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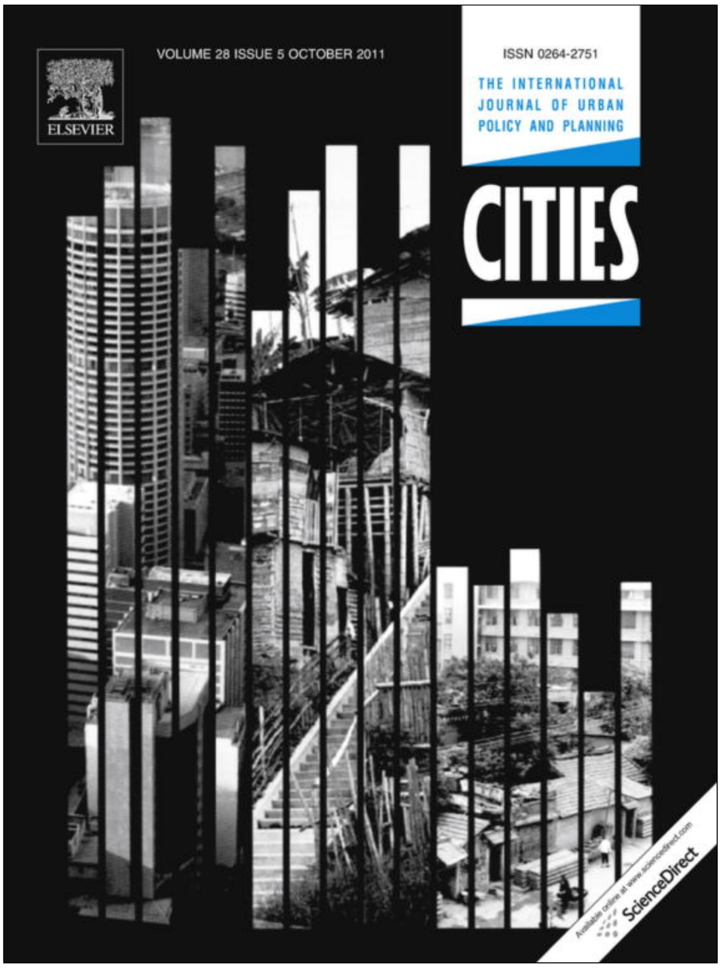
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Multi criteria analysis for locating sustainable suburban centers: A case study from Ramallah Governorate, Palestine

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A B S T R A C T

Currently, over 65% of Palestinians live in urban areas, exceeding the international urbanization rate of 50%. The Ramallah Governorate is the most rapidly growing governorate within the Palestinian territory. This accelerating urban growth is accompanied by significant pressure on services, employment opportunities, and accommodations. This study aimed at finding sustainable areas for absorbing urban growth within Ramallah in order to alleviate the pressure on the city center as well as find accommodations for young families looking for better living conditions. This research was conducted in two major phases. Site selection was the first phase, using Geographic Information System (GIS to identify 13 sites according to the determined criteria. In Phase Two, Multi Criteria Analysis (MCA) was applied to evaluate these sites considering a set of indicators, which were evaluated and assessed by a wide range of stakeholders. Expert and public participation were included in this study. As a result of consideration of over 20 variables, a site was selected to be the most sustainable place for developing a suburban center within the study area.

Introduction

Urbanization has been accelerating worldwide in recent decades, threatening natural resources and landscape quality. In developing countries, human agglomerations attract populations from the surrounding areas. As a result, urban populations are increasing in these countries, contributing to the escalation of existing problems (Lavalle, Demicheli, Turchini, Casals Carrasco, & Niederhuber, 2001). More than one-half of the world's 6.6 billion people reside in urban areas (United Nations, 2008). The proportion of the world's population living in urban areas reached 5% in 1800. This proportion increased to 47% in 2000, and it is expected to reach 65% in 2030 (UNFPA, 1991).

The rapid growth of the world's cities, along with the associated problems of unemployment, poverty, inadequate health, poor sanitation, urban slums and environmental degradation, has been impacting many developing countries (Turner et al., 1990; United Nations, 2004).

The uncontrolled population growth is presenting urban planners and developers with numerous problems, such as providing essential services (UN-HABITAT, 2004). There is an urgent need to find new places that can ease the pressure on city centers and to create residential areas close to urban areas (Goldstein, 1990).

Managing urban growth has increased in importance and has become one of the most important challenges of the 21st century (Cohen, 2003). Various policies have been introduced in an attempt to meet the challenges facing urban planners.

1. Concentration policy is focused mainly on locating people and activities on a minimum area of land with a vertical expansion option. The ideas are applied by establishing a number of new cities and satellite towns close to existing urban areas or the creation of suburbs. The creation of these new areas allows people to live in a reasonably pleasant location away from the pollution and poverty of the inner-city and to commute to the economically booming urban areas, thus distributing some of the services to relieve the pressure on major cities (Pugh, 1995). This policy requires planners to promote development in the center of the cities and inner suburbs through the construction of high-rise buildings that could accommodate the forecasted population. Such a policy is suitable for a city with limited land resources. The compact city and satellite cities are two examples of concentration policy. The compact city model was introduced as an alternative to urban sprawl and focuses on limiting the peripheral expansion of urban areas.

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The satellite city model is intended for a small or medium-sized city that is located near a large central city (Alexander & Tomalty, 2002).

2. Decentralization is a policy that primarily promotes the horizontal distribution of urban centers to distribute social and economic activities in subcenters, which will minimize the population density away from the main urban center. Broadacre City was a type of decentralized community and was an urban development concept proposed by Frank Lloyd Wright as a solution to urbanization. Each family was given one acre (4000 m^2) of land, and each city was inhabited by 1400 families (Wright, 1932).

   The galaxy model is a decentralization policy, and it represents an urban form in which the older center and subcenters of a city are separated into small units, each with a relatively dense central core and linked by a transportation network (Bourne, 2001).

3. In many countries, building new towns has involved a policy of managing urban growth in rapidly growing urban areas. The British model has basically concentrated on developing garden cities and new towns. However, the idea of developing new towns has also succeeded in other countries, such as Israel, France and Egypt (Pakzad, 2007).

The idea of new cities is not new and has been in existence since the end of the 19th century when Ebenezer Howard proposed the creation of Garden City in England. Garden City gained global attention during the 20th century, especially in the period after the Second World War when large numbers of new cities in many countries worldwide were created as a means to confine surplus from cities within planned developments rather than allowing random and unplanned urban growth. These new towns were started either from scratch or from an already existing human settlement or rural community with sufficient urbanizing potential to provide the most modern facilities, schools, shopping centers or parking lots. However, the reasons for building new cities are numerous and varied and include reducing the population density in the main cities, transferring inhabitants to areas of low density (as in the case of Great Britain) and easing pressure on major cities, such as in France and Egypt (Thomas, 1985). In the case of Australia and Brazil, building new capitals was the main reason. In Saudi Arabia, the purpose was to exploit natural resources, such as gas. In the United States, the purpose was to absorb more migrants (Praeger, 1969; Stewart, 1996).

Urban planners use a variety of tools when developing strategies and plans for managing urban growth, such as geographical information system (GIS; Webster, 1994), computer-aided drafting (CAD) and three-dimensional (3D) visualization packages (Levy, 1995) as well as traditional artist's sketches and physical 3D scale models (Appleton & Lovett, 2005). In the last few decades, researchers have been developing modeling techniques to describe and predict urban growth (Wu, 2005, chap. 15). More recent studies that deal with allocation issues use multi-criteria analysis (MCA) to serve as an aid for thinking and decision making. MCA includes a full range of social, environmental, technical, economic and financial criteria (DTLR, 2001; Sanders and Ruiter, 1988). MCA was developed for complex multi-criteria problems that include qualitative and/or quantitative aspects of the problem in the decision-making process (Mendoza et al., 1999). GIS and MCA are tools that deal mainly with suitability analysis. MCA is used primarily for analyzing and evaluating different sites for future urban development (Anavberokhai, 2008).

