among other factors, had on their evaluations. The trade-offs and uncertainty relating to whether the 'correct' set of candidate sites was included in the evaluation was addressed in Chapter 5 and is not repeated here.

6.4.1 Sources of Uncertainty

6.4.1.1 Criterion Uncertainty

Ensuring that all relevant aspects of a decision problem are encompassed within the set of evaluation criteria available to participants is vital to the defensibility of the decision outcomes. In practice, this involves trade-offs between the comprehensiveness of the criteria set and the amount of effort that can be expended on data collection (Malczewski, 1999a, 107). Since planning problems are most frequently multi-disciplinary in nature, it is also important that an adequate balance be maintained between the criteria representing different facets of the planning issue (e.g. environmental, economic, social) and that these criteria represent valid and, in the case of quantitative MCA techniques, measurable translations of planning objectives (Voogd, 1983, 192-193).

The difficulties associated with providing the case study participants with a complete set of measurable criteria were outlined earlier in Chapter 4 as well as sections 6.2.1 and 6.2.2. In particular, the problems of data availability, recency, quality, and confidentiality had significant impacts on the research, but it should be noted that they are likely to be much more pronounced in other Caribbean nations that lack the information resources and capabilities evident in government and NGO (i.e. National Trust) agencies in the C.I. Notwithstanding this proviso, the study participants were able to identify, in response to an open-ended question, a number of criteria that would be critical in subsequent evaluation analyses (Table 6.12).

Additional Criteria Required	Need Identified By
Character of the seabed	Deputy Director of Planning
Current land use	National Trust Scientist
Distance from storm ridge to the sea	Deputy Director of Planning
Ease of changing parcel's current zoning to permit tourism development	Hotel Operator / Developer, CPA Member
Infrastructure capacity (electrical, water, sewerage)	Deputy Director of Planning
Land costs	Hotel Operator / Developer, Real Estate / Developer, Business Owner, Deputy Director of Planning
Marine and onshore habitats	Director of Environment, Deputy Director of Planning, National Trust Scientist
Scenic value	CPA Member
Soil conditions	Deputy Director of Planning
Vegetation cover	National Trust Scientist

TABLE 6.12 ADDITIONAL EVALUATION CRITERIA IDENTIFIED

The absence of land costs proved to be somewhat problematic for the pro-development participants and, to a lesser extent, the Deputy Director of Planning as it is a key determinant of the type and scale of tourist accommodation that would be required on a given parcel for development to be economically feasible. However, it is unlikely that the lack of land cost information would invalidate any of the candidate sites examined in the preceding sections, as land costs for beachfront hotel and condominium projects are captured to a large extent by the D2TourZone and D2Sand criteria. Had it been possible to apply even an ordinal classification of estimated purchase price (e.g. very low, low, moderate, and so on through to very high) to the study area land parcels, the four participants listed above and possibly also the CPA Member would have likely approached the evaluation procedure from a somewhat different perspective.

A similar argument could be made for the Deputy Director of Planning and the two pro-conservation participants with respect to the lack of criteria to represent specific marine and terrestrial habitats in the study area. As mentioned earlier, criteria such as D2Wetland, D2Mangrove, D2Replent can serve only as rough proxies for how close a specific property is to sensitive eco-systems and how these eco-systems would be affected by developing the property.

Although the lists of existing and desired criteria (Tables 6.2 and 6.12) appear to address many of the important developmental, environmental, and economic dimensions of the accommodation siting issue, it was somewhat surprising that no participants identified the need for additional tourism-related criteria that extend beyond the D2Hotel, D2Shop, and scenic quality measures. Some possible indicators referred to in the literature that could be useful in this type of planning context include: maximum host-tourist density for specific locales, proximity to historical and cultural attractions, and various measures of carrying capacity (Gunn, 1997, 49; Mathieson and Wall, 1982, 21). The familiarity of the participants with the existing tourist accommodation and the dynamics of the sector in West Bay may account for this apparent omission.

Two other aspects of uncertainty relevant to the case study include whether redundancy in the criteria set could skew the evaluation results through possible "double-counting" of some facet of the decision problem (Malczewski, 1999a, 108) and whether the definition of a criterion represents fairly the objective(s) and/or features that it is intended for (Voogd, 1983, 192). Strong correlation between criteria pairs can indicate possible redundancy, as noted by Malczewski (1999a, 109). However, further investigation may be required before specific criteria are excluded from an evaluation given that spatial proximity between different features, phenomena, or characteristics is often reflected in criteria attribute data and thus reduces the possibility of complete criteria independence. To illustrate, strong negative correlation would be anticipated in most SIS between land costs and proximity to a sandy beach, but this correlation alone could not justify the removal of either one of these criteria from an evaluation. The potential for criteria redundancy was greatest in the case study with respect to the two indicators of proximity to roadways (D2PrimRd and D2SecRd), but since participants were discouraged from selecting both of these criteria, the redundancy problem was minimised.

Uncertainty relating to how accurately planning objectives were represented by specific criteria likely had a greater affect on the evaluation outcomes than the redundancy problem. Recall that the distance-related criteria, such as D2Replent, D2Wetland, and D2Hotel, were surrogates for either the attractiveness of a property as an accommodation site or the potential impacts that construction or tourist activities may have on nearby, fragile ecosystems. However, the use of straight-line distance may not have been appropriate for several of these criteria (e.g. D2Reef, D2Marine, and D2Replent) as it disregards the level of active tourist use (e.g. scuba diving, snorkelling, boating) associated with a property's development. More importantly, it is probable that that certain types of externality fields are non-linear in character, although this aspect is addressed to some extent in the process of normalising criteria scores. Finally, distance may be of secondary importance to other functional factors. For example, the National Trust Scientist indicated that a key shortcoming of the D2Reef criterion was that reefs are damaged not only from nearby development and tourist activities (e.g. excessive numbers of divers, anchor damage, etc.), but also because they can be suffocated by the transport of sediments from upstream developments through long-shore drift and tidal movements.

6.4.1.2 Assessment Uncertainty

In most applications of MCA methods to planning issues, it is unlikely that there is complete confidence in the accuracy of the data values, or scores, associated with different evaluation criteria (Janssen, 1992, 91). This type of uncertainty can arise from several sources, however those most relevant to the case study in this thesis include: 1) measurement errors, 2) taxonomic errors and, 3) representational or conceptual errors.

Measurement errors can occur for any criterion through recording or input errors or inappropriate assumptions in data collection procedures. Further, criteria derived from a GIS framework can incorporate measurement errors relating to positional accuracy, generalisation effects, and data conversion errors linked to the conversion of hardcopy map data into digital form (Lodwick et al, 1990, 420). Although the cadastral data used in the case study were somewhat dated, it was of sufficient quality in positional terms to allow it to be used for legal land registry purposes by the C.I. Lands and Survey Department. In contrast, generalisation and data conversion effects were more pronounced in the data layers that were used to represent coastal (D2Sand, D2Rock, D2Mangrove, D2SeaPond, D2Reef) and wetland (D2Wetland) features. A prime example of these effects is the omission of a number of small, but ecologically significant, reefs from the coastal features map layer.

Taxonomic uncertainty centres on errors that may be present in criteria due to inaccuracies in the attribute information associated with specific spatial entities (Malczewski, 1999a, 263). For example, some stretches of North Sound coastline were coded as mangrove but had subsequently been reclaimed for development, thereby causing D2Mangrove values to be understated somewhat in some parts of the study area. However, it is probable that the overly general classification system that was applied to the coastline map layer had a more significant impact on the evaluation results. Unfortunately, no distinctions were made within the broad categories of sand, rock (ironshore), mangrove, and artificial [2] to differentiate higher quality sand beaches (e.g. Seven Mile Beach) or mangrove habitats from their lower quality counterparts. Hence, the D2Sand criterion reflected the distance to the closest sand beach, but not necessarily the distance to the closest sand beach that would be attractive to tourists. The D2Rock and D2Mangrove criteria were affected similarly by this type of classification error.

To some degree, the taxonomic errors discussed above are compounded by uncertainty concerning how some concepts, objects, and phenomena are represented or conceptualised within the GIS data model. For instance, many spatially-referenced features, such as surveyed land parcels, can be delimited in unambiguous terms while the extent and characteristics of many others, such as habitats, wetland boundaries, and transitions between soil or vegetation types are imprecise or "fuzzy" in character (Burrough and McDonnell, 1998, 267). The representation and any associated manipulation of indeterminate objects within vector-based GIS has been based traditionally upon assumptions that they have clearly-defined or "crisp" boundaries (Wang and Hall, 1996, 262). This shortcoming is shared by the *TourPlan* decision support tool and consequently an element of representational error is introduced to the data values calculated for proximity-based criteria. The phenomena represented by the D2Wetland, D2Mangrove, and D2Reef criteria are affected by representational errors in particular as well as the D2Hotel criterion given uncertainty

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[2] The 'artificial' coastline class was added by the researcher to account for human-built canals and shoreline building lots.

concerning point(s) of access to specific hotel/condominium properties. In contrast, while marine parks and replenishment zones are delimited clearly by fiat, they are inherently indeterminate from a functional perspective.

