Comprehensive Analysis of Coastal Landscape Resources: Quantitative Approach

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Abstract: Coastal landscapes face increasing demands for space and resources that they support. These demands generally conflict with each other and with the potential of landscape systems. Owing to the fact that landscapes of interest on the coast are complex, multifaceted quantitative analysis is highly necessary to understand variations in space and time. These variations may result from natural and/or human-induced processes. Recently completed research project in a coastal region on Turkish Mediterranean coast provided a framework for a comprehensive analysis of coastal landscapes. This paper provides a brief summary of the outcomes from this project. Quantitative analysis procedures were highlighted and discussions were made.

Key-Words: Landscapes, coastal zone, Turkey, Mediterranean, quantitative analysis

1 Introduction

Coastal landscapes support diverse biological/physical systems and processes. They provide space for building development, tourism, transportation and many other sectors. Coastal landscapes have many different physical resources that attract various land uses such as quarrying activities. In addition, visibility value of landscapes is another asset that determines human preferences for some activities. For example, several researches show that good scenery is an important criterion for site selection in building development and, therefore, it adds an economic value to the property values. For these and many other reasons, management of coastal landscapes is a complex issue due to inherent biophysical diversity of ecological systems and competing demands of land uses [1-7].

2 Study Area

The coastal zone of Erdemli, located in the west of the central district of Mersin (SE Mediterranean Coast of Turkey) has faced problems due to development of multistory buildings as summer apartments near the coastline. This development on the coast threatens both agriculture areas and natural vegetation and causes landscape fragmentation. This development occurs as a narrow zone of built-up patches aligned with the coastline, generally not exceeding a few hundred meters in width [8, 9]. Therefore, mapping and monitoring of built-up development on the Mediterranean coast requires higher level of spatial detail. Complex landscape patterns resulting from agricultural, natural and built-up patches of varying spectral responses also requires multispectral capabilities for understanding patterns and processes in these landscapes [3, 10, 11].

The facts that acceleration of the above mentioned built-up development trends date back to 1980s and that the landscape patterns are complex make it necessary to provide historical datasets (i.e., satellite images) of regularly repeated land observations with high spatial and multispectral details for effective monitoring [9, 12-14].

3 Digital datasets

Selection of digital datasets (i.e., satellite images) is the most critical part of a comprehensive analysis of coastal landscape resources. There are many reasons that support this statement.

Coastal landscapes are complex systems. This complexity arises from spatial and temporal diversity of biological and physical systems and human activities interfering with these systems.

Above mentioned diversity requires representation of landscapes in many different spatial and time scales. The concept of variable spatial and time scales makes it necessary to run analyses (e.g.

landscape mapping and change detection) using datasets from different sources.

In this respect, each dataset has its own merits and costs. For example, a change study that focuses on built-up changes on coastal zone requires a broader time period and relatively higher spatial resolution. These requirements should be met simultaneously to perform a comprehensive landscape assessment on the coastal zone.

SPOT is short for *Satellite Pour l'Observation de la Terre*, a series of French satellites that have been acquiring panchromatic and multispectral images with considerably high spatial resolution for over three decades. Fig. 1 shows subsets of SPOT panchromatic images for a period between 1989 and 2007.

Fig 1. Development of built-up patches over time.

As shown in Figure 1, start date of image series is 1989, while the end date is 2007. Frequency of image acquisitions is six years. This Figure shows critical importance of spatial and temporal specifications of image datasets.

Determining a start date in a time series is critically important for a change analysis. This helps to analyze driving forces for development and their impacts on the environment.

As shown in Fig. 1, development on the east coast of Erdemli (Turkey) started in early 1990's. This statement can be justified by checking the 1989 image. As depicted in Fig. 1, areas on the coast are free of development in 1989 (i.e, red rectangle). Start of the development can be seen on the 1995 image. Built-up areas emerge as bright patches on this image. The 2001 image suggests that development accelerated after 1995. As a result, the coast was extensively occupied by buildings and sealed surfaces. This development was even more extensive after 2001. Between 2001 and 2007, the coastline is completely occupied by buildings. This development trend may be seen more clearly in Fig. 2, which belongs to the neighboring coast in the east.