The main aim of this study was to define the most sustainable site to be developed as a suburban center around the major city of Ramallah to alleviate pressure on the city.

In this study, GIS was used to find candidate sites (site selection) for potential areas to be considered as suburban centers around Ramallah city. In this stage, buffering analysis was conducted to eliminate the areas that did not comply with the defined criteria. MCA was used in the evaluation process to select the most sustainable site among many. In the evaluation process, the following considerations were incorporated: political and administrative issues, physical issues, national guidelines, socioeconomic factors, infrastructure availability and environmental concerns.

This study provides a conceptual model of growth management options and complements other similar studies (Dawkins & Nelson, 2002; Evers, Ben-Zadok, & Faludi, 2000; Gul, Gezer, & Kane, 2006; Putman & Chan, 2001; Rothblatt, 1994; Saleh & Al Rawashdi, 2007; Yeh & Li, 1998). The study covers more than 20 variables to find the most sustainable site for the proposed development of a suburban center around one of the fastest growing cities in Palestine.

Study area

The governorate of Ramallah is located in the middle part of the West Bank (Fig. 1) with an area of 830 km^2 and a population of 279,730. Ramallah and the adjacent city of Al Bireh are considered to be the center of the governorate. The population concentrated in this urban agglomeration is approximately 62,000. Most services, including health, financial, education, governmental and commercial services, are located within this center, which has resulted in accelerating urban growth (Palestinian Central Bureau of Statics (PCBS), 2009).

The 2007 census stated that the governorate has 279,730 inhabitants (Palestinian Central Bureau of Statistics (PCBS), 2007). The governorate population is distributed as follows: 52% live in urban areas, 42% live in rural areas and 6% live in refugee camps. The population of the Ramallah governorate is approximately 12% of the total population of the West Bank (Palestinian Central Bureau of Statistics (PCBS), 2008). The governorate population is expected to reach 552, 071 by the year 2030, an increase of 97.0%, with a natural growth rate of 3.44% (Palestinian Central Bureau of Statistics (PCBS), 2008).

The population density in Ramallah governorate was 217 persons/km^2 in 1997 and 327 persons/km^2 in 2007 (PSBC, 2007). The population density is expected to increase because of high population growth and the limited availability of land.

The urban expansion of Ramallah has reached its limits (municipal boundary) in all directions (Ramallah Municipality, 2008). Ramallah, unlike other West Bank cities, is experiencing a population boom accompanied by significant pressure on services and employment opportunities (Suisman, 2005; Thawaba, 2009).

The built-up area of Ramallah expanded 16.1% during the period 1989–1994 with a growth rate of 397,000 m^2 per year. In the period between 1994 and 2000, Ramallah grew by 24.5% with a growth rate of 585,000 m^2 per year (Khamaiseh, 2006; Ministry of Planning (MOP), 1998).

What type of urban expansion is possible for Ramallah? The opportunities for urban expansion in Ramallah are very limited because Jabal Al Taweel (Psagot-Israeli colony) is closing any eastern expansion. The Givait Zeev colony is preventing southern and western expansion, while the Beit Eil colony is closing northeast expansion. Ramallah has only one option for expansion: the northwest (Applied Research Institute-Jerusalem-Applied Research Institute-Jerusalem-ARIJ, 2006). In addition, the Wall is considered a delaminating factor. The Wall was built by Israelis on the Palestinian confiscated lands and is considered as an apartheid wall. Another constraint affecting urban expansion is land classification (A–C). These classifications were the product of the Oslo Accords, which were signed by Israel and Palestine in 1994. The

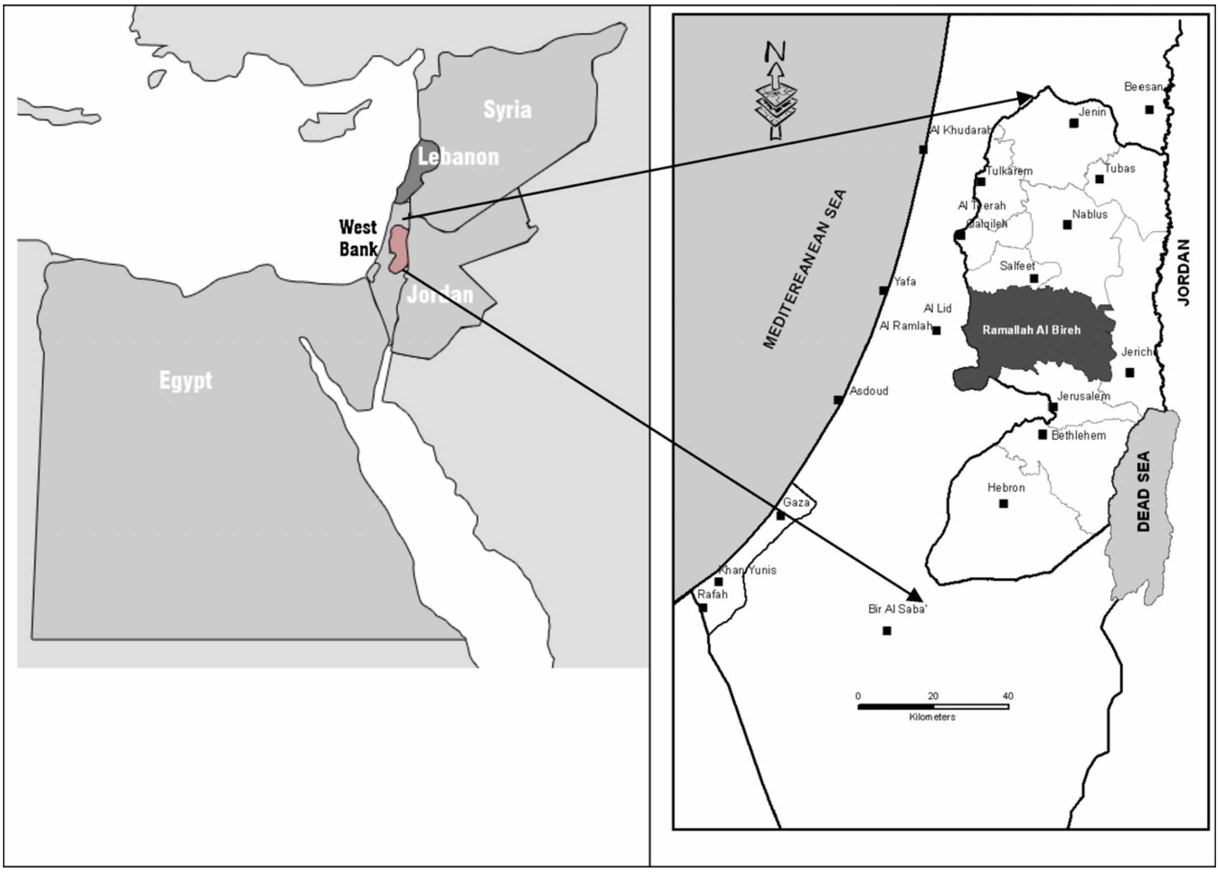

Fig. 1. Study area.

classifications are that Area A is under Palestinian authority, the civil services of Area B are under Palestinian authority and Area C is fully under Israeli authority (ARIJ, 2006).

These challenges necessitate a comprehensive plan to absorb the flux of people in a sustainable way. This type of comprehensive plan can be created by developing certain criteria that will assess and find new sites for future expansion and manage urban expansion in a sustainable way, which was the main aim of this study.

Methods

GIS analysis and databases are employed in a variety of decision-making contexts in which critical and politically sensitive decisions are based on the predictions of GIS-based models (Lowry, Miller, & Hepner, 1995). MCA has been used in different studies related to optimum facility sites (Joerin, Theriault, & Musy, 2001; Nijkamp, Rietveld, & Voogd, 1990), land use planning (Proctor, 1999; Sharifi, van den Toorn, Rico, & Emmanuel, 2002) and landscape planning (Van Elegem, Embo, Muys, & Lust 2002).