6.4.1.3 *Priority Uncertainty*

One of the strengths of MCA methods is that they permit subjective factors to be incorporated directly into an evaluation of competing alternatives through the specification of criteria weights. Subjective factors are, by their very nature, difficult to define with complete confidence and consistency. Given the substantial influence that criteria weights can have on evaluation outcomes, they are the focus of a considerable amount of attention in the literature concerning uncertainties and sensitivity analysis in MCA evaluations (Malczewski, 1999a; Jankowski et al, 1995).

Priority uncertainty can be ascribed to four sources. First, since criteria weights are defined in an *ex ante* manner, decision makers must specify the relative importance of different criteria without full knowledge of the impact that these weights will have on the outcome of an evaluation (Massam, 1993, 77). Second, while decision makers may be able to indicate the ordinal importance of criteria relatively easily, developing the ratio level weights that are required by many MCA techniques requires much greater cognitive effort (Van Deft and Nijkamp, 1977, 40). In part, these difficulties stem from the problem of *ex ante* weight specification, but they may also be due to the reluctance of a decision maker to reveal his or her preferences explicitly, particularly in a multi-interest or politically-charged decision context (Saaty, 1989, 65). Third, these difficulties can be accentuated by method-induced bias arising from the technique that is used to extract criteria preferences from decision makers. Finally, it is important to recall that criteria weights are estimates of the relative importance of different decision elements and are not absolute "truths" in any sense. Consequently, they are conditional on, among other factors, the set of choice alternatives being evaluated (e.g. similar or dissimilar alternatives), the nature of the decision making task (e.g. ranking, elimination of dominated alternatives, etc.), and the dynamics of the decision making environment (e.g. co-operative versus confrontational).

Recognition of the conditional nature of criteria weights was a key factor in determining both the degree of criterion uncertainty that participants experienced and the source(s) of this uncertainty. Keeping this notion foremost in their deliberations appeared to be most difficult for the two participants who used the pair-wise comparison method (Deputy Director of Planning and Director of Environment). The sheer number of criterion-by-criterion assessments inherent to the method, the incomparability of some criteria pairs, the partial view enforced by the pair-wise comparison methodology, and the high number of criteria involved in their evaluations (11 and 12 respectively) isolated the weight generation process from the case study context to some degree and focused it on more abstract, and frequently uncertain, criteria-pair assessments. Some of these difficulties could have been reduced if the software had supported an AHP-like hierarchical approach to criteria weighting, as participants could have first assessed the relative importance of pairs of thematic criteria groups (e.g. environmental factors versus social factors) and then compared individual criteria within each branch of the hierarchy on a pair-wise basis. Despite this shortcoming in the software design, most of the initial uncertainty dissipated once the participants completed the initial run of the weighting procedure and they were able to review and adjust the resultant weightings as necessary.

In contrast, the participants who used the seven-point method appeared to be less apt to see criteria weights as absolute values independent of the case study and had a much clearer understanding of how weights were actually calculated. In almost all cases, these participants adopted a less demanding two-stage approach to the weighting task which involved sorting the criteria first by ordinal importance and then subsequently refining the relative separation of individual criterion within the set in a stepwise and recursive fashion. While less method-induced uncertainty was experienced by the participants who used the seven-point method, not all participants were satisfied with its results. The National Trust Scientist, in particular, felt that the method was inadequate in terms of capturing all of the necessary nuances in a criteria weight set. As noted earlier, given the time constraints on the case study, the participants were not able to experiment using both of the available methods for generating criteria weights.

6.4.1.4 Method Uncertainty

In addition to the biases that are introduced by a particular criteria weighting technique, it is necessary to consider how evaluation results are affected by the MCA method that was used to combine criteria weights with their respective scores. For this reason, several researchers have suggested the results generated from more than one MCA routine be compared for a given problem (Buede and Maxwell, 1995; Heywood et al, 1994; Massam, 1991). Investigations into the effects of differences in the methodological idiosyncrasies, key assumptions, and data requirements of specific MCA methods have shown, in general, that method-related effects are most prominent when: a) the number of alternatives and/or criteria under consideration is large, or b) the structure of the methods (e.g. utility-based weighted summation versus multi-dimensional scaling methods such as Ideal Point Analysis) are dissimilar (Voogd, 1983, 199-201; Janssen, 1992, 100). Variations in the details of how a particular MCA structure is operationalised, termed the "content" of the structure by Voogd, reportedly have a lesser impact on evaluation results than structural variations do. The effect of method structure on the case study results is examined in section 6.4.2.2.

6.4.2 Application of Selected Sensitivity Analysis Methods to Case Study Results

Having outlined some of the major sources of uncertainty pertinent to the case study evaluations, the following sections describe the sensitivity analysis methods that were applied *post hoc* to the results presented in this thesis. It is beyond the scope of the research to examine empirically all of the aspects of uncertainty discussed above. For example, assessment uncertainty is not addressed as it would require further field verification (e.g. gather GPS co-ordinates for "missing" reefs, code shoreline types more accurately, etc.), the development of alternative data structures to support indeterminate feature boundaries (e.g. variable extent of wetlands and mangroves), or the collection of probabilistic assessments of the distribution of error, or confidence intervals, around the data values for each criterion (e.g. expected D2Wetland value = observed D2Wetland value plus or minus 20 feet).

Instead, attention is concentrated on addressing the sensitivity of the results to choice of criteria weightings and MCA method as these sources of uncertainty appeared to figure most prominently in participants' evaluations. The choice of the type of sensitivity analysis approach to apply was guided by a concern for what is feasible and appropriate for a diverse, multi-participant group in the early stages of a planning process and by the constraints inherent to any *post hoc* analysis.

6.4.2.1 Priority Sensitivity

Two main approaches to dealing with priority uncertainty are represented in the literature, namely, probabilistic methods and sensitivity analysis. Both approaches involve observing the outcomes of rerunning the evaluation procedure with altered criteria weight sets, however they differ in terms of methodology, underlying assumptions, and computational process.

Probabilistic approaches assume that, while criterion weights may not be known with complete certainty, one can define a range around each criterion weight within which a "true" weight can be found. A Monte Carlo simulation approach is used to select criteria weights randomly from within these ranges, or distributions of error, subject to an additivity constraint. Typically, these randomly-selected criteria weight sets are required to respect the rank order of the original criteria weights (Van Huylenbroeck and Coppens, 1990, 404). Alternatively, each decision maker can define a confidence interval around each criteria weight based on their past experience, available information, and intuition (Malczewski, 1999a, 264). These randomly-generated weight sets are fed into several hundred runs of the evaluation procedure thereby allowing the probability that alternative i has a rank of n to be expressed in probability table or histogram format (Janssen, 1992, 92). Most of the criticism of this approach has centred on the assumptions of normality in the distribution of error and the mutual independence of the criteria (Voogd, 1983, 196).

In contrast, sensitivity-based approaches are not dependent on any assumptions concerning the statistical distribution of error around criterion weights. Instead, the stability of an evaluation is investigated in a more *ad hoc*, and often interactive, manner by introducing a known amount of change to one or more criterion weights and observing any changes in the rankings of alternatives (Van Huylenbroeck and Coppens, 1990, 401). Relative to probabilistic methods, this approach supplies more immediate feedback to participants, is easier for non-experts to understand, and provides a mechanism to explore the decision problem and learn how changes in criteria weights affect evaluation outcomes. For these reasons, sensitivity-based approaches to investigating priority uncertainty have been used frequently in applied contexts characterised by more than one decision maker (Jankowski et al, 1997, 597; Lewis, 1993, 219).

The sensitivity of each participant's site rankings to changes in any one criterion weight was investigated through a series of evaluation runs in which one criterion weight was altered by plus or minus 5, 10, or 15 percent. All other criteria were then adjusted proportionally to satisfy the additivity constraint. This resulted in a total of $n * 6$ evaluation runs being conducted for each participant where n represents the number of criteria in the evaluation. Hence, the number of runs per participant ranged from a high of 72 (Director of Environment - 12 criteria) to a low of 30 (Hotel Operator / Developer and Real Estate / Developer - 5 criteria each). The site rankings that resulted from these runs were compared to the original rankings discussed in section 6.3 to determine both the general stability of a participant's original rankings following weight changes and to identify any specific criteria that affected the results most noticeably in response to a weighting change.

Visualising the results of these comparisons can be problematic given the number of evaluation runs that this approach entails (Malczewski, 1999a, 268). The graphs displayed in Figures 6.15 to 6.17 illustrate, on a criterion-by-criterion basis, the effects of varying weights at 5 percent increments as described above. The original ranks of the candidate sites are arranged along the *x*-axis of the graphs from most preferred (1) to least preferred (53) rank[3]. Note that these graphs are participant-specific. As a result, comparisons between graphs can be made only with the understanding that the rankings portrayed on the x-axes pertain usually to *different* sites (see Table 6.9). The y-axes of these graphs display the maximum absolute deviation between the original rank of a site and the ranks the same site received when each of their criteria weights were increased and decreased successively by 5 percent. To illustrate, the site that was originally ranked 17th by the Director of Environment (11D_37 in Table 6.9) received a rank of 16 when the D2Mangrove weight was increased by 5 percent (deviation of 1) and maintained its 17th position when the weight was decreased by the same amount.

[3] For display purposes only, the *x*-axes of the graphs in Figures 6.15 to 6.17 range from 1 to 53 although the actual range of ranks may differ for some participants due to tied ranks.

