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Anne A. Gharaibeh
Jordan University of Science and Technology, Department of Urban Planning, Irbid, Jordan

Haneen A. Sawalqah
Jordan University, Department of Architectural Engineering, Amman, Jordan

Greenway Planning; Developing A Network Methodology For Jordan

Anne A. Gharaibeh[1], Haneen A. Sawalqah[2]
[1]*Jordan University of Science and Technology, Department of Urban Planning, Irbid, Jordan,* [2]*Jordan University, Department of Architectural Engineering, Amman, Jordan*

Greenway network planning has become an acknowledged tool for allocating land for recreational purposes. Within developing countries such as Jordan, urban laws lack implementation plans and/or policies regarding green open spaces, ecological networks and greenway planning. A review of the currently effective planning policies and city mandates of Jordan reveals that the concept of preserving land for environmental and recreational purposes is addressed (Laws no: 79/15/F, 79/19/F, 79/23/F, 79/52/F, 79/58/F, 1966), yet no strategies are present to instrument land acquisition other than land subdivision laws (Law no: 12/6, 1976 and 1980). Since these measures were not part of the physical planning of districts in Jordan, this study proposes a methodology that predicates on seizing opportunities for implementing such networks. Consequently, as no land is planned for the network; this study is engaging allotted land for drainage and natural water courses as a prospect solution. The process systematizes the selection of the network links based on three factors; assessment of connectivity supplies; assessment of site suitability; and assessment of accessibility. This study creates a modified planning system that considers recreational land allocation based on local legislations and land provision strategies for the first time in Jordan. Al-Jubaiha District (population: 50,800 people, 2004) in Greater Amman Municipality is chosen to test the applicability of the proposed hypothesis and methodology. The main reason is its physiography, its demography, and the potential abundance of vacant undeveloped land.

Introduction

Jordan is a Middle Eastern Country, with a population of 9.5 million (Alrai, 11, Jan, 2016). Jordan's environments are vulnerable due to the pressure on natural resources and the urban development in natural environments caused by the urban growth and the attracted regional immigrants and investors seeking refuge. For example; poor public land management causes the loss of water courses to built-up areas instead of protecting them and investing in collecting water runoff to create environments for the wildlife. Lack of planned open areas, greenways or ecological corridors also creates a threat to the air and visual pollution. The negative impacts on nature call for an immediate change to improve the city's environment and increase green spaces (Al-Rawashdeh, 2011).

The Jordanian Laws support the creation, development, and preservation of open spaces for recreational purposes such as parks, plazas, and squares. Since its establishment, Jordan Legislation made bearings to increase green areas. However, the average open space per person is dramatically low in Jordan reaching alarming percentages (Table 1).

Table 1. Percentage of open space per city dweller in some of Amman districts. Calculated by authors

District	Population (2004)	Percentage of green open space per city dweller
Al-Jubaiha	50,800	0.73m^2
Al-Abdali	105,709	0.51m^2
Wadi Al-Seer	138,350	0.37m^2
Tla'a Al-Ali	128,350	0.64m^2

Compared to the international rates this is quite low (Figure 1). However, the major concern of this study is the process by which these laws can be incorporated into a well-established, consistent and effective framework that guides the process of allocating land for recreation through open space planning.

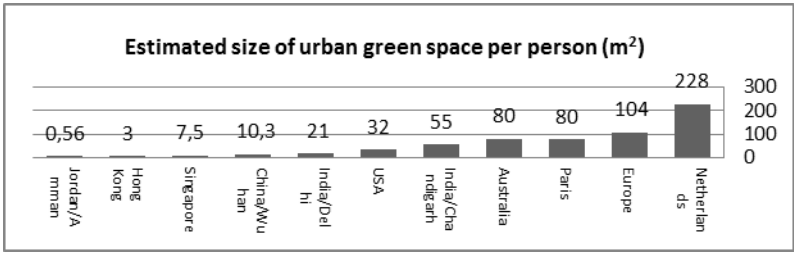

Figure 1. Estimated size of urban green space (modified after Singh et al., 2010)

This study hypothesizes that allocating a proposed network of greenways that is comprehensively distributed and that create a balanced physical- natural system in Al-Jubaiha district in the country of Jordan can be done by creating the methods and the "HOW" to allocate land for recreational purposes. This is done in order to develop an integrated approach concerning planning and maintaining green spaces to improve environmental sustainability.