The study depended on two main stages. In the first stage, GIS buffer analysis takes into consideration all of the major factors in the study area (constraints). In this stage, the constraints were defined, shape files were prepared and buffer analysis was conducted to determine the candidate sites (Fig. 2). This analysis was conducted using Arc GIS (ver. 9.3). Buffering and overlaying were the major tasks performed that depended on the software capabilities and the criteria settings. The second stage dealt with weighing and evaluating the candidate sites by using a set of parameters. Both quantitative and qualitative parameters were considered, which is why MCA was used. In this stage, a wide range of stakeholders participated in developing the weights and sub-criteria. They included planners, professionals, key personnel from governmental institutions, academics, land surveyors, environmentalists, land brokers and other decision makers.

Stage one (excluding)

Five constraints were defined, depending on the planners' point of view and according to the manuals used by governmental agencies in Palestine (MOP, 1998). These constraints have also been used by other researchers in similar studies (Appleton & Lovett, 2005; Oh, 2001; Webster, 1994). They are as follows.

- Urban center: This study is trying to locate new development areas near pre-existing areas, taking into consideration the natural growth of these areas. A buffer of 2 km was made around these communities.
- Israeli colonies and military zones: A buffer of 2 km was imposed around these areas. "Thirty Israeli colonies, which have an area of 30 km^2, are located in the governorate."
- The Wall: In the Ramallah governorate, the Wall, which was built along the West Bank by Israelis, extends along the western part of the governorate.
- Road network: The road network in this governorate occupies a total area of 13.1 km^2 and is 695.9 km in length.
- Slope: The topographic map of the governorate shows the undulating terrain, which stretches from the western slope 350 m above sea level (ASL) through the mountain ridge (800 m ASL) and the Dead Sea (100 m ASL). According to the Ministry of Local Government (MOLG), areas with a slope over 25% are not suitable for urban expansion and are considered restricted areas.

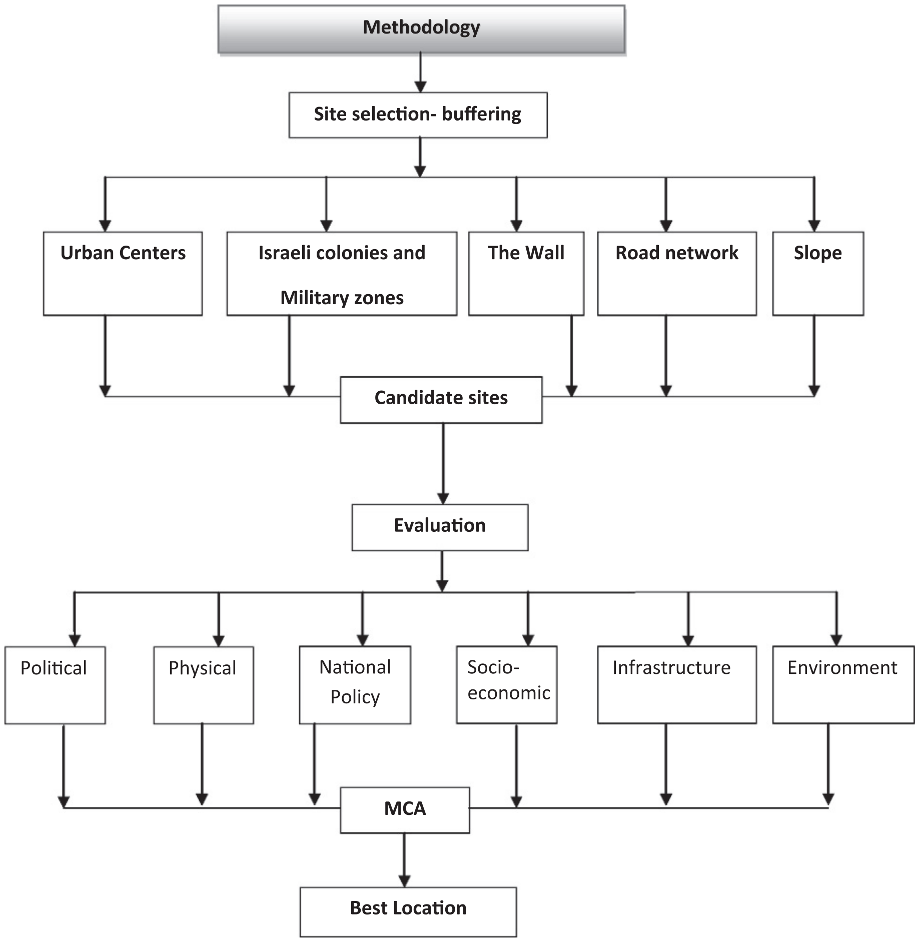

Fig. 2. Methodology chart.

In this stage, Arc GIS 9.3 was used. The following GIS functions were involved in this process: overlay function, classification, buffering, proximity, spatial analyst and measurement. The initial selection stage consisted of two parts. The first was to exclude all areas that did not meet the criteria for future development, and the second part was to filter these areas based on continuity and size.

Buffer zones of 2 km were created around the urban areas, Israeli colonies and military zones, and buffer zones of 70 m were created around the road network. Areas inside the Wall and areas with a slope greater than 25% were excluded (Fig. 3).

The five constraint layers were used to locate candidate areas for urban development. The map was produced by overlaying each individual layer with the study area and then excluding the areas that did not comply with the criteria. This method produced a constraint map for each layer. The consecutive exclusion process produced the final constraint map, identifying a group of selected sites. The result of this process was a map showing the areas that complied with the defined criteria. More than 20 scattered areas were located (Fig. 4).

The area of the candidate site should be more than 2.5 km^2 to accommodate 10,000 inhabitants, according to the standards used by MOLG. The resulting map (Fig. 4) was then refined, and clusters were made according to the size and continuity of the site.

The final result obtained from the selection process was a map showing 13 sites that were selected as potential areas for urban development. Fig. 5 shows the candidate sites for urban development, and Table 1 provides the size of each site and the name of the nearest locality.

Stage two

MCA is a methodology that consists of techniques for evaluating options on individual, often conflicting, criteria and combines the separate evaluations into a single overall evaluation (Janssen, 2001; Joerin et al., 2001; Malczewski, 1999).

The 13 selected sites were analyzed and evaluated to determine the most ideal site. MCA was adopted as a tool for decision making and was used to make a comparative assessment for the candidate sites, taking into account several indicators.

The overall evaluation was achieved by establishing preferences between options with reference to a set of defined criteria. In this study, the evaluation method followed was based on the method developed by UNESCO (UNESCO, 1988).

Evaluation criteria

The first and most sensitive stage of MCA is the development of the criteria to be used to quantify the impact of relevant issues. The criteria were based on a literature review, taking into consideration planning guidelines within the Palestinian context and a survey targeting the experts in this field (planners, staff of MOP and MOLG and experts) as well as the public. As a result, two major criteria were assigned, and six sub-criteria and 20 indicators were defined. The survey resulted in giving weights for each criterion, sub-criterion and indicator (Table 2).

The twenty indicators, derived from the six sub-criteria, were evaluated and assigned a number for each of the following (Table 3).