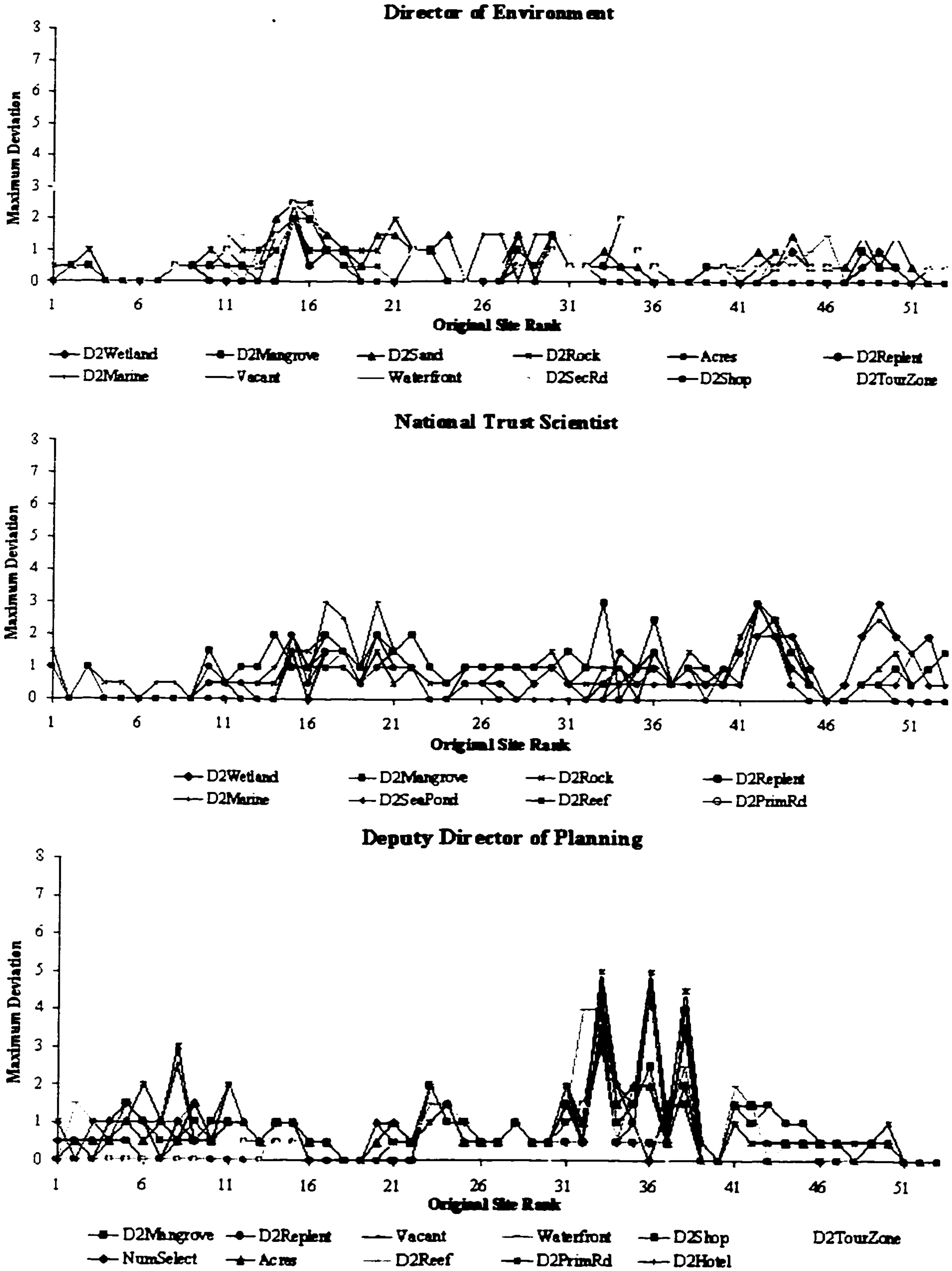

FIGURE 6.15 CHANGE IN RANKS WITH A 5 % CHANGE IN CRITERIA WEIGHTS – 1

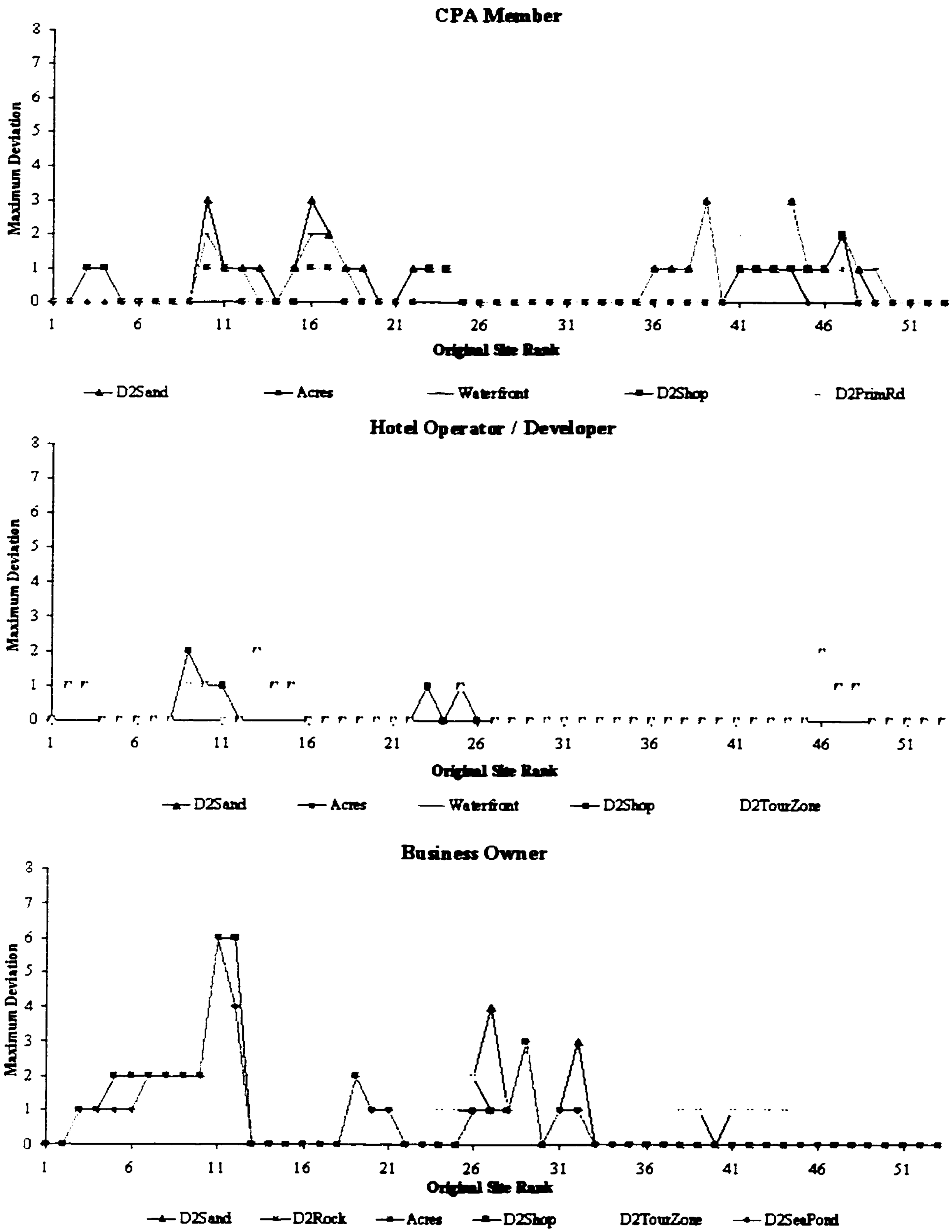

FIGURE 6.16 CHANGE IN RANKS WITH A 5 % CHANGE IN CRITERIA WEIGHTS – 2

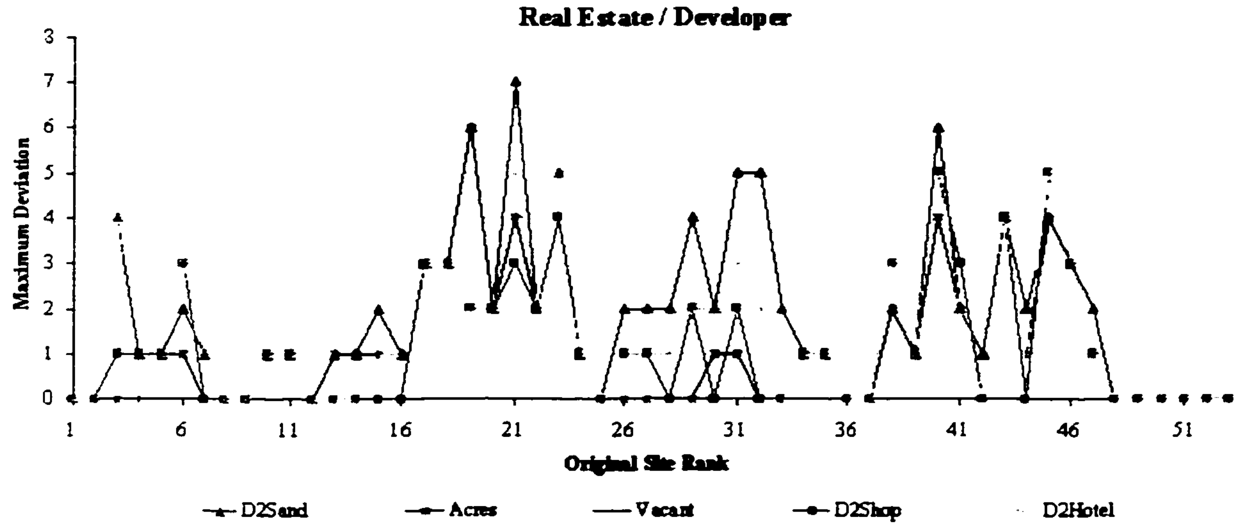

FIGURE 6.17 CHANGE IN RANKS WITH A 5 % CHANGE IN CRITERIA WEIGHTS – 3

Several observations can be made based on an examination of the graphs that are relevant to the case study in particular and the sensitivity methodology in general. Foremost, the criteria that are most frequently found to be highly sensitive to weight changes (i.e. ranks changed by more than 2 positions) are D2TourZone (4 participants [4]), D2Sand (4 participants [5]), and Acres (3 participants [6]).