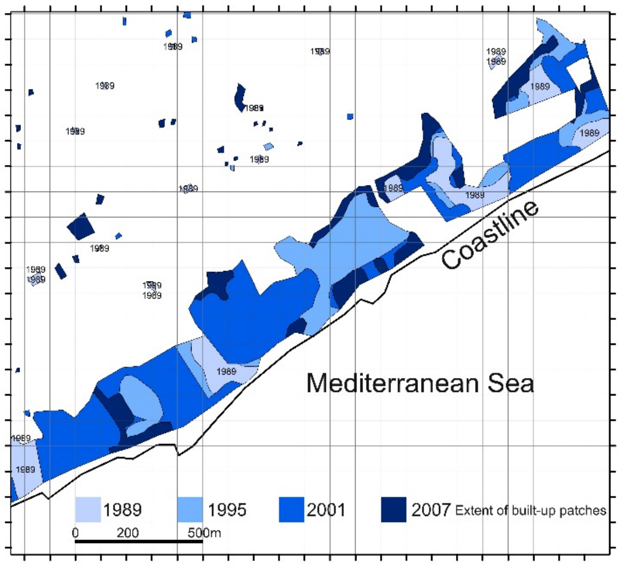

Fig. 2. Thematic representation of coastal built-up change in Arpacbahsis, near Erdemli (Turkey).

As Seen in Fig. 2, major proportion of the coast is occupied during the period between 1995 and 2001. There is not an extensive built up change at this part of the coast after 2001. This is due to the fact that space for building development became scarce until 2001. As a result, development with relatively smaller patches was observed in the period between 2001 and 2007.

2.1 Workflow and Procedures

A five-step analysis procedure may be described for comprehensive assessment of coastal landscape resources in the Mediterranean. The quality of the information strongly depends upon data selection and analytical procedures such as land cover mapping, change analysis, pattern analysis and modeling of future development. These procedures were used to gather information on landscape resources within the project area.

2.1.1 Data Selection

Mediterranean coasts witnessed rapid building development. Acceleration of this development dates back to 1980's. Therefore monitoring of development strongly requires relatively higher resolution datasets dating back to these dates.

Since relatively higher resolution datasets are required, spatial enhancement techniques may be employed. PCA resolution merge was employed using SPOT and Landsat scenes to produce a time series between 1989 and 2007.

2.1.2 Land Cover Mapping

Mapping can be considered as the first step to analyze landscape systems. Many analytical techniques that deal with patterns and processes need accurate land cover maps.

A first step is to adopt a classification scheme to extract thematic information appropriately. CORINE land cover classification scheme is used during classification.

A second step includes image classifications. Selection of an appropriate classification algorithm strongly depends on the quality of datasets and the level of thematic information required.

In such cases that a perfect temporal and spectral consistency cannot be achieved, a hybrid approach may be performed. Image segmentation may yield satisfactory results.

Image segmentation is a part of so-called object-based image analysis procedure. In this approach, image datasets are coded as groups of segments that contain spectrally similar pixel groups. These segments may then be classified using *a priori* defined land cover classes.

2.1.3 Analysis of Change

Change analysis in Mediterranean landscapes requires careful selection of image processing protocols due to the facts that (1) landscape patches are rather small and (2) instead of clear boundaries, transition gradients exist between various land cover classes.

Building patches on the coastal zone represent a character that contrasts with the surrounding environment. Majority of the areas without building development consist of agriculture. Owing to the fact that agriculture areas are mostly citrus groves, the land surface is covered throughout the year. This even increases the impact of contrasting composition of bright grey and green (Fig. 3).

Figure 3. Locations of massive apartment buildings on the coastal zone

Land cover change analysis includes pre- and post-classification techniques. Pre-classification may generally yield better results when medium resolution images are involved. In case of very high spatial resolution datasets, pre-classification is prone to environmental heterogeneity and variation in image dataset. Therefore post classification comparison can also be considered for change analysis.

Road development and coastline changes can also be analyzed for use as either individually or as inputs to other models such as urban development models.

2.1.4 Analysis of Landscape Pattern

Landscapes are diverse in the Mediterranean. Therefore, spatial arrangement and the composition of land cover change very rapidly due both to natural processes and human interference. Composition and configuration need to be analyzed in order to employ a comprehensive analysis of landscape systems and the change processes that they support.

Area-edge, shape, aggregation and diversity metrics can be analyzed both at class and landscape levels.

2.1.5 Projections for Future Development

Predictions for future development may be an important input during preparation of development plans. This information may act as a basis to manage future growth on a sustainable manner.