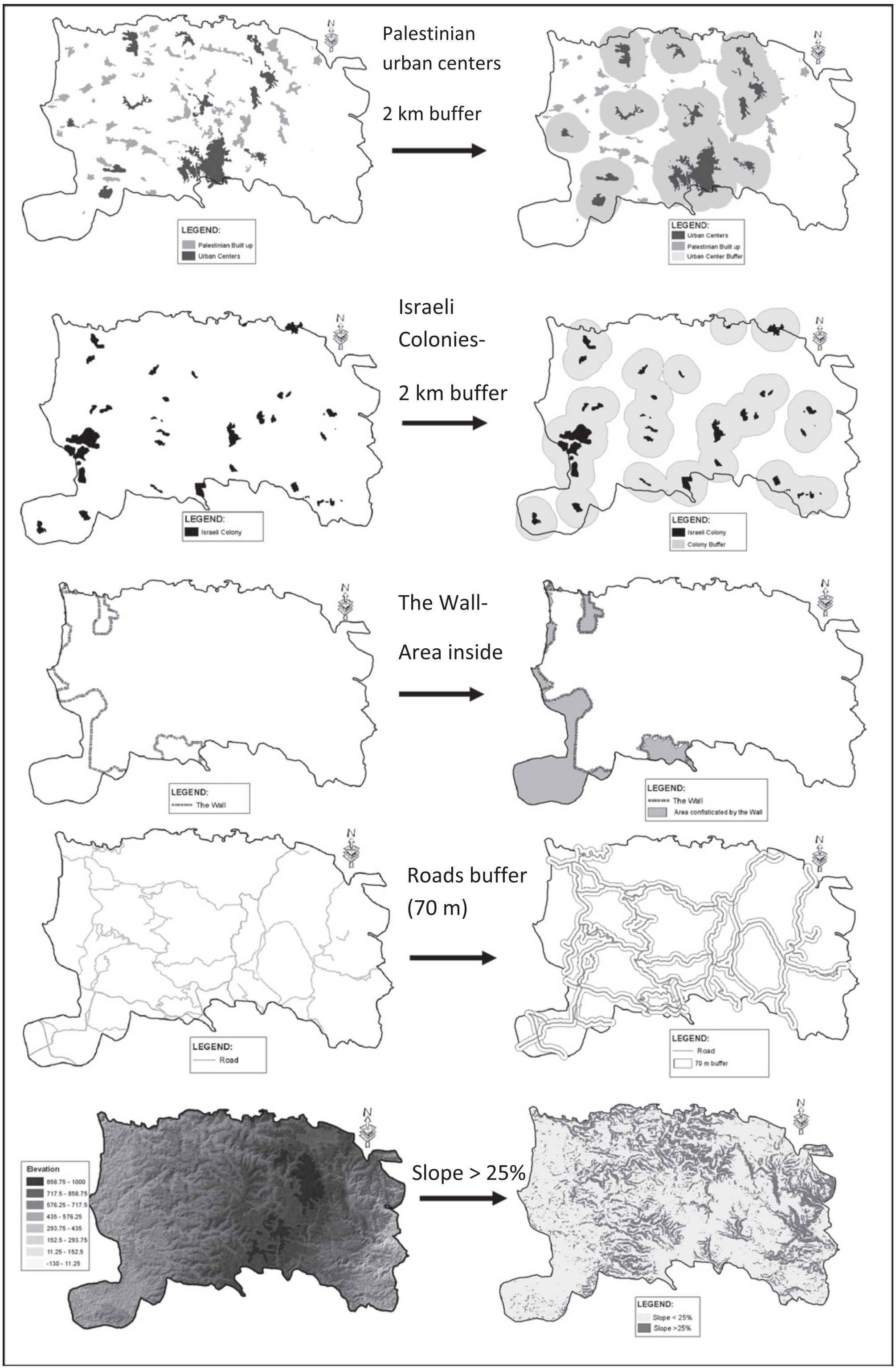

Fig. 3. Elimination process for each input layer.

(i) Political sub-criteria. In Palestine, political context plays a major role in urban planning issues. The current political conditions imposed on Palestinian land impact its urban development. These sub-criteria deal with the following.

- Land classification. According to the Oslo Accords, Palestinian land is divided into three categories (A–C) with different regulations and restrictions (ARIJ, 2006) as mentioned earlier. In each candidate site, the percentage of A, B, and C areas were calculated by using GIS. Then, a value of 0 was assigned to Area A, 1 for B and 2 for C (Table 3).
- Distance from colonies. Israeli colonies and military zones are located around Palestinian communities, which is considered an obstacle in planning development. The average aerial distance to the nearest colony or military zone was calculated in km for each candidate site.

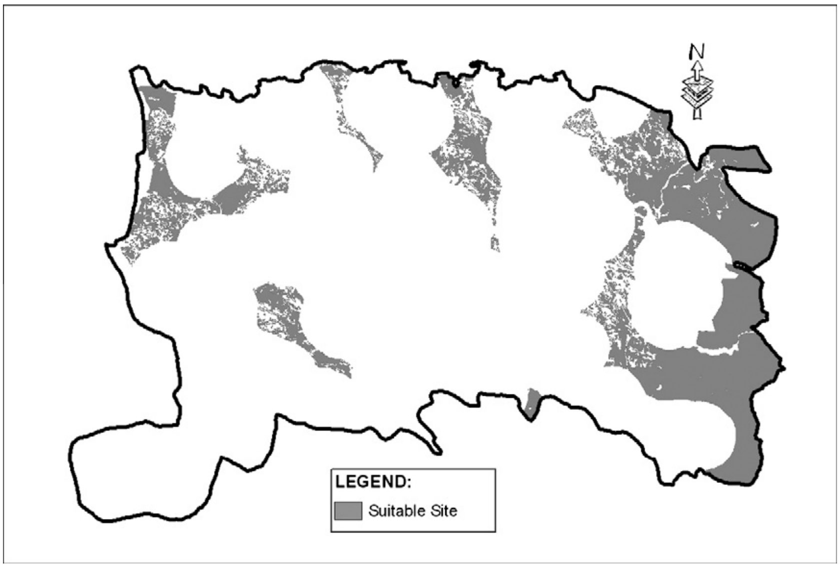

Fig. 4. Areas complying with the selection criteria.

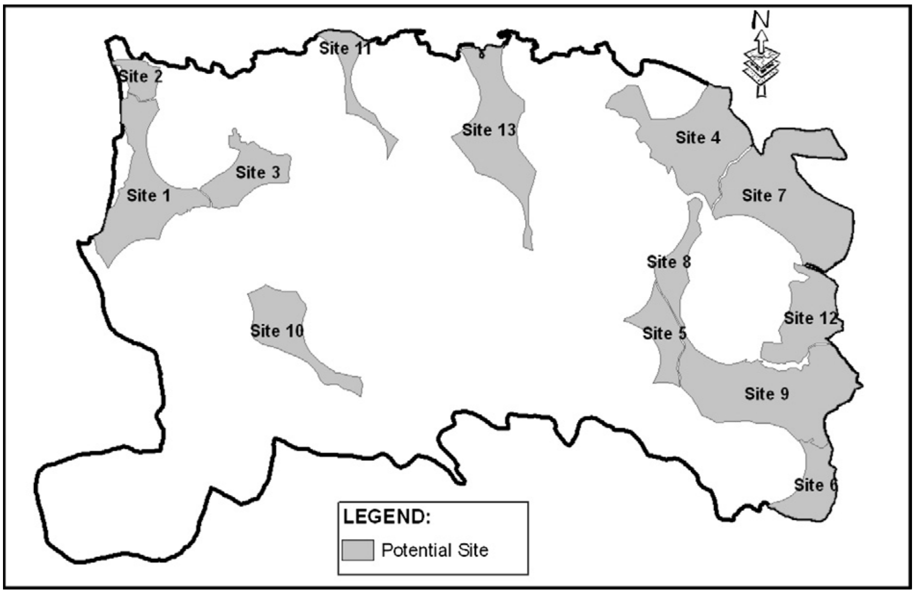

Fig. 5. Candidate sites.

Table 1
Candidate sites.

SITE	Area (km^2)	Name of nearest locality
Site 1	18.74	Shuqqba, Qibya
Site 2	3.32	Rantis
Site 3	9.07	Aboud
Site 4	22.59	Turmus'ayya
Site 5	7.27	Rammun
Site 6	7.58	Bedu Al muarrajat
Site 7	29.23	Ein Samia
Site 8	5.99	Al Taybeh, Kufr Malik
Site 9	29.92	Bedu Al muarrajat
Site 10	10.94	Deir Ibzie'
Site 11	4.89	Qarawet Bani Zeit
Site 12	11.60	Ein Samia
Site 13	18.88	Attara

- Distance from the Wall. The separation wall is constructed on Palestinian land, fragmenting the Palestinian communities. The distance from the separation wall reflects the sensitivity of any site. The distance from the Wall was calculated for each candidate site.

