A GIS-BASED ANALYSIS AND PREDICTION OF LAND-USE CHANGE IN A COASTAL TOURISM DESTINATION AREA

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Abstract: South Carolina is the nation's second largest coastal resort state in terms of beach destination trips, superseded only by Florida. Its coastal resources and tourism industry are now undergoing tremendous coastal change due to tourism development and associated commercial and residential growth. As the negative elements of coastal change draw more public attention, and sustainable development becomes a goal for many coastal communities, the continuing coastal change associated with accelerated growth becomes a critical issue. Many agencies and organizations have initiated research programs to develop new techniques for obtaining timely and valid land-use change information to assist in coastal management. This study, as an integral part of a five-year multi-disciplinary and multi-institutional coastal research project funded by NASA/SC-EPSCoR, is designed to develop and apply GIS-based methodologies for analysis, modeling and prediction of coastal land-use change. It takes a micro approach to examine the parcel-based land-use change at the local scale. A spatial multivariate logistic regression model was developed and 20 variables were selected for predicting the possibilities of land-use change for Murrells Inlet.

The results indicate that GIS has advantages over conventional methods in integrating various data sources, performing spatial analysis, modeling spatial process, and mapping the results in land-use change studies. It appears that building permits and parcel data should be used as alternative data sources for change detection and analysis because they contain detailed change information. They are available in digital format and can be updated on a regular basis as more local government agencies utilize GIS for creating and maintaining parcel maps. The logistic regression model used successfully predicted spatial land-use change. Both maps and statistical results show that the primary roads, commercial cluster, commercial zoning, private ownership, and land availability are significant predictor variables for commercial parcel land use. In addition, beachfront, open view, residential zoning, private ownership, land availability, primary roads and commercial centers are major factors that predict residential development.

The results also indicate that Murrells Inlet has experienced tremendous land-use change over the last three decades. The recent period from 1982 to 1996 has brought about rapid residential growth, but little commercial development. The continuing growth appears to be transforming the area into a residential community for metropolitan Myrtle Beach. There is a significant difference in spatial preference between commercial and residential land uses with commercial parcels linearly distributed along the primary roads. As beachfront and waterfront areas are encroached mainly by seasonal homes, residential development moves inland though somewhat restricted by existing parklands and wetlands.
Overall spatial patterns show that the area is lacking an integrated plan for development. Limited public access to waterfront and beachfront and the lack of a focal point in the business district are major problems from the tourism planning perspective.

**Keywords**: land use planning, waterfront development, technological tools/data or information/GIS development

**Introduction**

South Carolina is the nation’s second largest coastal resort tourism state in terms of beach destination trips only superseded by Florida. Coastal tourism in this state generates approximately USD$4.2 billion in revenues annually. For many South Carolina coastal communities, the tourism industry is the mainstay of the local economy. Unfortunately, both tourism resources and the tourism industry are now threatened by dramatic coastal change induced by human activities. Large-scale tourism, residential and commercial development over the past three decades have transformed vast coastal areas, especially those with extraordinary tourism-recreational resources and those close to big cities, into urban environments, resulting in so-called “tourism urbanization” or “coastal residentialization”. This process involves at various degrees, transformation of the landscape, degradation of the natural environment, destruction of coastal ecosystems, introduction of new residents, alteration of the existing social structure, and use conflicts. All these physical, economic, and sociocultural changes are undermining the foundation upon which coastal tourism relies. As the negative elements of coastal change draw more public attention and sustainable development becomes a goal for most coastal communities, the continuing coastal change will become a critical issue for planners, developers, managers, policy makers and communities. In order to address this situation, the detection, analysis, modeling and prediction of coastal change are currently priority topics of research of various governmental agencies and other organizations.

