Regulating outdoor advertisement boards; employing spatial decision support system to control urban visual pollution

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Abstract. Unmanaged placement, size, location, structure and contents of outdoor advertisement boards have resulted in severe urban visual pollution and deterioration of the socio-physical living environment in urban centres of Pakistan. As per the regulatory instruments, the approval decision for a new advertisement installation is supposed to be based on the locational density of existing boards and their proximity or remoteness to certain land-uses. In cities, where regulatory tools for the control of advertisement boards exist, responsible authorities are handicapped in effective implementation due to the absence of geospatial analysis capacity. This study presents the development of a spatial decision support system (SDSS) for regularization of advertisement boards in terms of their location and placement. The knowledge module of the proposed SDSS is based on provisions and restrictions prescribed in regulatory documents. While the user interface allows visualization and scenario evaluation to understand if the new board will affect existing linear density on a particular road and if it violates any buffer restrictions around a particular land use. Technically the structure of the proposed SDSS is a web-based solution which includes open geospatial tools such as OpenGeo Suite, GeoExt, PostgreSQL, and PHP. It uses three key data sets including road network, locations of existing billboards and building parcels with land use information to perform the analysis. Locational suitability has been calculated using pairwise comparison through analytical hierarchy process (AHP) and weighted linear combination (WLC). Our results indicate that open geospatial tools can be helpful in developing an SDSS which can assist solving space related iterative decision challenges on outdoor advertisements. Employing such a system will result in effective implementation of regulations resulting in visual harmony and aesthetic improvement in urban communities.
Billboards and hoardings; challenges and opportunities for local governments

Major cities in Pakistan are losing their aesthetics because of the high concentration of billboards and hoardings, their improper locations, inappropriate size, bad heights, unsuitable colors and faulty construction [1]. These advertisement structures on busy roads and urban centers are not only disturbing urban visual fabrics, deteriorating the social and physical living environment, causing nuisance for surrounding land uses and road users, but also result in physical losses and causalities under storm conditions [2]–[6]. On the other hand, hoarding and billboards have emerged as a lucrative revenue source for controlling authorities. Only from Karachi (the largest city of the country) city government earned more than Rupees 825 million rupees from billboard in year 2012-13. On the other hand, Clifton Cantonment (a cantonment town in Karachi) generated Rupees 147 million for the same year [7]–[10].

Throughout Pakistan, regulatory instruments for controlling and management of outdoor advertisement boards are at a very nascent stage [11]. Only few large cities such as Karachi, Lahore and Faisalabad follow regulations to manage billboards but with prime focus on revenue generation [12], [13]. Only two years back, in 2013, Punjab government devised the very first provincial level policy - Punjab Outdoor Advertisement and Signboards Policy - requiring the local authorities formulate their bylaws on the subject [14]. Response from local governments has been slow but gradually they are formulating legal instruments talking about the location, size, type and density of outdoor advertisements boards.

All of the regulatory instruments advise to base the approval decision for a new advertisement installation on linear density of existing billboards and their proximity or remoteness from certain land-uses. However, such decisions are mostly driven by political pressure or revenue potential rather than urban visual harmony. Other than Karachi, there appears no use of spatial information in deciding location of advertisement boards in any other city. In case of Karachi, City Government has been using diagrammatic illustrations (not to scale) to demarcate and allocate sites for hoardings of various sizes (see Figure 1). In both cases, responsible authorities remain handicapped in effective implementation of regulations due to the absence of geospatial analysis capacity.

Intermittent and irregular control results in mushroom growth of boards under corporate pressure. From time to time, political leaders pushes authorities to start ‘war-on-billboards’ causing immense stress on local authorities as well as advertisers [4], [15], [16]. In a nutshell, there exists no decision support system which can be used to identify the problematic locations because of boards, extent of compliance with the policies and rules and identification of optimal locations for new installments from advertisers and planning authorities’ point of view.

This study targets at solving decision challenges in billboards’ location by conceptualizing and developing an SDSS based on open source tools including OpenGeo Suite, PHP and GeoExt. For effective functioning, the SDSS must have the following capabilities:

1. Visualization: to visualize the existing and proposed sites of advertisement boards in relation with the legal requirements of location and distance in residential areas or on roads
2. Scenario evaluation: to evaluate the impact of change in permissible linear density of boards and to evaluate the impact of change in buffer restriction around a particular landuse
3. Generation of reports
4. Iteration: to provide user friendly interfaces where user can define and redefine parameters

Figure 1. Sample of diagram used by Karachi City Government to allocate sites for billboards of various sizes on a primary road.
2. Related work
The related work provides evidences that spatial technologies have been in practice to identify best locations for advertisements. Haidu et al. have analyzed the potential of GIS implementation for optimizing advertisements. They believed that effectiveness of advertisement is linked with geo-demographic, socio-economic and educational characteristics and the infrastructure of the targeted area. Hence, they used spatial analysis to locate certain categories of potential clients. They employed a series of factors which would attract or repel various advertisement activities including street network pattern, advertisement prohibited areas, population density, and regulatory bindings to identify and grade advertising area [17].

Luke et al. have used GIS to explain locations and characteristics of tobacco billboards in St Louis. They used GIS based analysis to measure the extent to which tobacco companies were placing billboards in close proximity to minority neighborhoods and schools [18]. Similarly, Hillier et al. have studied the clustering of unhealthy outdoor advertisements around child serving institutions and have emphasized the need of regulatory provisions to keep outdoor advertisement boards’ locations away for such institutions [19].

