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A framework for using open green spaces for climate change adaptation and resilience in Barranquilla, Colombia

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Abstract:

This paper demonstrates how open green space offers local governments the opportunity to implement low cost, highly effective climate adaptation strategies. A framework was developed in Barranquilla, Colombia to identify sites for new or retrofit open green space. Inventories of existing open space and best practices were first created. Site selection criteria were then developed including amount of stormwater runoff, permeability, public support, vulnerability, and capacity for multiple interventions. These were mapped using geographic information systems (GIS) to select sites for scalable, multifunctional interventions to exemplify potential strategies for climate change adaptation within the city, through the use of green infrastructure.

Keywords:

Adaptation, Open green space, GIS, Spatial strategies, Colombia

1. Open green space as a public asset

As cities begin to experience the effects of climate change, increasing urban resilience has become a priority for decision makers across the world. Adaptive capacity is a key element to urban resilience and is defined by the IPCC as "the ability or potential of a system to respond successfully to climate variability and change" (Parry et al, 2007). In order to identify opportunities for adaptation within a city, it is imperative to integrate evaluations of climate variability (natural hazards) and climate change with evaluations of current *and* proposed urban environments. Furthermore, open and public spaces within the city can serve a multitude of functions, including climate change adaptation, and should therefore be considered an integral component when planning for resilience.

Open space is typically characterized under the following perspectives: 1) open spaces act as independent sites or 2) open spaces act as a solution to current problems only (typically social). However, open spaces have the potential to be designed in such a way that they can become part of a network of interventions that act at multiple scales throughout the entirety of the city and can act as a proactive solution to both current and future problems, addressing social, environmental, and temporal issues simultaneously. This considered, open spaces within cities represent a significant public asset and can be characterized by the types of roles they can have within the city. Many types of open space typologies can be identified: parks and gardens, green corridors, sport facilities, playgrounds, protected/conservation/natural areas,, residual urban spaces, vacant land, urban forests, trails, bike paths, and civic spaces and plazas. These typologies have characteristics that lend themselves to different types of potential adaptation strategies based on their inherent characteristics (the primary focus has been on public spaces, although similar private spaces could also be used for similar purposes). For example, highly impervious spaces such as civic spaces, plazas or sporting areas can be retrofitted or designed to provide water retention (during intense rain events), or cooling areas (for exceedingly hot days). On the other hand, vegetated spaces such as parks or gardens can provide infiltration areas (to minimize flood risk) or provide for biodiversity within the urban environment. While providing functions that adapt to the impacts of climate change, these spaces also provide important social and economic functions to the communities, which also increase community resilience.

The multi-faceted benefits of the application of adaptation strategies to open spaces become increasingly relevant in countries and cities where open and green space is limited. Rapidly growing cities in Colombia provide such a case. As such, the Ministry of Environment and Sustainable Development in Colombia (Ministerio de Ambiente y Desarrollo Sostenible de la República de Colombia) and FONADE (Fondo Financiero de Proyectos de Desarrollo) approached GeoAdaptive with a challenge: to develop a framework which identifies evaluation and site selection criteria for existing public open spaces as a

means to incorporate climate change adaptation strategies in Colombian cities. GeoAdaptive developed this framework for three cities in Colombia: Cali, Bucaramanga, and Barranquilla. This framework is described here, and presents Barranquilla as a case study for climate change adaptation through public open spaces.

2. Case study: Barranquilla, Colombia

2.1 Barranquilla's challenges

Barranquilla, Colombia is a tropical city which is expected to grow rapidly in the next 20 years. The current population is approximately 1,112,889 inhabitants (Departamento Administrativo Nacional de Estadística, 2005). Located along the Northern coast of Colombia, it is a city of increasing national importance due to the strategic location of its port along the Magdalena River. The city experiences a number of natural hazards and human-induced challenges including: extreme urban flooding from precipitation events, riverine flooding, sea level rise, mass wasting (extreme landslides), urban heat island effect and erosion. Climate change will likely exacerbate these challenges, increasing the need for adaptation within the city. GeoAdaptive had recently conducted an analysis of these risks, under the Emerging and Sustainable Cities Initiative for the Inter American Development Bank (ESCI- IDB). The results of this technical study show that the city experiences an estimated COP $3.66 billion average annualized losses and 11,281 people exposed to urban flooding alone, which is the most recurring hazard in the city. Urban flooding in Barranquilla is a risk which is highly mitigatable and is caused, in part, by high levels of impervious development across the city, development in areas that were historically wetlands or streams, and a lack of a comprehensive drainage system.