This sensitivity to weight changes can be accounted for by three interrelated factors. First, the participants assigned these criteria either the highest or second-highest weights in their respective evaluations, with the only exception being Acres in case of the Deputy Director of Planning. Accordingly, a 5 percent change in these weights had a considerably larger absolute impact on the entire weight set than the same percentage change would have with criteria that were assigned much lower initial weights.

Second, with only two exceptions, these criteria were assigned a weight that was equal to at least one other criterion within a given participant's evaluation. To illustrate, the Real Estate / Developer gave the same weight to D2Sand and Acres, D2Sand and D2TourZone were both weighted the same by the Hotel Operator / Developer, and the Business Owner weighted Acres and D2SeaPond equally. When the weight of one of these criteria is changed by a set percentage and all other criteria are adjusted proportionally, the ordinal structure of a participant's weight vector is altered. This effect was particularly significant for the Real Estate / Developer who had assigned equal and highest weights to two criteria (Vacant and D2Sand), while giving the same lower weight to the three remaining criteria (D2Hotel, D2Shhop, and Acres).

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[4] Director of Environment, Hotel Operator / Developer, Business Owner, and Deputy Director of Planning.

[5] CPA Member, Real Estate / Developer, Hotel Operator / Developer, and Business Owner.

[6] Real Estate / Developer, Business Owner, and Deputy Director of Planning.

Finally, the sensitivity of the Business Owner, the Real Estate / Developer, and the Deputy Director of Planning rankings to small weight changes can be also be attributed in part to the effective data ranges (i.e. practical minimum and maximum values) that these participants established for certain criteria in the normalisation process. It is important to recall that a criterion weight actually reflects the relative importance of moving from the criterion's minimum data value to its maximum data value (Malczewski, 1999b, 23). Evaluation results therefore become more sensitive to change if the range of acceptable criterion scores is limited in breadth. In the case of the Deputy Director of Planning, for example, several criteria were transformed into "near unary" (D2Mangrove, D2Reef), binary (D2TourZone) or "near binary" (D2Shop) states. Thus, the "near unary" and "near binary" criteria became somewhat superfluous to the evaluation as a slight advantage in another criterion generated a more than commensurate change in site rankings. While the Deputy Director of Planning used the NCD method in his evaluation, it should be noted that this problem is particularly relevant in the case of the WS method since normalised criteria scores are multiplied by their corresponding weight values.

Site	Deviations of 3 or more	Criteria Affected and Original Site Rank for Individual Participants	Copeland Rank
8A_89	9	Real Estate / Developer (D2Sand, Vacant, D2Hotel, 40), Deputy Director of Planning (D2TourZone, D2PrimRd, D2Mangrove, D2Hotel, NumSelect, Acres, 32.5)	36
1C_33	7	Business Owner (D2TourZone, D2Sand, Acres, D2Shop, 27), Hotel Operator / Developer (D2TourZone, D2Sand, 26)	19.5
11B_67	6	National Trust Scientist (D2Marine, 16.5), Business Owner (D2TourZone, D2Sand, Acres, D2Shop, D2Rock, 11)	3.5
11B_68	5	National Trust Scientist (D2Marine, 21), Business Owner (D2TourZone, D2Sand, D2Shop, D2Rock, 29)	30.5
8A_2	4	National Trust Scientist (D2Mangrove, D2Wetland, D2Marine, D2Replent, 41.5)	19.5
11D_31	3	Director of Environment (D2Sand, Waterfront, D2Rock, 15.5)	1
17A_10	3	Director of Environment (D2Mangrove, 33.5), Real Estate / Developer (D2Sand, Vacant, 19)	7

TABLE 6.13 SITES MOST SENSITIVE TO A 5 % CRITERIA WEIGHT CHANGE

Another finding of interest was that a large majority of the most prominent deviations displayed in Figures 6.15 to 6.17 are confined to a small subset of actual sites. This concentration of weight sensitivity is not evident in the figures since the *x*-axes of the graphs pertain to site rank on a participant-specific basis and, therefore, the position of a given site along the axis varies from one graph to another. Table 6.13 isolates the 7 sites for which these deviations are most frequent and lists in the second column the number of times that a site's rank changed by at least 3 positions in response to a 5 percent change in any criterion weight. The third column of the table lists, on a participant-specific basis, the criteria that were responsible for these deviations and the original rank that was assigned to the site. For example, the ranks recorded for site 8A_89 differed by 3 or more positions a total of 9 times. This count of 9 was composed of 3 Real Estate /

Developer criteria and 6 Deputy Director of Planning criteria. The Copeland rank from Table 6.9 is repeated in the final column for reference.

Table 6.13 shows that the sites most sensitive to criteria weight changes are, in general, those that occupy the middle range of a participant's ranks. The sensitivity of these sites to weight changes can be attributed at least in part to the fact that they neither clearly dominate, or are clearly dominated by, the majority of all other sites in a participant's evaluation. As a result, the ranks of these sites often change in response to small weight changes, especially in cases where tied ranks were common in the original evaluation (e.g. Deputy Director of Planning). In a multi-participant context, weight sensitivity is particularly important for the sites that are ranked highly on a collective basis, as indicated by the Copeland ranks in Table 6.13. Although Figures 6.15 to 6.17 display rank changes only in terms of absolute deviations, it should be noted that all of the rank deviations for sites 11D_31, 11B_67, and 17A_10 brought the participant ranks closer to the aggregate Copeland rank.