**Background**

The rationale for studying land-use change at the local level or small scale is multifold. (1) Coastal tourism destination areas together with urban fringes, mountainous areas, and lakeshore environments are the fastest growing areas with rapid land-use change. The impacts, positive or negative, of land-use change are therefore relatively more serious. (2) Land use, land tenure, and land value can be decisive factors in tourism development (Davis and Simmons, 1982; Pearce, 1989). (3) 95% of land use decisions are made at the local level (Kleppel, 1998). This implies that appropriate decisions lead to favorable land-use changes and sustainable development. (4) Previous research on land-use change at this level is not adequate (Pearce, 1995). Coastal tourism has perhaps been studied more than any other form of tourism. Many conceptual models about spatial structure (Pearce and Kirk, 1986; Jeans, 1990), spatial evolution (Lundgren, 1974; Miossec, 1976; Oppermann, 1993), and temporal change (Bulter, 1980) have been developed as a result of study on coastal resorts or coastal tourism. But as Pearce (1987 and 1995) has noted, most studies found in the literature of tourism have discussed land-use change only in general terms. (5) Conventional methodologies have some limitations on the detection (monitoring), assessment (analysis), modeling (assimilation), and predicting (projection) of land-use change. On the other hand, new data sources and GIS technology provide some promise to improve tourism destination land-use change studies.

The application of GIS in tourism research has been minimal though GIS technology has been discussed in the tourism literature for over a decade (Gunn and Larsen, 1988). Tourism planning, recreation and park management, and visual resource assessment are the three tourism-related fields
where most applications of GIS have been found (Gunn, 1990; Wicks et al., 1993; Boyd et al., 1994; Bishop and Hulse, 1994). In tourism marketing, it is still difficult to find good examples of applications of GIS in solving real world problems, though the role of GIS in tourism marketing and business has been discussed by a few researchers (Sussmann and Rashad, 1994; Elliott-White and Finn, 1998). Currently, no tourism research has taken a GIS approach to address land use and land-use change at the parcel level.

Techniques and methods of using satellite imageries as data sources have been developed and successfully applied for land use classification and change detection in various environments including rural, urban, and urban fringes (Shepard, 1964; Robinove et al., 1981; Jensen and Toll, 1982; Fung, 1990). However, studies on land-use change utilizing satellite images are lacking in the tourism literature. This is perhaps because tourism destination areas are relatively small in size and satellite images are generally coarse (cover large areas) in spatial resolution. Satellite-based remote sensing technology cannot yet be used to monitor land use at the level of accuracy required by developers, engineers, planners, and real estate interests. Thus, new techniques for study of tourism resources at local scales are needed.

The building permit system has been used for monitoring and controlling building activities in Europe and the U.S. for over three decades. Building permits and building inspections are now common data sources at the county or municipal level. The utility of building permits has been recognized in studies on tourism and urbanization (Pearce, 1995). Building permits generally record an applicant’s name, owner’s name, address, parcel identification number (PIN), building activity (e.g., new, add, convert), structure type (e.g., commercial, single-family residence, multi-family residence), ground area, floor area, housing units, estimated value and cost, and date as well as plats if new structures are involved. Multi-year building permits can provide detailed land-use change information over a period of time. But, building permits show only the intent to build. For change detection, it is important to know which parcels have been both permitted and built. This information can be derived from the building inspection.

Cadastral data or parcel data usually include two sets: assessor’s information and parcel maps. The former has the owner’s name, address, land-use code, assessed value, tax status, legal description, and recent sale price and date. The latter depicts the boundaries of land ownership parcels, each with a parcel identification number (PIN), site address, tax map number and parcel number. There is a trend that more and more counties and municipalities across the country are creating their digital parcel maps using GIS. Combined with building permits, parcel maps can provide more information about land-use change in the finest spatial resolution with the highest accuracy in terms of spatial analysis because parcels are the smallest units of geographic divisions commonly delineated.

