Measuring Quality of Life: an Integrated Evaluation of Built Environment

Hitomi Nakanishi*, Hamish Sinclair, Jessica Lintern

Faculty of Business, Government & Law, University of Canberra, Australia
hitomi.nakanishi@canberra.edu.au; hamish.sinclair@canberra.edu.au; Jessica.Lintern@act.gov.au

Abstract

Despite efforts developing the quality of life indicators to monitor the progress and impact of urban policy, they do not necessarily reflect the residents' quality of life priorities. This paper proposes an integrated planning support tool to enable the evaluation of the built environment from the perspective of residents' quality of life (QoL). The planning support tool that consists of QoL indicators is applied to seven districts of Canberra, Australia. The QoL level in each district is compared and key indicators to improve two of the districts that have lower QoL level are identified. The paper simulates the change in QoL level by improving the key factors using scenario analysis. The finding shows that there is a high potential that only minimum intervention to improve the most influential indicator has a significant impact on enhancing QoL. The paper proposes a method to map the cross-cutting indicator related to urban policy, and concludes with the implications to urban planning and further analysis.

1. Introduction

After significant economic growth, focus in contemporary urban planning has shifted to enhancing quality of life (QoL) and sustainability (Das 2007;

Higgins et al. 2012; Nakanishi and Doi 2003). Urban planners have advocated for planning processes, projects and outcomes to change conditions and circumstances to enhance the milieu within which QoL improves (Massam 2002). After Local Agenda 21 was adopted at the 1992 Earth Summit, a growing number of cities began developing indicators to try and measure the progress toward sustainability (Briassoulis 2001; Chiesura 2004). The indicators included quality of life, often a synonym for sustainability indicators. In the UK the City of Bristol introduced indicators to measure QoL in Bristol's communities, the sustainability of the locality, the council's performance progress, and to influence policy (McMahon 2002). Like Bristol, many cities have applied QoL indicators as a vehicle for understanding and addressing local issues. They are regarded as most useful when directly tied to public policy (Swain and Hollar 2003). However despite efforts in developing QoL indicators, they do not necessarily reflect the residents' priorities for quality of life as the indicators are usually decided by local governments. Governments prefer indicators that are accountable and easy to monitor while residents prefer indicators that reflect their daily concerns and priorities (Nakanishi et al. 2005). Therefore indicators that residents prefer are often cross-cutting and hard to connect with specific contents (e.g. urban form, land use) of the built environment. Also evaluation of QoL is influenced by the individual's value system and on the cultural and social environment of where they live. Depending on the values and perceptions of individuals, urban policy may or may not enhance quality of life. The evaluation system that enables us to examine how the priorities of individuals in QoL are linked with satisfaction with the specific part of urban environment is yet to be established.

This research proposes an integrated planning support tool that can reflect the individual's value (weight) on the evaluation of QoL, as an end outcome of urban policy. In this research, individual's quality of life is defined as the set of satisfaction level and value assigned to each of the five domains of QoL being – community safety and security, prosperity and diversity, culture and education, community well-being, and quality environment and sustainability (The details of which are described in section 2). Individual's feelings and perceptions that are surveyed in this study are not measured qualitatively but quantitatively. The significance of analyzing qualitative QoL in quantitative way is that it enables planners and stakeholders to compare the outcomes spatially and chronologically, which will better assist decision making and consensus building. The tool contains the policy input mapping that addresses the issues of complex and interdisciplinary nature of QoL and can connect with related policy. With these features the tool enables planners to identify the relevant planning

options for bettering quality of life of residents. The proposed QoL-oriented evaluation is an experimental method. It is empirically demonstrated in Canberra, Australia. Based on the resident questionnaire survey on QoL and living environment, satisfaction with the issues related to the built environment is calculated. The residents' value and QoL which affect their priorities in QoL are also estimated. A spatial analysis of the results is conducted to identify those neighborhoods that are achieving lower QoL and the options that enhance QoL are examined.

This paper is organized as follows. The next section reviews the literature on assessing QoL in the context of urban planning, backgrounds the urban planning of Canberra, and the methodology of research. Section three describes the results. Section four demonstrates the scenario analysis followed by the discussion. The paper concludes with the implications of the research for urban planning and decision making.

2. Background

2.1. Literature on urban planning and quality of life

Quality of life (QoL) is a complex, multifaceted concept that requires multiple approaches from different theoretical angles (Diener and Suh 1997). In the past century, quality of life was understood in terms of material wealth or welfare. Therefore GDP has long been referred to as the indicator of economic performance in many countries. Subsequent changes in the perception of the meaning of life and values have facilitated the quality of life conception in the psychology field (Van Praag and Ferrer-i-Carbonell 2008). After the works of Kahneman (1997) and Frey and Stutzer (2002), it has been attempted to apply the concepts of "well-being" and "happiness" to policy evaluation. However the strong focus on GDP remained. Stiglitz et al. (2010) reported that GDP is an inadequate metric to gauge well-being over time particularly in its economic, environmental and social dimensions. They recommend that QoL depends on people's objective conditions and capabilities and steps should be taken to improve measures of people's health, education, personal activities and environmental conditions.

The conceptualization of QoL in the urban planning context began with the age of the industrial revolution when the living environment worsened, while the application of QoL index to decision making has only been

focused on since the 1960s (Doi et al. 2003). Over the last two decades urban planners and academics have increasingly developed QoL indicators (e.g., Besleme and Mullin 1997; McMahon 2002; Swain and Hollar 2007), often using them to measure the progress toward sustainability. Leitman (1999) described that quality of life indicators are relevant to the extent that they can yield information about whether the intervention is moving a city towards or away from sustainable development. Gatersleben (2001) suggested 16 indicators of quality of life - social relations, education and development, comfort, pleasure, material beauty, work, health, privacy, income, social recognition, safety, nature, environmental resources, freedom/control, leisure time, and social justice. While these indicators focus on social aspects of sustainability they are too broad to provide effective feedback on urban policy. Sen (1993) argued QoL is to be assessed in terms of the capability to achieve valuable functioning. In the context of urban planning, the authors consider that QoL is affected by how the built environment is situated to enhance the individuals' capability. In other words, how much an individual could access opportunities can be improved by better urban design, the mix of buildings and land use, and open green spaces. Capability is also affected by the circumstances of individuals. Nakanishi (2006) developed the quality of life measures to evaluate the impact of port infrastructure development after a disaster, considering the residents' perception on priorities in life (safety and security vs other dimensions of quality of life) and capability to access these. Doi et al. (2008) applied the QoL measures to spatial analysis of location efficiency and residents' QoL performance. In recent studies, Higgins et al. (2012) examined the London's quality of life to identify the spatial inequality by conducting a borough-level analysis. They suggest that the spatial inequality in London exists in economic well-being, community safety and community cohesion. Delmelle et al. (2013) attempted the empirical analysis of the spatio-temporal QoL trend in Charlotte, NC, employing a geocomputational and visual technique. The study identified that the highest quality of life had a large spatial presence on the outermost ring of the city and its neighbourhoods proved to be most stable across the decade while the neighbourhood located in the city's middle ring underwent significant transformations. These studies used the objective QoL data. Applying subjective data, Thompson et al. (2013) explored how green space intervention could influence the individual's perceptions of woodlands and quality of life. The study provides evidence of potential contribution of quality neighbourhood environment to quality of life. Senlier et al. (2009) used both subjective and objective indicators to measure the perceptions of QoL in Kocaeli, Turkey, compared with European cities. The study concluded that the variable having highest