(ii) Physical sub-criteria. Physical characteristics were taken into consideration. The following are physical features that are commonly studied in residential site selection.

- Slope. Areas with slopes less than 25% were determined as the ideal sites, whereas the areas with slopes greater than 25% were avoided because of the high cost for development. GIS Spatial Analyst was used to calculate the slope percentage at each site.
- Aspect. The indicator reflects the direction the slope faces. By using Spatial Analyst, the aspect was derived and calculated for each site. A value of 0 was assigned for south and southwest. A value of 1 was assigned for

Table 2
Criteria, sub-criteria, and indicators (weight).

No.	Indicator weight		Sub-criteria	Criteria
1	Land classification	0.47	Political	
2	Distance from settlement (km)	0.28	0.2	Management
3	Distance from the wall (km)	0.25		0.58
4	Slope (percentage of slope < 25)	0.17	Physical	
5	Aspect	0.1	0.35	
6	Land continuity (no. of pieces)	0.17		
7	Cadastre and land registration	0.1		
8	Available land for building (remaining area)	0.46		
9	Agreement to national perspective	0.66	National policy 0.45	
10	Land ownership	0.34	Socio-economic	Socio-economic infrastructure and environmental
11	Access to Ramallah (min/trip)	0.32	0.5	0.42
12	Agricultural land (km^2)	0.13		
13	Cultural heritage	0.075		
14	Social acceptance	0.23		
15	Average land price (US dollar/donum)	0.17		
16	No of existing residence	0.075		
17	Distance to water resources	0.53	Infrastructure	
18	Distance to electricity network	0.47	0.25	
19	Greenery	0.38	Environmental	
20	Vulnerability to ground water	0.62	0.25	

east, west and southeast. A value of 2 was assigned for north, northeast and northwest. A value of 3 was assigned to flat areas (this value was based on the survey and public consensus).

- Land continuity. Land continuity reflects the fragmentation and complexity of each site for the purpose of urban development. This indicator was measured by counting the number of pieces within each site.
- Cadaster and land registration. A value of 0 was given to sites with no title or registration, and the value of 1 was given to registered sites.
- Available land for building. Land size was calculated in km^2 by using GIS. Site size measures the availability of land to accommodate a designated number of people at each site.

(iii) National planning policy and guidelines sub-criteria.

- Agreement to national perspectives. This indicator reflects the level of preference between the candidate sites regarding the national plans and governmental vision for development. This indicator was examined by interviewing planners and experts from MOLG and MOP. The sites are ranked according to the degree of agreement.

(iv) Socio-economic sub-criteria

- Land ownership. Data were gathered from the Land Authority and from local councils and municipalities to determine the ownership of each site (private or public). The preference was for a publicly owned site. A value of 0 was given to sites where most of the parcels are privately owned. A value of 1 was given to public sites, and a value of 2 was given to sites with unknown landownership.
- Accessibility. Accessibility is an important issue for new urban development because it provides continuity between communities. By using GIS, the travel distance was calculated between each site and the urban center of Ramallah city.
- Agricultural sites. The size of the agricultural land at each site was calculated in km^2.
- Cultural heritage. The existence of significant archeological or cultural monuments in the site was assessed. If the site has any monuments or is considered to be an important cultural heritage site, then it was given a value of 1. An empty site was given a value of 0. The locations of cultural heritage areas and sites were obtained from MOP (1998).

Table 3
Indicators Values.

No.	Indicator	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site7	Site 8	Site 9	Site 10	Site 11	Site 12	Site 13
1	Land classification	1.83	2	1.35	1.29	1.37	2	2	1.23	2	1.52	0.12	2	0.33
2	Distance from settlement (km)	2	2	2	1.5	2.5	3	3	1.8	2	2	2	2.3	2
3	Distance from the wall	0	0	0	21	23	19	31	23	13.6	0.5	5.5	30	13
4	Slope (percentage of slope < 25)	94.5	91.6	79.2	84	93	93	54	86	65	73	63	60	49
5	Aspect	1	0.94	1.1	1.1	0.94	0.94	0.98	0.95	1	1	1	0.99	0.95
6	Land coninuinty (no. of pieces)	3	1	16	9	1	2	64	4	48	27	21	58	127
7	Cadastral	0	0	0	0	0	0	0	0	0	0	0	0	0
8	Available land for building	14.83	3.04	5.24	14.36	5.69	7.06	14.44	4.93	19.35	6.72	2.76	6.99	8.50
9	Agreement to national	6	3	5	4	6	7	9	8	5	8	5	7	3
10	Land ownership	1.83	2	1.35	1.29	1.37	2	2	1.23	2	1.52	0.12	2	0.33
11	Acess to Ramallah (min/trip)	23	32	24	22	13	28	28	15	13.5	18	18	18	12.5
12	Agricultural land (km^2)	1.23	0.00	0.19	3.60	1.04	0.00	1.66	0.53	1.14	0	0	0	0.76
13	Arcological zones	1	0	0	0	0	0	1	0	0	1	0	0	0
14	Social acceptance	0	0	0.03	0.17	0.17	4.5	0	10.5	6	9	6	1	26
15	Average land price (US dollar/donum)	8500	4000	8500	55,000	12,500	3750	8500	11,000	4750	17,500	12,500	7500	17,500
16	No of existing residence	12,531	0	5269	9494	2469	0	0	1364	0	11,307	6250	0	6431
17	Distance to water resources	2.5	1.5	1.5	1.5	1	1	0	2	1	1	1	0	2
IS	Distance to electricity network	0	1	0	0	1.5	14	1	1	5	0	0	4	0
19	Greenery	42.65	23.3	49	41.6	49.55	0	6.1	59.83	4.14	41.57	62	0.25	49
20	Vulnerability to ground water	1	1	0	0	0	2	0	1	0	1	1	0	2

Table 4
Indicators values (normalized).

No.	Indicators	Site l	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12	Site 13
1	Land classification	0.92	1.00	0.68	0.65	0.69	1.00	1.00	0.62	1.00	1.76	0.06	1.00	0.17
2	Distance from settlement (km)	0.67	0.67	0.67	1.00	0.33	0.00	0.00	0.80	0.67	0.67	0.67	0.47	0.67
3	Distance from the wall	1.00	1.00	1.00	0.32	0.25	0.39	0.00	0.26	0.56	0.98	0.82	0.03	0.58
4	Slope (percentage of slope < 25)	0.00	0.06	0.34	0.23	0.03	0.03	0.89	0.19	0.65	0.47	0.69	0.76	1.00
5	Aspect	0.33	0.31	0.37	0.37	0.31	0.31	0.33	0.32	0.33	0.33	0.33	0.33	0.32
6	Land coninunity (no. of pieces)	0.02	0.00	0.12	0.06	0.00	0.01	0.50	0.02	0.37	0.21	016	0.45	1.00
7	Cadastral and land registration	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.00	1.00	0.00	0.00	1.00	0.00
3	Available land for building (remaining area)	0.27	098	0.85	0.30	0.82	0.74	0.30	0.87	0.00	0.76	1.00	0.75	0.65
9	Agreement to national perspective	0.33	0.83	0.42	0.08	0.50	0.92	0.75	0.17	0.67	1.00	0.55	0.25	0.00
10	Land ownership	0.00	0.00	0.00	0.50	0.50	1.00	0.00	1.00	1.00	0.00	000	1.00	0.00
11	Acess to Ramallah (min/trip)	0.54	1.00	0.59	0.49	0.03	0.79	0.79	0.13	0.05	0.28	0.28	0.28	0.00
12	Agricultural land (km^2)	0.34	0.00	0.05	1.00	0.29	0.00	0.46	0.15	0.32	0.00	0.00	0.00	0.21
13	Cultural heritage	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.00
14	Social acceptance	1.00	1.00	1.00	0.99	0.99	0.83	1.00	0.60	0.77	0.65	0 77	0.96	0.00
15	Average land price (US dollar/donum)	0.09	0.00	0.09	1.00	0.17	0.00	0.09	0.14	0.02	0.27	0.17	0.07	0.27
16	No of existing residence	1.00	0.00	0.42	0.76	0.20	0.00	0.00	0.11	0.00	090	0.50	0.00	0.51
17	Distance to water resources	1.00	0.60	0.60	0.60	0.40	0.40	0.00	0.80	0.40	0.40	0.40	0.00	0.80
18	Distance to electricity network	0.00	0.07	0.00	0.00	0.11	1.00	0.07	0.07	0.36	0.00	0.00	0.29	0.00
19	Green areas	0.31	0.62	0.21	0.33	0.20	1.00	0.90	0.03	0.93	0.33	000	1.00	0.21
20	Vulnerability to ground water	0.50	0.50	0.00	0.00	0.00	1.00	0.00	0.50	0.00	0.50	0.50	0.00	1.00

