Development of a Vegetative Based LID Suitability Index for Coastal Counties of South Carolina

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Abstract

Low-impact design (LID) attempts to maintain natural hydrologic conditions in urban development. Vegetative based LID practices (stormwater wetlands and bioretention cells) have become popular as a stormwater control measure (SCM) in Coastal South Carolina (SC). A suitability index was developed using two approaches: (1) Weighted suitability score and (2) Spatial query method, to identify appropriate sites for wetland (retention-based) versus bioretention (infiltration-based) systems in South Carolina's four most populated coastal counties (Georgetown, Horry, Charleston, and Beaufort). The index utilized a GIS based model that integrates seven key landscape features (land cover, water table depth, hydrologic soil group, drainage class, slope and percent impervious data) based on the siting criteria from the Coastal SC LID Manual and South Carolina Department of Health Environmental Control (DHEC) BMP Manual. The index allows the user to make an informed decision on LID practice and placement location within a site under development based on science and not just by visual inspection. The suitability index is available as an online GIS tool (http://bit.ly/clemson-cri) as well as an online story map (http://bit.ly/clemson-cri-story-map). The model demonstrated that a larger percentage of land is suitable for bioretention systems over wetland based systems irrespective of the adopted approach. This was prominent in the Horry county where there seasonally high water table is lower and there is low relief. The Suitability Index can serve as an informational and educational tool for planners, developers, engineers, land managers, regulators, among others. However, the index will need significant ground-truthing and checks for accuracy before it can fully be implemented as a decision-making tool.

Introduction

The rapid expansion of geographic information systems (GIS) has allowed suitability analysis to become a widespread tool for urban planners, landscape architects, and other development professionals. There have been efforts (Viavattene *et al.,* 2008) to develop BMP decision support systems for the communication of BMP criteria. Scholz (2006) developed a GIS-based BMP placement decision support system matrices to identify alternative BMPs given a set of criteria and Morari (2003) developed an integrated GIS – numerical model solution to support BMP irrigation and fertilization requirements for agriculture. The process of suitability model development generally occurs in three-steps: first, spatial datasets are formatted for compatibility, then a flowchart is developed that creates the suitability's framework, and finally the suitability model will be executed based on the framework. LID has increasingly become part of the discussion of innovative designs for stormwater management. Implementing these designs into a municipality's network in a comprehensive way has proven to be a challenge. This study seeks to address this key issue and push forward the implementation of LID in rapidly developing urban areas in SC coastal counties by creating a GIS-based SI.

Goals and Objectives

Goal: Develop a tool to identify the best vegetative based LID practices for coastal South Carolina.

Objectives:

- To mine existing data and develop metrics and LID suitability indices to populate the online Community Resource Inventory (CRI) (http://bit.ly/clemson-cri).
- To increase the utility of the CRI for LID decision-making.
- To convey these results to practitioners and decision-makers via the online CRI.

Methodology

- A decision support key was created based on siting criteria from the Coastal SC LID Manual (Ellis *et al*., 2014) (Figure 1). The decision support key was then integrated into Arc GIS (ArcMap 10.2.2) using two steps: **(1) Weighted Suitability Score and (2) Spatial Query** (Figures 2a and 2b).

Step 1: Weighted Suitability Score

Suitability index values (% suitability) and weights were allocated for each variable (equal weights allocated for each variable)

$$Suitability = \sum_{i=1}^{n} SI_i W_i$$

Where:

SI_i is the suitability index score for variable *I*, and

W_i is the weight given to variable *I* (Lonkhuyzen et al., 2004)

Step 2: Spatial Query

Develop a spatial query within GIS using the raster calculator to select the high suitability layer.

- As the final step, data layers including soil type & characteristics, water table elevations, topography, vegetation characteristics and land use and cover (Table 1, Figures 3a-d) were overlaid based on the recommendations of the Coastal SC LID Manual to create the final suitability maps for bioretention and stormwater wetland systems (Figures 4a-b and 5a-b).