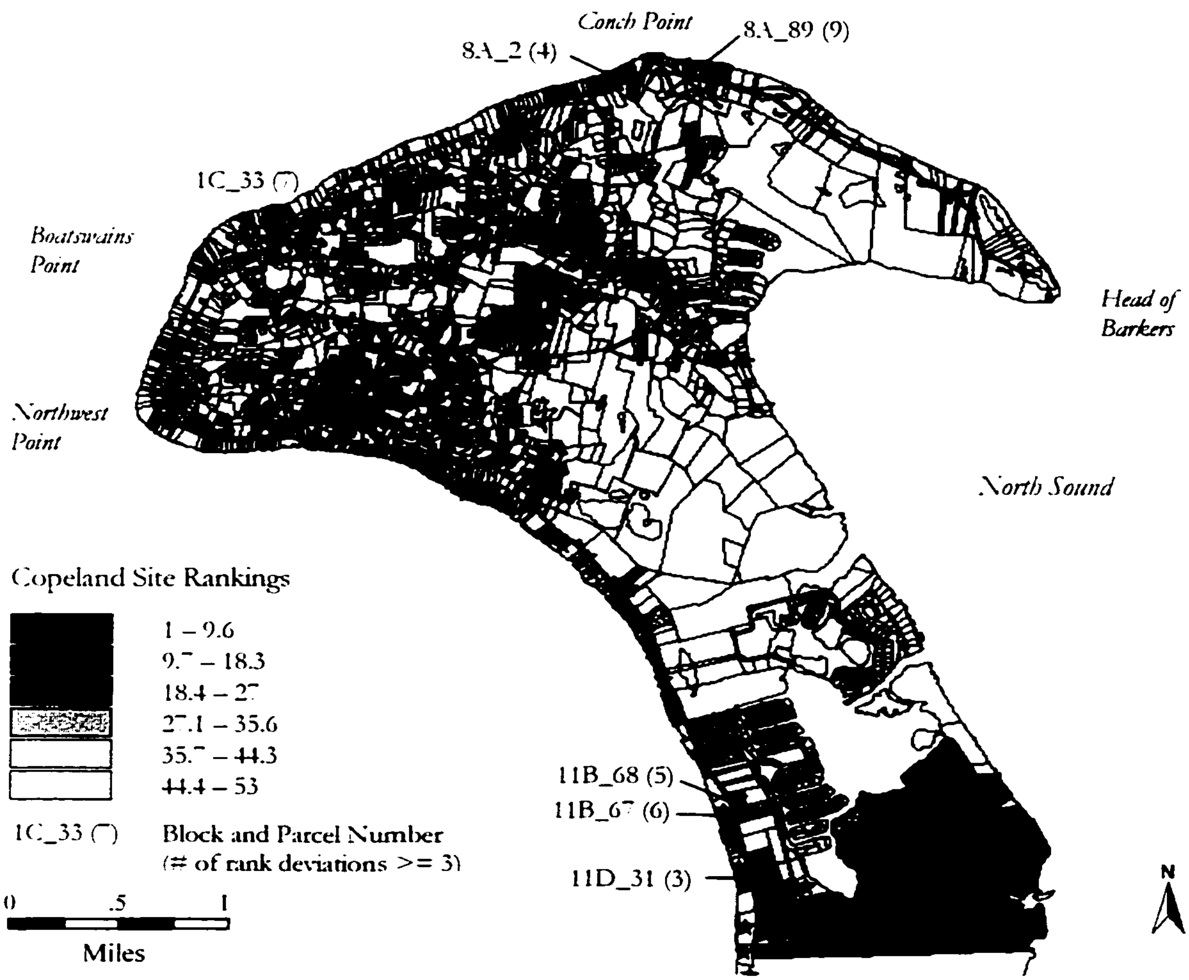

FIGURE 6.18 SITES MOST SENSITIVE TO CRITERIA WEIGHT CHANGES

Figure 6.18 supports the discussion above by highlighting the location of the seven sites most sensitive to criteria weight changes. By cross-referencing Figure 6.18 with the general context map (Figure 6.3) and Table 6.4 which lists the user-specified data bounds, one can see that the sites most sensitive to weight changes would be expected to have strong, and close to maximum, scores for two or more of the criteria listed in the Table 6.13. A small change in the weight of one of these criteria would then be sufficient to alter the rank of these sites relative to other sites with similar characteristics. Site 8A_89 is the most apparent example as it has strong normalised data scores for all six Deputy Director of Planning criteria for which it proved to be sensitive to be highly sensitive to weight changes. Similarly, five of the other sites listed in Table 6.13 display a sensitivity to D2Sand in combination with either D2Shop or D2TourZone. These sites are located in or near a tourism zone (D2TourZone), are on or very close to a sand beach (D2TourZone) and are in close proximity to a commercial zone (D2Shop).

Finally, support for the above discussions concerning tied criteria weights and data normalisation effects can be found in the sensitivity runs that were conducted using 10 and 15 percent weight changes. Although it is beyond the scope of the thesis to examine the outputs of these runs in any detail, it is worth adding that the rank deviations changed relatively little for most of the participants' evaluations. For example, the maximum deviation found across all of the Director of Environment's criteria increased from 5 rank positions with a 5 percent weight change to a high of 5.5 positions when the amount of change was increased to 15 percent. Similarly, the maximum deviation for the Deputy Director of Planning increased from 5 positions to 6.5 positions, while the corresponding figure for the Business Owner's evaluation was an increase of 1. In contrast, the maximum deviations in the CPA Member and the Hotel Operator / Developer evaluations rose from 3 at the 5 percent change level to highs of 8 and 6 respectively when subjected to 15 percent variation in criteria weights. In these cases, a 15 percent change to criteria weights was sufficient to alter completely the ordinal structure of their respective weight vectors.

These results suggest that the evaluations were, in aggregate terms, relatively insensitive to small weight changes for the sites that were assigned either high or low ranks. However, for the sites with ranks between these extremes, the evaluations were affected noticeably by weight disturbances. This effect was most apparent in the evaluations that included a large number of criteria in their evaluation (Deputy Director of Planning and Director of Environment) and those where the same weight was assigned to several criteria (Real Estate / Developer, Business Owner) which was most common where the seven-point method was used. In several cases, these effects were accentuated by the normalisation parameters specified by the participants, by the strong correlation of several criteria (e.g. D2Sand and D2Hotel, D2Sand and D2TourZone), or by a criterion (Vacant) that was an artefact of the 242 site evaluations and was rendered almost redundant in the 53 site set.

6.4.2.2 *Method Sensitivity*

As noted at the start of this Chapter, four case study participants chose to base their evaluations on the WS method, while the remaining three group members chose NCD (Table 6.1). To gauge the effect that MCA method choice had on the individual and collective rankings discussed in sections 6.3.3 and 6.3.4, additional evaluation runs were conducted where only the choice of MCA method was altered. Consequently, this issue is addressed relative to the two techniques used in the case study and is not intended as a general examination of MCA method effects, although some of the findings may be transferable to other contexts.

Table 6.13 lists the ranks that were generated for each participant using both the weighted summation and the net concordance-discordance methods. In addition, three variants of the aggregate Borda and Copeland rankings are provided: a) "Mixed" ranks which are based on the participant's original rankings and method choices, b) "All WS" ranks that are calculated from all of the participants' weighted summation ranks, and c) "All NCD" ranks that are derived from the individual NCD ranks. For brevity and correspondence with Table 6.9, only the sites that were ranked in the top 30 original (Mixed method) Copeland ranks are included in Table 6.14.

On a group-wide basis, the results listed in the table display relatively little method sensitivity for both the highest ranked sites and those that are least preferred (not shown in Table 6.14). One site, 11D_31, was ranked first by all six Borda and Copeland variants. Within the group of 9 sites that comprise the top class in Figure 6.15, 7 sites have Borda ranks (Mixed, all WS, and all NCD) that differ at most by one position, while 4 sites are ranked with the same degree of consistency by the Copeland technique. In terms of the least preferred class of candidate sites, both techniques produced ranks that are identical in their Mixed, all WS, all NCD ranks or differed at most by 1 position for 5 of the 9 lowest ranked sites. Between these extremes, somewhat less variation is evident in the Copeland ranks than in the Borda ranks due to the greater influence of outlying participant ranks on the latter, as noted in section 6.3.2.1.

On a participant-by-participant basis, the WS and NCD ranks are most similar for the Business Owner and, baring two exceptions, the Hotel Operator / Developer. The average deviations between the WS and NCD rankings across all 53 sites for these two participants as well as the CPA Member and National Trust Scientist range from 2.13 to 2.5. Corresponding figures for the Director of Environment, Real Estate / Developer, and the Deputy Director of Planning are 3.13, 4.34, and 7.30. The individual deviations underlying these averages were particularly extreme in the case of the Deputy Director of Planning as the 20th ranked site according to the NCD method was assigned a rank of 2 with the WS method.

Block Parcel	Dir. of Environment		CPA Member		Nat. Trust Scientist		Real Estate / Developer		Hotel Oper. / Developer		Business Owner		Deputy Dir. Planning		Borda			Copeland		
	NCD	WS	WS	NCD	NCD	WS	WS	NCD	WS	NCD	WS	NCD	NCD	WS	Mixed	All WS	All NCD	Mixed	All WS	All NCD
11D_31	15	16	5	3	7.5	7	5	8	4	3	2	3.5	6	4	1	1	1	1	1	1
17A_14	17.5	14	7	9	18	14	2	1.5	3	4	21	13	10	18	4	3	3	2.5	2.5	2.5
17A_12	3	1	2	11	25.5	23	3	5	19	14	30	29	4.5	19	6	6	7	2.5	5.5	6
11B_67	19.5	19	12	11	15.5	13	6	6	5	5.5	5	6	3	1	2	2	2	4	4	4
11B_17	24	23	4	2	34.5	32	4	3.5	2	2	3	3.5	13	23	5	5	5	5	5.5	2.5
11B_76	13.5	21	13	11	10.5	10	7	7	6	5.5	8	8	8.5	22	3	4	4	6	7	5
17A_10	33.5	37	1	1	34.5	26	17	26	1	1	1	1	14.5	15	7	7	6	7	2.5	7
10E_35	30	25	3	4	39	37	11	19	7	7	17	20	11.5	25	8	8	12	8	8	9
10E_9	28.5	26	10	6	39	39	12	17.5	8	8	16	16	14.5	16	9	10	14	9	9.5	8
8A_3	31	31	8	6	43.5	46	20	14	9	11.5	10	6	20	2	11	9	15	10	9.5	10
8A_60	25	28	16	14	39	42	22	20	11	13	7	6	26	17	12	14	18	11	12	11
11B_61	4	7	30	33.5	28	28	9	13	24	26	20	18	16.5	12	10	11	8	12	15	14
8A_68	26.5	29	14	14	46	47	24	27	15	17.5	11	10.5	21.5	10	19	17.5	27	13	13	17
3D_110	26.5	27	22	22.5	41.5	43	23	22.5	13	16	6	12	23.5	24	17.5	21	25	14.5	17	18
3D_23	28.5	32	20	16	48	44	27	25	12	11.5	4	2	21.5	5	22	15	26	14.5	11	12
11B_62	6	8	38	43	32	30	19	35.5	24	25	24	22	4.5	7	13.5	17.5	23	17	19	28
17A_11	13.5	15	11	14	23	17	38	28	20	10	38	37	7	20	15	22	9	17	28	13
8A_7	35	33	6	8	51	49	28	33	10	9	12	9	18	3	20	12.5	30	17	15	15
1C_33	39.5	47	9	6	3	3	1	1.5	26	22	28	32	41	47	13.5	23.5	10.5	19.5	19	16
8A_2	32	30	23	28	43.5	45	21	16	17	21	9	10.5	23.5	11	24	20	28.5	19.5	15	22.5
11D_49	19.5	17	17	19	9	9	46	37.5	22	17.5	41	40	1	14	17.5	25	13	21	30	20
8A_16	43.5	49	18	17.5	49	53	25	31	14	19	15	15	11.5	8	27	29	34	22	19	21
11D_4/1/5	1	2	31	30	1	2	13	10	31	28	25	26	50	37	16	12.5	10.5	23	22	22.5
8A_14	49	53	21	24	51	52	26	35.5	16	20	14	17	16.5	9	31	31	36	24	22	25
8A_13	45	52	19	20	53	51	29	41	18	27	13	14	19	13	32	32.5	37	25	22	27
11D_32	7	6	32	31	6	6	14	11	35	36.5	22	24	44.5	33	21	16	16	26	24	26
11D_14	8	5	33	33.5	7.5	8	16	15	37	39	23	27	42.5	32	23	19	22	27	26	29
11B_15	2	4	29	26.5	36	33	10	9	32	30	19	19	46	34	26	23.5	20	28	26	24
11B_69	9	9	28	25	30.5	25	8	3.5	34	34.5	18	21	52	46	28	26	19	29	26	30
11C_238	21	18	24	21	12	12	42	31	21	15	43	42.5	8.5	21	25	28	17	30.5	31.5	19