- Social acceptance. This indicator reflects the expected general public acceptance to live at the site. A questionnaire was completed by 100 random persons to obtain public perception regarding each site.
- Land prices. The average land price for each site was investigated by interviewing land brokers in the study area.
- Number of existing residences. The number of people living in/or surrounding the area of each site was calculated using data obtained from PCBS (2007).

(v) Infrastructure sub-criteria
- Distance to water sources. This indicator reflects the accessibility to a water supply, which is an important issue in the region and is considered a scarce resource. This value was calculated by using GIS.
- Distance to electricity network. This indicator was calculated by measuring the distance to the nearest locality with a power station.

(vi) Environmental sub-criteria. The environmental quality in Palestine is rapidly deteriorating, particularly the groundwater and landscape quality.
- Green areas. This indicator reflects the percentage of green areas at each site. By using GIS, the percentage of green and high-quality landscape areas was calculated (MOP, 1998).
- Groundwater vulnerability. The groundwater sensitivity of each potential site was evaluated, and this was classified into three categories: high, moderate and low (Aliewi & Mimi, 2006). A value of 0 was given to high vulnerable, 1 to moderate and 2 to low.

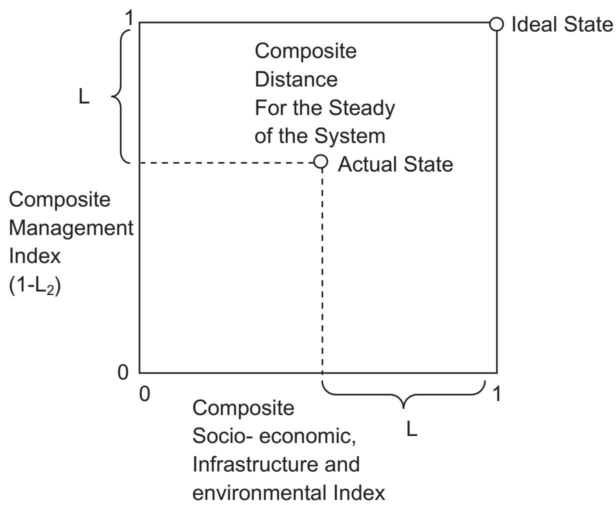

Fig. 6. Graphical representation of the results.

Normalizing and quantification

An assessment for the 13 sites was conducted regarding all of the described indicators. Because the units and quantities are different (e.g., percentages (%), prices (dollar/m^2), areas (km^2) and distance (km)), the future trade-off analysis requires that the actual values be normalized, i.e., transformed into the interval 0–1. Table 4 summarizes the indicators' values calculated after applying the normalization

$$S_i = \frac{Z_{i+} - Z_i}{Z_{i+} - Z_{i-}} \tag{1}$$

Table 5
Sub-criteria values (normalized).

Site	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12	Site 13
Political	0.88	0.92	0.77	0.71	0.52	0.71	0.69	0.61	0.82	0.80	0.54	0.73	0.47
Physical	0.38	0.74	0.68	0.25	0.57	0.60	0.57	0.60	0.45	0.57	0.75	0.71	0.74
National planning policy	0.27	0.68	0.34	0.30	0.50	0.95	0.61	0.60	0.80	0.81	0.47	0.62	0.00
Socio-economic	0.70	0.74	0.60	0.80	0.50	0.60	0.73	0.31	0.39	0.52	0.43	0.49	0.19
Infrastructure	0.73	0.44	0.44	0.44	0.30	0.74	0.05	0.58	0.38	0.29	0.29	0.20	0.58
Environmental	0.44	0.55	0.13	0.20	0.12	1.00	0.56	0.39	0.58	0.44	0.39	0.61	0.80

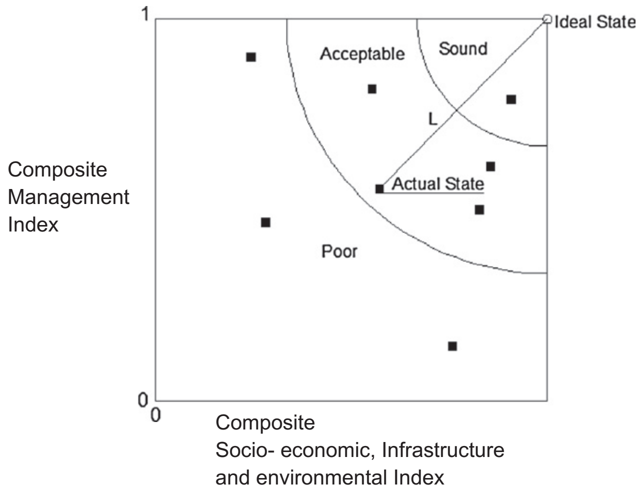

Fig. 7. Graphical representation of a set of ranked management.

where Z_i^+ is the best value and Z_i^- is the worst value in which $S_i = 0$ corresponds to the best value and $S_i = 1$ corresponds to the worst value.

The second level of analysis combined these indicators into six sub-criteria (Table 5) (political, physical, national planning policy, socio-economic, infrastructure and environmental) instead of 20 separate ones by using Eq. (2)

$$L_j = \left[\sum_{i=1}^{n_j} \alpha_{ij}\, S_{ij}^2\right]^{1/2} \tag{2}$$

where $S_{i,j}$ criterion i in group j, $\alpha_{i,j}$ weight applied to the ith indicated grouping, n_j criterion i in group j and L_j the value of the criterion.

The third step was to calculate the normalized values. The six sub-criteria were grouped into two groups: (1) management and (2) socioeconomic, environmental and infrastructure criteria. This grouping was performed by using Eq. (3):

$$L_k = \left[\sum_{j=1}^{m_k} \alpha_{jk}\, L_{jk}^2\right]^{1/2} \tag{3}$$

where $k = 1$ for management criteria; $k = 2$ for socio-economic and infrastructure and environmental criteria and m_k is the number of elements in each third level group.

To calculate the overall scores, Eq. (4) was used.

$$L = \left[\alpha_1\, L_1^2 + \alpha_2\, L_2^2\right]^{1/2} \tag{4}$$

Results presentation

The overall score of each site is presented graphically in a two-dimensional (2D) plane as shown in Fig. 6. The location of each site in the plane represents the degree of achieving the ideal location for developing a new urban area that satisfies all of the mentioned aspects. The x-axis signifies the composite value of the socioeconomic, environmental and infrastructure group, which ranges from 0 to 1, and the y-axis represents the composite value of the management group, which also ranges from 0 to 1.

Sites classification using the 2D plane

The plane shown in Fig. 7 is divided into three zones: sound, acceptable and poor. The boundary of these zones was calculated based on Eq. (5). This classification is used to help the decision maker filter the evaluated sites, i.e., all of the sites located in the poor zone could be ignored.

$$\beta = \left[\alpha_1(1-x)^2 + \alpha_2(1-y)^2\right]^{1/2} \tag{5}$$

where (x, y) is the location of the sites on the plane.

The scores from the different perspectives (planners, the public and MOP) were represented graphically in the same way. Any site that is located in the poor zone in terms of any perspective is rejected. Fig. 7 shows that Sites 1, 2, 7, 6 and 12 were eliminated

Table 6
Criteria values (normalized).