**Purpose and Objectives**

As an integrated part of the NASA/SC-EPSCoR Wetland Research Project involving three institutions in South Carolina, this study focuses on the land-use change and its impacts. The overall purpose is to better understand the process of coastal land-use change and its consequences in order to minimize negative impacts and to sustain coastal resources and development around nearby wetlands. The project is funded for five years and covers three geographic areas in coastal South Carolina: Murrells Inlet near Myrtle Beach, Mount Pleasant near Charleston, and Hunting Island near Hilton Head. All of these three areas are among the most important coastal tourism destinations in the state. For the Murrells Inlet component of the project, four immediate objectives were:
• Seek an alternative approach that emphasizes human aspects of issues related to land-use change.
• Develop a parcel based GIS model for assessing land-use change in the past.
• Apply this model to observe and map tenure change, residential change and commercial change for the Murrells Inlet area.
• Build and apply a logistic regression model to predict the possibilities of future land-use change for the area.

The contribution of this study will be to further understand the process of parcel based land-use change and the factors and constraints that affect this process. It will add an alternative methodology to the literature in land-use change analysis, especially in terms of understanding change in tourism destination areas.

**Methodology**

The study area for this research is Murrells Inlet, South Carolina and its vicinity. It is located on the southern fringe of metropolitan Myrtle Beach, SC about 85 miles northeast of Charleston. Sandwiched by the Atlantic Ocean to the east and Waccamaw River to the west, there is no place within this area that is over four miles away from either the water front or the major highway (US 17). This unique location gives Murrells Inlet an advantage as a gateway to Myrtle Beach, controlling all the tourist flow moving from south to north along the coast. In addition, this area is well bestowed by Mother Nature with sandy beaches, estuaries and bays, salt marshes, forests, and many wildlife species including alligators, dolphins, and rare birds, all of which are significant tourism resources. Pollution from residential use and recreational boating has resulted in the permanent closure of the shellfish ground in the northern part of Murrells Inlet and the frequent closure of the entire inlet, especially after strong storms. A few restaurants have been driven out of business because of reduced number of tourists or overdevelopment. Unlike declining commercial development, the area has seen a rapid residential growth over the past two decades. It has become obvious that the area is transforming from a major tourist destination into a residential area for metropolitan Myrtle Beach. This is the major concern of the local community and a special community-wide program has been set up for dealing with these problems.

**Database Development**

A GIS database has been created for the NASA/SCEPSCoR Wetland Research Project and is shared by all the project teams from Clemson University, the University of South Carolina and the College of Charleston. A specific database has been built for assessing parcel based land-use change in the past and predicting land-use change in the future. This database consists of three key data sets: building permits (tabular data), parcel maps (coverage), and miscellaneous data that were used for deriving spatial variables (coverages) for prediction of the likelihood of development.

The building permit data was provided by Georgetown County, South Carolina. Only those permits issued during 1982-96 were selected to be compatible with the temporal series of data used by other teams of the project.

The digital parcel map was provided by the GIS department of Georgetown County. The original coverage was registered to the South Carolina state plane system. A good match of the major roads was found when overlaying the parcel map onto the USGS 7.5° quadrangle topographic map of the area, indicating that the overall quality of the parcel map was within the acceptable standard error.

The database also includes land cover, roads, digital elevation model (DEM), and tourism resources. Land cover data is used for three purposes: checking parcel based land use classifications, deriving polygon
coverage of tourism resources, and deriving spatial variables for establishing the relationships with parcel land use. Because the study area is relatively small, about half of the size of a topographic quad, a land cover map with detailed classifications was highly desired. Locations of tourist facilities and businesses including retail stores and restaurants were collected from the field by using GPS (Global Positioning System) and then differentially correcting (error reducing) the point data.

**GIS Models**

Although land use classification is not the focus of this study, it is necessary to briefly describe the land use classifications used for this study to avoid any ambiguity. It is a general classification that includes the commercial, institutional, multi-family residential, single-family residential, public/semi-public, utility, and undeveloped/vacant areas. This research is designed for assessing and predicting the parcel-based land use in order to provide information about what, when and where land-use change has occurred in the past and will take place in the future. These two issues are related but two separate models are needed.