Suitability Model Development

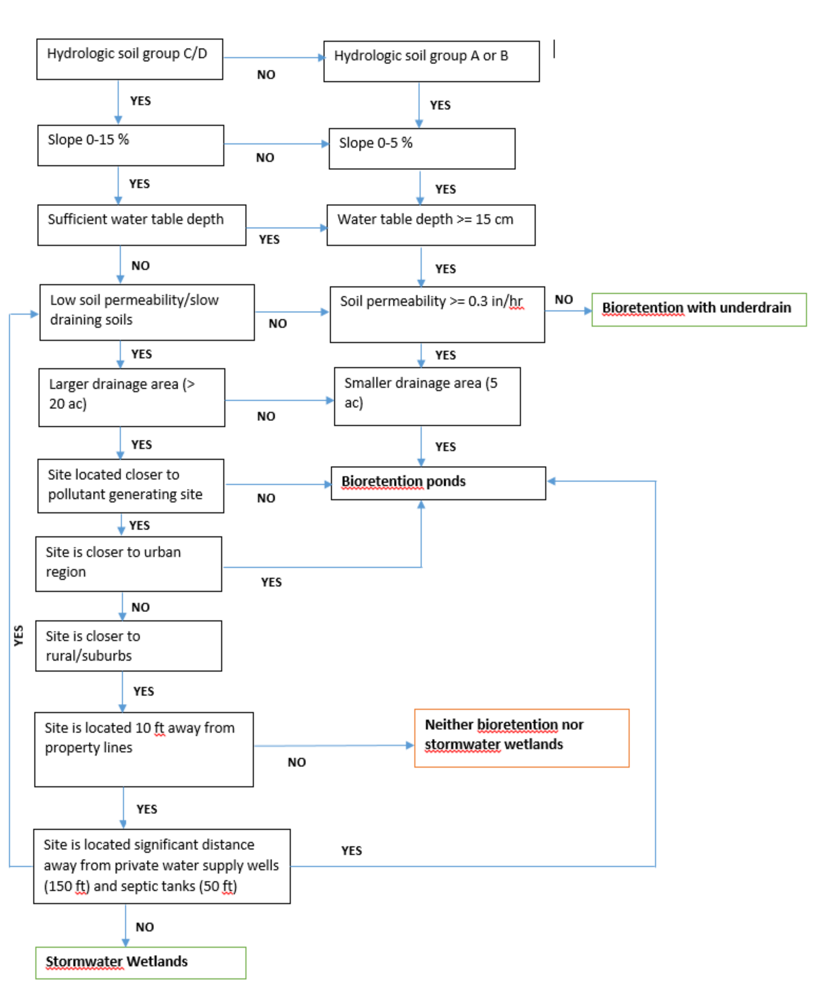

Figure 1: Decision support key for the selection of vegetative based LID practices for coastal SC.

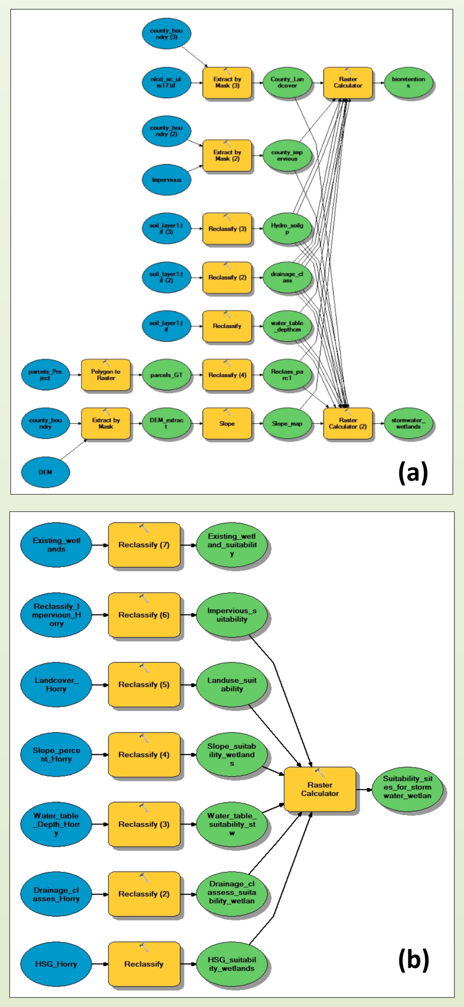

Figure 2 : Example LID Suitability index model based on the suitability criteria using (a) spatial query method and (b) weighted suitability score method.