No.	Name	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12	Site 13
1	Management	0.44	0.21	0.34	0.55	0.46	0.28	0.38	0.40	0.34	0.30	0.36	0.30	0.42
2	Socio-economic and environmental aspects	0.36	0.36	0.53	0.39	0.62	0.23	0.40	0.60	0.55	0.54	0.60	0.51	0.47

Table 7
Summary of the most acceptable sites from different perspectives.

Management aspects	Site 3 (%)	Site 4 (%)	Site 5 (%)	Site 8 (%)	Site 11 (%)	Site 13 (%)
Mopic	50.3	63.1	45.3	34.0	43.2	65.1
Public	40.7	58.9	47.1	40.7	39.4	48.4
Planner	43.8	60.4	50.1	43.8	42.5	50.3
Avg (weight)	34.2	55.2	46.0	39.5	35.8	41.7
Average (score)	42.2	59.4	47.1	39.5	40.2	51.4
Socio-economic, infrastructure, and environmental aspects						
Mopic	56.0	45.9	71.1	58.3	67.0	50.0
Public	41.6	30.8	48.5	56.0	53.1	50.2
Planner	57.0	36.8	63.0	59.6	62.4	47.9
Avg (weight)	53.0	38.9	61.8	59.7	60.5	47.3
Average (score)	51.9	38.1	61.1	58.4	60.8	48.9
Overall						
Avg	40.2	45.6	51.1	46.2	44.0	42.5
Public	41.2	41.7	47.9	48.6	46.5	49.4
Planner	48.7	49.6	54.8	49.5	49.5	49.4
Avg (weight)	40.2	45.6	51.1	46.2	44.0	42.5
Average (score)	42.6	45.6	51.2	47.6	46.0	45.9

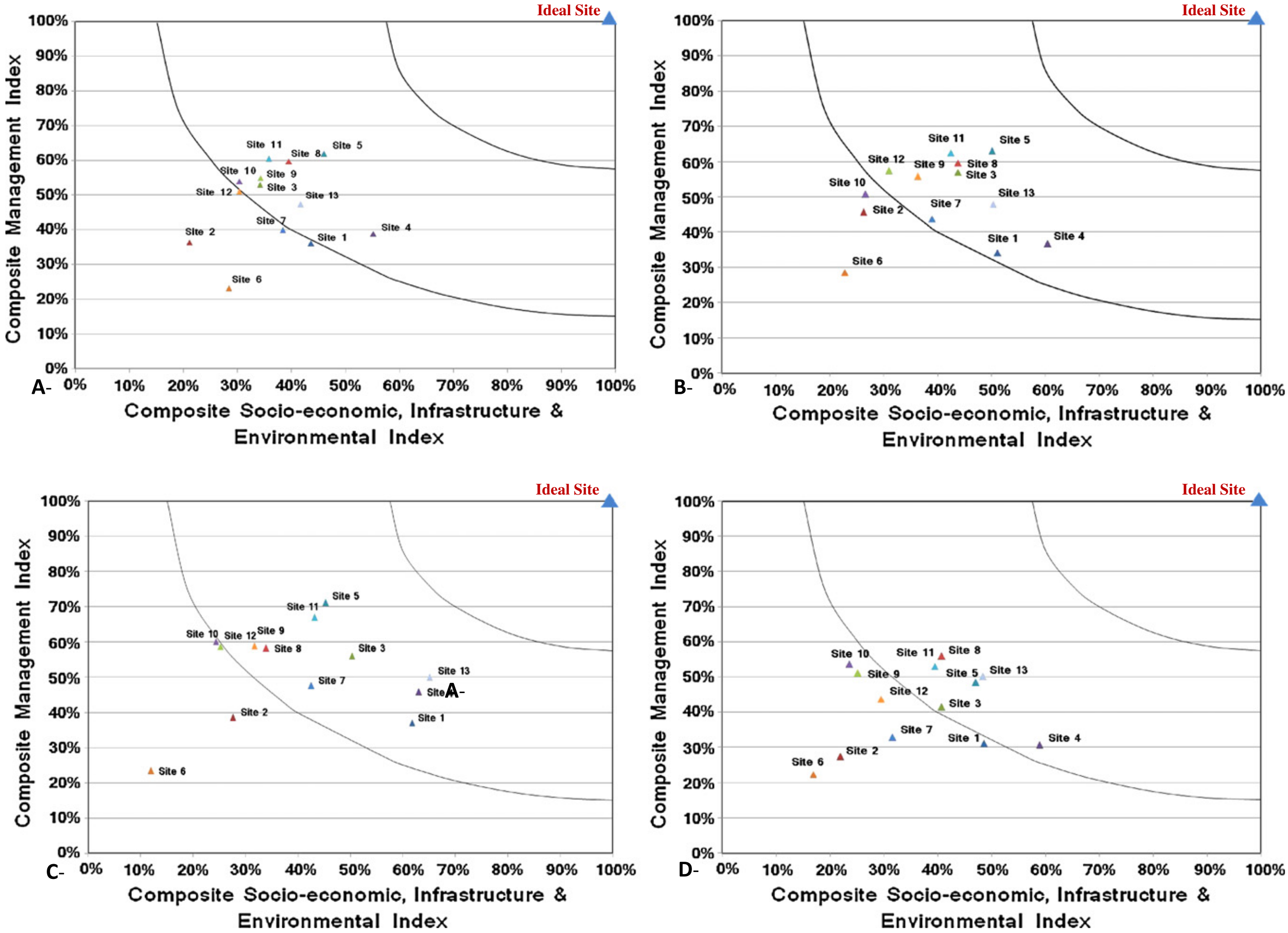

Fig. 8. Graphical representation (closeness to ideal location) (a) overall perception (b) Planners perceptions (c) MOP perception (d) Public perception.

from the list, while Sites 3, 4, 5,8, 11 and 13 were the most acceptable sites for establishing new urban development (see Table 6).

Results and discussion

The results obtained after the detailed analysis of the selected six sites are shown in Table 7. Based on the management aspects, Site 4 (near Turmus'yya) is the most acceptable site, while Site 8 (near Al Taybeh) is the least acceptable site. The accepted sites were ranked in the following order: 4, 13, 5, 3, 11 and 8. According to the socioeconomic, infrastructure and environmental aspects, Site 5 (near Rammun) is the best site, while Site 4 (near Turmus'yya) is the worst. Based on these indicators, the sites were ranked 5, 11, 8, 3, 13 and 4. From an overall perspective, Site 5 (near Rammun) is the best site, while Site 3 (near Abud) is the worst site.

The overall normalized scores of the 13 sites were calculated. Fig. 9 shows the site scores based on the averaged weights according to the assessment criteria.

The results show that Site 5 is the best site among the thirteen sites, while Site 6 is the worst. Site 4 is the best in terms of

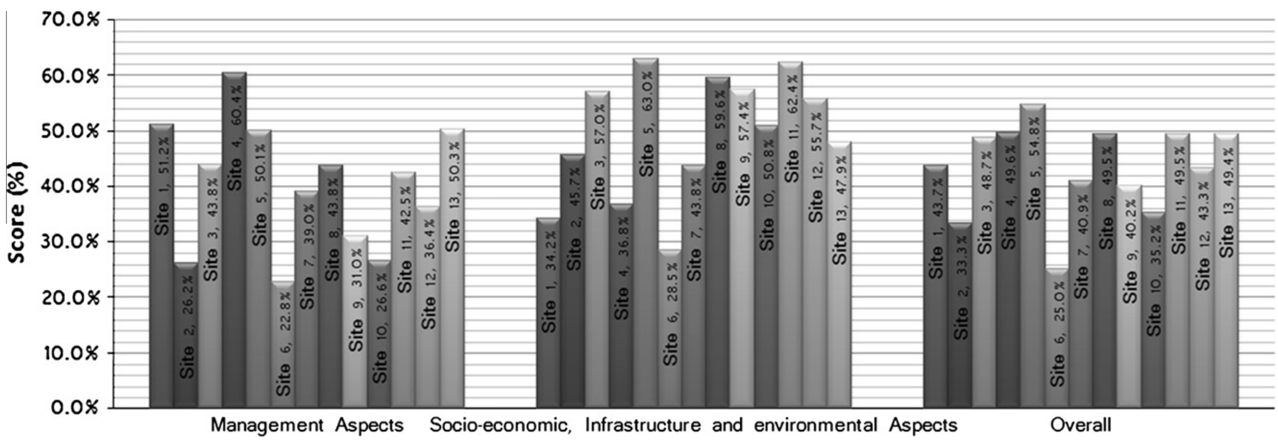

Fig. 9. Site scores.