Notes: 1. NCD: net concordance-discordance. 2. WS: weighted summation. 3. original ranks are listed first for a participant. 4. Mixed: Aggregate ranks based on original participant ranks. 5 All NCD: Aggregate ranks derived from net concordance-discordance participant ranks. 6. All WS: Aggregate ranks based on weighted summation participant ranks.

TABLE 6.14 COMPARISON OF RANKINGS BY MCA METHOD

Upon further examination, the different means that the WS and NCD methods deal with tied criteria values was identified as a major source of these discrepancies. The NCD method is based on pair-wise comparison of alternatives and produces ranks based on the extent to which an alternative is preferred over all other alternatives (concordance) and the degree to which other alternatives or, in this case, sites dominate it (discordance). In the concordance stage, the alternative with the highest normalised score for a given criterion receives the value of the criterion weight. If the alternatives are tied on that criterion, they both are awarded ½ of the criterion weight in the *Tour*Plan implementation of the method, as discussed by Massam (1980, 239). In contrast, the WS method produces an overall utility score for each alternative by simply summing the products of each standardised criterion score and its corresponding weight and does not make any distinction for tied scores.

When the normalised criterion scores are examined for each participant with this methodological difference in mind, the different degrees of method sensitivity across the participant group can be accounted for. As discussed in the previous section, the effective domains of several criteria were truncated substantially during the score normalisation process. In the case of the Deputy Director of Planning, there was little difference in the normalised data scores of many sites. Hence, the importance of the remaining criteria in determining the final WS utility scores was elevated and reflected in the WS rankings. While this problem was most acute with the Deputy Director of Planning's criteria set, it was encountered to a lesser extent with the Real Estate / Developer and the Director of Environment.

To conclude, it should be noted that the ranks in Table 6.14 support Voogd's (1983, 199) observation that method effects tend to be more pronounced when higher numbers of criteria are included in the evaluation. To illustrate, the Director of Environment and Deputy Director of Planning chose 12 and 11 criteria respectively and had ranks that displayed high method-related deviations compared to those associated with the CPA Member (5 criteria), Hotel Operator / Developer (5 criteria), and Business Owner (6 criteria). For the reasons described in the previous paragraph, the Real Estate / Developer (5 criteria) proved to be an exception.

6.5 Summary

The aim of this chapter was to evaluate the suitability of candidate sites relative to the subjective interests and priorities of the case study participants and, most importantly, to identify which sites would garner the most support if developed for tourist accommodation. This was addressed by applying the participants' criteria sets to two groups of candidate sites with the majority of the chapter being focused on the *post hoc* analysis of a 53 site subset that was developed from the selections discussed in Chapter 5. Similarities and differences between the participant's ranking of the candidate sites were explored in two ways. First, aggregate rankings of the sites were developed using both the Borda and the Copeland functions and subsequently presented in both tabular and map format. Second, the degree of association between participant ranks and between participant and aggregate ranking vectors was examined using Spearman's rank correlation coefficient.

Despite the differences in participant objectives, method choices, and criteria sets, a reasonably strong degree of consensus was evident for several candidate sites in the southern portion of the West Bay District (Figures 6.13 and 6.14). A similar degree of consensus was apparent with respect to the properties that would be least desirable for tourist accommodation. However, given the uncertainties surrounding the influence of MCA method choice and criteria weights on the evaluations, it was necessary to investigate the sensitivity of the results to changes in these factors. With one exception, all of the participants' evaluations displayed relatively little sensitivity to varying the MCA method used for their most preferred 8 to 10 sites and also for a similar number of least preferred sites. A similar pattern was evident when criteria weight sensitivity was examined, although in this instance outcomes did vary noticeably when criteria such as D2TourZone and D2Sand were subjected to small changes in their weight in combination with restrictive user-specified data bounds.

However, the sites with Borda and Copeland ranks between 1 and 9 in Figures 6.13 and 6.14 either displayed little sensitivity to weight and method changes or responded with participant ranks that were more closely aligned to the aggregate ranks than the original ranks were (i.e. 11D_31, 11B_67, and 17A_10 in Table 6.13). With the exception of the two Crystal Harbour properties with less desirable water frontage (ranks of 2.5 in Figure 6.14), this group of sites could be expected to generate relatively little conflict among pro-environment, pro-development, or neutral participants as locations for waterfront hotels / resorts that cater to international tourists. These sites offer potential tourists nearby attractions of shopping, a sandy beachfront, and other hotels and restaurants along Seven Mile Beach. From an environmental perspective, a further concentration of tourist accommodation in this area may be preferred over strategies that would disperse development to undisturbed parts of the District (e.g. Barkers peninsula), given that the subject sites are generally as far from sensitive ecosystems as is possible. Moreover, since the former sites are already zoned for tourism uses and have access to the main roadway and associated hard services of Seven Mile Beach Road, development could proceed in the short-term without major capital expenses being incurred.

Given these considerations and the preference of three participants (Hotel Operator / Developer, Business Owner, CPA Member - see Table 5.1) for this form of accommodation, the above sites should be viable and relatively conflict-free locations for medium- to larger-sized beachfront hotels. Four other participants stated either a preference (Deputy Director of Planning, Director of Environment, National Trust Scientist) for, or acknowledged the possibility (Business Owner) of, promoting a lower-density form of tourist accommodation that would cater to tourists who value access to natural phenomena (e.g. reefs and wetlands) more than an abundance of nearby human-built attractions. This type of ecological- or culturally-centred tourism could not be located feasibly in the Seven Mile Beach corridor, given the nature of its existing development and associated land costs. However, the properties between Conch Point and the Villas Papagallo were identified by several participants during the site selection stage as promising candidates for lower-density forms of accommodation. These preferences were reflected in the moderately high to high participant-specific (Business Owner, CPA Member, Hotel Operator / Developer) and aggregate ranks assigned to several sites in this vicinity and, in particular, those labelled with the ranks of 10, 11, and 13 in Figure 6.14. Nevertheless, even assuming an appropriate scale of development, the National Trust Scientist's rankings for these sites indicate that avoiding development-related conflict may be difficult unless detailed and site-specific environmental impact analyses are conducted to ensure the integrity of sensitive environmental features and that the pace of land use change is considerably slower than is characteristic in the southern limits of the District.

Finally, one of the justifications for investigating the use of MP-SDSS as a mechanism to improve land use and, by extension, tourism planning is a desire to be able to develop compromise or consensus-based strategies in a timely manner. This chapter has demonstrated a methodology for incorporating the subjective priorities of a diverse participant group into the site evaluation process and producing, in relatively short order, a consensual foundation on which the detailed staging of land conversion for tourist accommodation can be based. Some support for this type of flexible, exploratory, and efficient method of aiding the formulation of development strategies has been provided by development initiatives that have taken place since the field research was conducted. In particular, a 325 room hotel (the Sovereign) has been constructed on the parcel that received the highest Borda and Copeland ranks, while the Hyatt Regency facilities have been extended across the road to Seven Mile Beach on previously-developed parcels to provide an additional 53 rooms of beachfront accommodation.

The following chapter concludes the thesis by assessing the extent to which its objectives have been satisfied. Moreover, the main contributions are summarised by way of a synopsis of the research findings. Directions are stated for future research into the use of MP-SDSS for land and tourism-related planning in general and in SIS in particular.

Chapter Seven

CONCLUSIONS

The primary goal of this thesis, as described in Chapter One, was to develop and implement a GIS-based approach to assist the decision making process for strategic tourism-related land development in SIS. Several subsidiary goals were also stated in the introduction. In addition to reviewing the contributions of the thesis, this chapter provides a synopsis of the main arguments and findings and identifies directions for future research. The first section provides a review of the extent to which the thesis objectives are satisfied. Next, the primary methodological and substantive contributions of the thesis are summarised and known shortcomings with the research are discussed. Lastly, in light of the thesis results, some suggestions are offered for future research.