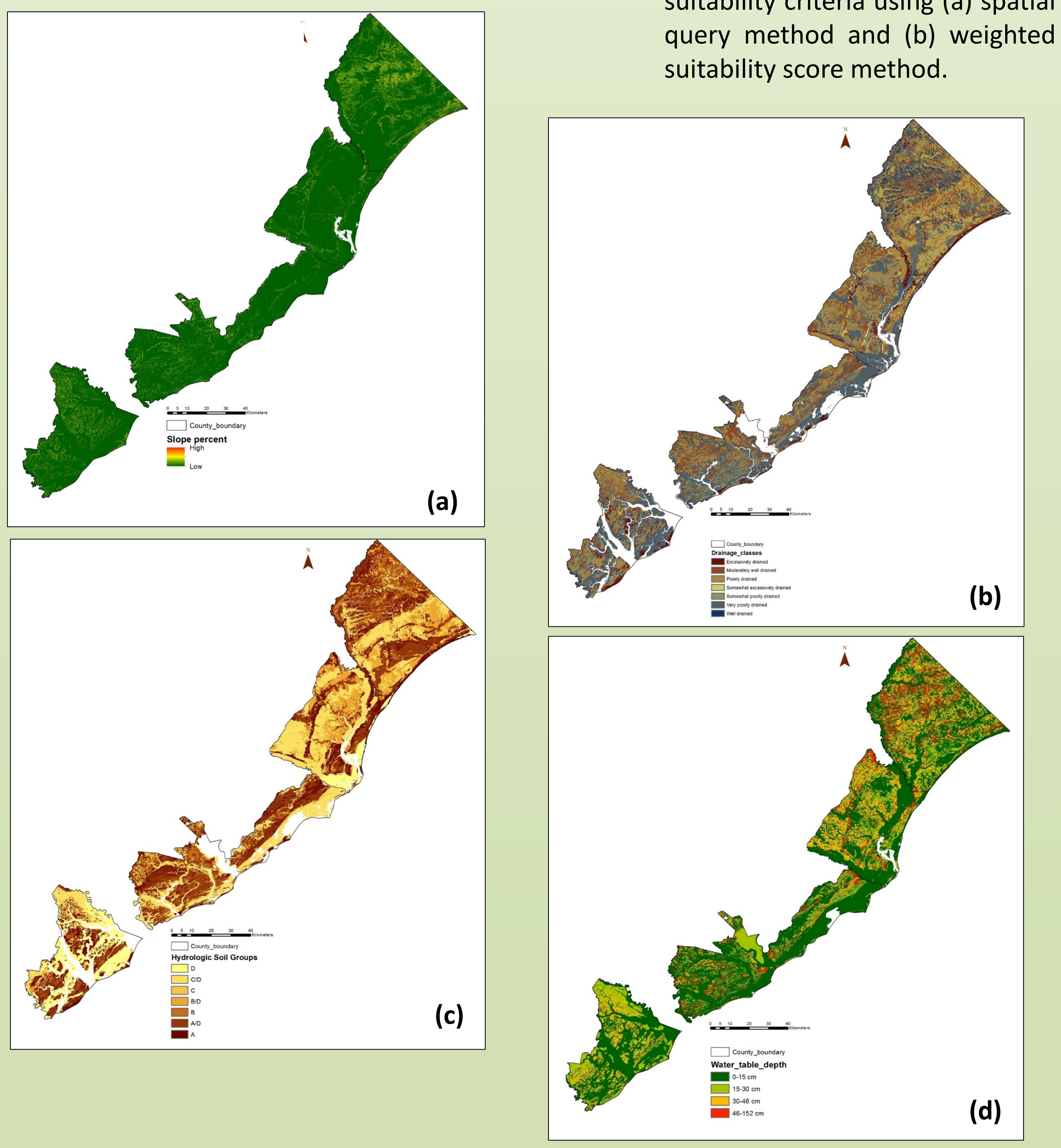

Figure 3: Data layers used to develop the suitability index using the spatial query method: (a) Slope, (b) Drainage class, (c) Hydrologic soil group, and (d) Seasonal high water table depth.

Table 1: Data sources for the suitability index development (all projected in NAD_1983_UTM_17N).

Data Layer	Description	Source
DEM	DEM quadrangles with 30 m resolution	GeoSpatial Data Gateway - USGS
Soil	Gridded SSURGO	GeoSpatial Data Gateway - USGS
Percent Impervious	% impervious for SC	GeoSpatial Data Gateway - USGS
Land Cover	Land Cover Data for SC– NLCD 2011	GeoSpatial Data Gateway - USGS
County Boundary	County boundaries	US Census Bureau