Background

Researchers and planners follow principles of landscape ecology to develop networks of green spaces in order to restore and preserve biodiversity and connectivity (Kong et al., 2010; and Linehan et al., 1995; Ahern, 1995; Fabos and Ahern, 1995; Kong et al., 2010; Searns, 1995).

A case study in Milan, Pavia, (Fumagalli and Toccolini, 2012) provided some guidance to this research. The greenway is planned along the lines of the water system (Ticino River and Bereguardo Canal line) while connecting its long path with each urban agglomeration. Their purpose is to create an ecological network and a greenway network plan benefiting from the existing green trails network to connect demand areas.

Conine et. al, 2004, created a multi-purpose greenway plan for Concord, north Carolina. They centered the greenway planning process on three factors: demand areas, connectivity supplies, and site suitability factors. Demand areas are the locations that must be connected via the greenways such as residential areas, commercial centers, and recreational facilities. Connectivity supplies are the linear features in the landscape that connect the demand areas such as sewer lines and transportation infrastructures. Site suitability factors values lands based on their suitability for greenways supported by a Rating and Weighting (RAW) method.

Du, et al, 2012, on the other hand, based the planning process on land use, suitability, and analysis. The researchers employed capability scores on six factors; Critical Source Areas (CSAs), economic loss, birds nature reserve, cultural sites, land use, and population density. They superimposed the calculated suitability map on demand areas (need areas) in order to delineate the location and extent of existing and potential greenways. Goals included: mitigating impacts of Agricultural Non-point Source Pollution ANSP; travel routes and historical protection; and multiple other goals.

Goals and Objectives

The goal of this research is to develop a model for planning a multipurpose greenway network that is comprehensively distributed and that creates a balanced physical-natural system. It develops the methods to allocate land for recreational purposes by applying this methodology on the case of Al-Jubaiha district in Amman city. Objectives include: first; serving demand areas, which are defined as locations where human activities take place and destinations of the potential corridors. Second; using connectivity supplies as greenway networks, which are defined as existing linear features that can be utilized in order to link areas of demand. Then they are evaluated. Third; proposing a greenway network modified after existing accessibility, approachability and proximity analyses.

Methods

The model is based on the analysis of satellite data through geographical mapping; data collected include GIS maps in addition to a number of previous case studies and a questionnaire distributed among professionals in the landscape and planning fields. This study adopts a modified methodology based on four assessments by which a final greenway network is implemented. These include: assessment of demand areas; assessment of connectivity supplies; assessment of site suitability; assessment of accessibility; and delineation of greenway corridors.

The assessment of site suitability is based on specific numerical scores obtained from published literature of similar studies identifying factors affecting land suitability for greenway use (Chandio et al., 2014; Conine et al., 2004; Lepage and Vasilakos, 1999; and Steiner et al., 2000). A group of experts are consulted on the assessment of the weights on the suitability map in addition to the weights of demand area. Satellite imagery and GIS tools are employed to identify the distribution of vegetation cover and other prospect suitability maps of the proposed network. The methodology is defined through surveys and meetings with planners, officials, and residents. All the needs were deeply studied, and incorporated into the process of planning. The Methodology of this Study is based on the Following Steps:

1. Assessment of Demand Areas

Demand areas are locations where most human activities take place. Examples include parks, residential areas, schools, employment and commercial centers, recreational facilities, and many others. As these attraction nodes necessitate a requirement for linkage, demand areas are considered attractions that require corridor assessments. The major demand areas in Al-Jubaiha District include: governmental institutions and ministries, schools and kindergartens, mosques and churches, cultural centers, universities and colleges, parks and gardens, hospitals and health centers, police and health defense centers, embassies, post offices, the sports centers and commercial facilities. One of the main objectives of this study is to create greenways that are as close as possible to demand areas, for this reason small buffers of a radius equal to 200 meters is employed (Figure 2a).