The first model, a procedural GIS model for assessing parcel-based land-use change in the past was developed. The operation of this model requires an input comprised of a parcel map linked through parcel identification number with two attribute data sets: cadastral records and building permits. Through spatial database management and map algebra operations in a GIS environment, a series of maps are derived.

Tenure change over time can be easily derived from the model because it involves only manipulation of tabular data of the parcel map using database management functionality provided by the GIS software. Dates on the deed show when the parcels have been sold or resold, split or created. They provide important information about the tenure change or ownership change of parcels over time. Dates in the attribute table can be aggregated by year. Then the total number and acres of parcels were calculated on a yearly basis.

Land-use change in Murrells Inlet was assessed using this model. The historical land use map for 1981 was overlaid over the NAPP aerial photograph to check if any parcel was vacant but misclassified as developed since some parcels were permitted before the study period but developed during the study period. Those permit data were not collected. Parcels that belong to this category were eliminated from the 1981 map and added to the land-use change map. The parcel change in use intensity was mapped by selecting those parcels onto which a type of structure has been added. In other words, an "add" activity had occurred. Using spatial statistical tools, descriptive and referential statistical analyses were performed interactively on the map.

The second model, a predictive model for parcel based land-use change is based on logistic regression (Tabachnick and Fidell, 1996). Factors that influence land-use change are so complex that predicting land-use change is extremely difficult. However, substantial need exists to warrant efforts to make predictions. The driving philosophy is that a better prediction will reduce risks in land use decision-making. Prediction of land-use change involves several steps: selecting the predictor variables, obtaining the measurements (preparing the variable coverages), establishing the relationships between the dependent variables and independent variables, building and running the prediction model, and mapping out the predicted values.

As has been discussed previously, variables used for predicting land-use change in other settings are not appropriate for predicting in tourist destination areas. Variables used by Gunn (1990) for identifying the potential tourism destination areas in Upstate South Carolina and those used by Boyd et al. (1994) for identifying the ecotourism area in Ontario Canada are not appropriate for our
prediction because of the differences in scale. Three criteria were used for selecting 20 variables for our prediction. (1) Variables must characterize coastal tourism destination areas; (2) variables must represent the spatial relationships; and (3) variables must reflect the properties of parcels. As a result, two predictive logistic models were developed for residential land-use change and commercial land-use change respectively.

Results

Parcel Tenure Change
Tenure change occurs when a parcel splits or the ownership of a parcel changes. It is a legal process that reflects overall trends of parcel development over time. Although this legal change of parcels could take place pre- or post-development, it is often the case that parcel use change occurs after a parcel is purchased, especially when a building activity is involved. Tenure change therefore sets up a framework for other land-use change induced by humans. There are five aspects of parcel-based change in which we are particularly interested: (1) overall trends of temporal changes that reveal factors that affect the change during a specific period; (2) parcel physical parameters such as number and size; (3) spatial patterns and their spatial relationships to tourism and recreation resources; and (4) ownership of large parcels that indicate who or which agents have been involved in the parcel-based land-use change.

In Murrells Inlet, the period before 1973 saw little land transaction. The fastest growing period has occurred since the mid-'80's and the pace has slowed slightly in the '90's. It is interesting that the land-use change in terms of tenure change at this micro level shows a strong correlation with the macroeconomic conditions in the nation over the same period. Because virtually no industry, agriculture or commercial fishing exists in the area, tourism development, commercial development and residential development are the key factors that caused the land-use change.

Big developers, conservation groups and government agencies were key players in the transaction of large pieces of properties during this period. It is noted that many parcels created after 1991 are surrounded by large properties purchased in the 80s, suggesting that they are the parcels split, built or unbuilt, and resold by the big developers mentioned above. They look like well-planned subdivisions following the clustering development principles. Clusters of small parcels generally indicate where the human activities are intensive. They are mainly located along the beach, waterfront, major roads, or in the inland subdivisions. Large parcels, on the other hand, are mainly the wetlands within Murrells Inlet and along the Waccamaw River, the parkland in Brookgreen Gardens and Huntington Beach State Park in the south, and the forestland along the county border to the north and adjacent to Brookgreen Gardens to the south. As the wetlands and parklands are restricted from development, the private forestlands contain the only large parcels that may be available for cluster housing development in the future.