References

- Ellis, K., Berg, C., Caraco,D.,Drescher, S.,Hoffmann,G.,Keppler, B., LaRocco, M. and Turner. A., 2014. Low Impact Development in Coastal South Carolina: A Planning and Design Guide. ACE Basin and North Inlet – Winyah Bay National Estuarine Research Reserves, 462 pp.
- Morari, F., Lugato, E., Borin, M. 2004. An integrated non-point source model-GIS system for selecting criteria of best management practices in the Po Valley, North Italy. *Agriculture Ecosystems & Environment*, 102: 247-262.
- Scholz, M. 2006. Decision-support tools for sustainable drainage. *Proceedings of the ICE-Engineering Sustainability*, 159(3): 117-125.
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Results and Discussion

- Overall, coastal SC is more suitable for bioretention cells than for stormwater wetlands (Table 2, Figures 4a-b, 5a-b).
- **Horry** has the highest land area suitable for bioretention systems. This is due to the presence of well drained soils with lower seasonally high water tables.
- In certain counties and cities, (*i.e.* Beaufort and Myrtle Beach, Figures 4a-b, 5a-5b), landscape parameters indicate preference for wetland-based systems. This may be due to the more shallow seasonally high water tables.
- The SI allows the user to decide which SCM or LID practice option(s) is (are) desirable for a site under development, rather than recommending a specific practice for a specific location in the landscape and watershed.
- The Si can be found at the CRI webpage () and the story map outlining ithe creation of the SI can be found at .

Table 2: Suitable sites for the construction of bioretentions and stormwater wetlands.

	Bioretention Cells		Stormwater Wetlands	
County	**# of sites**	**Total area (ac)**	**# of sites**	**Total area (ac)**
Beaufort	20,835	4,634	28,708	6,385
Charleston	66,264	14,737	12,387	2,755
Georgetown	16,375	3,642	23,266	5,174
Horry	81,289	18,078	37,869	8,422