2. Assessment of Connectivity Supplies

Connectivity supplies are linear features which include existing transportation infrastructure, sewer lines and hydrology. This data is used to identify how these features can be utilized to link areas of connectivity defined previously. Maps include, first; streets with 16 meters or more buffered on each side by

1.6m (Figure 2b). Second; sewer lines network. Building is already prohibited above the main sewer lines according to municipal practices. All main sewer lines with widths more than 400mm are buffered on each side by 1.5m from centerlines (Figure 2b). Third; hydrological stream ordering method is used so as to assign numeric values to each link in the stream network using digital elevation model (DEM) according to hierarchy of tributaries (Figure 2b).

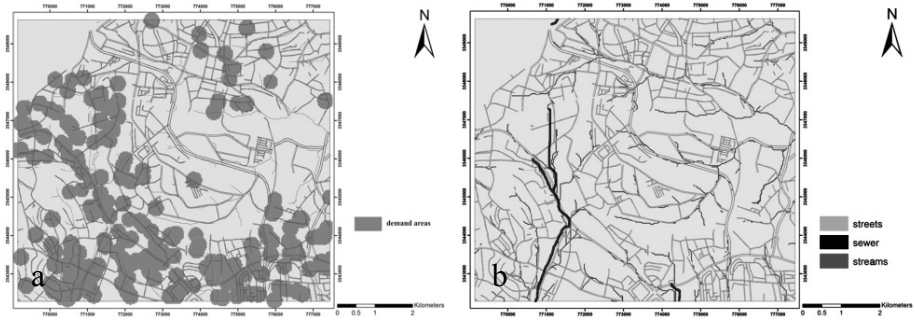

Figure 2. a: demand areas. b: connectivity supplies

3. Assessment of Site Suitability

Site suitability is defined as the process of combining and classifying data in order to identify suitable sites. First: factors to be used in the suitability analysis are determined and given weights that indicate if their presence is favorable or unfavorable to the desired use. Second: categories within each factor are ranked and given capability scores in order to define the degree of suitability within each factor. Third: each category's capability score within each factor is multiplied by its factor's respective weight in order to perform the suitability analysis.

The factors considered in this study are: Land use, slope, vacant land and population density. Total points are calculated for factors' existence in each study. It is foreseen that the frequency of use of the factors to evaluate the suitability is an indicator of its importance. These four factors are then weighted through a questionnaire that is distributed among a number of experts and professionals related to the field of landscape and urban planning. Factors weights are calculated through the formula:

(Each factor's percentage / Total percentages of all factors)

The final weights of the selected factors added together should give a sum of 1. The results of the weights calculated for the four suitability analysis factors are very convergent, which reflects that the four factors are almost of the same

importance in the suitability analysis phase. The four layers of slope, land use, vacant land and population density are converted into raster images in order to apply the suitability analysis assessment (Table 2).

Table 2. Weights calculated for suitability analysis factors

Suitability factor	Slope	Land use	Vacant land	Population density	Sum
Factor weights	0.28	0.24	0.22	0.26	1

Capability scores are calculated within each factor, they are scaled between zero and one (0, 0.25, 0.5, 0.75, 1). Capability scores are determined through a comprehensive review of a number of previous studies in the field of greenway planning (Du et al., 2012; Miller et al., 1998; Conine et al., 2004; Rattray, 2011). Special conditions and characteristics in Al-Jubaiha district are also considered. Capability scores are assigned as values for each of the four factors in the suitability analysis (Table 3). Each category's capability score within each factor is multiplied by its factor's respective weight in order to perform the suitability analysis. Land use, population densities, slope and vacant land layers are converted into raster images in order to apply the suitability analysis assessment (Figures 3).