Commercial Land-Use Change
Business in Murrells Inlet can be roughly grouped into three categories: tourism, fisheries, and local services. Tourism related businesses include restaurants, marinas, accommodations, rentals, fishing suppliers, and gift shops. The terms “commercial” and “business” were used interchangeably in this study to include all the service and retail establishments. Only 24 out of 36 permitted parcels have been transformed into commercial use over the period 1982-1996, indicating little commercial growth in this area. These results are congruent with the perception of locals. Most of the commercial growth occurred in the mid-'80s with little in the '90s. It is also found that some restaurants have been closed due to lack of business. Slowing down or declining of business in Murrells Inlet has made the local community so concerned that a special revitalizing plan-2007 was established in 1997.
It is also noted that there is no dominant commercial center or town square found in this destination area, though few relatively small and sparsely distributed business clusters are identifiable. Because Murrells Inlet is a non-incorporated area, this has become one of the disadvantages it has in competition against its commercialized neighbors. Essentially, none of these commercial clusters are big enough to attract more tourists to stop or stay longer. Even though Murrells Inlet is one of the primary cuisine destinations in the Grand Strand tourism region, most tourists leave immediately after dining. The growth of local service businesses and decline of restaurant businesses suggests that Murrells Inlet is undergoing some transformation of its functionality. Factors and constraints that form the environment for business development should be studied.

**Residential Land-Use Change**

The most significant land-use changes that have occurred in Murrells Inlet over the last 15 years were mainly due to the residential development of both primary homes and vacation homes. Unlike commercial development, there have been 947 permits issued for residential development, of which 715 parcels have been built over the period 1981-1996, totaling 440 acres. The turnover rate is much higher too, about 76% compared to 33% for commercial development (Figure 1). Three peaks of growth occurred respectively in 1985, 1990, and 1996 at an interval of approximately five years. Single-family dwellings have led all categories in number of newly built house units since 1986. There are over 50 house units built per year and this number has increased to 200 in 1996, showing a strong trend of continuing growth in the future. In contrast, condominiums were the biggest contributor to the increased housing units in the early ‘80's but none have been built since 1988. Murrells Inlet has also seen a fast growth in mobile home dwellings in the recent years. Over 300 permits have been issued for new mobile homes and 200 have changed ownership.

**Tourism Land-Use Change**

Four aspects of changes that have occurred are worth emphasizing. First, government agencies and interest groups have acquired large pieces of wetlands for conservation purposes. The first land transaction was done by the South Carolina Wildlife and Marine Resources Department acquiring 64 acres of wetland within the inlet area in 1984. Brookgreen Gardens Society and S E Flora & Fauna purchased over 304 acres of former rice fields along the Waccamaw River and annexed them to its wildlife park of Brookgreen Gardens. Those lands are important wildlife habitats, have a great potential for ecotourism uses, but are threatened by development. Second, accompanying the residential or resort development, 210 acres of forestland have been converted into a golf course and provide more recreational tourism opportunities in the Murrells Inlet area. Another golf course has been planned and parcels for that have been demarcated. Third, through a public-private partnership agreement with the Brookgreen Gardens Foundation, the South Carolina Department of Parks, Recreation and Tourism extended the lease of Huntington Beach State Park for another 30 years in order to preserve the pristine beach, fresh water lagoons, saltwater marshes, and natural habitats for wading birds and coastal raptors. Finally, the filling-in of residential development by private owners along the beachfront and waterfront has eroded the public open space. Views are blocked; access is limited; and on-site activities are confined. The overall quality of tourism recreational resources have been degraded.