effect on QoL was safety. However, few studies developed the application to the comprehensive assessment of urban policy and governance of QoL indicators to the operational stages in decision making. This research adds to the literature by proposing a QoL-oriented planning support systems that enable the evaluation of urban policy and identification of the neighbourhoods that need improvement.

2.2. Concept of planning support system

Planning Support System (PSS) is an instrument used by decision makers and planners that includes a wide range of geo-information tools, spatial and temporal analysis, and visualisation etc. A variety of instruments have emerged from GIS-based decision making tools to web-based system for co-operative spatial planning (Geertman and Stillwell 2004; Hopkins 1999) in the past decades. PSS has incorporated an evolving view of planning; "applied science", "politics", "communication", and has been developed as an information system that can be used as a knowledge and decision support system (Klosterman 2001). The PSS is often used as a synonym for decision support tools. These are being adapted to the kind of decision and management functions that lie at the heart of the planning process (Batty and Densham 1996). Geneletti (2008) reviewed the discussion on the application of PSS and confirmed the existing PSS's limited capability to provide needed output. In particular, it was argued that the improvements would relate to both ease of use and usefulness. Recent PSS studies utilise the integrated GIS as a main tool (e.g. Sarmiento et al. 2012; Schafer and Lindquist 2013). The PSS is also applicable to collaborative/participatory planning and consensus building (e.g. Nakanishi 2006; Shen et al. 2012).

Data used in PSS is usually objective information that represents the status of the target area or spatial characteristics. In this paper, we apply the indicator of QoL into the PSS to provide the spatial analysis of subjective well-being. As the focus on urban development has shifted from 'quantity' (e.g. GDP) to 'quality' (well-being), it is required that the policy assessment tool is adapted to provide relevant information to meet this focus. QoL indicators inform the focused issues' current situation but have rarely been used for simulating how QoL is affected by planning. The integrated evaluation method that this paper presents extends the application of subjective QoL to an assessment system of urban planning.

2.3. Canberra

Established in 1913, Canberra is the national capital of Australia. Canberra's population of 365,621 (Census 2011), is spread across an area of 807.6km2. This area supports an urban population density of 452.2 persons/km^2 with an average household of 2.6 persons and 1.7 motor vehicles. Canberra's development has been influenced by three different planning principles for neighbourhood design: Garden City, Y Plan, and New Urbanism.

The Garden City, incorporating elements of the city beautiful movement, informed the initial underpinning of Canberra's development. Walter Burley Griffin designed public transport orientated neighbourhoods; with one handy district school or more for the children, and with a local playground, game fields, church, club, and social amenities, accessible without crossing traffic (Commonwealth of Australia 1913 in Hall 2002).

The Y plan was conceptualized and implemented in the 1960's and 1970's, by National Capital Development Commission (NCDC). In response to population growth and the increasing traffic demands associated with growth in private motor vehicle use, the Y plan aimed "to produce a structure for the future metropolis which would be least likely to lead to traffic congestion and lend itself to the establishment of an effective system of public transport, to achieve the most economical planning solution for future transportation" (Fischer 1984). The Y Plan responded to a land use and transportation study and the resulting neighbourhoods were developed as such. Reflecting the modernism's movement, the Y plan delivered collectively the auto-dependent suburbia.

New Urbanism is a more recent construct. Australian New Urbanism aims to "… improve the urban sustainability, vitality and quality of life for existing Australian towns and cities, as well as for new urban extensions" (Kaufman et al. 2006). In Canberra, the northern town centre of Gungahlin is recognised as a street-based mixed-use town centre, guided by New Urbanism principles.
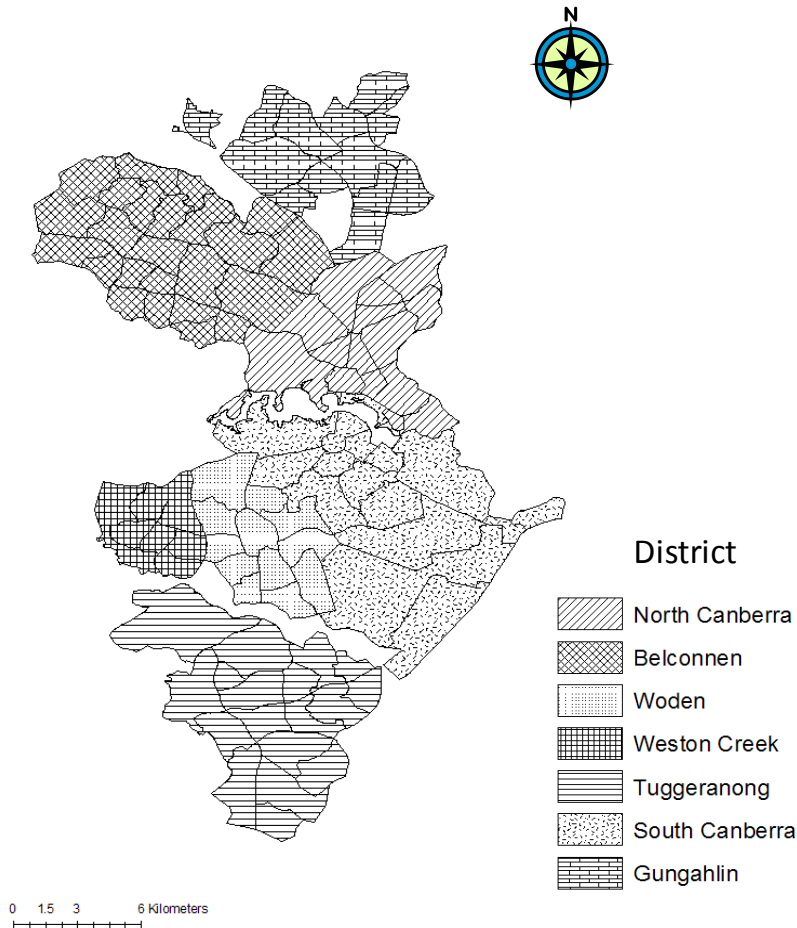
Fig.1. Districts in Canberra

(based on ABS Census Statistical Division, 2011)

The urban form that appears in Canberra today reflects the planning principles described above. Canberra today is divided into seven districts (ABS Census Statistical Division 2011) as shown in Figure 1. North Canberra and South Canberra are strongly influenced by Garden City principles. Gungahlin is the newest district and is based on the Australian New Urbanism concepts. The districts of Belconnen, Woden, Weston Creek and Tuggeranong were developed as part of the Y plan.