7.1 Thesis Objectives and Summary

The need for spatial decision support tools that are capable of constructing consensual, multi-participant land development strategies flow from both the characteristics of these decision problems and the limitations of commercial GIS. The former are often complex, non-routine, and pluralistic problems that cross disciplinary, organisational, and spatial domains. Since conflict between interests and objectives is not unusual, decision making is judged as often by the calibre of its process as the validity of its outcomes. While commercial GIS do provide important capabilities for examining the spatial implications of a given decision path, their inadequacies in terms of representing the priorities and viewpoints of multiple decision-makers across multiple criteria has constrained their usefulness in this context.

Several research objectives that arise from both the generic spatial decision support problem and from the specific applied task of identifying and evaluating potential tourist sites in SIS gave impetus to this thesis. These objectives, as stated in Chapter One, are:

1. to identify the key decision support needs that are inherent to strategic land use and development planning in general and specifically in SIS;
2. to conceptualise the nexus of land use and tourism planning in SIS;
3. to develop a methodology, appropriate to the conditions in and needs of SIS, that incorporates multi-participant and multi-criteria decision support tools into the strategic level of land use and tourism planning and that operationalises the land use and tourism planning nexus;

4. to design and develop a prototype MP-SDSS that permits individuals or groups with diverse interests and objectives to construct alternative "scenarios" or development futures for an area, with specific emphasis on identifying and evaluating candidate locations for tourism development;

5. to apply the prototype MP-SDSS to a tourism planning case study in a Caribbean SIS with the aim of using it to identify consensual sites for staging tourism land use conversions based on the site selections and evaluations of a representative and differentiated sample of participants;

6. to conduct a *post hoc* assessment of the appropriateness of the methodologies used, the design of the prototype MP-SDSS, and to examine possible extensions and improvements to both based on the case study findings.

These objectives have been satisfied in the following manner. First, several generic decision support needs were identified as being intrinsic to strategic land use planning. These needs include: a) an integrative framework that permits the analysis and visualisation of large volumes of thematically-diverse, and spatially-referenced, data, b) flexible problem-solving environments that accommodate a multi-pass decision process in which problem definitions and resolution alternatives can be refined and redefined as necessary in an expeditious manner, c) mechanisms to represent different interpretations of planning issues in the processes of plan generation and evaluation and to identify areas of potential consensus and conflict among multiple interests, and d), creation of user-friendly and problem-specific information tools that support the decision making processes of users with diverse interests, computer skills, and planning objectives.

The need for strategic land use planning is heightened in SIS given the susceptibility of their economic, environmental, and social structures to disturbance through inappropriate development. However, strategic planning activities are frequently constrained within SIS by scarce financial, human, technological, and data resources and immediate concerns relating to development control. Decision support systems intended for this context, therefore, must be designed with these constraints in mind and must also be targeted at the types of planning decisions that can affect land use patterns most significantly. The *Tour*Plan tool developed to facilitate the analysis in this thesis was designed, precisely, with these objectives in mind.

The second thesis objective focused on the nexus of strategic land use planning and tourism planning in SIS. The allocation of scarce land resources to tourism development is one of the more strategically important, and potentially conflict-laden, land use issues encountered in SIS. Conflict arises often after development has surpassed a critical threshold and local residents begin to see tourism as a comparative threat to their quality-of-life rather than a comparative advantage. The intersection between tourism and other activities was conceptualised in Chapter Two in the following manner. First, the interdependencies between tourism planning and general land use planning in SIS were described with particular attention directed to the localised impacts of tourism-related development and the catalytic effect that it can have on subsequent land conversions. Second, based on the general relationships between accommodation type, tourist type, and tourism impacts, the importance of locating tourist accommodation appropriately was highlighted. Third, it was suggested that the land use planning system provides a structure for: a) exerting some measure of control over tourism-related impacts and long-term resource utilisation, b) assessing the trade-offs between competing visions and reducing conflict within and beyond the sector, and c) integrating tourist planning, and hence tourism development, into the broader societal planning efforts. The thesis has contributed in this regard as there is little discussion in the literature that centralises tourism development in SIS within the general land use planning nexus.

The third research objective concerned developing a methodology that would meet the decision support needs of SIS and operationalise the land use and tourism planning nexus. This objective was satisfied in part by articulating the potential roles of a MP-SDSS in three generic multi-participant decision-making contexts common to both tourism planning and strategic land use planning. Next, general design principles and functional requirements based on local conditions for technology use in SIS were outlined. Based on these design parameters, a methodology was developed for operationalising the land use and tourism planning nexus through the multi-participant construction and evaluation of tourism accommodation scenarios.

The fourth objective centred on designing and programming a prototype MP-SDSS that provides individuals or groups user-friendly capabilities for constructing and evaluating alternative development futures for an area of interest. *Tour*Plan is based on a tight-coupling of selected GIS, MCA, and group management functionality. Particular attention was given to the operational details underlying the tool's scenario-based site selection and MCA evaluation decision aids. The first assistant permits one or more stakeholders to identify candidate sites for tourist accommodation based on their own objectives and selection criteria. The second assistant allows several stakeholders to work singularly or collectively to assess the suitability of these potential sites according to their own preferences and priorities and to also display the extent of conflict and consensus in these evaluations in map and tabular form. This contribution is especially significant, given the inability of commercial GIS to satisfy the needs of MP-SDSS problems.

In order to fulfil the fifth objective, the prototype MP-SDSS was applied to a case study in the West Bay District of Grand Cayman, B.W.I. A small sample of participants with diverse interests in land use and tourism planning issues used a two-stage process for designating land parcels with the greatest potential for multi-participant support and evaluating these alternatives according to differentially weighted evaluation criteria. Data gathered during the field research were applied *post hoc* to a smaller subset of land parcels that met more restrictive thresholds of selection consensus and conflict minimisation. First-order approximations of consensus and conflict within the group were derived from the participants' land use designations. Next, both individual and aggregate rankings were produced for the participant group and used to highlight which candidate sites could reasonably represent consensual tourism development options.

The sensitivity of the participants' ranking to MCA method and criterion weight changes was examined and the implications of these analyses to the most favoured group-level sites was discussed. The contributions derived from this aspect of the thesis are revealing in regards to the MCA literature as they deal with a substantially larger comparison/decision set than most other research. Moreover, they suggest that the approach advocated in thesis is indeed feasible to operationalise in developing a mid- to long-range strategic development plan.

The final research objective centres on assessing the appropriateness of the methodologies used in the thesis and the design of the prototype MP-SDSS design in light of the case study findings. The contributions noted above, along with possible extensions and improvements to them are discussed in the following two sections.

7.2 Research Contributions

In satisfying the above objectives, the thesis has made a number of conceptual, methodological and substantive contributions, noted but not expanded upon in the previous section. An important conceptual contribution that the thesis makes concerns the linkages that were established between types of decision making processes, land use planning issues, and decision support requirements. More specifically, the need for multi-participant spatial decision support tools that support strategic land resources management was justified by relating the characteristics of these decision problems and contexts to the interactionist mode of progressing through Simon's (1976, 40-41) intelligence, design, and choice stages of decision making. There are comparatively few other instances in the literature that bridge the connection between information processing and land resource management.

To date, the application of spatial information technology to land-related issues in developing countries has been confined almost exclusively to data processing functions, such as maintaining cadastral or land parcel records and hard copy map generation. This observation applies to a lesser degree in many GIS installations in developed nations as well. The single user perspective inherent to commercial GIS is not problematic when these systems are confined to the "value-free" operational tasks, however it proves to be a significant constraint when poorly-structured, multi-party strategic decision problems are encountered (Goodchild, 1995, 36).

The thesis has made a number of methodological contributions that address this shortcoming. Moreover, it has shown a way forward to overcome, possibly, several other barriers to using spatial information technology explicitly to assist strategic-level decision making. First, the prototype decision support tool, *Tan*Plan, that was developed to facilitate the thesis research represents one of a relatively few examples of

MCA procedures tightly coupled with an easy-to-use GIS framework. This allows expert and non-expert computer users alike to make use of the spatial relationships between geographic features in their site selection processes, to derive evaluation criteria based on these relationships (e.g. adjacency and proximity), and to visualise the results in map and tabular form.

Second, no commercial GIS product currently available supports multi-participant decision making to any meaningful degree despite the need for these capabilities when dealing with complex and multi-dimensional decision problems. The few examples found in the literature of linking commercial GIS and MCA products (Jankowski et al, 1997) or adding custom programmed MCA routines to expensive general-purpose GIS (e.g the use of ARC/INFO by Lin et al, 1997 and Carver 1991) either do not provide the same complement of multi-participant facilities or are less appropriate for the SIS context due to the financial and human resource demands inherent to these systems. Hence, the scenario-based, multi-participant support that *Tarn*Plan provides represents a significant contribution to the GIS literature and its potential application to land resource decision problems.

Third, *Tarn*Plan demonstrates that multi-participant support based on an integration of GIS and MCA can be provided in a framework that is sufficiently flexible to accommodate the diversity of objectives, skills, problem-solving approaches, and decision contexts (e.g. adversarial versus consensual, homogeneous group versus heterogeneous groups, etc.) that are characteristic to strategic decision making processes. These decision support capabilities are provided in a manner that recognises explicitly through multiple, and often redundant, pathways to required functionality. In part, this is an issue of user-interface design. More significantly, the MCA assistant provides participants with multiple methods to accomplish a given task such as establishing criteria weights (e.g. seven point method versus pair-wise comparison) or combining criterion scores and weights to produce rankings (e.g. WS, NCD, and subtractive summation method). Few examples can be found in the literature of spatial decision support tools with these characteristics.