Table 3. Capability scores calculated of land use

Capability Score	**0**	**0.25**	**0.5**	**0.75**	**1**
Land use	Industrial	Commercial	Residential	Agricultural	Public parks and land
Population densities (D)	≤ 0.004414	> 0.004414 or ≤ 0.008828	> 0.008828 or ≤ 0.013242	> 0.013242 or ≤ 0.017656	> 0.017656 or ≤ 0.022070
Slope (S)	≤ 4%	> 4% or ≤ 8%	> 8% or ≤ 11%	> 11% or ≤ 15%	> 15%
vacant parcels ($m^{2)}$	147 – 220,000	220,000 – 440,000	440,000 – 660,000	660,000 – 880,000	880,000 – 1,100,000

4. Assessment of Accessibility

Accessibility is determined by addressing approachability and proximity analyses. Approachability analysis is carried out in order to define areas accessible by transportation infrastructure and by sewer and hydrology lines. Proximity analysis determines which regions are close to major demand areas. In proximity analysis, a questionnaire is distributed among experts, and professionals related to the field of landscape and urban planning. They are asked to give each of the categories mentioned in the assessment of demand areas a degree of significance based on the demanded degree of connectivity to the proposed greenway network. Considering that demand areas would serve as main origins and destinations of greenways, a map of proximity is produced.

In the approachability analysis, areas where intersections occur between suitability polygons and buffers of hydrology lines and sewer lines are given an approachability score of 1, areas where intersections occur between suitability polygons and buffers of streets are given an approachability score of 0.5 while areas outside these intersections are given an approachability score of 0.

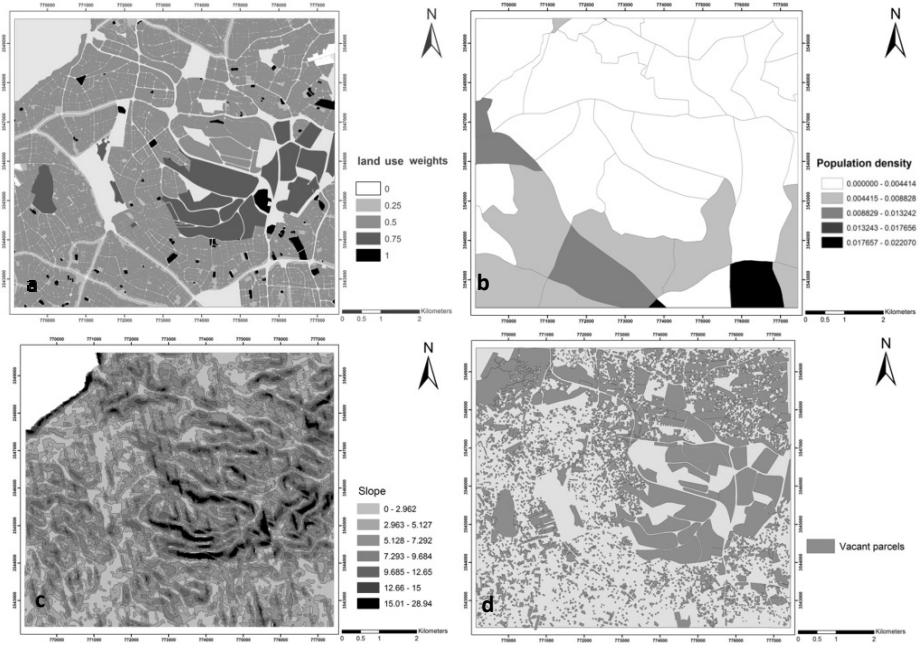

Figure 3. a: land use weights. b, population density. c: slope. d: vacant parcels

5. Delineation of Greenway Corridors

Maps of suitability, approachability and proximity are then overlaid and intersected. The weight of each map is equal to 1 and the composite weight is equal to three (Figure 4a). Dark gray shades represent areas that are highly suitable. After performing the suitability analysis and the intersection process, some of these areas are not shown since they are large vacant parcels of land that do not include any demand areas. These areas are taken into account in the greenways alignment process since they are considered as potentials for future development.