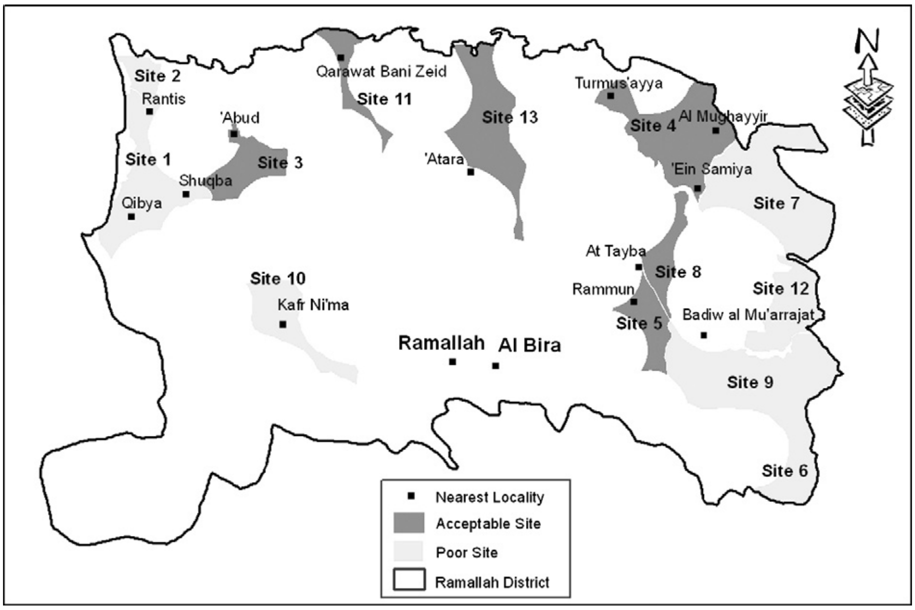

Fig. 10. The most acceptable sites.

management, while Sites 5, 8 and 11 are the best locations in terms of socioeconomic, infrastructure and environmental aspects.

The final result obtained in this research is also represented on the map, which shows six suitable sites for new urban development (Fig. 10). These six sites are ranked from the most acceptable site to the least acceptable site. The green color indicates the accepted sites, and the red colors indicate the least acceptable sites (Fig. 8).

The result of the research showed that Site 4 (near Turmus'ayya village) is the most suitable location in terms of management aspects. This site is followed by Site 13 (near Atara village), Site 5 (near Rammun village), Site 3 (near Aboud village) and Site 11 (near Qarawa bani zeid village). Site 8 (near Al Taybeh village) is the least acceptable among the six sites.

Site 5 (near Rammun) is the most suitable site in terms of the socioeconomic, environmental and infrastructure aspects. This site is followed by Site 8 (near Al Taybeh), Site 11 (near Qaraweh bani zeid) and Site 13 (near Atara). Site 3 (near Aboud) and Site 4 (near Turmus'ayya) are the least acceptable sites.

Based on the overall averages, Fig. 11 shows that Site 5 (near Rammun), Site 8 (near Al Taybeh) and Site 11 (near Qarawet Bani Zeid) are ranked as the first, second and third options, while Site 13 (near Atara), Site 4 (near Turmus'ayya) and Site 3 (near Abud) are ranked as the fourth, fifth and the sixth options. The green color indicates the accepted sites, and red colors indicate the least acceptable sites.

Of the six potential sites, Site 5 (near Rammun) is the most suitable site from an overall perspective. The site is located in the

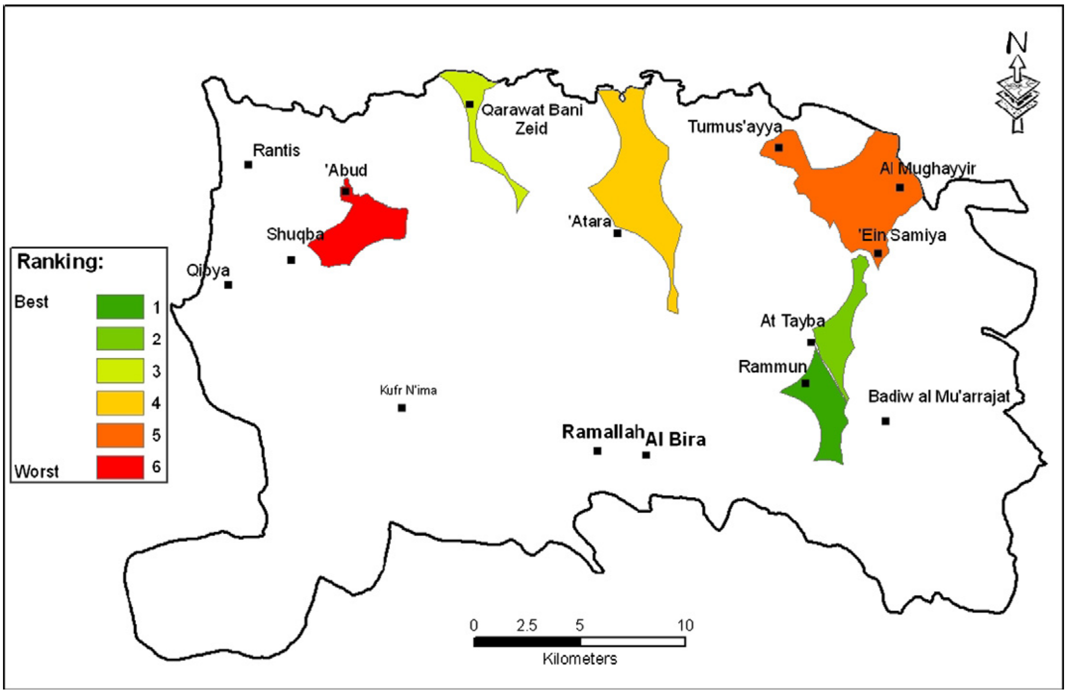

Fig. 11. Ranked sites.

south central region of the governorate, and it faces the coastal area of Palestine, 12 km east of Ramallah. The site has a reasonable size (7.22 km^2) to be considered as a suburban center. Site 5 is located near Rammun village and has a significant position in terms of landscape setting because it is situated on and around the summit of a hill and visible from all directions. Moreover, the site received high acceptance from the people who completed the questionnaire.

Conclusion

Sustainability tools and techniques are important in planning issues and in the decision-making process, enabling planners to analyze interactions in multiple ways (Steiner, McSherry, & Cohen, 2000). MCA proved to be a practical and flexible tool for selecting areas to be developed as suburban centers. This study gives an example of how to implement such a tool, taking into consideration the public and professionals' participation in developing criteria, sub-criteria and indicators and determining the attached weights for each item to be used in MCA.

The findings from this study show that locating areas for new urban developments is urgently required and that the most important consideration is where to locate these sites in a sustainable way. In this study, site-selection criteria and a methodology for evaluating and ranking these sites were developed. The successful use of MCA to select areas for future development in Ramallah governorate indicates that other areas in Palestine might also benefit from using MCA to address their needs. This technique can be easily adapted to fit the local conditions and priorities of other communities.

Refined guidelines are still needed to achieve more accurate results and to determine more useful decision-making processes. A number of preparation steps at the national level are recommended to facilitate the adaptation of this methodology as a national guideline for the development of new urban/suburban areas.

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