Fourth, the thesis fills a void in the GIS literature by demonstrating one of several proposed methods for integrating a MP-SDSS, such as *Tarn*Plan, into the process of strategic land use planning. The case study illustrates how a planner, charged both with crafting mid- to long-range strategic plans and applying development allowances in accordance with these plans, could use this approach to solicit input from stakeholders with diverse and even conflicting interests while ensuring their anonymity. Face-to-face group problem structuring is also supported within the *Tarn*Plan design, although this capability was not utilised in the case study for the reasons discussed in Chapters Two and Three. In either type of decision context, the tool allows the output of individual site selection or evaluation scenarios to be coalesced and measures of group-wide consensus (or conflict) to be calculated and displayed in map and tabular form.

Fifth, few examples of GIS use can be found in the tourism literature, particularly with respect to tourism planning in SIS. This may be due in part to the composite nature of the sector, the lack of organisational and functional linkages within government departments and ministries, and planning efforts that emphasise promotion and product development over proactive mitigation of social and environmental impacts. Hence, this thesis provides a flexible and effective methodology for using spatial decision support tools to help integrate strategic-level tourism and land use planning in SIS. This represents more, however, than simply finding 'another use for GIS technology' as it advances both the technology as well as its usefulness in the planning process.

The approach developed in this thesis provides a flexible, yet structured, method for identifying a set of tourist accommodation sites that, at least, have the potential to minimise the amount of conflict within a diverse participant group. These results can then be subjected to rigorous sensitivity analysis as demonstrated in the case study. While these capabilities are particularly important in SIS tourism planning case, they clearly are also highly relevant to other conflict-laden problem domains. The approach used in the thesis therefore offers possibilities for other application areas beyond the tourism development problem in SIS.

Sixth, in contrast to most other examples of linked or integrated GIS and MCA functionality, the design of *TourPlan*'s site selection and evaluation components uses land parcels as its fundamental unit of spatial data. While this approach can require more development alternatives to be considered, it can offer several advantages over methodologies that rely on more aggregate data. These advantages include: a) explicit acknowledgement of the fragmented and interdependent nature of land ownership and land use activities, b) potential access to a host of property-level data sets, c) decision process credibility based on a recognition that most land-related decisions relate directly or indirectly to the parcel fabric, and d) leveraging existing spatial data investments by providing a new end-user community for expensive cadastral databases. Demonstrating that GIS and MCA functionality can be applied successfully in an integrated framework to comparatively large numbers of alternatives represents another significant contribution of this research as it addresses the fundamental reality that many land use decision issues involve large numbers of land parcels and interests in the uses of these lands. This demonstration may provide an impetus for applying MCA methods to the more frequently-occurring site-by-site evaluation problems in addition to the more conventional approach of evaluating considerably fewer aggregated plans.

A related contribution concerns the sensitivity analysis results from the case study. In particular, the output from these tests illustrated that the collective rankings produced for the large number of sites were relatively stable despite differences in the participants' choices concerning MCA method, criteria weighting procedures, and criteria choices. This represents a particularly significant contribution to the GIS and MCA literature as it illustrates the feasibility of integrating multiple MCA methods within a spatial information framework and applying this functionality to large numbers of decision alternatives.

Collectively, these contributions suggest that a tool like *Tara*Plan potentially has an important role in strategic planning in SIS. However, there are several areas where the methodology could be improved upon. For example, while mapping evaluation results does allow the spatial dimensions of conflict and consensus to be visualised, it can be difficult to interpret mapped ranks in areas where the parcel fabric is dense. Removing the boundaries between parcels of the same ranking class would aid this situation as could efforts to hide parcel boundaries for lands that are not included in the evaluation. Similarly, improvements are required to the tabular output from the evaluation procedures for it to be suitable for use in public decision making.

One shortcoming of *Tara*Plan that was highlighted in Chapter Six is the need for a more complete and sophisticated complement of functional forms for criteria normalisation. Further, additional refinement of the user interface in the *Tara*Plan tool is required to provide more guidance to users who are unfamiliar with the procedures embedded in the tool. This limitation is especially relevant in terms of establishing data ranges for the criterion normalisation process and for interpreting the outputs of sensitivity analysis procedures. At a more general level, the need for additional user guidance reduces somewhat the potential for using the tool in the absence of a technically skilled moderator.

In addition, the multi-participant procedures embedded in *Tara*Plan for site selection and evaluation are limited purposely to a maximum of ten participants (i.e. individuals or group representatives) within a given scenario. This is an acceptable limitation for many strategic decision making contexts, but it is not appropriate for situations where this comparatively small number of representative participants or coalitions cannot be identified easily. Hence, an interesting and insightful extension of the research presented in the thesis would be to apply the tool to a problem context in which there are fewer choice alternatives and relatively more evaluators than the seven used in the current research. This would also allow greater attention to be paid to the dynamics of the use of the tool, such as group settings, unguided use and guided or moderated use.

Finally, although *Tara*Plan makes use of property-level data, its lack of basic spatial data processing capabilities do not allow participants to create "new" choice alternatives by either severing or amalgamating parcels. Although data processing should not be the focus of multi-participant strategic decision making, it is clear that the parcel fabric does not necessarily remain static over time as land ownership and activities change. The need for these capabilities was noted in the case study by several participants who wanted to either assemble several small beachfront parcels to create a site for a large resort (Business Owner, Hotel Operator / Developer) or subdivide a large parcel into portions with developable and protected status (National Trust Scientist, Deputy Director of Planning).

7.3 Directions for Future Research

The preceding section outlined the contributions that the thesis has made to the fields of spatial decision support, SIS tourism planning, and land use planning in general and identified some areas for future work. However, further efforts are required in a number of areas to extend both the approach and the substance of the research in the thesis. For example, the financial, human, and spatial data constraints on information technology use in the Cayman Islands are much less restrictive than is typical in most SIS. For this reason, it is desirable for the approach developed in the thesis to be subjected to additional field analysis in other SIS contexts, where there is relatively less source GIS data to draw upon and the human resource base is more restrictive. Additional field research is also required in order to test the methodology within different group decision making environments (e.g. a homogeneous decision making context such as the Cayman Islands National Trust) and to compare the usefulness of the methodology in situations where inter-personal communication between participants is allowed. Further, the case study research was purposely generalised in some respects. As mentioned in the previous section, participants were restricted from assembling or severing land parcels as needed. Moreover, they were required to identify and evaluate tourism sites without being able to differentiate between the suitability of these sites for different types of accommodation types.

It is not problematic from a technical perspective to address the need for minimal capabilities for spatial data editing in a MP-SDSS, however this functionality should be packaged carefully to ensure that the focus of the *Tour*Plan tool continues to be on decision support, rather than data processing. The issue of evaluating site suitability for several related uses, such as different types of tourist accommodation, has potential as an area of future research activity. For example, Arentze et al (1996a) describe a site selection methodology where desired site characteristics for a given land use are assembled as profiles and are used as the basis for allocating land to competing different uses. Similarly, Clayton and Waters (1999) describe a spatial decision support tool that uses case-based reasoning to help decision makers to resolve new decision problems by retrieving and relating non-quantifiable information from similar problems in the past. By combining methodologies such as these within a MP-SDSS, the capability of such a tool for examining conflict in participants' assessments of the suitability of sites for different land uses (e.g. large resorts, condominiums, guest houses, etc.) could be enhanced considerably.

One area of research that clearly needs further attention is that of actually implementing a MP-SDSS in a SIS with the knowledge that the tool will be used in the strategic land use planning process. Although a significant body of research has been constructed concerning GIS implementation in organisations, the previous chapters have demonstrated that MP-SDSS can have considerably different roles in the planning process. Implementation issues are particularly compounded in developing countries as source data are often limited and human resource development levels are frequently lower than in economically advanced countries.

Finally, additional research should also be directed at continuing to improve the usefulness of SDSS to higher-level users who are required to resolve complex and semi-structured strategic land use decision problems. The approach developed in this thesis addresses some of the central factors that have inhibited the applicability of GIS technology for strategic land-related decision making. However, one shortcoming of spatial information systems like *Tan*Plan as decision making aids is their reliance on Boolean logic for constructing both attribute- and distance-based queries. Incorporating fuzzy set operators in the site selection process and in the procedures for deriving spatially-based evaluation criteria would allow participants to recognise the inherent imprecision of many phenomena (e.g. wetland boundaries) and cognitive constructs (e.g. "near", "far", small, "large") in their decision making (Stefanakis et al, 1999; Molenaar, 1998; Burrough, 1996; Wang and Hall, 1996).

Finally, this thesis has asserted that the particular historical, geographic, political and economic contexts of many SIS make their land and societies especially vulnerable to uncoordinated and organic patterns of land use. With the long term objective in mind of improving the viability of these nations and reducing the threat from rapid and not necessarily consensual land use change, it is hoped that the research presented here can play some small role. Further research in this area and those suggested above will provide a clearer understanding of how formal decision support methods can assist in the construction of broadly-considered and widely-supported strategies for utilisation of their scarce land resources.

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