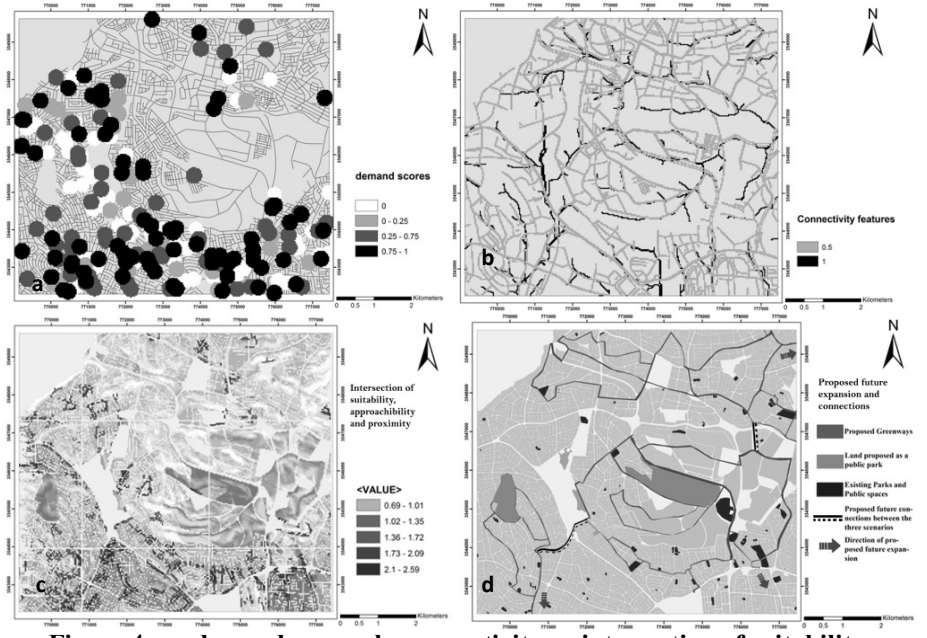

Figure 4. a: demand scores, b: connectivity, c: intersection of suitability, approachability and proximity maps, d: proposed future expansion and connections

Results

Alignments that connect cells of the highest merged scores are created. They connect with highest demand areas and represent best possible greenway corridors that preserve open spaces and meet demands for connectivity (Figure 4a). Industrial and commercial land uses are avoided in order to minimize the negative impact and pressure on the delineated greenways.

Finally, the overlay of suitability, approachability, and proximity intersection weights has the basic map lines for the proposed network upon which a final delineation is proposed (Figure 4d). The delineation and prospect implementation of the proposed corridors provide a chance to create cultural awareness of greenways and an opportunity to propose direct demand for policies and legislations that encourage their existence. The proposed network of greenways serves the dense area adjacent to the residential area surrounding The University of Jordan and The Sports City, in addition to a number of lower density neighborhoods surrounding Applied Science University. The commercial and industrial land uses are avoided by the alignments of greenways. The eastern section is not very dense but there is a high potential for development due to the existence of a number of hydrology lines. The greenways connect a number of small parks and publicly owned parcels.

In addition, a large parcel is proposed for water harvesting purposes. In order to serve the ecological role and improve the ecological conditions of the greenway network proposed. This parcel is allocated in one of the catchment areas where rain water harvesting is possible according to the existing hydrological network. The proposed greenways in this area are wider than three meters as planned in other areas; this is applicable because of the large areas of agricultural land. Widths of greenways can reach more than six meters in the eastern section helps to improve the ecological conditions by enhancing the wildlife movement (Figure 5).

Conclusions and Recommendations

This study presents a methodology through which the Laws and acts can be applied by locating a comprehensively distributed network of greenways that creates a balanced physical-natural system in Al-Jubaiha district. A number of actions can be undertaken in order to improve the development of land for recreational purposes in Jordan:

Figure 5. Area 3, photo by the authors

— Creating a formal legislative framework and planning guidelines that support and give more attention to the process of creation of green networks, land acquisition, allocation and implementation to create green open spaces and greenway networks.
— Obtaining adequate funding sources in order to replenish defect in the implementation acts. It was inevitable that other acts or methodologies should be applied to acquire more land for recreation in Jordan. In addition to, finding methods of financial support from tax money; for example; fuel taxes, sales of federal properties, communication taxes (phone lines), etc.
— Gaining public support and participation in such districts can aid the planning of greenways in densely urbanized areas.
— Using rehabilitation strategies in other locations that contain quarries and mining sites like Al-Rusaifeh district for example and other quarry areas.

Due to similarities in barriers between Al-Jubaiha district and other districts in Amman and Jordan in general, the same methodology used in this study can be adopted for other districts with slight differences due to each district's local conditions, demand areas and characteristics.

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