**Future Land-Use Change**

Future land use in Murrells Inlet was predicted in terms of the possibilities of parcel transition using a logistic regression model. The results are reported in three parts: model reliability, predictor variables, and predicted results for residential land use and commercial land use. Figure 2 depicts the predicted residential change using the
Figure 1. Parcel-Based land-use change 1981-1996, Murrells Inlet, South Carolina, U.S.A.
year 2010 as a cut off value in the logistic regression model.

A spatial logistic regression analysis was performed on all 20 predictors over 4107 total cases (parcels) of which 2591 were used as the “selected” for building the model and 1516 as the “unselected” for validating the model. Of the total parcels, 2139 were residential and coded as 1 while 1968 were non-residential and coded as 0. The slope variable was dropped off because it was determined not significant for this coastal area. A test of the full model with 19 predictors against a constant-only model was statistically reliable, $x^2 (19, N = 4107) = 2342.048, p < 0.001$, indicating that the 19 predictors, as a set, distinguished between residential and non-residential parcel use. Prediction success was very impressive, with 90% for the residential and 92% for the non-residential correctly predicted, for an overall success rate of 91% for the selected cases. The prediction success rates were even better for the unselected cases, 95%, 91%, and 93% respectively.

A similar spatial logistic regression analysis was performed on commercial land use predictors over 113 cases of commercial use and 3994 cases of non-commercial use with residential zoning replaced with commercial zoning. The analysis indicated that a full model with 19 variables was also statistically reliable, $x^2 (19, N = 4107) = 709, p < 0.001$. Prediction success was relatively less impressive because only 69% of commercial parcels were correctly predicted, though 99.57% was predicted for non-commercial use and 98.73% for overall success. The Wald test shows that proximity to the primary roads, proximity to commercial clusters, commercial zone, private ownership, and vacancy are significant predictors ($p < 0.05$). A model built upon these five predictors shows an adequate fit to the perfect model according to the result of a Hosmer and Lemeshow goodness-of-fit test, $x^2 (8, N = 4107) = 26.5, p < 0.001$. The prediction success rates are 65% for the commercial, 99.65% for the non-commercial, and 98.69% for the overall. The predicted possibilities of commercial land-use change in the future show that commercial development will most likely take place along US 17 Bypass with most development in the northern part of Murrells Inlet.

**Conclusion**

This study used GIS as an integrating system and analysis tool to assess and predict parcel-based land-use change. It appears that building permits and cadastral data contain timely and valid information about land-use change. They are the important alternatives of data sources for change analysis. This is especially significant for tourism destination areas as they are often too small to be analyzed with traditional land-use change analysis techniques. GIS has advantages over the conventional methods in integrating various data sources, performing spatial analysis, and mapping the results in land-use change studies. The Murrells Inlet study shows that using GIS in conjunction with building permits and parcel data can generate sufficient information about parcel tenure change, land use type change, temporal change and spatial change. The logistic regression model appears to be appropriate for the prediction of spatial land-use change. The success rates of prediction are 89% and 65% for the residential and commercial land-use change respectively, with overall rates over 90% for both cases. The ArcView based land-use change analysis and predicting model is a handy tool for county and local planners.

It is admitted that there are some limitations of this study. These limitations are mainly due to the data constraints and parcel properties. Obtaining the status of building permits (already built or not yet built) and improving data quality are critical to deriving the accurate information of parcel-based land-use change. An integration of imagery-based change detection and parcel-based change analysis is recommended in order to
get timely and valid information on both physical change and social economic change at the finest resolutions possible. Although future spatial land-use change can be predicted with reasonable error, it is difficult to determine exactly when this change is going to happen. Murrells Inlet is only a small area and its land-use change is a function of many different factors including physical, economic, political and social change at a regional level. How to integrate the regional variables into a local predictive model is still a great challenge. At this point the authors have identified no GIS-based research that has addressed land-use changes involving different geographic scales.

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