In Nigeria, private companies have been using GIS to keep updated inventory of advertisement boards for outdoor advertisement industry clients [20]. While in USA, Europe and Canada, Software as a Service (SaaS) has been in practice where service provider make use of demographic data, traffic flow, elevation and exposure data to help advertisers decide locations and return on investment for their outdoor advertisements [21]. Additionally, open source geospatial technologies have gained momentum in the last decade or so. In a very interesting study, several open source technologies are discussed which can be applied in many domains [22]. In another study, the authors conducted an online survey and asked the users of these geospatial technologies about their experience while using these technologies [23]. Some of the technologies which scored higher were used in our study such as PostgreSQL, OpenLayers, ExtJS and GeoExt. These well-known open source geospatial technologies have also been used in different applications such as map personalization in the context of location-based services [24].

However, most of the literature focuses on advertisers’ perspective where GIS is used to make location of advertisement more and more profitable. While our study focuses more on outdoor advertisement’s management from local authorities stand point by making use of an SDSS. Controlling authorities are largely concerned about checking if the new installation request complies with the policy requirements in spatial terms or who will be affected if a change is made in the threshold of linear density of boards on roads or a buffer restriction around a particular land-use.

3. Methodology
This study has followed a four step methodology to reach the desired objective. First, it reviews the relevant regulations to enlist all the prescribed spatial provisions and restrictions in the form of knowledge module of the system. Secondly, database module has been developed by arranging relevant data layers with desired attributes in a geo-database. Thirdly, site suitability analysis has been performed using analytical hierarchy process with three criteria layers. Finally, a web application has been developed using open source tools to provide users with a friendly interface to perform iterative actions.

4. Results and discussions
4.1. Review of relevant regulations
This study has reviewed all the available regulatory documents which are in practice in various urban areas of Pakistan and include the following:
   i. Regulations for outdoor Advertisements and Billboards by Parks and Horticulture Authority (PHA)
   ii. Punjab Local Government Ordinance 2001
   iii. City District Government Faisalabad Advertisement Bye-laws 2013 [25]
   iv. Punjab Outdoor Advertisements and Sign Boards Policy 2008 by Punjab Housing and Urban Development Department (PHUDD)[26]
v. SOP-Hoarding in Cantonment Areas, July 2011
vi. Military Lands and Cantt Hoarding Policy 2012 [27]
vii. Advertisement, Signage Bye-laws for Karachi 2003 [28]

As per these regulatory instruments, the approval decision for a new advertisement installation is supposed to be based on two key factors:

a. The linear density of existing billboards; spacing between two boards vary from 150 to 250 feet based on their location (within city, intercity road, highway) and size (20X60 feet or 30X90 feet) [25], [26]

b. The proximity or remoteness of a billboard/ hoarding from certain land-uses; prevailing regulations in Pakistan have specified locations prohibited for placing advertisements such as residential buildings, notified areas of heritage importance and road medians [25]–[28]. International practices provide more comprehensive criteria related to placement near parks, educational and religious buildings, monuments and cultural sites etc. [17], [29]

4.2. Preparation of geo-data

Primarily, three data sets have been used in this study and have been managed using PostgreSQL database with PostGIS as a spatial extension. These include building parcels along with land-use information, road network and location of existing billboards. Table 1 provides details about type, associated attributes and data format of each data layers.

| Sr. # | Data set (name & snapshot) | Type | Attribute | Data format |
|-------|----------------------------|------|-----------|-------------|
| 1     | Parcel Land-use            | Polygon | Commercial, residential, religious, historical, educational, health institutions | Vector |
| 2     | Road network               | Polyline | Length, width, type | Vector |
| 3     | Location of boards         | Points | Height, size, number, type (traditional, mechanical, electrical), display surfaces | Vector |

4.3. Site Suitability Analysis

Site suitability analysis has been used to identify suitable locations for siting new bill boards. Locational suitability has been calculated using pairwise comparison through AHP and WLC where distances from roads, existing billboards and educational institutions have been taken into consideration. For this purpose Quantum GIS, loaded with Easy AHP – a QGIS python plugin, has been used. Figure 2 explains the step by step process involved in finding suitable sites for new installations using AHP and WLC. From step 1 to step 3, criteria map layers are illustrated; step 4
shows the pairwise comparison for AHP; step 5 depicts the weight assignment for WLC while step 6 shows the identified resultant sites.

**Figure 2.** Finding suitable sites for new installation using AHP and WLC.

4.4. Web Application Development

Finally, an OpenLayers based web application has been developed to display datasets and resultant raster of AHP process. OpenLayers allows users to display data layers while using OpenStreetMap and Google Street Map as background. The raster layer showing suitable areas can be adjusted for opacity via slider tool. Additionally users can view the linear density of existing advertisement boards along a selected road. Figure 3 illustrates the final shape of web SDSS application where individual map layers are shown to the right which can be turned on and off while corresponding legend appears to the left of Web interface. Based on the location of existing billboards, users can see the linear density along any selected road.

**Figure 3.** Snapshots of the user interface of web application.
5. Conclusions

This study reflects that open geospatial tools can be helpful in developing an SDSS which can assist solving space related iterative decision challenges on outdoor advertisements. It has been demonstrated that, in the light of existing outdoor advertisement regulations, such system can work with minimum need of datasets i.e. spatial road inventory, location of existing boards and land-use parcels while AHP and WLC can be used for spatial multi-criteria decision making for site suitability analysis. Although the main structure of the system has been established under this study, considerable amount of programming related effort is required to strengthen the graphical user interface. In this exercise, all criterion maps have been developed in QGIS and pairwise comparisons have been performed using Easy-AHP. However, for a robust SDSS on-the-fly calculations are desired. Efforts are required to further improve the system in order to perform these tasks in an online environment with user given inputs. Employing such a system will result in effective implementation of regulations resulting in visual harmony and aesthetic improvement in urban communities.

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