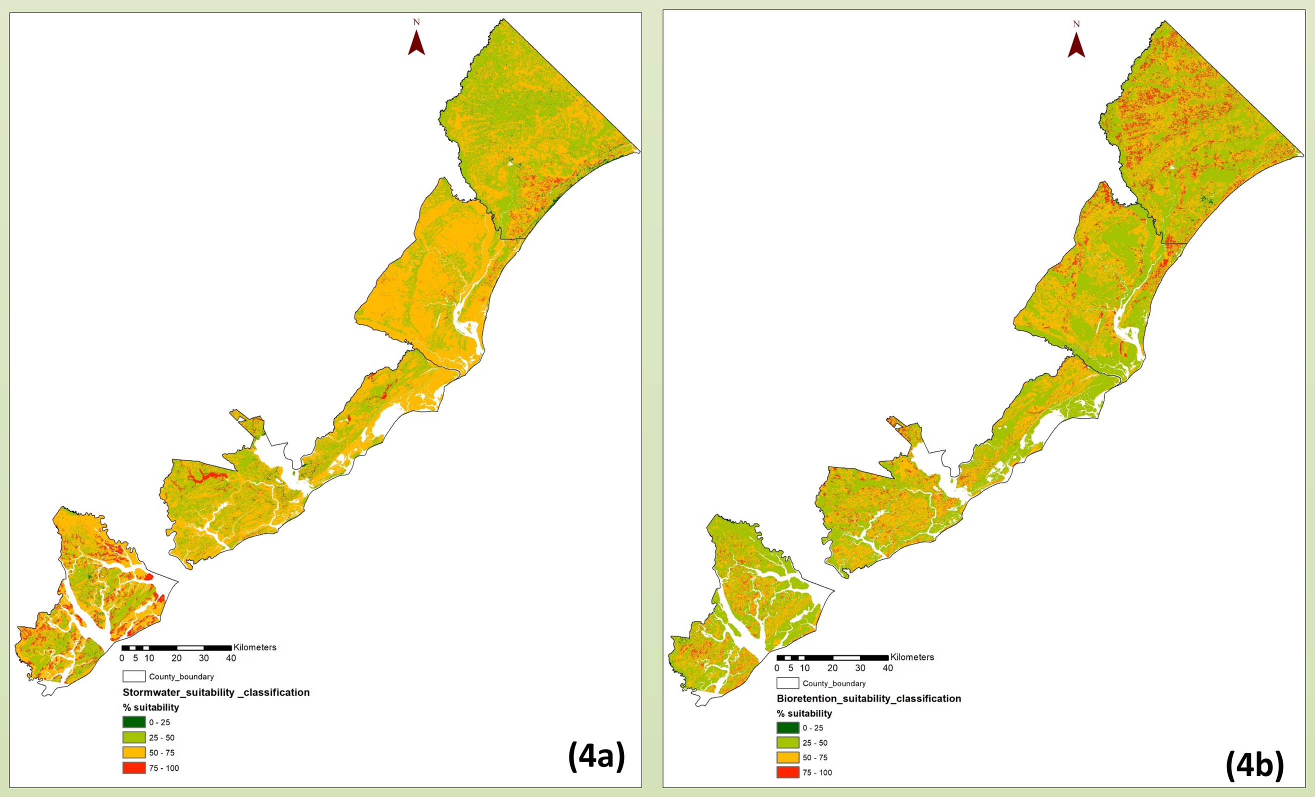

Figure 4: Suitability map identifying sites appropriate for the construction of (a) stormwater wetlands (b) bioretention systems for coastal SC using the weighted suitability score method.

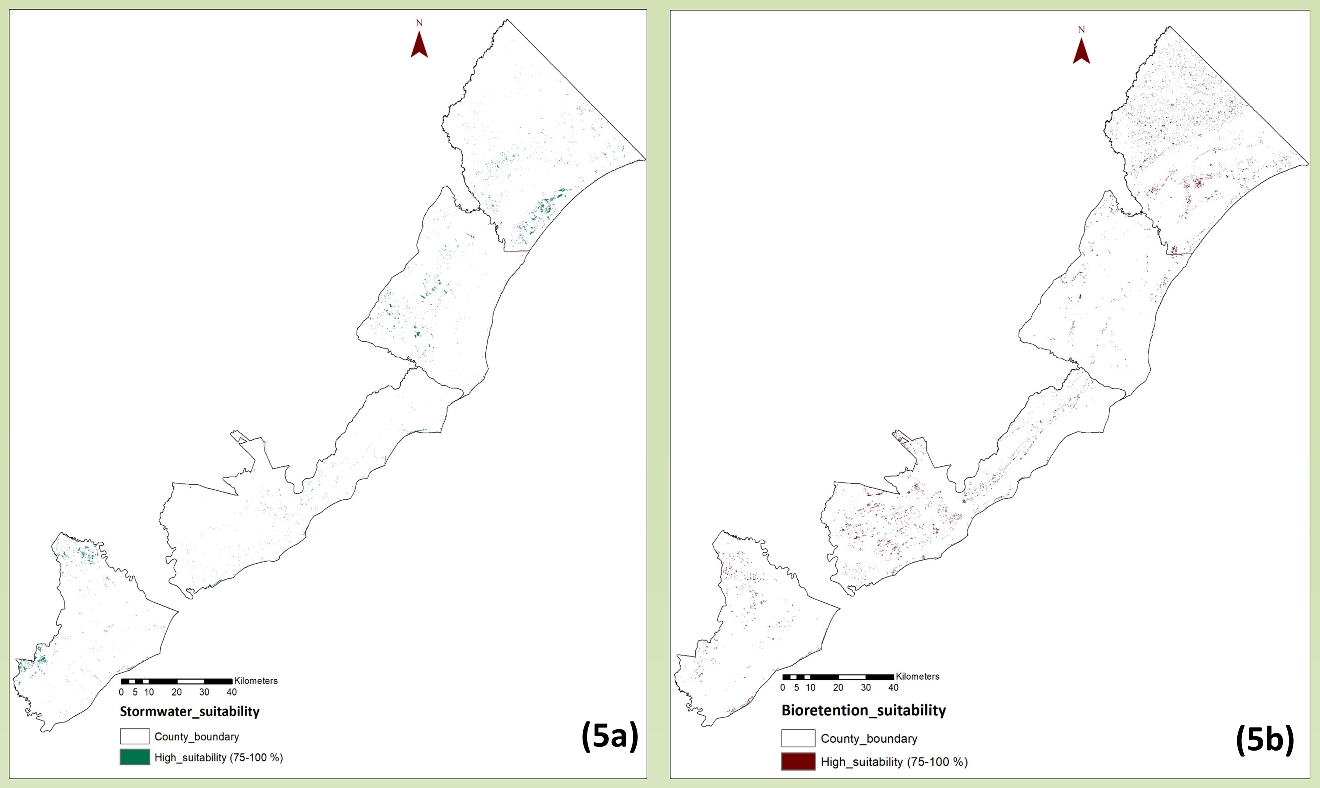

Figure 5: Final suitability map identifying sites appropriate for the construction of (a) stormwater wetlands (b) bioretention systems for coastal SC based on the spatial query method.