Table 1. Population and built environment of each district

District	Population (2011)	Population density (persons/ km²)	Urban open space density (person/ha of open space)	Planning principle
North Canberra	496,74	240.6	188.2	Garden City
Belconnen	94,947	726.7	93.1	Y Plan
Woden Valley	34,530	1207.3	101.0	Y Plan
Weston Creek	23,760	227.9	167.3	Y Plan
Tuggeranong	88,382	553.5	105.8	Y Plan
South Canberra	26,880	307.4	164.9	Garden City
Gungahlin	47,067	519.6	72.4	New Urbanism

2.4. Methodology

In this research, the QoL is defined as the set of satisfaction level and value with the five domains of QoL – community safety and security, prosperity and diversity, culture and education, community well-being, and quality environment and sustainability. These domains were discussed by focus group of residents and planners to fit into Canberra context. The domains reflect the hierarchical structure in the context of basic needs (community safety and security) to higher demand (quality environment and sustainability). QoL is subjective and this is partly hindered to be applied in operational stage in existing studies. However, it is possible to evaluate the QoL by selecting the indicators that are recognised by residents as 'important' and estimating the general satisfaction incorporating the weight (value) on each domain. QoL indicators that are selected in this paper are shown in Table 2.

After selecting the potential indicators from a wide range of international sources ([1]one hundred in total), the indicators for Canberra were selected, based on focus group discussions.

---

[1] UK: Audit Commission, Bristol, Hastings & St. Leonards-East Sussex, Cornwall, Lewes District- East Sussex, Herefordshire, Peterborough, Stafford-

Table 2. Indicators of quality of life (Canberra)

Domain	QoL Indicators
Community safety and security	num. of domestic crimes per 1,000 households in Canberra, % of residents who feel "fairly safe" or "very safe" after dark, num. of new affordable housing in Canberra
Prosperity and diversity	access to service facilities accessible by disabled people in Canberra, job availability in Canberra, % of people agree that people from different backgrounds get on well, access to broadband network, cost of living, walking distance to the closest bus stop, quality of public transport system
Culture and education	English language skills of immigrants in Canberra, % of young people (16-24 yrs old) in full-time education or employment in Canberra, access to cultural facilities, student/staff ratio in higher education in Canberra
Community well-being	access to health and social care facilities and service quality, residents who feel they have ability to influence decisions in Canberra, amount of green space within walking distance, % of people who are overweight or obesity in Canberra, illegal drug use in Canberra
Quality environment and sustainability	EER (energy efficiency rating) of house, num. of wild birds in neighbourhood, amount of household waste recycle in Canberra, residents concerned about the impact of climate change, air quality (air pollution) in Canberra

The Quality of Life model is presented as[2]:

$$QoL = \sum_{k=1} \left\{ w_k S_k^{-\rho} \right\}^{-\frac{1}{\rho}} \qquad (1)$$

Where S_k is the vector of satisfaction score by domain k

w_k is the vector of weight by domain k

ρ is the parameter of elasticity of substitution across domains

shire, Woking, Liverpool, Eastbourne-East Sussex, USA: Boston, Jacksonville, King County, NYC (USA), Mercer index. (http://www.mercer.com.au/press-releases/quality-of-living-report-2012 accessed 13 February 2013), Brooks et al. (2005)

[2] A detailed formalisation of QoL and weight is provided in Doi et al. (2008).

The model was originally developed to assess the impact of infrastructure development on QoL (Doi et al. 2008; Nakanishi 2006). In this research the model has been applied to compare QoL by district. The model endogenously applies the individual's satisfaction psychology (Felce and Perry 1995; Van Praag and Ferrer-i-Carbonell 2008). The influence of individuals' value (weighting) on quality of life assessment has been discussed in literature (Rogerson et al. 1989). Most cases apply expert's weighting, while this study uses the individual's reported weightings. The weighting is expressed as relative importance to "community safety and security", which is the basic need.

The weight of each domain is determined by applying the model below.

$$\Delta S_m = \sum_{k \neq m} \frac{w_k}{w_m} \frac{S_{0k}^{-(1+\rho)}}{S_{0m}^{-(1+\rho)}} \Delta S_k \qquad (2)$$

Where, ΔS_m ; improved satisfaction level of domain m, ΔS_k ; sacrificed satisfaction level of domain k, S_{0k} , S_{0m} ; current satisfaction level of domains k and m, w_k , w_m ; value of domains k and m, and ρ ; substitution parameter between domains.

The weight w_k and ρ are estimated by a nonlinear regression model of relational expression of the change in satisfaction score of domain k and satisfaction score of other domains which are reflected by the change in individual's satisfaction for k.

The statistical software Statistica 8 is used for the analysis. To provide the spatial analysis, the data is aggregated by the seven districts in Canberra (Fig. 1). Satisfaction level for each indicator is estimated in the scale of 0 to 100. The parameters for the above quality of life model and weight model are estimated by nonlinear regression analysis. A cluster analysis is conducted to check if districts could be aggregated into groups. Then QoL for each of the seven districts is estimated.
Based on the estimated QoL level by district, districts that have relatively lower QoL are chosen and the most influential factor that affect the QoL of these districts is examined by multi regression analysis. A scenario analysis is conducted to identify the options that have potentials to enhance QoL in these districts.

3. Survey and results

3.1. Survey

"The quality of life in your city and living environment questionnaire survey" was conducted during the period of May – August 2012. The questionnaire survey sheet was sent to 2,000 households in Canberra. These households were randomly-selected from Google Map, in proportion to the 2011 population of each suburb (Australian Bureau of Statistics 2011 Census). Concurrently, an on-line version of the survey was conducted using Survey Monkey. The link to the survey was widely circulated via email. Approximately 1,000 emails were sent to students, academics, professionals, non-professionals via the mailing list of local government and university, and individual recipient of the emails. The same questions were used in both surveys and only residents over the age of 18 years were asked to answer the questions.

The questionnaire consisted of four sections – 1) perceptions about neighbourhood and built environment, 2) value (weight in quality of life), 3) personal information and 4) free comments on living environment. In section one, respondents answered on a five-point scale for 24 aspects of neighbourhood that are equivalent to QoL indicators (Table 1). Section two sought the priorities in QoL, followed by a question on how much the respondent was prepared to trade-off other domains if "community safety and security" was going to be improved as the basic needs.

The total number of responses including both off-line (370) and on-line (278) surveys was 648 (Male 230: 37.4%; Female 385: 62.6%). In this study, data from on-line surveys and off-line surveys are merged for the analysis. Compared with the 2011 Census breakdown of gender, it was found that proportion of male respondents was 12 % lower than reported and that the percentage of female respondents was 12 % higher. In terms of age breakdown, there was a significantly higher proportion of respondents who were 50-59 years old (23.3%) and 60-69 years old (14.6%), and over 70 years old (10.7%) than the Census data (21.3%, 8.7%, 7.2%, respectively).

As shown in Table 3, the location of respondents closely matched population Census data with greatest variance being 7% more for North Canberra residents and 6 % less for Tuggeranong residents.

Table 3. Location of respondents compared with Census 2011 population distribution

Area	Respondents	Census 2011 population distribution
North Canberra	21 %	14 %
Belconnen	32 %	26 %
Woden	9 %	9 %
Weston	7 %	6 %
Tuggeranong	18 %	24 %
South Canberra	4 %	7 %
Gungahlin	9 %	13 %

The respondents' background is shown in Table 4. The highest percentage of respondents in each district was female. The largest percentage of respondents from the 40-50s age bracket occur in North Canberra, Belconnen and Gungahlin, while the largest percentage of over 60s age bracket occurs in Woden, Weston Creek, Tuggeranong, and South Canberra. Over 60% of respondents have no dependent children except for Tuggeranong and South Canberra. The number of children per household is higher in Belconnen, South Canberra and Gungahlin. The majority of respondents are full time workers except for Woden and South Canberra. Majority of the respondents have lived in the same neighbourhood for more than ten years except for the new district of Gungahlin. The respondents in South Canberra have the highest incomes while those respondents' in Woden and Tuggeranong have the lowest.

Table 4. Respondents' background by district

	Gender Male Female	Age -30s 40-50s 60s-	Dependent Children 0 1[*] 2[*] 3 + over[*]	Occupation (3 most reported)	Period of living in current home -2 yrs 2-5 yrs 5-10 yrs 10 yrs + over	Gross annual income (average range)
North Canberra	M-39.5% F- 60.5%	36.3% 41.9% 21.8%	66.6% 45.2%[*] 42.9%[*] 11.9%[*]	Full time (51.6%) Part time (14.3%) Retired (12.7%)	30.2% 21.4% 10.3% 38.1%	$70,000 - $89,999
Belconnen	M-36.2% F-63.8%	32.4% 45.8% 21.8%	63.3% 34.8%[*] 40.9%[*] 24.2%[*]	Full time (52.2%) Part time (15.2%) Retired (14.0%)	22.5% 13.5% 20.8% 43.3%	$70,000 - $89,999
Woden	M-36.8% F-63.2%	14.0% 40.4% 45.6%	63.2% 42.9%[*] 38.1%[*] 19.0%[*]	Retried (33.3%) Full time (26.3%) Part time (17.5%)	7.0% 8.8% 10.5% 73.4%	$70,000 - $89,999
Weston Creek	M-42.5% F-57.5%	15.4% 38.5% 46.2%	70.0% 58.3%[*] 33.3%[*] 8.3%[*]	Full time (50.0%) Retired (15.0%) Part time (10.0%)	17.5% 7.5% 30.0% 45.0%	$50,000 - $69,999

Table 4.(cont.)

Tuggeranong	M-35.5% F-64.5%	9.3% 41.1% 49.5%	55.1% 41.7%[*] 43.8%[*] 14.6%[*]	Full time (51.4%) Retired (14.3%) Part time (11.4%)	16.0% 9.4% 22.6% 51.9%	$50,000 - $69,999
South Canberra	M- 41.0% F-59.0%	20.0% 35.0% 45.0%	57.5% 29.4%[*] 64.7%[*] 5.9%[*]	Full time (37.5%) Part time (22.5%) Retired (17.5%)	15.0% 10.0% 20.0% 55.0%	$80,000 -$99,999
Gungahlin	M-32.1% F-67.9%	22.2% 46.3% 31.5%	60.4% 28.6%[*] 61.9%[*] 9.5%[*]	Full time (58.5%) Part time (15.1%) Retired (7.5%)	24.1% 24.1% 25.9% 25.9%	$70,000 - $89,999

*: among household with dependent children

3.2. Satisfaction level

Based on the data obtained from the questionnaire survey, satisfaction level for each indicator is estimated in the scale of 0 to 100. Average estimated satisfaction by district by each domain of QoL is shown in Figures 2 and 3.
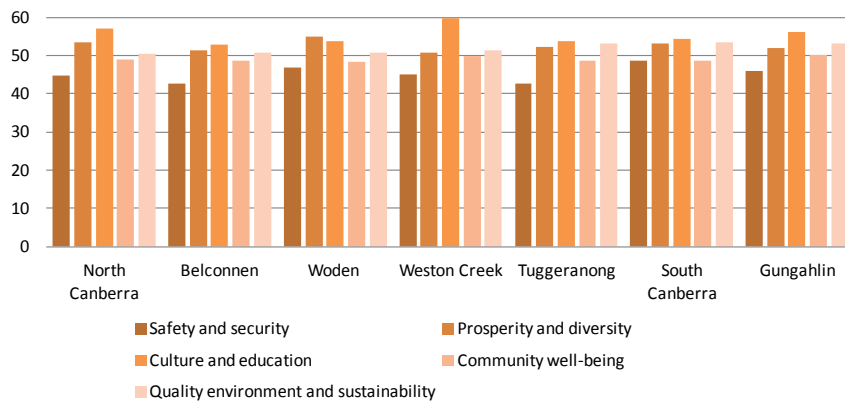

Fig. 2. Estimated satisfaction score with each domain

From Figure 2, a common pattern of satisfaction with each domain is seen among North Canberra, Belconnen, Weston Creek, Tuggeranong, South Canberra, and Gungahlin. Residents in these districts are most satisfied with "culture and education" and least satisfied with "safety and security" whilst the satisfaction of Weston Creek residents with "culture and education" is particularly high. Residents in Woden district have lowest satisfaction with "safety and security" and most satisfied with "prosperity and diversity". As shown in the Figure 2, the difference of satisfaction level is small among districts. However it is worth exploring the spatial pattern of satisfaction level. As shown in Figure 3, satisfaction with "safety and security" is lower in outer suburbs such as Belconnen and Tuggeranong. Higher satisfaction with "prosperity and diversity" is seen in Woden, South Canberra and North Canberra and the residents in Weston Creek and Belconnen are less satisfied. In terms of "culture and education", residents in Weston Creek, North Canberra and Gungahlin have higher satisfaction whilst the satisfaction in Belconnen district is low. Residents in Gungahlin have higher satisfaction with "community well-
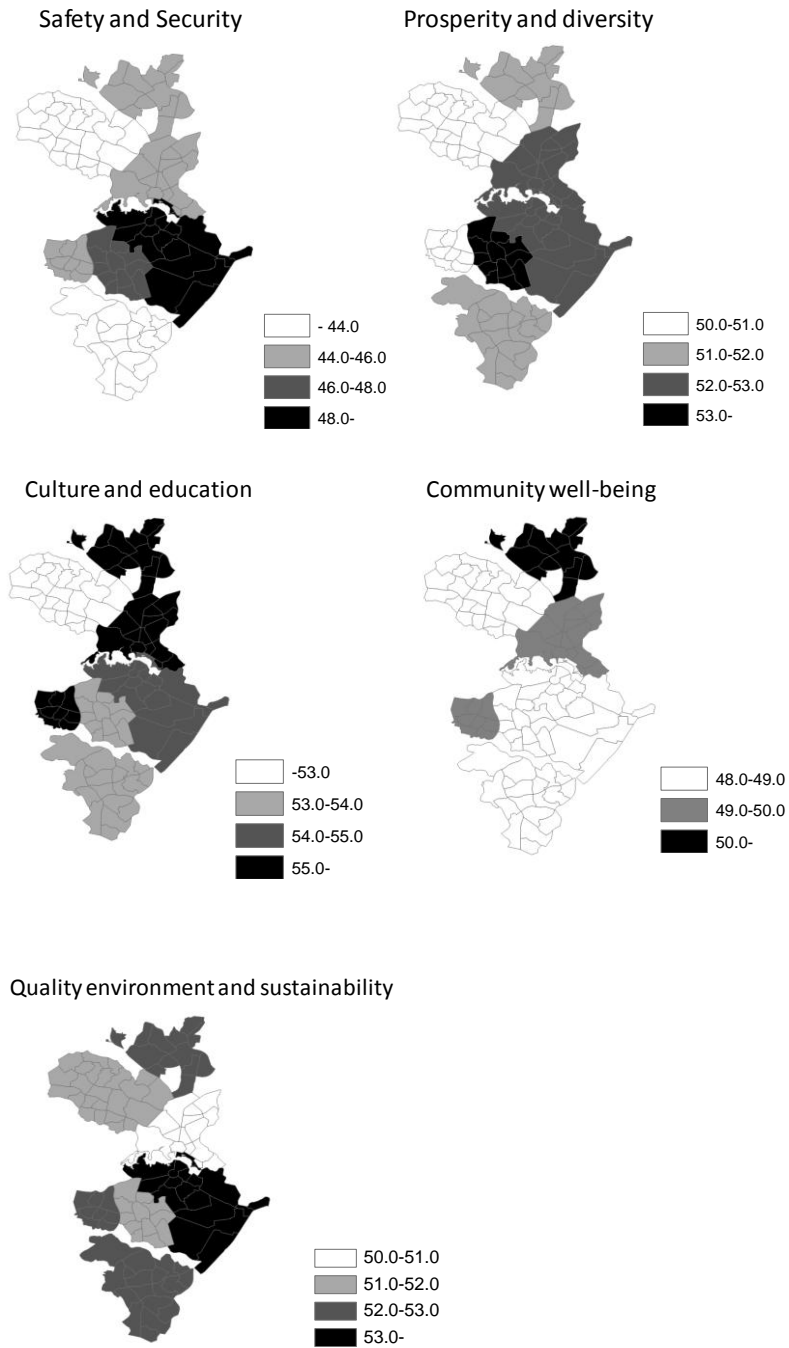
Safety and Security   Prosperity and diversity

- 44.0

44.0-46.0

46.0-48.0

48.0-

50.0-51.0

51.0-52.0

52.0-53.0

53.0-

Culture and education   Community well-being

-53.0

53.0-54.0

54.0-55.0

55.0-

48.0-49.0

49.0-50.0

50.0-

Quality environment and sustainability

50.0-51.0

51.0-52.0

52.0-53.0

53.0-

Fig. 3. Spatial distribution of satisfaction level

being". However residents in Belconnen, South Canberra, Woden, and Tuggeranong are less satisfied. Residents in Gungahlin, South Canberra,Weston Creek and Tuggeranong have higher satisfaction with "quality environment and sustainability". Meanwhile residents in Belconnen, North Canberra, and Woden are less satisfied.

3.3. Weight

Table 5 and Figure 4 show the estimated weight by district. These results are statistically significant at the 5% level. As shown in Table 5 and Figure 4, North Canberra, Woden, Weston Creek, Tuggeranong, and Gungahlin have highest weight on "prosperity and diversity". Belconnen and South Canberra have highest weight on "community well-being" and "culture and education", respectively. Woden and Weston Creek also have relatively high weight on "culture and education". South Canberra and Tuggeranong put high weight on "quality environment and sustainability". On the other hand, North Canberra, Weston Creek, South Canberra, and Gungahlin put lowest weight on "community well-being". To some extent the weight may relate to the built environment and residents background. For example, the high weight on "culture and education" of respondents in South Canberra may reflect the fact that they have relatively higher number of children/household and income. Cluster analysis was also conducted to explore the commonality in weight distribution. It is found that North Canberra and Gungahlin have similar patterns. South Canberra and Belconnen has significantly different patterns from the other districts. However, the priorities in life are determined by more complex factors. Life circumstances and individual's value system play a central part in choices of opportunities and may form criteria for the evaluation of individual's attitudes and actions (Doi et al. 2008). As the result of the cluster analysis wasn't significant enough to guide the aggregation of the districts into groups, it was decided that the following analysis be continued by district level.

Table 5. Weight by district

	Safety and security	Prosperity and diversity	Culture and education	Community well-being	Quality environment and sustainability
North Canberra	0.15	0.51	0.11	0.10	0.13
Belconnen	0.13	0.21	0.18	0.33	0.15
Woden	0.15	0.34	0.29	0.16	0.06
Weston Creek	0.13	0.36	0.27	0.07	0.17
Tuggeranong	0.15	0.44	0.03	0.16	0.22
South Canberra	0.14	0.21	0.30	0.07	0.27
Gungahlin	0.13	0.47	0.19	0.08	0.13
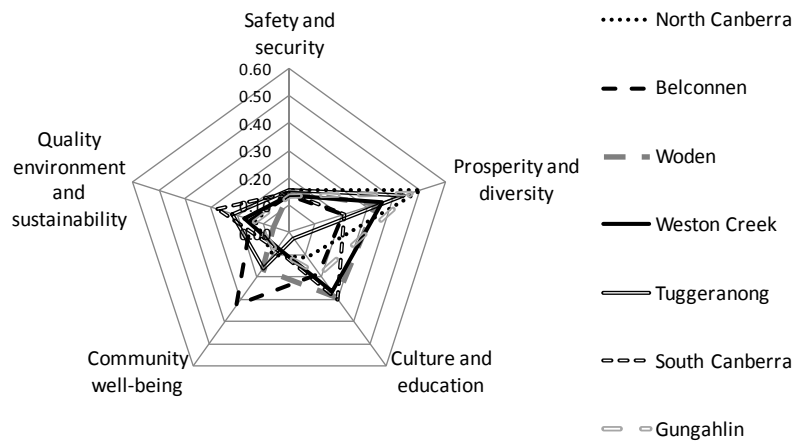
Fig. 4. Weight distribution by district

3.4. Quality of life

Based on the QoL model explained in the methodology section, the QoL level by each district is estimated. The results are shown in Figure 5.
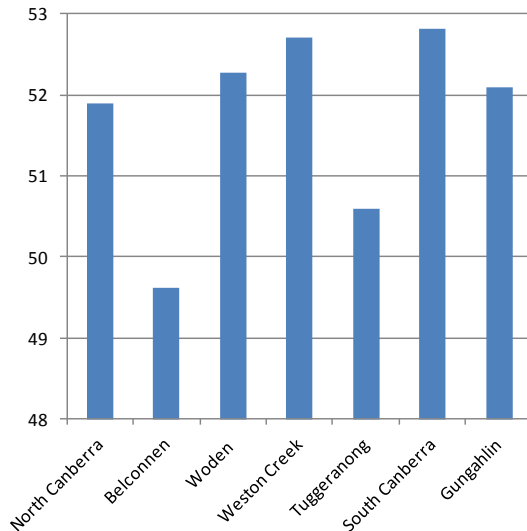

Fig. 5. QoL level by district

Figure 5 shows the 3 point gap between highest QoL and lowest QoL is minimal. However it is clear that there is opportunity to increase the QoL levels in Belconnen and Tuggeranong to deliver equal level of QoL to other districts. We assume that lower satisfaction level of "community well-being" and high weight on this domain is affecting the overall QoL in Belconnen. Belconnen residents are less satisfied with "safety and security" but the relative weight on this domain is not high. Tuggeranong residents are satisfied with the domains that have higher weight – "prosperity and diversity" and "quality environment and sustainability". Residents in this district are less satisfied with culture and education but the weight on this domain is significantly low. Therefore it can be shown that factors related to "safety and security" and "community well-being" are affecting overall QoL in Tuggeranong.

4. Bettering quality of life

4.1. Factors that affect satisfaction

The factors that are affecting the satisfaction level with "safety and security" and "community well-being" are explored to identify the options to improve QoL in Belconnen and Tuggeranong. Multiple regression analysis was conducted to identify the most influential factors (satisfaction with each indicator) to the aggregated satisfaction level of these domains in these districts. Results are shown in Tables 6-8.

Table 6. Multiple regression analysis result (Belconnen – community well-being)

	Beta	t value
Intercept		2.1
Satisfaction with "access to health and social care facilities and quality"	0.404	15.7
Satisfaction with "ability to influence decisions in Canberra"	0.324	12.4
Satisfaction with "amount of green space within walking distance"	0.305	12.1
Satisfaction with "% of overweight or obesity in Canberra"	0.307	11.7
Satisfaction with "illegal drug use"	0.341	13.0

($R^2 = 0.90$)

Table 7. Multiple regression analysis result (Tuggeranong – safety and security)

	Beta	t value
Intercept		1.9
Satisfaction with "domestic crime per 1,000 households in Canberra"	0.396	11.2
Satisfaction with "% of residents who feel safe walking alone after dark"	0.522	15.0
Satisfaction with "housing affordability"	0.406	11.9

($R^2 = 0.90$)

Table 8. Multiple regression analysis result (Tuggeranong – community well-being)

	Beta	t value
Intercept		1.5
Satisfaction with "access to health and social care facilities and quality"	0.379	11.3
Satisfaction with "ability to influence decisions in Canberra"	0.323	9.6
Satisfaction with "amount of green space within walking distance"	0.343	10.7
Satisfaction with "% of overweight or obesity in Canberra"	0.295	8.7
Satisfaction with "illegal drug use"	0.337	9.9

($R^2 = 0.90$)

The results show the expected sign for all independent variables and statistically significant. It is found that "satisfaction with access to health and social care facilities and quality" is most influential to the aggregated satisfaction of "community well-being" in Belconnen. The second influential factor is the "satisfaction with illegal drug use". In Tuggeranong, "satisfaction with the percentage of residents who feel safe walking alone after dark" and "satisfaction with access to health and social care facilities and quality" are most influential to each domain's satisfaction. The second influential factor is "satisfaction with housing affordability" and "satisfaction with amount of green space within walking distance", respectively.

4.2. Scenario analysis

In this section, a scenario analysis which examines the options to enhance QoL in Belconnen and Tuggeranong is demonstrated. The scenarios are set as follows in Tables 9-11. The parameters shown in Tables 6-8 are used for the estimation of the change in satisfaction level.

Table 9. Scenarios - Belconnen

Scenario 1	Increase the "satisfaction with access to health and social care facilities and quality" for 5%
Scenario 2	Increase the "satisfaction with access to health and social care facilities and quality" for 10%
Scenario 3	Increase the "satisfaction with access to health and social care facilities and quality" for 5% and increase the "satisfaction with illegal drug use" for 5 %

Table 10. Scenarios – Tuggeranong option 1

Scenario 1	Increase the "satisfaction with % of residents who feel safe walking alone after dark" for 5%
Scenario 2	Increase the "satisfaction with % of residents who feel safe walking alone after dark" for 10%
Scenario 3	Increase the "satisfaction with % of residents who feel safe walking alone after dark" for 5% and increase the "satisfaction with housing affordability" for 5 %

Table 11. Scenarios – Tuggeranong option 2

Scenario 1	Increase the "satisfaction with access to health and social care facilities and quality" for 5%
Scenario 2	Increase the "satisfaction with access to health and social care facilities and quality" for 10%
Scenario 3	Increase the "satisfaction with access to health and social care facilities and quality" for 5% and increase the "satisfaction with amount of green space within walking distance" for 5 %

Table 12. Scenario analysis results

	Belconnen		Tuggeranong option 1		Tuggeranong option 2	
Scenario 1	Change in satisfaction level of domain "community well-being"	+37.9	Change in satisfaction level of domain "safety and security"	+18.9	Change in satisfaction level of domain "community well-being"	+37.2
	Change in QoL level	+14.3	Change in QoL level	+2.9	Change in QoL level	+10.0
Scenario 2	Change in satisfaction level of domain "community well-being"	+39.3	Change in satisfaction level of domain "safety and security"	+20.2	Change in satisfaction level of domain "community well-being"	+38.3
	Change in QoL level	+14.8	Change in QoL level	+3.2	Change in QoL level	+10.2
Scenario 3	Change in satisfaction level for domain "community well-being"	+38.5	Change in satisfaction level of domain "safety and security"	+19.6	Change in satisfaction level of domain "community well-being"	+38.4
	Change in QoL level	+14.8	Change in QoL level	+3.1	Change in QoL level	+10.2

Table 12 shows the results of the scenario analysis. As shown in Table 12, increasing the "satisfaction with access to health and social care facilities and quality" for 5% enhances QoL for more than 10 points in Belconnen. The results of scenario 2 and 3 are similar, which implicates that the combination of approaches also works well to enhance QoL. In Tuggeranong, it is found that option 2 improves QoL better than the option 1. In terms of the change in QoL level, Belconnen and Tuggeranong (options 1 and 2) both show minimal difference between scenarios 1, 2 and 3. This means that there is a high potential that only enhancing 5 % of satisfaction of the most influential indicator has a significant impact on improving QoL.

4.3. Discussion

In this paper, the approach to identify the key indicators to enhance quality of life based on residents' values is demonstrated in the application of the QoL-oriented evaluation method to Canberra. Two districts with lower QoL and their most influential indicators to enhance QoL were chosen. The change in QoL is simulated by scenarios that enhance the satisfaction level of the key indicators. The demonstration shows that QoL is significantly improved by increasing the satisfaction level of the key indicators by 5 %. The results are useful in considering the planning options to enhance quality of life. However it is stressed that this is still an experimental stage and the results need further testing. The factors that affect the priorities in QoL (value) are complex. They depend on individual's socio-demographic circumstances, such as gender, age, income, etc. The respondents backgrounds are compared by district, but it is hard to indentify which circumstances have the most influence. The factors that affect the individual's values are not limited to these circumstances. In this research, the value is understood by one aspect of resident – living district. Even if living in the same district, the residents' values vary and this research hasn't explored the varied value of residents in same district. In addition to the difference in value, understanding the causal relationship of latent factors that affect individual's perception, satisfaction, and QoL helps to identify an effective approach.

Even allowing for methodological limitations, the results of this study suggests options to focus planning on delivering better QoL. To consider the possible options, the policy input mapping shown in Figure 6 is proposed.
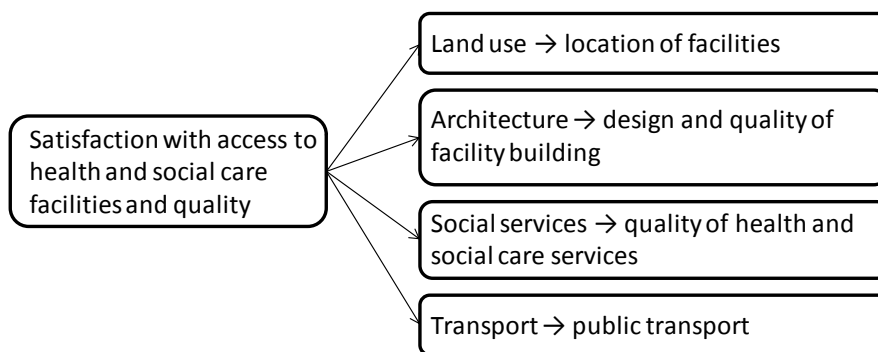

Fig. 6. Example of policy input mapping (Belconnen)

In the case of Belconnen, to increase the cross-cutting "satisfaction with access to health and social care facilities and quality", at least four inputs are considered: land use, architecture, social services, and transport. In conventional planning processes, the choice between these options is affected by policies (e.g. planning strategy, master plan) and financial situation. For efficient and effective investment to enhance QoL, understanding of those options that are most related to the residents satisfaction is needed. The most common approach to understanding these needs is through community engagement. Community engagement also provides opportunity to explore the differences in individual priority for each resident and to communicate these differences while sharing the goal of community improvement. In addition, building consensus on indicators of how to monitor the improvement can also be achieved in community engagement. In QoL-oriented evaluation, it is critical that residents' values are considered throughout the process: from indicator setting to evaluation. This may require significant time to build consensus among residents and stakeholders. Understanding the different values can reduce the time taken to develop social capital, and promotes a stronger planning capacity in the community.

5. Conclusions

This research demonstrated an application of the integrated planning support tool which focuses on quality of life and value of residents. The experimental tool is applied in Canberra, Australia, using empirical data. The two districts that have lower QoL and their key indicators for improving QoL are identified. Based on these findings, a method is proposed to map the cross-cutting indicator to policy inputs. The demonstrated mapping is one of the options among the various approaches. It is recommended that planners develop suitable ways to link the key factors to urban policy under the local circumstances. This requires balancing the priorities within the government (often affected by the political and financial situation) and what the residents need. In this context, this paper discussed that QoL indicators are useful to set the mutual goal for the community. The proposed planning support tool enables the integration of community engagement to the cycle of policy evaluation and potentially builds social capital that strengthens the community.

This paper distinguished the residents group by living district for spatial analysis. Although the research obtained similar distribution of survey re-

spondents to Census in terms of the living district, further examination of the cohort of residents is needed to provide greater clarity of the representative results. Residents' weight might have a relationship with the planning principles of their living district, but this also needs further analysis to clarify. If spatial analysis is not the priority, there are various ways to cluster the residents into groups and estimate their value. Groups of residents that have similar values can be found across the districts. The scenario analysis demonstrated in this paper can be applied to find the key indicators to equalise the QoL level of residents groups that have different values.

It is stressed that the results presented in this paper are subject to current indicator sets and value (weight) distribution in Canberra. Different indicators can be selected according to the economic, social, and environmental circumstances and these circumstances also affect the weightings. In applying the QoL-oriented evaluation tool to planning, foreseeing future value (weight) of residents would be of help for setting up long-term goals of the community (Hayahsi and Sugiyama 2003). The research implicates the opportunities to further analyze the shift of value that affect individual's priorities in QoL and how it is related to the satisfaction with the built environment.

Acknowledgement

References

Australian Bureau of Statistics (2011) Census of population and housing basic community profile http://www.abs.gov.au/websitedbs/censushome.nsf/home/communityprofiles?opendocument&navpos=230 (accessed 2 February 2013)

Batty M, Densham, PJ (1996) Decision support, GIS, and urban planning. Sistema terra 5(1): 72-76

Besleme K, M Mullin (1997) Community indicators and healthy communities. National Civic Review 86(1): 43-52

Briassoulis H (2001) Sustainable development and its indicators: through a (planner's) glass darkly. Journal of Environmental Planning and Management 44: 409-27

Brooks N, Neil Adger W, Mick Kelly P (2005) The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. Global Environmental Change 15(2): 151-163

Chiesura A (2004) The role of urban parks for the sustainable city. Landscape and Urban Planning 68: 129-38

Commonwealth of Australia Department of Home Affairs (1913) The federal capital: Report explanatory of the preliminary general plan. (C. 9681.) Albert J. Mullett, Government Printer, Melbourne.

Das D (2008) Urban quality of life: a case study of guwahati. Social Indicators Research 88: 297-310

Delmelle E, Thill JC, Furuseth O, Ludden T (2013) Trajectories of multidimensional neighbourhood quality of life change. Urban Studies 50 (5): 923-941

Diener E, Suh E (1997) Measuring quality of life: economic, social, and subjective indicators. Social Indicators Research 40**:** 189–216

Doi K, Kii M, Nakanishi H (2003) How to consider quality of life in operations research? Application of QoL concept to policy management and evaluation (in Japanese). The Journal of Operations Research Society of Japan 48: 808-813

Doi K, Kii M, Nakanishi H (2008) An integrated evaluation method of accessibility, quality of life, and social interaction. Environment and Planning B: Planning and Design 35: 1098-1116

Felce D, Perry J (1995) Quality of life: its definition and measurement. Research in Developmental Disabilities 16: 51-74

Fischer KF (1984) Canberra: myths and models: forces at work in the formation of the Australian capital. Institute of Asian Affairs, Hamburg

Frey B, Stutzer A (2002) Happiness and economics. Princeton University Press, New Jersey

Gatersleben B (2001) Sustainable household consumption and quality of life: the acceptability of sustainable consumption patterns and consumer policy strategies. Int. J.Environment and Pollution 15 (2): 200–216

Geertman S, Stillwell J (2004) Planning support system: an inventory of current practice. Computers, Environment and Urban Systems 28: 291-310

Geneletti (2008) Incorporating biodiversity assets in spatial planning: methodological proposal and development of a planning support system. Landscape and Urban Planning 84: 252-265

Hall P (2002) Cities of Tomorrow. An intellectual history of urban planning and design in the twentieth century. 3rd edn, Blackwell Publishing, Oxford Carlton

Hayashi Y, Sugiyama I (2003) Dual strategies for the environmental and financial goals of sustainable cities: de-suburbanization and social capitalization. Built Environment 29: 8-15

Higginson S, Walker P, Terry A, Robbins C (2003) Making indicators count, how to make quality of life indicators, make a difference to quality of life. The New Economic Foundation and the Faculty of the Built Environment, University of the West of England, Bristol

Hopkins, L. (1999) Structure of a planning support system for urban development. Environment and Planning B: Planning and Design 26: 333–343

Kahneman D, Wakker PP, Sarin R (1997) Back to Bentham? Explorations of experienced unitlity. The Quarterly Journal of Economics 112 (2): 375-406

Kaufman C, Morris W, Jones E, Richards P (2006) Australian new urbanism - an overview and update. In: ACNU & Ecologically Sustainable Design Ltd. (eds.) Australian new urbanism: a guide to projects (2nd edn). Australian Council for New Urbanism, Melbourne, pp 6-16

Klosterman, R (2001) Planning support systems: a new perspective on computer-aided planning. In Brail, R and Kloster man, R (eds), Planning support systems: integrating geographic systems, models, and visualization tools, ESRI, Inc., Redlands, California

Leitmann J (1999) Can city QOL indicators be objective and relevant? Towards a participatory tool for sustaining urban development. Local Environment 4(2): 169-180

Massam BH (2002) Quality of life: public planning and private living. Progress in Planning 58(3): 141-227

McMahon SK (2002) The development of quality of life indicators-a case study from the City of Bristol, UK. Ecological Indicators 2: 177-85

Nakanishi H (2006) A study on multi-dimensional assessment of urban infrastructures based on QoL and strategic partnership (in Japanese). Ph.D. thesis, Kagawa University, collection of Japan National Diet Library

Nakanishi H, Doi K (2003) Organization of quality of life concepts relevant to policy evaluation and benchmark system (in Japanese). paper delivered to the 27th Conference on Infrastructure Planning Committee, Japan Society of Civil Engineers, Tokyo, 6-8 June

Nakanishi H, Doi K, Shibata H, Sugiyama I, Terabe S (2005) The role of qol indicators on policy evaluation in U.K. and its implication to Japan (in Japanese). Journal of Journal of Infrastructure Planning and Management, Japan Society of Civil Engineers, Vol 793 IV-68: 73-83

Rogerson RJ, Findlay, AM, Morris AS, Coomebs MG (1989) Indicators of quality of life: some methodological issues. Environment and Planning A 21(12): 1655-1666

Sarmiento CJS, Gonzalez RM, Castro PM (2012) Development of a spatial information-based decision support system for multi-stakeholder dam reservoir operation. Geo-information for Disaster Management–Best Practices: 67

Schafer SE, Lindquist PS (2013) Decision support system for smart growth innovation in urban midwest: GIS connection between brownfield site redevelopment and transportation. In: Transportation Research Board 92nd Annual Meeting (No. 13-1721)

Sen A (1993) Capability and well-being. In: Nussbaum MC, Sen A (eds) The quality of life. Oxford University Press, New York, pp 30-54

Senlier N, Yildiz R, Aktaş ED (2009) A perception survey for the evaluation of urban quality of life in Kocaeli and a comparison of the life satisfaction with the European cities. Social indicators research 94(2): 213-226

Shen Z, Kawakami M, Lu F, Bian L, Long Y, Gao L, Zhou D (2012) A planning support system for retrieving planning alternatives of historical conservation areas from spatial data using GIS. In: Balram S, Dragicevic S (eds) Geospatial Techniques in Urban Planning. Springer Berlin Heidelberg, pp 307-321

Stiglitz JE, Sen A, Fitoussi JP (2010) Mismeasuring our lives: why GDP doesn't add up. The New Press, New York

Swain D, Hollar D (2003) Measuring progress: community indicators and the quality of life. International Journal of Public Administration 26: 789-814

Thompson CW, Roe J, Aspinall P (2013) Woodland improvements in deprived urban communities: what impact do they have on people's activities and quality of life? Landscape and Urban Planning in Press

Van Praag BM, Ferrer-i-Carbonell A (2008) Happiness quantified: a satisfaction calculus approach: a satisfaction calculus approach. Oxford University Press, Oxford