Several development models exist for urban growth. SLEUTH, UrbanSim, CLUE and CA-Markov models can be used to analyze future growth. For those areas that support small patches of built-up areas in a linear development pattern along the coastline, the models originally produced to predict urban growth may not work effectively. Relative effectiveness of these models needs to be tested

4 Conclusion

This paper provided a brief summary of a recently completed research project conducted in the Mediterranean coastal region of Turkey. It highlighted the importance of composing digital geo-referenced information on the coastal landscape and its bio-physical resources.

Since landscapes are composed of biophysical systems and processes working at various spatial and time scales, their comprehensive analysis require studying these systems and processes using a multi-level approach. This multi-level approach must combine information derived from various spatial and time scales. To do so, may help understand landscapes more effectively. This will obviously provide a strong assistance to decision making processes with regard to land management issues. This holds a strong potential for optimal use of land and water resources and and for achieving sustainable resource allocation

Natural and and/or human-induced processes strongly affect Mediterranean coastal landscapes. Anthropogenic impacts are far stronger than the natural processes in shaping and transforming these landscapes.

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References:

[1] Hossen, H. and A. Negm, Change detection in the water bodies of Burullus Lake, Northern Nile Delta, Egypt, using RS/GIS. *12th International Conference on Hydroinformatics (Hic 2016) - Smart Water for the Future*, 2016, **154**: p. 951-958.

[2] Esmail, M., M. Ali, and A. Negm, Monitoring Land Use/Land Cover Changes Around Damietta Promontory, Egypt, Using RS/GIS. *12th International Conference on Hydroinformatics (Hic 2016) - Smart Water for the Future*, 2016. **154**: p. 936-942.

[3] Alphan, H. and L. Guvensoy, Detecting Coastal Urbanization and Land Use Change in Southern Turkey. Journal of *Environmental Engineering and Landscape Management*, 2016. **24**(2): p. 97-107.

[4] Zitti, M., C. Ferrara, L. Perini, M. Carlucci, and L. Salvati, Long-Term Urban Growth and Land Use Efficiency in Southern Europe: Implications for Sustainable Land Management. *Sustainability*, 2015. **7**(3): p. 3359-3385.

[5] Basnou, C., E. Alvarez, G. Bagaria, M. Guardiola, R. Isern, P. Vicente, and J. Pino, Spatial Patterns of Land Use Changes Across a Mediterranean Metropolitan Landscape: Implications for Biodiversity Management. *Environmental Management*, 2013. **52**(4): p. 971-980.

[6] Parcerisas, L., J. Marull, J. Pino, E. Tello, F. Coll, and C. Basnou, Land use changes, landscape ecology and their socioeconomic driving forces in the Spanish Mediterranean coast (El Maresme County, 1850-2005). *Environmental Science & Policy*, 2012. **23**: p. 120-132.

[7] Aguilar, J.A.P., C. Ano, A. Valera, and J. Sanchez, Urban growth dynamics (1956-1998) in Mediterranean coastal regions: The case of Alicante, Spain. *Desertification in the Mediterranean Region. A Security Issue*, 2006. **3**: p. 325-+.

[8] Alphan, H. and N. Celik, Monitoring changes in landscape pattern: use of Ikonos and Quickbird images. *Environmental Monitoring and Assessment*, 2016. **188**(2).

[9] Alphan, H. and M.A. Derse, Change Detection in Southern Turkey Using Normalized Difference Vegetation Index (Ndvi). *Journal of Environmental Engineering and Landscape Management*, 2013. **21**(1): p. 12-18.

[10] Alphan, H., Analysis of landscape changes as an indicator for environmental monitoring.

Environmental Monitoring and Assessment, 2017. **189**(1).

[11] Alphan, H. and K.T. Yilmaz, Monitoring environmental changes in the Mediterranean coastal landscape: The case of Cukurova, Turkey. *Environmental Management*, 2005. **35**(5): p. 607-619.

[12] Alphan, H., Bi-Temporal Analysis of Landscape Changes in the Easternmost Mediterranean Deltas Using Binary and Classified Change Information. *Environmental Management*, 2013. **51**(3): p. 541-554.

[13] Alphan, H., H. Doygun, and Y.I. Unlukaplan, Post-classification comparison of land cover using multitemporal Landsat and ASTER imagery: the case of Kahramanmara angstrom, Turkey. *Environmental Monitoring and Assessment*, 2009. **151**(1-4): p. 327-336.

[14] Alphan, H., Land-use change and urbanization of Adana, Turkey. *Land Degradation & Development*, 2003. **14**(6): p. 575-586.