Furthermore, Barranquilla currently has a low ratio of public open space per person (an estimated 3.34 m^2/person; in comparison to New York City with19 m^2/person and Copenhagen with 42.4 m^2/person). This could mean a lower adaptive capacity potential across the city for preventing, responding to, and recovering from natural disasters. With the goal of increasing the adaptive capacity within these limited spaces, a framework was developed to 1) identify and evaluate the state of existing open spaces for each city, 2) identify best practices which could be applied to different typologies of open space in Colombia, 3) develop site selection criteria to identify prime spaces for open space adaptation, and 4) illustrate, conceptually, how design strategies could be implemented in selected sites for climate change adaptation. In addition, the identification of design strategies aimed to inform planners as to how public spaces could contribute to risk reduction/management and increased resilience.

2.2 Methods

First, an inventory of existing open spaces and the impacts of climate change were assessed. City-wide analyses were conducted using remote sensing data, publicly available from satellite technology. These data were used to derive information such as impermeability, vegetation health, temperature, surface water, development intensity, slope and topography, and land cover change over time. This information was used to indicate areas where extreme heat may be the most concentrated (i.e. dangerous), where flooding or poor drainage was likely to be a challenge, and to indicate the location of existing green spaces. This information was supplemented with GIS data provided by local and national offices (at the neighborhood/community level), indicating population density, socio-economic strata, recreational/public facilities, and land use. The GIS data, together with remote sensing data, fieldwork observations, local validation, and meetings with local experts and community leaders, were used to develop a set of criteria for selecting the most appropriate site.

In order to apply this framework, two key sites were selected using the criteria developed from best management practices (BMP) from around the world. The criteria were divided into three main categories, water and land management and management of urban heat island effect, which were based on the identified adaptation strategies (including BMPs) that were most appropriate for Barranquilla. From these categories more specific criteria were defined based on the following characteristics: level of impermeability, slope, storm water retention, existing natural hazard areas, community support, population density, level of vulnerability, and the capacity for multiple interventions. These criteria were mapped using GIS to select the best locations to employ scalable and multifunctional interventions to exemplify potential strategies for climate change adaptation within the city. The selected sites were examined within the context of the city's urban characteristics, natural hazards and projected climate changes, and narrowed down to two sites with different open space typologies best positioned for the development of strategies for increasing resilience..

Specific urban and landscape design strategies were visualized for each, chosen based on the individual characteristics found at each site. In addition, schematic design sections were created to best reflect each set of adaptation strategies, which can be used as future guides to potential implementation projects.

3. Results and Discussion

Estimated calculations for the landscape strategies (retention pond and rain garden) suggested for one of the case study sites show a potential to retain 55,000 liters of runoff from the adjacent residential areas to the site (based on 4 inches of rainfall). In addition, property values could be increased up to 30% for

adjacent properties, through the improvement of public spaces (Correll et al., 1978; Crompton, 2001) and the increased vegetation (shade and evapotranspiration) within the space (by 10%) along with light color pavers could reduce temperatures in the surrounding areas by up to 2.5 C° (Gill et al., 2007). Channelization of runoff towards areas of retention also contributes to the prevention of further erosion of the site. Further analysis, engineering and soil studies would be needed to assess the exact design and impacts of those designs for each site specifically. However, through the suggestions of the types of interventions possible and most suitable for each type of existing public space, decision makers and planners can prioritize which strategies to explore in greater depth.

Because public open spaces are of the "public domain," local policies and political/planning mechanisms can be used to implement the adaptation strategies such as those identified for these examples. These mechanisms can include: payment for ecosystem services; special provisions on land use, zoning and urban plans; Green Planning Development Units; reverse auction of development rights; capacity zoning and eco-districts designations; and purchase of development rights. In addition, public-private partnerships (PPPs) can be used to help fund the design, implementation, and maintenance of these spaces.

This case represents only a sample of climate change impacts that can be addressed through a Strategic Framework for Open Space Adaptation Planning. This framework can inform strategies for increasing adaptive capacity. Through the use of public open spaces, cities can link spaces together to develop and maintain a green infrastructure network that can provide multiple social, environmental and economic co-benefits. Furthermore, with regards to risk management and increasing resilience to climate change, the public domain status of these spaces makes it possible, and oftentimes less costly to provide adaptation to existing natural hazard impacts and implement proactive measures for future events (as it requires less acquisition costs). As cities begin to take a more integrated approach to managing risk and increasing resilience, this framework can help guide decision makers and planners on how to increase adaptive capacity through strategic design and planning of open spaces.

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Bio:

Dr. Vargas-Moreno is the managing partner of GeoAdaptive, LLC. He is an urban and environmental specialist with 15 years of expertise in the analysis and planning of rapidly changing cities, with experience in the development of growth strategies amongst technical and institutional challenges and the integration of analysis and technological processes to improve the decision-making relevant to technical, political and institutional levels. This process has enabled Dr. Vargas-Moreno to assist in the design and planning and management strategies to ensure sustainable growth. Dr. Vargas-Moreno is an architect from the University of Costa Rica and holds both a Master of Regional Planning and Ecology; and a PhD in Regional Planning and Urban Information Systems from Harvard University. He is also an alumnus of the Sustainability Science and Policy Program Center from Kennedy School of Government and Public Policy at Harvard University.

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Attachments: