UNIVERSITI TEKNOLOGI MALAYSIA

BORANG PENGESAHAN
LAPORAN AKHIR PENYELIDIKAN

TAJUK PROJEK : **PEMBENTUKAN MODEL KUALITI HIDUP BANDAR DI MALAYSIA MENGGUNAKAN KAEDAH DATA ENVELOPMENT ANALYSIS**

Saya **HO CHIN SIONG**
(HURUF BESAR)

Mengaku membenarkan **Laporan Akhir Penyelidikan** ini disimpan di Perpustakaan Universiti Teknologi Malaysia dengan syarat-syarat kegunaan seperti berikut :

1. Laporan Akhir Penyelidikan ini adalah hakmilik Universiti Teknologi Malaysia.
2. Perpustakaan Universiti Teknologi Malaysia dibenarkan membuat salinan untuk tujuan rujukan sahaja.
3. Perpustakaan dibenarkan membuat penjualan salinan Laporan Akhir Penyelidikan ini bagi kategori TIDAK TERHAD.
4. * Sila tandakan (/)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau Kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972).
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh Organisasi/badan di mana penyelidikan dijalankan).
/	TIDAK TERHAD	

TANDATANGAN KETUA PENYELIDIK

Nama & Cop Ketua Penyelidik

Tarikh :

CATATAN : ***** *Jika Laporan Akhir Penyelidikan ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/ organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan ini perlu dikelaskan sebagai SULIT dan TERHAD.*

VOT 78513

MODELING URBAN QUALITY OF LIFE WITH DATA ENVELOPMENT ANALYSIS METHODS

(PEMBENTUKAN MODEL KUALITI HIDUP BANDAR DI MALAYSIA MENGGUNAKAN DATA ENVELOPMENT ANALYSIS)

PROF.DR.HO CHIN SIONG
DR. MUHAMMAD ZALY SHAH BIN MUHD HUSSEIN

FAKULTI ALAM BINA
UNIVERSITI TEKNOLOGI MALAYSIA

2008

ABSTRACT

The research examines the use of Data Envelopment Analysis (DEA) for the measuring performance of the urban quality of life in Malaysia using the CCR model. The Data Envelopment Analysis uses the general purpose linear programming version multi-input multi-output model for the estimation taking the selected cities as the decision making unit (DMUs). The performance measurement of the urban quality of life indicators based on seven (7) sectors out of eleven (11) sectors for better urban environment shows that Melaka city is the most efficient city compared with the others. The analysis result also showed that the two (2) significant sectors that influencing the urban quality of life are demography and land use sectors. From this analysis, the frontier cities indicate that the DEA method seems to be suitable for generating benchmarks for non-efficient cities. As a consequence, the reference city may be used as a stimulation for the other cities to improve their performances.

ABSTRAK

Penyelidikan ini adalah bertujuan untuk menguji penggunaan kaedah *Data Envelopment Analysis* dalam mengukur prestasi kualiti hidup bandar di Malaysia menggunakan model CCR. Kaedah *Data Envelopment Analysis* ini menggunapakai konsep program linear berasaskan model pelbagai *input* dan *output* sebagai anggaran dengan bandar-bandar terpilih sebagai *decision making unit* (DMUs). Berdasarkan analisis yang telah dijalankan menggunakan petunjuk-petunjuk yang terpilih ke atas bandar-bandar kajian mendapati bahawa bandaraya Melaka merupakan bandar yang paling efisien berbanding yang lain. Hasil kajian ini adalah berdasarkan daripada sebelas (11) sektor yang digunakan dan bandaraya Melaka adalah efisien dalam tujuh (7) sektor berkenaan. Sementara itu, hasil analisis juga mendapati terdapat dua (2) sektor yang signifikan dalam mempengaruhi kualiti hidup bandar pada tahun penyelidikan iaitu sektor demografi dan guna tanah. Secara keseluruhannya, daripada penyelidikan ini dapat membuktikan bahawa penggunaan kaedah *Data Envelopment Analysis* adalah yang terbaik dalam membuat perbandingan bagi bandar-bandar yang efisien. Dengan ini bandar yang efisien dapat dijadikan sebagai bandar rujukan bagi bandar-bandar lain untuk meningkatkan prestasi mereka dalam mewujudkan kualiti hidup bandar yang lebih baik.

TABLE OF CONTENTS

CHAPTER 3:
URBAN QUALITY OF LIFE FOR SELECTED CITY

CHAPTER 4:
ANALYSIS AND RECOMMENDATION

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION OF URBAN QUALITY OF LIFE STUDY

1.1 INTRODUCTION

Efficiency of resources management and planning are needed in ensuring adequate amenities and better urban quality of life. Data Envelopment Analysis (DEA) is one of the approaches in measuring efficiency of resources. DEA is a popular approach used by researchers in developed countries in benchmarking evaluation of quality.

For this research, DEA method is used as a new approach in evaluating our urban quality of life. It is a comprehensive approach to make sure, the use of balanced evaluating urban quality of life indicators.

1.2 GOAL AND OBJECTIVES

The goal of this study is:

"Identifying status of urban quality of life for selected cities in Malaysia by using Data Envelopment Analysis (DEA)"

Below are the objectives of this study;

1. To identify urban quality of life indicators,
2. To benchmark urban quality of life for selected cities by using DEA,
3. To identify significant sectors influencing the urban quality of life for selected cities in Malaysia.

1.3 STUDY APPROACH

The approaches used for this study include;

a) Data Collection

Data collection will be done based on primary and secondary data from the related local authority, which are;

- Majlis Bandaraya Johor Bahru,
- Majlis Bandaraya Melaka Bersejarah,
- Majlis Bandaraya Pulau Pinang,
- Majlis Perbandaran Kuantan.

Data collection is based on the identified indicators from the literature review in chapter 2. Selected local authorities are based on their size of population and urban hierarchy in national context. Among 4 of the selected cities, only Kuantan still remained with municipality as compared with the other three city halls. The reason for the selection of Kuantan is because its roles as hub of development in the

Peninsular Malaysia for east coast region as well as the relative big size of the city. However, Kuala Lumpur City has been eliminated from this list because of the high density area, less area for developing activities and its special role as a national capital area.

b) Measuring and Benchmarking

Measurement and benchmarking for this study will based on DEA method. Data will be limited for selected city and available data only. And the analysis is depends on the strength and effectiveness of DEA model used in this research.

1.4 RESEARCH METHODOLOGY

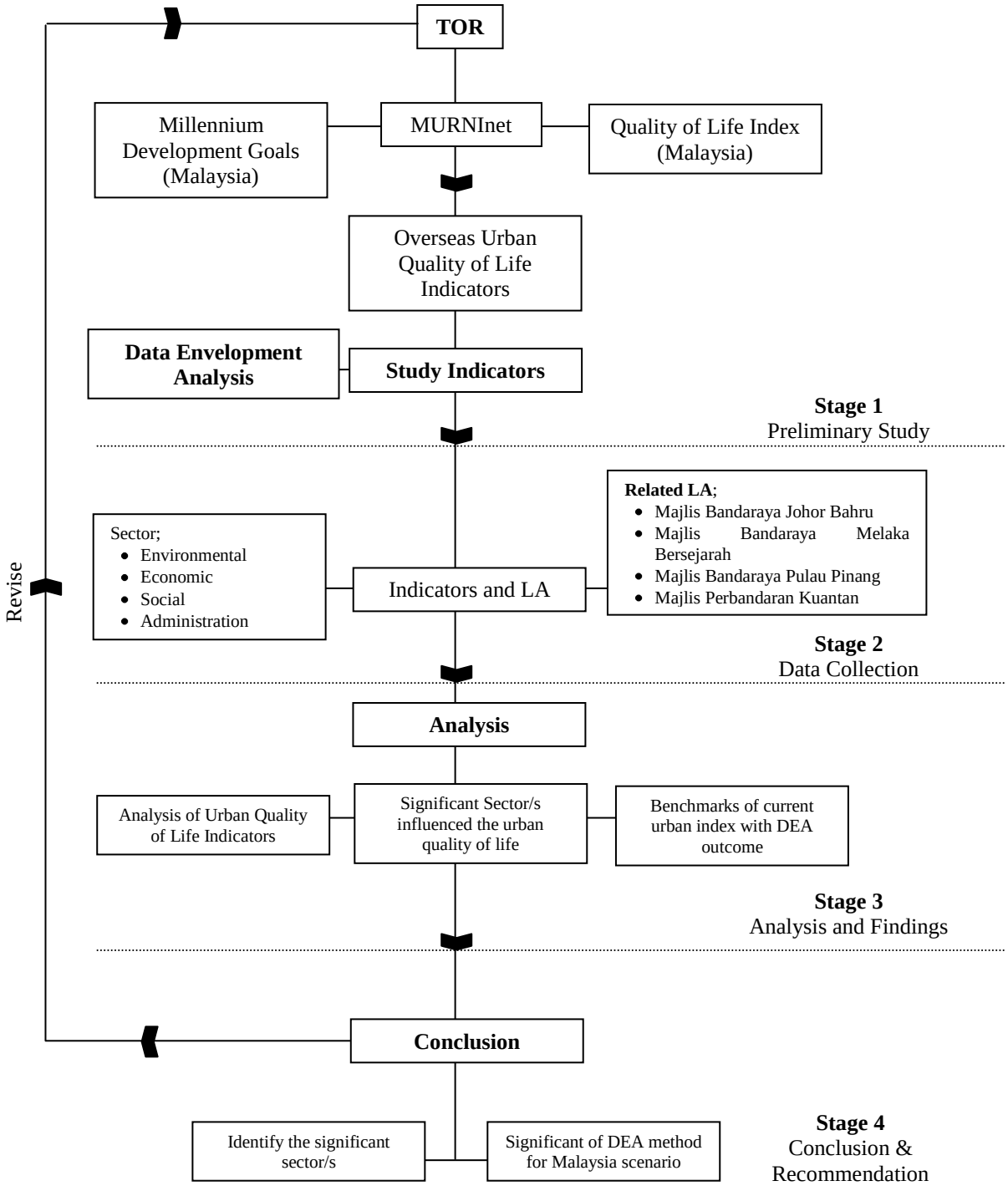


Figure 1: Research Methodology

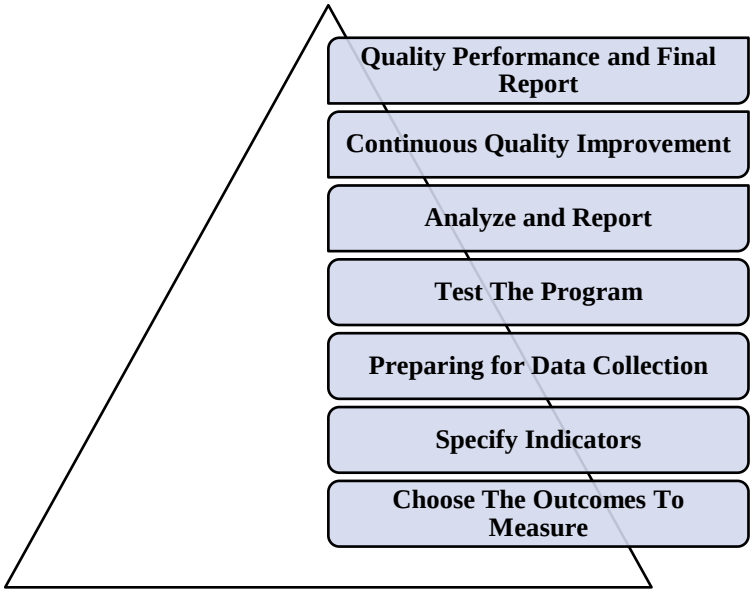


Figure 2: Research Methodology Hierarchy

Stage 1: Preliminary Study – This stage explains the Terms of Reference (TOR) and literature study on DEA and indicators for urban quality of life. It includes recent indicators used by local and overseas. In the local context, recent indicators used in MURNInet program developed by Town and Country Planning Department will be used as the basic example. It also includes the Malaysia Quality of Life Index Report and Millennium Development Goals in 1992. While at the international context, it relates to various sources especially from developed countries as parallel with our Vision 2020. Detail review of DEA concept is also being done at this stage for a better understanding of benchmarking and evaluation.

Stage 2: Data Collection – For data collection, it is based on primary and secondary sources. It is done with related local authorities for this research. At this stage, questionnaire forms will be used based on indicators identified in stage 1. The secondary data sources are from the urban report, technical report and from MURNInet website as the primary source for this research.

However, for some data such as amount of spending and revenue of the local authorities which are not included in their report, an appointment or telephone called will be made to the officer in charge to get those information. The phone call will be made for local authorities such Majlis Perbandaran Kuantan and Majlis Bandaraya Pulau Pinang.

Stage 3: Analysis and Findings – For analysis, DEA method is the main tool to measure urban quality of life indicators. This method will combine as the command analysis with the MATLAB R2008a software which includes a lot of engineering mathematics formula and solutions.

The DEA CCR model which been used in this research was been modified to ensure it can be used for the analysis of data collected. The result of this analysis can be used to benchmark the current index from the MURNInet.

Stage 4: Conclusion and Recommendation – This stage will identify the main indicators that influence the urban quality of life. This will also ensure the applicability of DEA method with our local environment in measuring the local urban quality of life. At the same time, it will also identify the significant factors affecting urban quality or life.

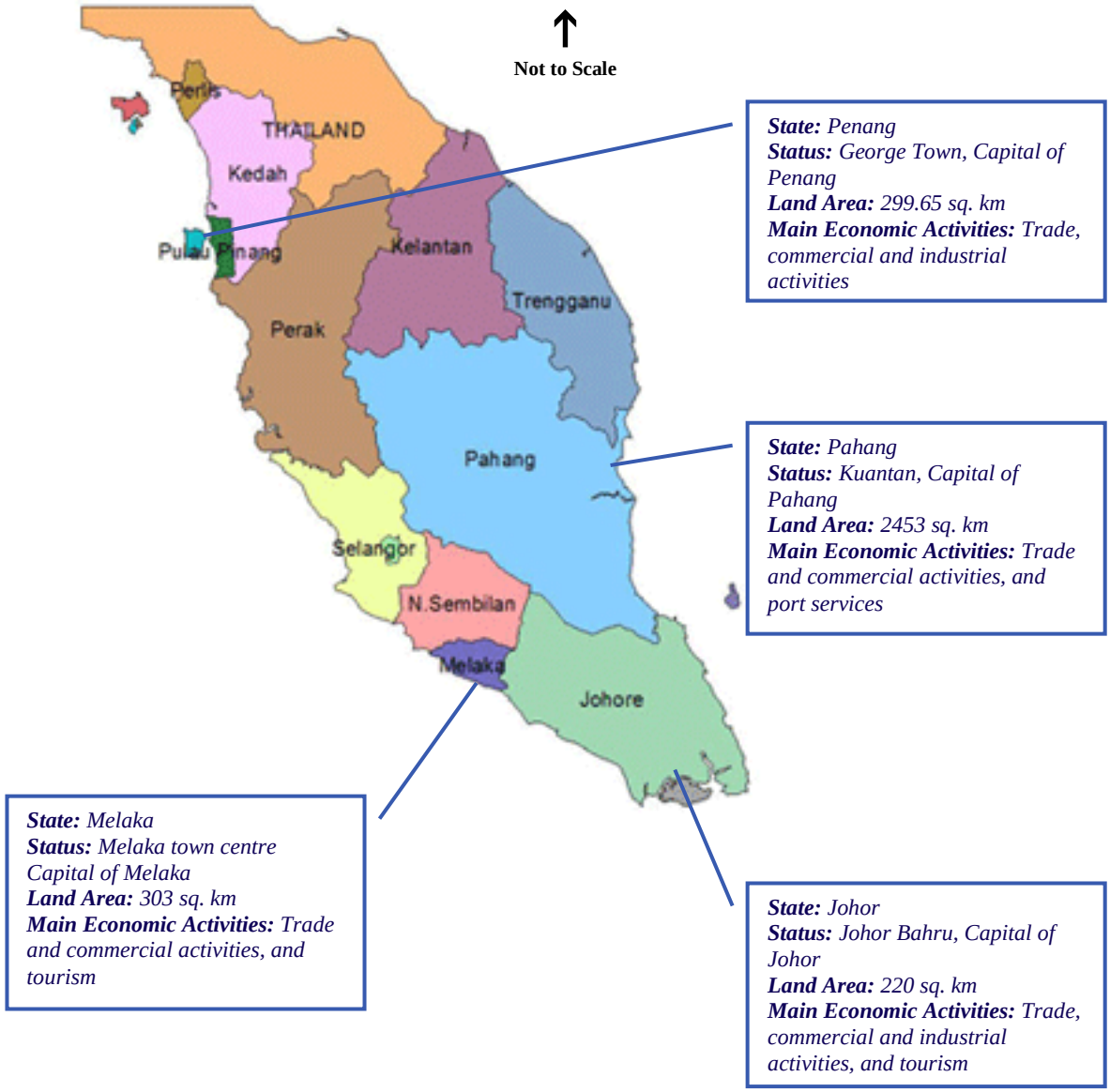
1.5 STUDY AREA

For this research four (4) main cities have been selected which are Johor Bahru, Melaka, George Town and Kuantan. The four cities accounted for about 30 percent of the total urban population of Malaysia in 2000 (**refer Figure 3**).

1.6 CONCLUSION

This research is the first time pioneer the use of DEA method in evaluating our urban quality of life in Malaysia. The data collection will focus on the related local authorities and in the significance of urban quality of life indicators with our local context. The research has been divided into four (4) main stages i.e.; from theoretical framework indicators identification, the outcomes and recommendations to allow better monitoring on the progress of the research work.

Figure 3: Profile of Research cities



CHAPTER 2

LITERATURE RIVIEW OF URBAN QUALITY OF LIFE AND DATA ENVELOPMENT ANALYSIS

2.1 INTRODUCTION

Since 1991, urbanization in Malaysia has been developed rapidly with 54.3% and up to 65.4% in 2000. It gave a huge impact to most of urban areas and amenities such as urban economic, utility and infrastructure, environment, public services, community convenience and it's affecting towards the urban population quality of life. At the same time, sustainable development which was introduced in the world summit at Rio de Janerio, Brazil in 1992 has already used in Malaysia. It covers three major dimensions which are environment, economic and social needs. It includes urban life aspects such as education, housing, transportation, health, security and environment. These dimensions promised for balanced in planning and development towards developed area. Variety of indicators and measuring methods are used in evaluated the development we brought with our quality of life status. And it is already been complex issues to discuss about the quality of life as it has to tackle various players (stakeholders) in fulfill their need.

2.2 URBAN QUALITY OF LIFE

The concept of quality of life has been popular since 1960's and 1970's when environmental crisis became major issues especially in developed countries such as United State. Since then, there are many players tried to use this concept of quality of life in their planning and management. It includes the scientists, local authorities, academicians, Non-Governmental Organization (NGO's), community and others. And it brings to diverse definitions depend on their background and requirement.

Quality of life can be interpreted in many different ways. For some it means security and safety, employment opportunities, a clean environment, ease of travel, access to services, adequate health care, good schools, efficient government, or simply time spent with family and friends. This wide interpretation of quality of life demands a broad representation of indicators to best reflect the overall health of the community.

However, in normal situation the definition of quality of life defined related with income per capita. The concept of quality of life has been used widely, but a research done by The Economist Intelligence Units (EIU) concluded that this concept cannot describe about the quality of life itself in certain area. It showed that individual needs consist of complexity of various aspects. It covers the human characteristics and feelings. It includes their happiness, sad, enjoyment, and more than that is their origin background.

Malaysia Quality of Life report (2004) defines the quality of life as self-developed, healthy life style, access and freedom in gained knowledge and enjoying more than basic needs and human psychology in achieving social consciousness towards national vision.

However, Laura Carnfield (2005) a research officer from Physiology Division finds that quality of life is about how a person received and evaluated their

life. It covers human feelings with their environment such as convenience, happy, sad and other feelings. Her researches on some developing countries show that individual quality of life is depending on their gender and age. For an example in Thailand, the aged population dreams of having better health and religious wellness rather than the young generation which dream of having a better job and vehicle ownership.

In the City of Jacksonville Progress Report 2006, quality of life is defined as the same meaning with Laura Carnfield as it refers to a feeling of well-being, fulfilment, or satisfaction resulting from factors in the external environments. For many people, the quality of close interpersonal relationships, rather than the external environments, is the primary factor in determining happiness.

As a conclusion, in general Malaysia quality of life is similar with other nations. In addition, Malaysia aims at progress and development of quality of life towards national vision to be among a developed country by year 2020. This defines the concept of our development towards own style and approach. However the basis is still same as it tries to improve its community environment lifestyle towards better day. Although the quality of life is a wide concept to discuss but the basis is that it includes feelings and needs of human to improve their life style for more convenience and enjoyable. Variety of dimensions should be taken into consideration to evaluate the quality of life. With the complexity of human environment to understand makes the measurement becomes more quantitative rather than qualitative.

2.3 SUSTAINABLE AND QUALITY OF LIFE

A widely-used international definition of sustainable development is;

'development which meets the needs of the present without compromising the ability of future generations to meet their own needs'.

However, United Nations Centre for Human Settlements (HABITAT) definition on sustainable urban in their Sustainable Urban Program is an urban area which can preserved their development in social, economic and physical development forever.

Through the Sustainable development concept, the UN-HABITAT has introduced the Sustainable Cities Programme (SCP). The SCP is a joint UN-HABITAT/UNEP facility established in the early 1990's to build capacities in urban environmental planning and management. The programme targets urban local authorities and their partners. It is founded on broad-based stakeholder participatory approaches.

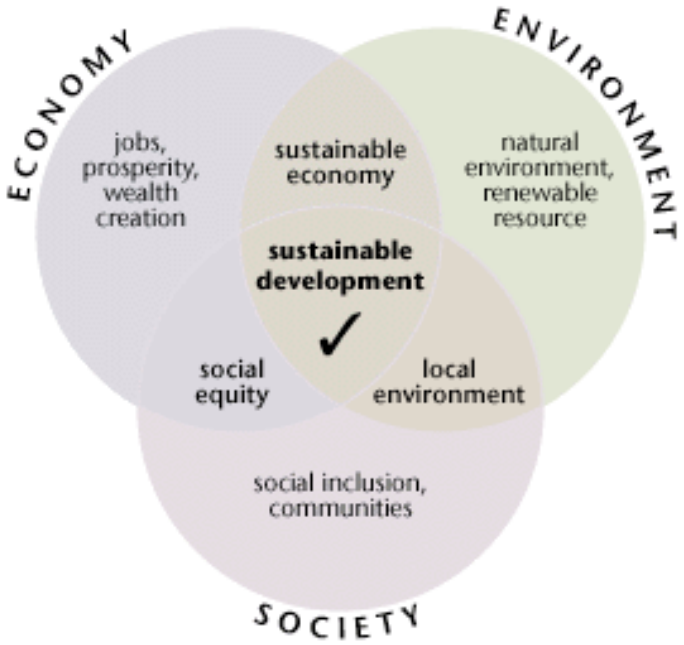


Figure 4: General concept of sustainable development

In promoting urban environmental governance processes SCP works closely with UN-HABITAT's Global Campaign on Urban Governance. The goal of the Global Campaign on Urban Governance is to reduce urban poverty through good

urban governance. Its objectives are the increased capacity of local governments and other stakeholders to practice good urban governance and raised awareness of and advocacy for good urban governance around the world.

"Urban governance is the sum of the many ways individuals and institutions, public and private, plan and manage the common affairs of the city. It is a continuing process through which conflicting or diverse interests may be accommodated and cooperative actions can be taken. It includes formal institutions as well as informal arrangements and the social capital of citizens.

Urban governance is inextricably linked to the welfare of the citizenry. Good urban governance must enable women and men to access the benefits of urban citizenship. Good urban governance, based on the principle of urban citizenship, affirms that no man, woman or child can be denied access to the necessities of urban life, including adequate shelter, security of tenure, safe water, sanitation, a clean environment, health, education and nutrition, employment and public safety and mobility.

Through good urban governance, citizens are provided with the platform which will allow them to use their talents to the full to improve their social and economic conditions." (*Source: Good Urban Governance: A Normative Framework (HS/C/PC.1/CRP.6), 26 February 2000, available at http://www.un-habitat.org*)

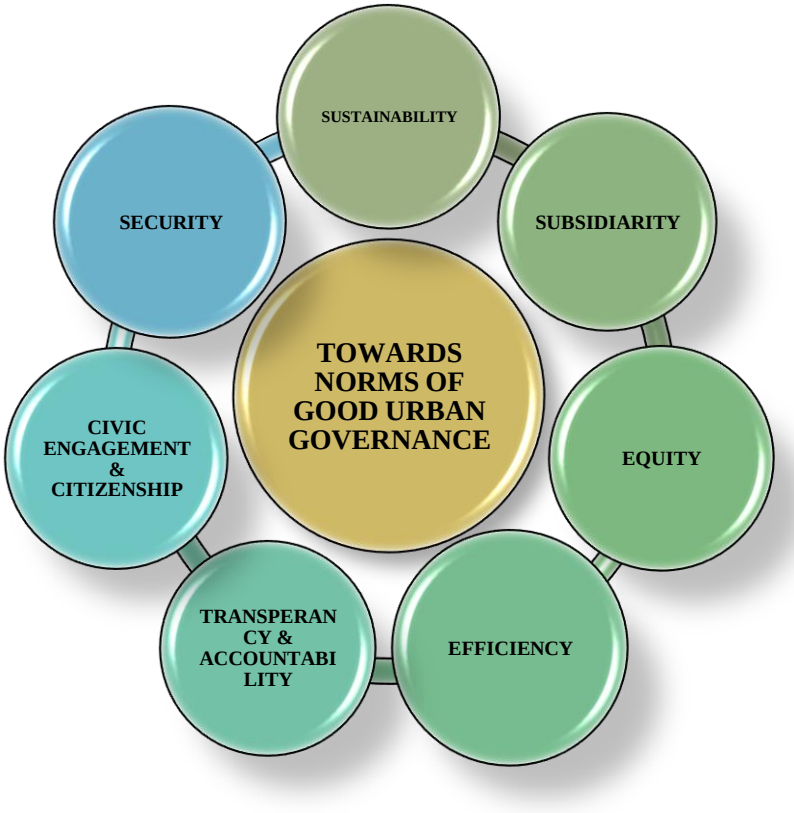


Figure 5: Towards norms of Good Urban Governance (*refer **Appendix II** for detail explanations)*

a) Sustainability in all dimensions of urban development

Cities must balance the social, economic and environmental needs of present and future generations. This should include a clear commitment to urban poverty reduction. Leaders of all sections of urban society must have a long term, strategic vision of sustainable human development and the ability to reconcile divergent interests for the common good.

b) Subsidiarity of authority and resources to the closest appropriate level

Responsibility for service provision should be allocated on the basis of the principle of subsidiarity, that is, at the closest appropriate level consistent with

efficient and cost-effective delivery of services. This will maximize the potential for inclusion of the citizenry in the process of urban governance.

Decentralization and local democracy should improve the responsiveness of policies and initiatives to the priorities and needs of citizens. Cities should be empowered with sufficient resources and autonomy to meet their responsibilities.

c) Equity of access to decision-making processes and the basic necessities of urban life

The sharing of power leads to equity in the access to and use of resources. Women and men must participate as equals in all urban decision-making, priority-setting and resource allocation processes. Inclusive cities provide everyone – be it the poor, the young or older persons, religious or ethnic minorities or the handicapped – with equitable access to nutrition, education, employment and livelihood, health care, shelter, safe drinking water, sanitation and other basic services.

d) Efficiency in the delivery of public services and in promoting local economic development

Cities must be financially sound and cost-effective in their management of revenue sources and expenditures, the administration and delivery of services, and in the enablement, based on comparative advantage, of government, the private sector and communities to contribute formally or informally to the urban economy. A key element in achieving efficiency is to recognize and enable the specific contribution of women to the urban economy.

e) Transparency and Accountability of decision-makers and all stakeholders

The accountability of local authorities to their citizens is a fundamental tenet of good governance. Similarly, there should be no place for corruption in cities. Corruption can undermine local government credibility and can deepen urban

poverty. Transparency and accountability are essential to stakeholder understanding of local government and to who is benefiting from decisions and actions. Access to information is fundamental to this understanding and to good governance. Laws and public policies should be applied in a transparent and predictable manner. Elected and appointed officials and other civil servant leaders need to set an example of high standards of professional and personal integrity. Citizen participation is a key element in promoting transparency and accountability.

f) Civic Engagement and Citizenship

People are the principal wealth of cities; they are both the object and the means of sustainable human development. Civic engagement implies that living together is not a passive exercise: in cities, people must actively contribute to the common good. Citizens, especially women, must be empowered to participate effectively in decision-making processes. The civic capital of the poor must be recognized and supported.

g) Security of individuals and their living environment

Every individual has the inalienable right to life, liberty and the security of person. Insecurity has a disproportionate impact in further marginalising poor communities. Cities must strive to avoid human conflicts and natural disasters by involving all stakeholders in crime and conflict prevention and disaster preparedness. Security also implies freedom from persecution, forced evictions and provides for security of tenure. Cities should also work with social mediation and conflict reduction agencies and encourage the cooperation between enforcement agencies and other social service providers (health, education and housing).

In Malaysia, the applied of quality of life concept has been applied in sustainable development concept. Sustainable development has been integrated into national development policies since the late 1970's and factors such as access to a quality of water supply have been a major success in Malaysia. More challenging

areas include implementation of national forestry management policies at state levels and environmentally acceptable and efficient expansion of energy generation capacity to meet expanding demand (Malaysia Development Goal, 2004).

The Malaysian government believes that economic growth is not an end in itself but a means to bring prosperity and better quality of life to all segments of society. In this respect, the principle of "growth with equity" has underlined all the national development efforts since the 1970s, which had contributed to a significant reduction in the incidence of poverty and a more equitable distribution of income (Development Planning in Malaysia, 2004).

In terms of the formation of sustainable urban indicators, Malaysia is based on the sustainable development and urban sustainability concept that is adopted in this country. This sustainability is condensed to sectoral sustainability where each has specific objectives and used as a reference to formation of indicators and indicator standards.

Since then, the sustainable concept comprehends various aspects in development, including;

i. Sustainable community
ii. Sustainable economic
iii. Sustainable social
iv. Sustainable culture
v. Sustainable agriculture
vi. Sustainable environment, and
vii. Sustainable urban

Table 1: The definition of sustainable development concept in Malaysia by Town and Country Planning Department, Malaysia

DEFINITION	OBJECTIVES
Sustainable Population	**Objective of Sustainable Population Indicator**
The total population within a settlement or a city is balance with the carrying capacity of the respective settlement or city from the aspect of infrastructure, facilities, economy and environment.	Towards achieving Vision 2020 with a quality of citizens that is harmonious, caring and formation of an ideal citizen.
Sustainable Housing	**Objective of Sustainable Housing Indicator**
To prepare adequate housing to handle population growth and the needs of all levels of society.	Housing development that prepares adequate, quality and affordable for citizens.
Sustainable Economy	**Objective of Sustainable Economy Indicator**
Enable an urban economic situation that is productive, stable and innovative in formulating a sustainable urban dynamism as a contributor of job opportunities.	To eradicate urban poverty, increase urban productivity and increase job opportunities to encourage perpetual urban growth.
Sustainable Utility and Infrastructure	**Objective of Sustainable Utility and Infrastructure Indicator**
Sustainable utility and infrastructure needs to be focused on water, electricity and telecommunication supply as compared to	Availability of infrastructure and utility supplies that is efficient and adequate to ensure the health and

demand, while minimizing the rate of wastage. For other utilities, which are solid waste disposal, sewerage and drainage, sustainability needs to be focused on a service level that ensures comfort, health and safety of residents.	well being of local residents.
Sustainable Public Facilities	**Objective of Sustainable Public Facilities Indicator**
Availability of adequate public and recreational facilities by the authorities need to be in line with population growth. This is to enable current and future residents will achieve a quality of life that is comfortable and healthy.	Preparation of adequate community and recreation facilities to achieve a population that is healthy and increase the quality of life.
Sustainable Environment	**Objective of Sustainable Environment Indicator**
Sustainable environment concept is based on the balance between development and environment. In other words, the economic development has to be encouraged but at the same time the environment has to be protected and conserved.	To ensure that physical development is balanced with environmental conservation because both of them are inter related and influence one another. Physical development without conservation will not ensure the quality of life that is hoped for.
Sustainable Sociology and Social Impact	**Objective of Sustainable Sociology and Social Impact Indicator**
Seen from the quality of life aspect	Indicators need to illustrate the

(peaceful, familial, safety, health and cleanliness - without pollution).	social characteristics of human life that is aimed for.
Sustainable Land Use	**Objective of Sustainable Land Use Indicator**
Land use that is planned and implemented by the Local Authority needs to consider the interests of all levels of society especially those marginalized. Issues such as housing accessibility and other social facilities are connected to land use planning that is supposed to be maximizing benefits and minimize costs.	To ensure a land use that is planned and implemented within the carrying capacity of the respective area.
Sustainable Urban and Heritage Design	**Objective of Sustainable Urban and Heritage Design**
Identification and usage of design and historical site characteristics to create an urban design that is suitable.	Inclusion of design elements within the design of the city that mirror local identity and image.
Sustainable Transportation	**Objective of Sustainable Transportation Indicator**
A transportation system where residents have access to work, commerce, recreation, culture and housing by utilizing minimum resources. **Sustainable transportation characteristics are safety, comfort and efficient from the aspect of economy and power usage while minimizing environmental pollution.**	To increase the usage level of public transportation, bicyclists, pedestrians and other non-motorized transportation while decreasing usage of motorized vehicles.

Sustainable Administration and Finance	Objective of Sustainable Administration and Finance Indicator
Sustainable Local Authority is an organization that can adjust and adapt for the long term.	Pro-active Local Authorities and have strong financial foundations with a high level of enforcement.

Source: Garis Panduan Penerapan Konsep Pembangunan Mampan Dalam Perancangan, October 2001

While, Research Triangle Institute (RTI) defined the sustainable urban as a metropolitan region which can emulate successfully at global level but still can preserved their culture and environment excellent.

Hence, the used of urban quality of life concept is corresponding with the sustainable concept that used in development planning. The applied of balancing sector in quality of life dimension and aspect can help to achieve fair and successful community.

As a conclusion, we have conclude that the urban quality of life is important to parallel with the sustainable development concept such mention before. Hence that, the mean of urban quality of life for this research is building better community environment with their lifestyle towards an enjoyable and better environment for future generation. Meaning that, the result of input/output decision making will be based on this urban quality of life understanding. However, the input/output result is still based on data availability.

2.4 URBAN QUALTIY OF LIFE INDICATORS

Many leading democracies around the world as well as major international institutions are involved in efforts to develop specialized and comprehensive indicator systems of societal performance (quality of life). Specialized indicator systems focus on specific topics or information areas, such as health, education, or children while comprehensive indicator systems focus on several information areas, generally within the broader categories of economic, social, and environmental arenas.

Several democracies, such as Canada and Australia, use comprehensive indicator systems and focus on information areas such as economic opportunities and innovation, the strength and safety of communities, national wealth, and national income. Within these information areas are indicators ranging from real national net wealth per capita and real disposable income per capita to life expectancy at birth and literacy.

Several states and communities within the United States, such as the State of Minnesota and the metropolitan area of Boston, also use comprehensive indicator systems. These indicator systems focus on information areas such as public safety, housing, and community and democracy and include indicators ranging from growth in gross state product and unemployment rate to volunteer time and prenatal care.

Comprehensive indicator systems have two primary characteristics;

a) Creating an overall picture of how a community (or region, nation, etc.) is doing.
b) Showing the interconnectedness of various key information areas, such as the interrelationship between economic development and environmental impact.

Through both these characteristics, a comprehensive indicator system allows for a deeper understanding of what is really happening in a society and significantly broadens the availability of that knowledge. Different entities take an individualized approach to grouping together key specialized information areas. For example, Australia's system includes biodiversity, crime, economic disadvantage and inequality, education and training, health, land, national income, national wealth, social attachment, water, and work.

We think our life is good when quality of life is high. Most of us, an ideal quality of life would measure a person's overall well-being, that is, an individual's total utility. An ideal index would depend upon things that money can buy. Traditional economic goods such as food and drink, shelter, clothing, transportation, and entertainment would be included among these things. Money income can be used as a metric to measure well being. The logic is straightforward. More money it minimizes our budget constraint and allows a person to purchase more things and achieve a higher level of utility.

However, quality of life is not about money only. An ideal would depend also upon social, environmental, and perceptual dimensions of well being. Moderate climate, fresh air, clean water, safe neighbourhoods, good schools, and good government would be included among these things. Furthermore, an ideal, holistic definition would depend on the way in which individuals and households combine marketed goods and services and environmental and community factors with their own time and energy to produce the things such as happy homes that give them utility directly and determine over well-being.

Based on ICLEI (1996), indicator is a measurement tool used effectively to evaluate an achievement of certain community or urban area. It describes how developed they are, increased or not, excellent or are they stick to their existing condition or maybe worst than before.

At the international level, especially the urban indicator project that was implemented by the UN Conference on Human Settlements (UNCHS 1996), UN Development Programmes's Human Development Reports (UNDP 1996), World Resources Institute (1994), Worldwatch Institute (Brown et. al.1997), World Bank (1996), and OECD (1994). For example, the Lancashire case where indicators were used comprehensively and it played various roles including administration and technical, formation of political objectives; public participation and also surveying action plan implementation.

Indicators are also accepted as a necessity for planning and enable the future to be more sustainable at the local and global level. For survey purposes, indicators have to be associated with its' objective. Data has to be easily obtainable and also easily prepared as structured information.

Generally, there are at a minimum, three broad purposes for indicator systems that are not mutually exclusive based on Forum on Key National Indicators in United States on 27 February 2003. These three purposes are as follows:

a) **Accelerate learning**: This type of indicator system contributes to scientific understanding as well as enhances the awareness, insight, and foresight provided to leadership and the public.
b) **Assess position and progress**: This type of indicator system involves a broad, constituent-focused aim and requires a generally accepted common vision and comprehensive framework that helps uncover especially challenging problems and beneficial opportunities.
c) **Measure performance**: This type of indicator system is specifically intended to determine to what degree institutions or projects are successful and are producing appropriate benefits for the resources they use.

Basically, the terms of urban quality on life indicators is based on HABITAT's indicator. It becomes a benchmarking tool for global urban areas to measure their achievements in urban development. The verity of indicators used are

based on this HABITAT's indicators which been complied with their urban and local environment. The reason is to make it easier for them to benchmark their urban strengths and weaknesses.

However, in Canada, based on a research done by Community-University Institute for Social Research (CUISR), they used various types of indicators to measure the urban neighborhood quality of life in Canada. But, urban indicators as generated by UNCHS (HABITAT) still remained the basic indicators used as the indicators are collected from various countries will be grouped within the Global Urban Indicator Database. In the research, they divided it into 9 main sectors with 56 indicators (**refer Table 2**). It was a holistic approach with summarize from different government departments and NGO's. It includes the Canada Mortgage and Housing Corporation (CMHC) and Federation of Canadian Municipalities (FCM).

In Malaysia, realizing how important the need for urban indicators, the Federal Department of Town and Country Planning Peninsular Malaysia has formulated 11 sectors with 55 Urban Indicators to measure the minimum quality of life standard that has to be achieved by each city in the country (**refer Table 2**). To simplify the usage of these indicators, a Malaysia Urban Indicators Network (MURNInet) application system has been produced.

MURNInet was created based on a computer network that was designed to analyze current urban conditions; effects of development, survey temporal change and formulate sustainable urban scenarios for the future based on fixed standards (Jabatan Perancangan Bandar dan Wilayah).

Table 2: Current Quality of Life Indicator

SECTOR	Urban Indictors Database, HABITAT (1993)	MURNInet, JPBD Malaysia (2003)	Community, University Institute for Social Research (2005)
SOCIAL	**1)** Population **2)** Annual population growth **3)** Tenure types **4)** Evictions **5)** Access to water **6)** Household connections **7)** Housing rights **8)** Under - five mortality **9)** Reported Crime rates **10)** Poor households **11)** Gross school enrolment ratios **12)** Urban violence **13)** Literacy **14)** Life expectancy at birth	**1)** Population Density. **2)** Average Population Growth Rate. **3)** Median Age. **4)** Average Household Size. **5)** Doctors and Population Ratio. **6)** Ratio of Public Open Space per 1,000 Populations. **7)** Primary Schoolchildren and Teacher Ratio. **8)** Kindergarten and Population Ratio. **9)** Civic Hall and Population Ratio. **10)** Percentage of the Population Involved In Community Program. **11)** The Quality Levels of Health Services. **12)** Ratio of Crime Index Case per 10,000	**1)** Population Growth **2)** Household & Family Compositions **3)** Average Income **4)** Renters & Owners **5)** Population Mobility **6)** Foreign Born **7)** New Immigrant Groups **8)** Language Spoken at Home **9)** Visible Minorities **10)** Aboriginal Population **11)** 30+ Income on Shelter **12)** 50%+ Income on Shelter **13)** Core Housing Need **14)** Substandard Unit **15)** Changing Face of Homelessness **16)** Vacancy Rates

	15) Urban violence	Populations. **13)** Ratio of Juvenal Case per 1,000 Populations. **14)** Ratio of Arrests Due to Social Ills per 1,000 Populations. **15)** Divorce Rate per 1,000 Marriages. **16)** Percentage of Public Bus Users. **17)** The Quality Level of Public Bus Services. **18)** Percentage of Single Occupancy Vehicle (SOV) Entering City Centre during Morning Peak Hour Period. **19)** Ratio of Road Accident Cases per 10,000 Populations. **20)** Percentage of Fatal Road Accident Cases.	**17)** Voter Turnout **18)** Women in Municipal Government **19)** Newspaper Circulation **20)** Volunteering **21)** Charitable Donations **22)** Education Levels **23)** Literacy Levels **24)** Adult Learning **25)** Education expenditures **26)** Classroom Size **27)** Student/Teacher Ratio **28)** Post-Secondary Tuition **29)** Spending on Private Education **30)** Youth Offenders **31)** Violent Crimes **32)** Property Crimes **33)** Injuries and Poisonings **34)** Low Birth Weight Babies **35)** Teen Births **36)** Premature Mortality **37)** Work Hours Lost

			38) Suicides **39)** Infant Mortality **40)** Social Housing Waiting Lists **41)** Rental-Geared-to-Income Housing **42)** Social Assistance Allowances **43)** Subsidized Child Care Spaces **44)** Public Transit Costs **45)** Social Services Professionals **46)** Lone Parent Family **47)** Incidence of Low Income Families **48)** Children Living in Poverty
ENVIRONMENT	**1)** Water Consumption **2)** Median water price **3)** Waste water treated **4)** Solid waste disposal **5)** Travel time **6)** Transport modes to work **7)** Disaster prevention & mitigation **8)** Local environmental plans	**1)** Urbanization Rate. **2)** Ratio of Floor Space Area per Person. **3)** Ratio of Housing Output per 1,000 Populations. **4)** Daily Water Consumption Rate of Every Population. **5)** Water Loss. **6)** Percentage of Flooding Prone Area. **7)** Average Garbage Collection per Day per	**1)** Air Quality **2)** Urban Transportation **3)** Population Density **4)** Water Consumption **5)** Wastewater Treatment **6)** Solid Waste **7)** Ecological Footprint **8)** Recreational Water Quality

		Population. **8)** Percentage of Residential Units Serviced by Centralized Sewerage. **9)** Ratio of Asthmatic Cases per 10,000 Populations. **10)** River Water Quality Index (WQI). **11)** Percentage of Area That Received Waste Disposal Services. **12)** Percentage of Solid Waste That Has Been Recycle. **13)** Number of Complaint Cases on Noise. **14)** Ratio of Water Bone and Food Diseases per 10,000 Populations. **15)** Air Quality Index. **16)** Percentage of Total Land Area for Public Facilities. **17)** Percentage of Residential Floor Space Area in City Centre.	

ECONOMIC	**1)** Land price to income ratios **2)** House price & rent **3)** Informal employment **4)** City product **5)** Unemployment **6)** Public-private partnership	**1)** Unemployment Rate. **2)** Employment Growth Rate. **3)** Labor Force Growth Rate. **4)** Poverty Rate. **5)** Income Distribution (Gini Coefficient). **6)** Housing Price and Income Ratio. **7)** Housing Rental and Income Ratio. **8)** Percentage of Tourism Attraction Area. **9)** Percentage of Financial Budget for Environmental Management. **10)** Percentage of Budget Allocation for Landscape Program. **11)** Percentage Expenditure on Maintenance of Heritage Elements and Urban Beautification. **12)** Percentage of Expenditure to Enhanced Accessibility System. **13)** Percentage of Administration Expenditure As Compared to Revenue.	**1)** Rental Housing Starts **2)** Monthly Rent **3)** Unemployment/Employment Rates **4)** Quality of Employment **5)** Long Term Unemployment **6)** Labor Force Replacement **7)** Business Bankruptcies **8)** Consumer Bankruptcies **9)** Hourly Wages **10)** Change in Family Income **11)** Building Permits **12)** Community Affordability **13)** Families Receiving EI/Social Assistance **14)** Economic Dependency Ratio **15)** Income Gap **16)** Private Health care Expenditures

		14) Local Authority per Capita Revenue. **15)** Tax Collection Rate. **16)** Cash Flow Ratio As Compared To Emoluments. **17)** Development Expenditure Per Capita.	
ADMINISTRATIVE	**1)** Decentralization **2)** Local government revenue & expenditures **3)** Citizens participation **4)** Transparency & accountability **5)** International cooperation	**1)** Ratio of Population per Professionals and Management Officers. **2)** Percentage of C.F.O Approvals.	

Source: 1- Urban Indicators Guidelines, HABITAT (1993)

2- MURNInet (version 2) Manual and Guidelines, JPBD (2003)

3- Community-University Institute for Social Research, CUISR (2005)

Based on table above, we can recognize which is the best quality of life indicator based on their quality and quantity. The most quantity indicators are easier to define rather than quality. It is because the quantity indicators are based on numbers of indicators its covering but for the most quality indicators there are a few things should be consider such as details of the indicators and how it was measured in terms of unit (example population density: is it measured by every 1000 population or every 10000 population).

However, as mentioned before, there are some countries come with comprehensive indicators and some with specific indicators. This issue occurred as the research boundary is not a constant value. There are indicators need comprehensive studies if it covers the entire country but if the study boundary covers an urban area the best indicators are covering specific indicators to present the condition of urban area.

2.5 METHODS OF INDICATOR MEASUREMENT

The quality of life approach usually categorized into two forms based on the subjective or objective form.

With the introduced of quantitative method and social indicator movement around 20-century, the **objective approach** has been used widely in quality of life study. This approach is a test to use in balanced the objective criteria and quantitative data in ensuring the individual value of quality of life. Most of the used are on statistic and census data and it was an approach with more advantages including the data availability and benchmarks between set. However, it was a method for indirect measurement and the outcomes is based on indicators interpretation.

While the **subjective approach** used the direct measurement happened to the human and their environment. Without the data availability, this approach needs more energy and effort in data collection on site.

A major difference between these two methods is objective indicator shows the materialistic life style while the subjective approach measures the individual life style perspectives. Hence the researchers have the own approach but most of them used the same basis of quality of life that is characteristic. And usually, the individual perspective and materialistic life style move correspondentially.

However, recently most of the researchers believed that both approach have their own strength and weaknesses. The integration both approach brings the completeness of quality of life measurement (Cobb, 2000).

2.6 DATA ENVELOPMENT ANALYSIS (DEA)

Data Envelopment Analysis (DEA) is a non-parametric approach that uses a linear programming technique (Charnes, Cooper, Lewin and Seiford, 1989). It is concerned with measuring the relative efficiency of a sample of producers, referred to as decision making units (DMU) (Charnes et al, 1989). It is a relatively new "data oriented" approach for evaluating the performance of a set of peer entities called Decision Making Units (DMUs) which convert multiple inputs into multiple outputs (Cooper, Lawrence and Zhu, 2004).

This section aims to illustrate the main concepts of DEA and how it can be used to identify efficient producers within a particular industry. The method was introduced by Charnes, Cooper and Rhodes (1978) based on frontier model by Farrell (1958). The main key of this method is optimizing of input to produce the

maximum outcome (output). The DEA defines the best practice frontier that serves as a benchmark and minimizes the relative distance to this benchmark.

DEA is about the flexibility in selecting data. Input and output can be in various types of variable whether continuous, ordinal or categorical variables. It can recognize the different variables including meter, dollar, hectare and etc. The terms of output can be defined in verity of means neither the output performance nor the quality of the performance. For efficiency, it comes in terms of efficiency evaluation, quality evaluation and the outcome.

Farrell (1958) introduced the concept of the best practice frontier, which delineates the technological limits of what a country can achieve with a given level of resources. The solid line in **figure 6** shows the best practice frontier computed by DEA in a situation in which two indicators are combined into one single performance index. Each dot in the diagram (A to D) stands for the performance of a country in the sample.

The DEA constructs an envelope for the observed indicator combinations of all countries in the sample under the constraint that all well-performing countries support the envelope. The frontier is called best practice frontier and allows us to classify countries into well performing units if they are at the frontier and into worse performing units if they lie below. A worse performing country could either augment the indicator number one or number two, or even both. The indicator of performance is then given by the relative distance between the actual observed performance and the nearest benchmark.

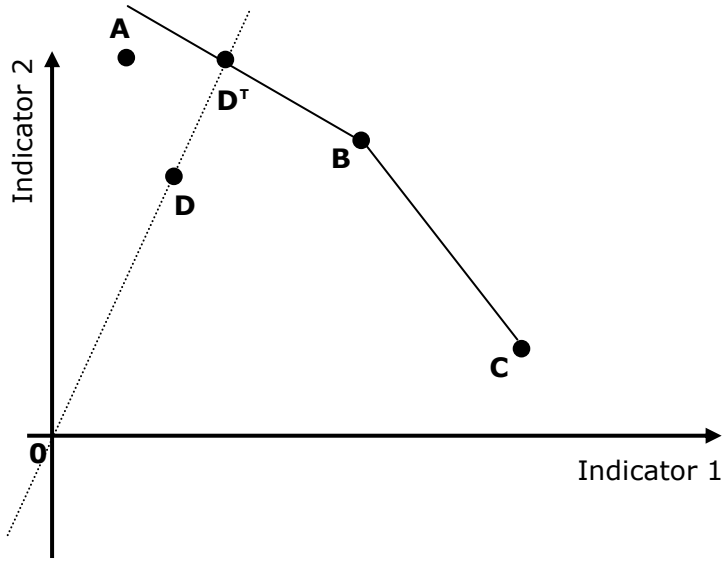


Figure 6: Determining the best performing countries with normal DEA

In f**igure 6**, three countries (A, B, and C) support the DEA — best practice frontier and are classified as best performing. Country D lies below the best practice frontier and is identified as worse performing. As a performance indicator we used the radial distance measure developed by Farrell (1957). It is defined as the ratio of the distance between the origin and the projected point of the examined country at the frontier divided by the distance between the origin and the actual observed point. For example, the performance of country D is $0D^T/0D$ (**figure 6**). The performance score for the best performing countries is 1 and for the worse performing countries it is larger than 1.

The case shown in **figure 6** is the aggregation of two indicators with the aid of an index-maximizing DEA. An index-maximizing DEA seeks to compute economic performance as a proportional augmentation in all indicators. The index-maximizing approach is applied if the scores of all indicators are preferred to be as high as possible (e.g., GDP, literacy rate, etc.).

The computation of the envelope and the development index can be reduced to a linear program for each individual country in which the following optimization problem is solved:

$$\min \sum_i v_i x_{i0} = Z_0$$

$$\text{s.t.} \quad \sum_r \mu_j y_{r0} = 1$$

$$-\sum_r \mu_r y_{rj} + \sum_i v_i x_{ij} \geq 0 \qquad \textit{(for each of the N countries)}$$

$$v_i \geq \varepsilon, \qquad \mu_r \geq \varepsilon$$

where

Z_O ... performance score,

ε ... non-archimedean variable ($\varepsilon = 10^{-8}$),[5]

x_{ij} ... i-th resource of the j-th country, $i = 1,..., m$, m ... number of resources, $m = 1$,

y_{rj} ... r-th indicator of the j-th country, $r = 1,..., s$, s ... number of indicators, $s = 4$,

$j = 1,..., N$, N ... number of countries, $N = 174$,

v_i ... weight of the i-th resource,

μ_r ... weight of the r-th indicator.

Source: Linear program was developed by Charnes et al. (1978).

This procedure computes the performance score Z_o of a single country that is equal to the weighted sum of the four indicators and must be repeated for each country in the sample. Because we combine the four indicators of the HDI, the resource side consists of the unity vector. The model computes the weights so that the country under instigation is ranked as best as possible. Every weight of individual indicators can lie between 0 and 1 and the sum of all weights must be equal to 1. The weights can differ from country to country in contrast to the standard definition of the HDI, where the weights are equal for all countries.

2.6.1 Models In DEA

Built upon the earlier work of Farrell (1957), DEA is a well established methodology to evaluate the relative efficiencies of a set of comparable entities by some specific mathematical programming models. These entities, often called decision making units (DMUs), perform the same function by transforming multiple inputs into multiple outputs. A main advantage of DEA is that it does not require any prior assumptions on the underlying functional relationships between inputs and outputs (Seiford and Thrall, 1990). It is therefore a nonparametric approach. In addition, DEA is a data-driven frontier analysis technique that floats a piecewise linear surface to rest on top of the empirical observations (Cooper et al., 2004).

As a body of concepts and methodologies that have now been incorporated in a collection of models with accompanying interpretative possibilities as follows (Cooper et al., 2004):

a) The CCR Ratio Model

Since the work by Charnes et al. (1978), DEA has rapidly grown into an exciting and fruitful field, in which Operations Research and Management Science (OR/MS) researchers, economists, and experts from various application areas have played their respective roles (Forsund and Sarafoglou, 2002, 2005). For comprehensive DEA expositions it was explained in publication by Cooper et al. (2006).

As an example, assume that there are K DMUs, e.g. electricity distribution utilities, to be evaluated that covert N inputs to M outputs. Further assume that DMUk consumes $x_{nk} \geq 0$ of input N to produce $y_{mk} \geq 0$ of output M and each DMU has at least one positive input and one positive output (Farell et al., 1994b; Cooper et al., 2004). Based on the efficiency concept in engineering, the efficiency of a DMU, says DMUo (0 = 1; 2; . . . ; K) can be estimated by the ratio of its virtual output

(weighted combination of outputs) to its virtual input (weighted combination of inputs).

To avoid bias in assigning the weights for inputs and outputs, Charnes et al. (1978) developed an optimization model known as the CCR in ratio form to determine the optimal weights for DMUo by maximizing its ratio of virtual output to virtual input while keeping the ratios for all the DMUs not more than one. This problem can be further transformed into an equivalent ‘‘output maximization’’ linear programming problem as follows:

$$
\begin{aligned}
\max \quad & \sum_{m=1}^{M} u_m y_{mo} \\
\text{s.t.} \quad & \sum_{m=1}^{M} u_m y_{mk} - \sum_{n=1}^{N} v_n x_{nk} \leqslant 0, \\
& \quad k = 1, 2, \ldots, K, \\
& \sum_{n=1}^{N} v_n x_{no} = 1, \\
& u_m, \quad v_n \geqslant 0, \quad m = 1, 2, \ldots, M; \\
& \quad n = 1, 2, \ldots, N.
\end{aligned}
\tag{1}
$$

Model (1) is known as the **CCR in multiplier form**. The efficiency scores of DMU1 to DMUK can be derived by solving K such models.

Despite the linear form of (1), efficiency score is usually calculated based on its dual problem:

$$
\begin{aligned}
\min \quad & \theta \\
\text{s.t.} \quad & \sum_{n=1}^{N} x_{nk}\lambda_k \leqslant \theta x_{no}, \quad n = 1, 2, \ldots, N, \\
& \sum_{m=1}^{M} y_{mk}\lambda_k \geqslant y_{mo}, \quad m = 1, 2, \ldots, M, \\
& \lambda_k \geqslant 0, \quad k = 1, \ldots, K.
\end{aligned} \tag{2}
$$

Model (2) is known as the **input-oriented CCR** in envelopment form (or the Farrell model), which attempts to proportionally contract DMUo's inputs as much as possible while not decreasing its current level of outputs. In economic literature, model (2) may date back to the activity analysis models introduced by Von Neumann (1945) and Koopmans (1951).

It has also a close relationship with the input distance function introduced by Shephard (1970). In a similar way, we can also derive the output-oriented CCR in envelopment form if efficiency is initially specified as the ratio of virtual input to virtual output. Note that the constraint set in model (2) is nicely corresponding to the piecewise linear production technology that exhibits constant returns to scale (CRS) and has strong disposable inputs and outputs:

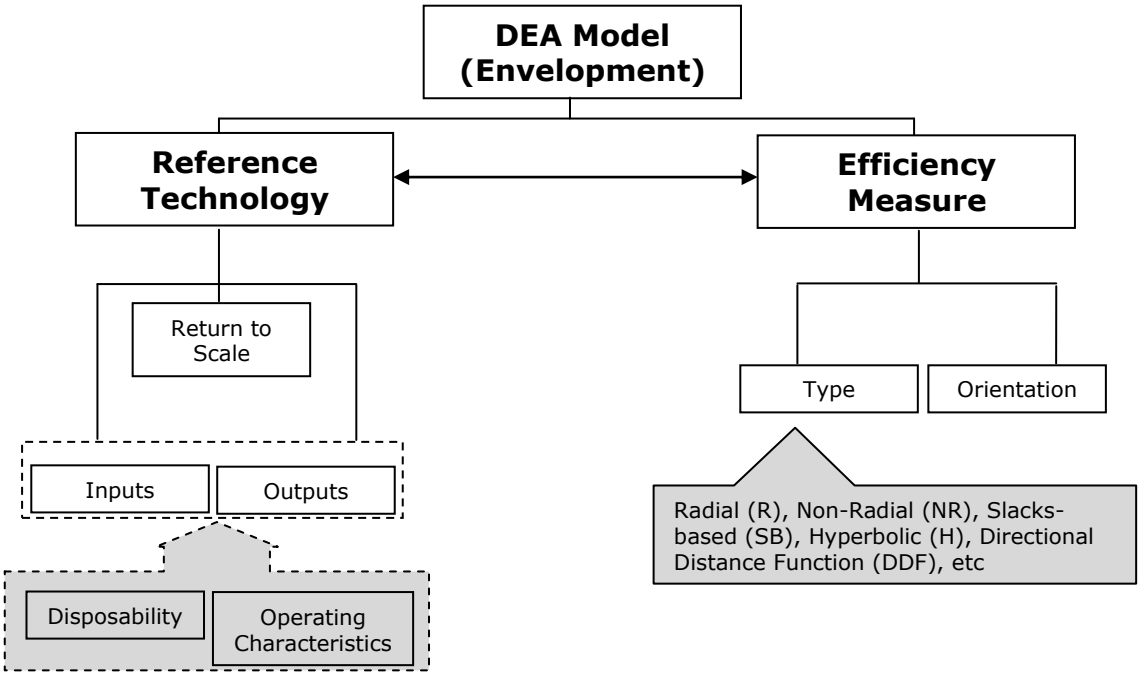
$$
\begin{aligned}
T = \Bigg\{ (\mathbf{x}, \mathbf{y}) : & \sum_{k=1}^{K} z_k x_{nk} \leqslant x_n, \quad n = 1, 2, \ldots, N, \\
& \sum_{k=1}^{K} z_k y_{mk} \geqslant y_m, \quad m = 1, 2, \ldots, M, \\
& z_k \geqslant 0, \quad k = 1, 2, \ldots, K \Bigg\},
\end{aligned} \tag{3}
$$

Where x = (x_1, x_2 . . . xn) and y = (y_1, y_2 . . . y_m) are respectively the vectors of inputs and outputs. Here we call T the reference technology that consists of all the feasible combinations of inputs and outputs.

According to (2) and (3), we may break a DEA model down into two parts: the efficiency measure and the reference technology. A DEA model is fully characterized by its reference technology and efficiency measure.

Furthermore, the reference technology can be characterized by the type of returns to scale (RTS), and the disposability and operating characteristics of inputs and outputs. The efficiency measure will be determined by its type and orientation.

Figure 7 shows the general structure of a DEA model as well as the most widely used efficiency measures energy and environmental studies.



Source: Zhou, P. et al (A survey of data envelopment analysis in energy, 2006)

Figure 7: The general structure of a DEA model (envelopment form)

b) The BCC Model (1984)

The CCR model assumes constant returns to scale while determining the efficiency of the DMUs. Banker, Charnes and Cooper (1984) modified the CCR model by adding a constraint to account for the variable returns to scale. The difference between the two models is illustrated by **figure 8.**

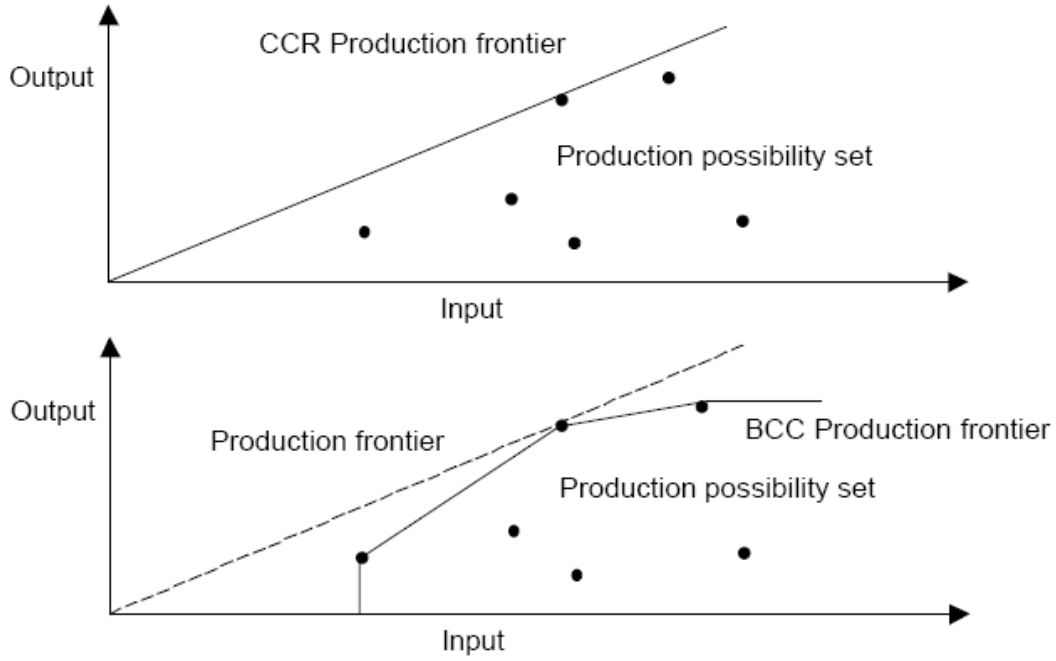


Figure 8: The difference of CCR and BCC models

The envelopment form of the BCC model would be the same as the dual for the CCR model but with an additional constraint,

$$e\lambda = \sum_{j=1}^{n} \lambda_j = 1$$

c) The Multiplicative models (Charnes et al. 1982, 1983)

A Log-linear envelopment or a picewise Cobb-Douglas interpretation of the production process (by reduction to the antecedent 1981 additive model of Charnes, Cooper and Seiford)

d) The Additive model (as better rendered in Charnes et al. 1985 and the extended Additive model (Charbes et al. 1987)

Relate DEA to the earlier Charnes-Cooper (1959) inefficiency analysis and in the process. It also relate the efficiency results to the economic concept of Pareto optimality as interpreted in the still earlier work of T. Koopmans (1949) in the volume that published the proceedings of the first conference on linear programming. This is also the work of Farell (1957) cites as the source of his (activity analysis) characterizations.

2.6.2 Input And Output

In DEA method, input and output variables played the main role in conducting a quality measurement. By identifying the right input and output for certain unit can affects the results of the research. For DEA, input is recognized as variables which come from the unit. As example is human resources such as number of staff, amount of asset and etc. While for output is variables come from activities worked of the unit. As example is number of transactions done by bank,

EFFICIENCY = OUTPUT/INPUT

The bigger output and smaller input of a unit it will produced the most efficient outcomes. This is the basic rule of DEA in measuring quality of certain unit.

In Assessment & Clinical Services Performance Handbook (2001), it defined the inputs and outputs as below;

i. **Inputs** include resources dedicated to, or consumed by, the program. Examples are money, staff and staff time, volunteers and volunteer time, facilities, equipment, and supplies. For instance, inputs for a parent education class include the hours of staff time spent designing and delivering the program. Inputs also include constraints on the program, such as laws, regulations, and requirements for receipt of funding.

ii. **Outputs** are the direct products of program activities and usually are measured in terms of the volume of work accomplished - for example, the numbers of classes taught, counseling sessions conducted, educational materials distributed, and participants served. Outputs have little inherent value in themselves. They are important because they are intended to lead to a desired benefit for participants or target populations.

Example in benchmarking a group of bank in optimizing used of their staff and modal asset in generating income activities such as loan, financial product selling and working with client transactions. The evaluation of efficiency for this case by using DEA method is the capability in controlling existing resources without depending on the final outcomes. In other words is the capability in optimizing existing resources without additional resources.

2.7 STRENGHTS AND WEAKNESSESS OF DEA

Such other methods, DEA also has own strengths and weaknesses. Below it describes overall strengths and weaknesses for DEA method.

2.7.1 Strengths

DEA is technically straight-forward to grasp. Consequently, policy-makers and advisors can understand the operation and output of a DEA analysis. In addition, a number of software applications, predominantly Frontier Analyst and DEA-Solver, provide a user-friendly approach to the operation and conducting of a DEA model. From an advisory point of view, within a sample a farm can be allocated a score and the input reduction needed for a farm to achieve technical efficiency can be obtained. Hence, the identification of inefficient resource use, along with cost minimization, would hopefully lead to improved competitiveness within the agricultural sector.

From a technical point of view, it is non-parametric technique, thus no implicit functional form is required to be imposed on the technology of that particular industry. Similarly, it can measure inefficiencies caused through an inappropriate mix of inputs or through an inappropriate scale.

Other benefits of DEA are:

a) No need to explicitly specify a mathematical form for the production function
b) Proven to be useful in uncovering relationships that remain hidden for other methodologies
c) Capable of handling multiple inputs and outputs

d) Capable of being used with any input-output measurement
e) The sources of inefficiency can be analyzed and quantified for every evaluated unit

2.7.2 Weaknesses

The major weakness of DEA is that it doesn't take account of weather or disease. Hence studies have to be based at a regional level. This will affect sample size and may constrain studies in smaller sectors, which may be evenly spread across the country. This is more demanding but can take account of these regional elements.

The same characteristics that make DEA a powerful tool can also create problems. An analyst should keep these limitations in mind when choosing whether or not to use DEA.

a) Since DEA is an extreme point technique, noise (even symmetrical noise with zero mean) such as measurement error can cause significant problems.
b) DEA is good at estimating "relative" efficiency of a DMU but it converges very slowly to "absolute" efficiency. In other words, it can tell how well the analysis doing compared to the peers but not compared to a "theoretical maximum."
c) Since DEA is a nonparametric technique, statistical hypothesis tests are difficult and are the focus of ongoing research.
d) Since a standard formulation of DEA creates a separate linear program for each DMU, large problems can be computationally intensive.

2.8 CONCLUSION

As conclusion, DEA is a new approach that tried to be used in this country. The application has been recognized by developed countries in measuring the relative efficiency for DMUs. The used of index method along this time in measuring the urban quality of life is an important element to benchmark and identify with the DEA method in defining the urban quality of life for this country. As the orientation of DEA on deriving the best-practice frontier and optimizing the individual DMU affords new ways of organizing and analyzing data and can result in new managerial and theoretical insights. The DEA should be noted that its calculation (Abraham Charnes, William W.Cooper, Arie Y. Lewin and Lawrence M. Seiford; 2000):

a) Focus on individual observations in contrast to population averages;
b) Produce a single aggregate measure for each DMU in terms of its utilization of input factors (independent variables) to produce desired outputs (dependent variables);
c) Can simultaneously utilize multiple outputs and multiple inputs with each being stated in different units of measurement;
d) Can adjust for exogenous variables;
e) Can incorporate categorical (dummy) variables;
f) Are value free and do not require specification on knowledge of a priori weights or prices for the inputs or outputs;
g) Place no restriction on the functional form of the production relationship;
h) Can accommodate judgment when desired;
i) Produce specific estimates for desired changes in inputs and/or outputs for projecting DMUs below the efficient frontier onto the efficient frontier;
j) Are Pareto optimal;
k) Focus on revealed best-practice frontiers rather than on central-tendency properties of frontiers;
l) Satisfy strict equity criteria in the relative evaluation of each DMU

The used of urban quality of life indicators become an important element to benchmark the current method. After considered the time frame and based on local environment and the availability of data for analysis below are the selected urban quality of life indicators for this research. Most of the indicators are based on the existing local indicators (MURNInet) as we tried to practice local environments. It also helps in data collection as we based on availability of data at selected local authorities.

Table 3: Research Indicators of Urban Quality of Life

SECTOR	INDICATOR
Demography	1. Urbanization Rate. 2. Population Density. 3. Average Population Growth Rate. 4. Average Household Size.
Housing	5. Ratio of Floor Space Area per Person. 6. Ratio of Housing Output per 1,000 Populations.
Urban Economic	7. Unemployment Rate. 8. Poverty Rate.
Utility and Infrastructure	9. Daily Water Consumption Rate of Every Population. 10. Water Loss. 11. Percentage of Flooding Prone Area. 12. Average Garbage Collection per Day per Population. 13. Percentage of Residential Units Serviced by Centralized Sewerage.
Public Facilities and Recreational	14. Doctors and Population Ratio. 15. Ratio of Public Open Space per 1,000 Populations. 16. Primary Schoolchildren and Teacher Ratio. 17. Kindergarten and Population Ratio. 18. Civic Hall and Population Ratio.
Environment	19. Percentage of Financial Budget for Environmental

		Management.
	20.	River Water Quality Index (WQI).
	21.	Percentage of Area That Received Waste Disposal Services.
	22.	Number of Complaint Cases on Noise.
	23.	Ratio of Water Bone and Food Diseases per 10,000 Populations.
	24.	Air Quality Index.
Sociology	25.	Ratio of Crime Index Case per 10,000 Populations.
	26.	Ratio of Juvenal Case per 1,000 Populations.
	27.	Ratio of Arrests Due to Social Ills per 1,000 Populations.
	28.	Divorce Rate per 1,000 Marriages.
Land use	29.	Percentage of C.F.O Approvals.
Urban design and Heritage	30.	Percentage Expenditure on Maintenance of Heritage Elements and Urban Beautification.
Transportation	31.	Ratio of Road Accident Cases per 10,000 Populations.
	32.	Percentage of Fatal Road Accident Cases.
Governance	33.	Local Authority per Capita Revenue.
	34.	Tax Collection Rate.
	35.	Cash Flow Ratio As Compared To Emoluments.
	36.	Development Expenditure Per Capita.
	37.	Ratio of Population per Professionals and Management Officers.
	38.	Percentage of Administration Expenditure As Compared to Revenue.

CHAPTER 3

CASE STUDY:
URBAN QUALITY OF LIFE FOR SELECTED CITIES

4.1 INTRODUCTION

For this research, 4 cities have been selected as mentioned early in the first chapter of this report. Those cities are under these local authorities which are Majlis Bandaraya Johor Bahru (MBJB), Majlis Bandaraya Pulau Pinang (MBPP), Majlis Bandaraya Melaka Bersejarah (MBMB) and Majlis Perbandaran Kuantan (MPK). This chapter has been divided into three main sections; the introduction, preview of quality of life index for selected cities and the conclusion. This is the important chapter as a data preview before the next chapter where analysis and recommendation will be done.

4.2 URBAN QUALITY OF LIFE INDEX

The urban quality of life indicators are divided into 11 major sections such as below (*for detail descriptions about each indicator refer to* ***Appendix I***);

3.2.1 Demography

Table 4 shows that Johor Bahru is the rapid development city with 85.78% urbanization rate and at the same time has the highest average population growth with 3.16. However, George Town is the highest density city with 22.28 people per hectare but has the lowest average population growth with 1.74. And it shows that, MPPP is controlling its population growth to optimize its density as the area is smaller than Johor Bahru and Kuantan.

For Melaka, it has the slowest urbanization rate with 16.29% but at the same time has average household size with 4.28 people per household. This shows that MBMB still manage to control its development although the household size is relatively high compare with the other cities. While Kuantan is the lowest population density with 1.91 people per hectare but at the same time has the highest average household size with 4.33. It shows that MPK has the less space per capita among the others although it has more land to develop to manage this issue.

Table 4: Demography Indicators

No.	Indicator	Johor Bahru	Kuantan	George Town	Melaka
1	Urbanization Rate	85.78	77.41	44.24	16.29
2	Population Density	21.94	1.91	22.28	14.18
3	Average Population Growth Rate	3.16	2.26	1.74	1.92
4	Average Household Size	4.06	4.33	4.26	4.28

Source: a) Laporan Petunjuk Bandar Kuantan, 2005

b) Laporan Petunjuk Bandar Melaka, 2005

c) Laporan Petunjuk Bandar George Town, 2005

d) Laporan Petunjuk Bandar Johor Bahru, 2005

c) Website MURNInet (http://rsj.townplan.gov.my/MURNINet)

3.2.2 Housing

In housing sector, table 5 shows that Johor Bahru has the highest residential floor area to population ratio of 91.78 m^2/person and percentage of housing stock unsold of 17.69%. Meanwhile, George Town residential floor area to population ratio is 64.20 m^2/person and with the lowest percentage of housing stock unsold with 0.22%.

This shows that, the rapid development activities influenced the residential floor area to population ratio and percentage of housing stock unsold on that city. It shows that when the residential floor area to population ratio increases, it will increase the comfortable of community living. When this happens there will be big booms in housing sector in Johor Bahru.

Table 5 : Housing Indicators

No.	Indicator	Johor Bahru	Kuantan	George Town	Melaka
1	Residential Floor Area to Population Ratio	91.78	22.70	64.20	20.38
2	Percentage of Housing Stock Unsold	17.69	1.60	0.22	0.98

Source: a) Laporan Petunjuk Bandar Kuantan, 2005

b) Laporan Petunjuk Bandar Melaka, 2005

c) Laporan Petunjuk Bandar George Town, 2005

d) Laporan Petunjuk Bandar Johor Bahru, 2005

c) Website MURNInet (http://rsj.townplan.gov.my/MURNINet)

3.2.3 Economic

In economic sector, Kuantan has the highest unemployment rate with 2.04 but at the same time is the lowest poverty rate with 0.24. However, Johor Bahru, Melaka and George Town are almost there with 1.80 and 1.83 for unemployment rate and 0.02, 0.01 and 0.00 for poverty rate.

It shows that unemployment rate for study areas are still at the low level and urban poverty problem is not serious in the study area.

Table 6: Economic Indicators

No.	Indicator	Johor Bahru	Kuantan	George Town	Melaka
1	Unemployment Rate	1.80	2.04	1.83	1.53
2	Poverty Rate	0.02	0.24	0.01	0.01

Source: a) Laporan Petunjuk Bandar Kuantan, 2005

b) Laporan Petunjuk Bandar Melaka, 2005

c) Laporan Petunjuk Bandar George Town, 2005

d) Laporan Petunjuk Bandar Johor Bahru, 2005

c) Website MURNInet (http://rsj.townplan.gov.my/MURNINet)

3.2.4 Utilities and Infrastructure

In utilities and infrastructure sector, table below shows that for daily water consumption rate per person, Kuantan indicates the lowest with 89.0 while George Town is the highest daily water consumption with 286.65.

However, for water loss rate Kuantan indicates the highest rate with 50.07 while George Town is the lowest water loss rate with 17.73. For Johor Bahru and Kuantan, both indicate 23.08 and 26.45.

Both conservation cities, Melaka and George Town are the highest city for flood prone area development rate with 100.00%. For Johor Bahru, it indicates the lowest with 0.59% and Kuantan with 49.91%.

Average daily garbage collection per person shows that George Town is the highest with 0.98 while Melaka is the lowest with 0.11. Johor Bahru and Kuantan indicate 0.56 and 0.60.

For percentage of residential units serviced by centralized sewerage, George Town has the highest with 85.0% of its housing area while Kuantan is the lowest with 32.64% only. For Johor Bahru and Melaka, both have more than half percent that are 63.245 and 66.45%.

In terms of utilities and infrastructure services shows that George Town is the best city while Kuantan is the poorest. For Johor Bahru and Melaka, both at the moderate level for their public utilities and infrastructure services.

Table 7: Utilities and Infrastructure Indicators

No.	Indicator	Johor Bahru	Kuantan	George Town	Melaka
1	Daily Water Consumption Rate Per Person	277.72	89.0	286.65	227.25
2	Water Loss Rate	23.08	50.07	17.73	26.45
3	Flood-Prone Area Development Rate (%)	0.59	49.91	100.00	100.00
4	Average Daily Garbage	0.56	0.60	0.98	0.11

	Collection Per Person				
5	Percentage of Residential Units Serviced by Centralized Sewerage	63.64	32.64	85.00	66.45

Source: a) Laporan Petunjuk Bandar Kuantan, 2005

b) Laporan Petunjuk Bandar Melaka, 2005

c) Laporan Petunjuk Bandar George Town, 2005

d) Laporan Petunjuk Bandar Johor Bahru, 2005

c) Website MURNInet (http://rsj.townplan.gov.my/MURNINet)

3.2.5 Public Facilities and Recreational

Table below shows the public facilities and recreational sector. Doctor to population ratio indicator shows that, Johor Bahru and George Town are best city with a doctor service for 1,581 people. Meanwhile Kuantan has the highest population to a doctor with ratio of 3,315.13.

For public open space to population ratio indicator, Melaka city has the highest ratio with 8.11 while George Town is the lowest ratio with 0.25. Meanwhile Johor Bahru and Kuantan, both indicate with 1.24 and 1.72.

A teacher to primary school children indicator shows that Kuantan is the best city with 17.14 while George Town is the poor with 20.69. Meanwhile both Johor Bahru and Melaka are with 17.50.

For kindergarten to population ratio indicator, Melaka has the best value with 2,136.63 people to a kindergarten while George Town is the poor with 22,250 people

to a kindergarten. However, both Johor Bahru and Kuantan are almost around Melaka with 2,182.96 and 2,144.02.

Meanwhile for civic hall tom population ratio indicator shows that Melaka city also is the best city with 10,276.19 people to a civic hall while George Town is the poor with 66,750.00.

This shows that, Melaka indicates the best city for its public facilities and recreational services than other cities. However Johor Bahru and Kuantan still have the opportunity to serve their community as it has more space and land to develop rather than Melaka and George Town.

Table 8: Public Facilities and Recreational Indicators

No.	Indicator	Johor Bahru	Kuantan	George Town	Melaka
1	Doctor to Population Ratio	1,580.77	3,315.13	1,581.75	2,877.33
2	Public Open Space to Population Ratio	1.24	1.72	0.25	8.11
3	Primary School children to Teacher Ratio	17.50	17.14	20.69	17.46
4	Kindergarten to Population Ratio	2,182.96	2,144.02	22,250.00	2,136.63
5	Civic Hall to Population Ratio	30,561.47	15,780.00	66,750.00	10,276.19

Source: a) Laporan Petunjuk Bandar Kuantan, 2005

b) Laporan Petunjuk Bandar Melaka, 2005

c) Laporan Petunjuk Bandar George Town, 2005

d) Laporan Petunjuk Bandar Johor Bahru, 2005

c) Website MURNInet (http://rsj.townplan.gov.my/MURNINet)

3.2.6 Environment

Table below shows the environment indicators. It indicates that Melaka city is the highest city spending their budget for landscape program with 85.06%. It follows by George Town with 6.57%, Johor Bahru with 5.99% and Kuantan with 1.57%.

For river water quality index, Kuantan scores the highest (clean) with79.55 and follows by Melaka with 73.50, Johor Bahru 62.00 and George Town with 45.00.

For percentage of area that received waste disposal services indicator, it indicates that George Town and Melaka almost covered 100% with 99.00% and 95.86% each. While for Johor Bahru and Kuantan, both score 65.12% and 15.74%.

Number of complaint cases on noise indicators indicates that George Town has the highest report with 102 cases, Kuantan with 23 cases, Johor Bahru with 13 cases and Melaka with 8 cases only. However there is still lot to be done to archive below 5 cases especially at developed area such as George Town and Johor Bahru.

For water borne and through food diseases to population ratio, it indicates that Kuantan has the highest number of cases ratio with 9.84, Melaka with 2.27 cases, George Town with 1.48 cases and Johor Bahru with 1.24 cases.

For air pollution index indicator, it indicates that Kuantan, George Town and Melaka score lower standard targets of 50 with 35.42, 38.00 and 39.50 each. However, Johor Bahru scores 56.00 higher than standard targets of 50 but it still managed lower than 100 as moderate level.

Table 9: Environment Indicators

No.	Indicator	Johor Bahru	Kuantan	George Town	Melaka
1	Percentage of Budget Allocation for Landscape Program	5.99	1.57	6.57	85.06
2	River Water Quality Index (WQI)	62.00	79.55	45.00	73.50
3	Percentage of Area that Received Waste Disposal Services	65.12	15.74	99.00	95.86
4	Number of Complaint Cases on Noise	13	23	102	8
5	Water Borne and Through Food Diseases to Population Ratio	1.24	9.84	1.48	2.27
6	Air Pollution Index	56.00	35.42	38.00	39.50

Source: a) Laporan Petunjuk Bandar Kuantan, 2005

b) Laporan Petunjuk Bandar Melaka, 2005

c) Laporan Petunjuk Bandar George Town, 2005

d) Laporan Petunjuk Bandar Johor Bahru, 2005

c) Website MURNInet (http://rsj.townplan.gov.my/MURNINet)

3.2.7 Social

Table below shows the social indicators value. For crime index cases to population ratio, Kuantan is the lowest crime index cases city with 53.56 and follows

by Melaka city with 59.80, George Town with 90.83 and Johor Bahru 138.06 (the highest).

While for juvenile cases to population ratio, George Town is the highest juvenile cases with 2.17 and follows by Kuantan with 1.19, Melaka with 0.51 and Johor Bahru with 0.48.

For social problem cases, the table indicates that Johor Bahru is the highest city of social problem cases with 5.58 and follows by Kuantan with 0.39, George Town with 0.28 and Melaka with 0.11.

However, divorce rate per 1,000 households table indicates that George Town scores the highest city with divorce rate with 7.62 and follows by Melaka with 5.26, Johor Bahru with 3.32 and George Town with 3.09.

Table 10: Social Indicators

No.	Indicator	Johor Bahru	Kuantan	George Town	Melaka
1	Crime Index Cases to Population Ratio	138.06	53.56	90.83	59.80
2	Juvenile Cases to Population Ratio	0.48	1.19	2.17	0.51
3	Social Problems Cases to Population Ratio	5.58	0.39	0.29	0.11
4	Divorce Rate Per 1,000 Households	3.32	3.09	7.62	5.26

Source: a) Laporan Petunjuk Bandar Kuantan, 2005

b) Laporan Petunjuk Bandar Melaka, 2005

c) Laporan Petunjuk Bandar George Town, 2005

d) Laporan Petunjuk Bandar Johor Bahru, 2005

c) Website MURNInet (http://rsj.townplan.gov.my/MURNINet)

3.2.8 Land Use

Table 11 below shows the land use indicators value that is for percentage of C.F.O approved in a year. It indicates that only George Town does not approved 100% of their C.F.O in a year with 73.33% only. While other cities achieved 100% C.F.O approved.

Table 11: Land Use Indicator

No.	Indicator	Johor Bahru	Kuantan	George Town	Melaka
1	Percentage of C.F.O. Approved	100.00	100.00	73.33	100.00

Source: a) Laporan Petunjuk Bandar Kuantan, 2005

b) Laporan Petunjuk Bandar Melaka, 2005

c) Laporan Petunjuk Bandar George Town, 2005

d) Laporan Petunjuk Bandar Johor Bahru, 2005

c) Website MURNInet (http://rsj.townplan.gov.my/MURNINet)

3.2.9 Urban Design and Heritage

For urban design and heritage, it only has one indicator that is percentage of maintenance and beautification expenditure on tourism attraction area. The table below shows that George Town has accommodated 25.09% of its annual expenditure for this indicator. It follows by Melaka with 9.17%, Kuantan with 2.91% and Johor Bahru with 0.82.

Table 12: Urban Design and Heritage Indicator

No.	Indicator	Johor Bahru	Kuantan	George Town	Melaka
1	Percentage of Maintenance and Beautification Expenditure on Tourism Attraction Area	0.82	2.91	25.09	9.17

Source: a) Laporan Petunjuk Bandar Kuantan, 2005

b) Laporan Petunjuk Bandar Melaka, 2005

c) Laporan Petunjuk Bandar George Town, 2005

d) Laporan Petunjuk Bandar Johor Bahru, 2005

c) Website MURNInet (http://rsj.townplan.gov.my/MURNINet)

3.2.10 Transportation and Accessibility

Table below shows the transportation and accessibility indicators. There are two indicators only that are road accident cases and percentage of fatal road accident cases. The table indicates that George Town scores the highest road accident cases to population ratio with 244.82 and follows by Melaka with 184.75, Kuantan with 148.57 and Johor Bahru with 138.43.

While for percentage of fatal road accident cases indicator, it indicates that Kuantan score the highest value with 2.08% and follows by Melaka with 1.64%, Johor Bahru with 1.13% and Kuantan with 0.85%.

Table 13: Transportation and Accessibility Indicators

No.	Indicator	Johor Bahru	Kuantan	George Town	Melaka
1	Road Accident Cases to Population Ratio	138.43	148.57	244.82	184.75
2	Percentage of Fatal Road Accident Cases	1.13	2.08	0.85	1.64

Source: a) Laporan Petunjuk Bandar Kuantan, 2005
b) Laporan Petunjuk Bandar Melaka, 2005
c) Laporan Petunjuk Bandar George Town, 2005
d) Laporan Petunjuk Bandar Johor Bahru, 2005
c) Website MURNInet (http://rsj.townplan.gov.my/MURNINet)

3.2.11 Financial Management

Table below shows the financial management indicators. For local authority per capita revenue, it indicates that Melaka gained 244.78 and follows by Johor Bahru with 224.63, George Town with 221.78 and Kuantan with 151.68.

For tax collection rate indicator, both Melaka and George Town score 100% tax collection at year 2005. However Johor Bahru and Kuantan only score 85.50 and 85.96 each.

While for cash flow to emoluments ration, only George Town manage to archive 3 and above with 3.98 while other cities are lower than that where Melaka with 1.07, Kuantan with 0.17 and Johor Bahru with 0. It shows that total monetary reserves for most local authorities are almost same with their emoluments expenditure.

For development expenditure per capita indicator shows that local authorities spend average around RM 50 per capita. But Kuantan only manage to spend about RM 5 per capita. It shows that there are still much to be done to achieve more than RM 100 for each local authority for their community satisfaction in development.

In professionals and management officers to population ratio indicator, it shows that average around 10,000 people to 13,000 people per officer for each local authority except Melaka with 20,552.38 people per officer. This shows that average local authority manage to cover their officer services to become more productive and manageable officer.

While for percentage of operating expenditure as compared to revenue indicator, it shows that only Melaka manage to be lower than 80 and Johor Bahru is still around that with 85.78. However there are still much to be done for Kuantan and George Town as both score 97.43 and 116.11.

Table 14: Financial Management Indicators

No.	Indicator	Johor Bahru	Kuantan	George Town	Melaka
1	Local Authority Per Capita Revenue	224.63	151.68	221.78	244.78
2	Tax Collection Rate	85.50	85.96	100.00	100.00
3	Cash Flow to Emoluments Ratio	0.00	0.17	3.98	1.07
4	Development Expenditure Per Capita	51.99	4.79	50.01	58.02
5	Professionals and Management Officers to Population Ratio	12,389.78	10,662.16	11,710.53	20,552.38

6	Percentage of Operating Expenditure as Compared to Revenue	85.78	97.43	116.11	70.15

Source: a) Laporan Petunjuk Bandar Kuantan, 2005

b) Laporan Petunjuk Bandar Melaka, 2005

c) Laporan Petunjuk Bandar George Town, 2005

d) Laporan Petunjuk Bandar Johor Bahru, 2005

c) Website MURNInet (http://rsj.townplan.gov.my/MURNINet)

4.3 CONCLUSION

As a conclusion based on the overall performance of sectoral benchmarking, Melaka city is the best city that performs the good urban quality of life. However, there are certain sectors need to be improved in producing better urban quality of life. As it is just about data benchmarking, the differences in terms of the most efficiency city in certain sectors are difficult to interpret. Hence that, the analysis chapter will describe this manner more detail with numbers and values for each sector to city. This will helps to produce the best values and practices for good urban quality of life.

CHAPTER 4

ANALYSIS AND RECOMMENDATION

4.1 INTRODUCTION

This chapter will discuss about the analysis which has been done using the Data Envelopment Analysis method. For the data analysis, MATLAB R2008a software used as the tool with combining of the DEA model CCR commands inside this software. In this chapter, the analysis was done sectorally to define the most efficient city. Detail descriptions about the urban quality of life of selected cities are also discussed in this chapter to ensure more effective recommendations to improve the MURNInet measuring performance. This chapter also includes the benchmarking between the analysis result with current urban quality of life index for selected cities and finally the findings and recommendations.

4.2 CCR INPUT MODEL ANALYSIS

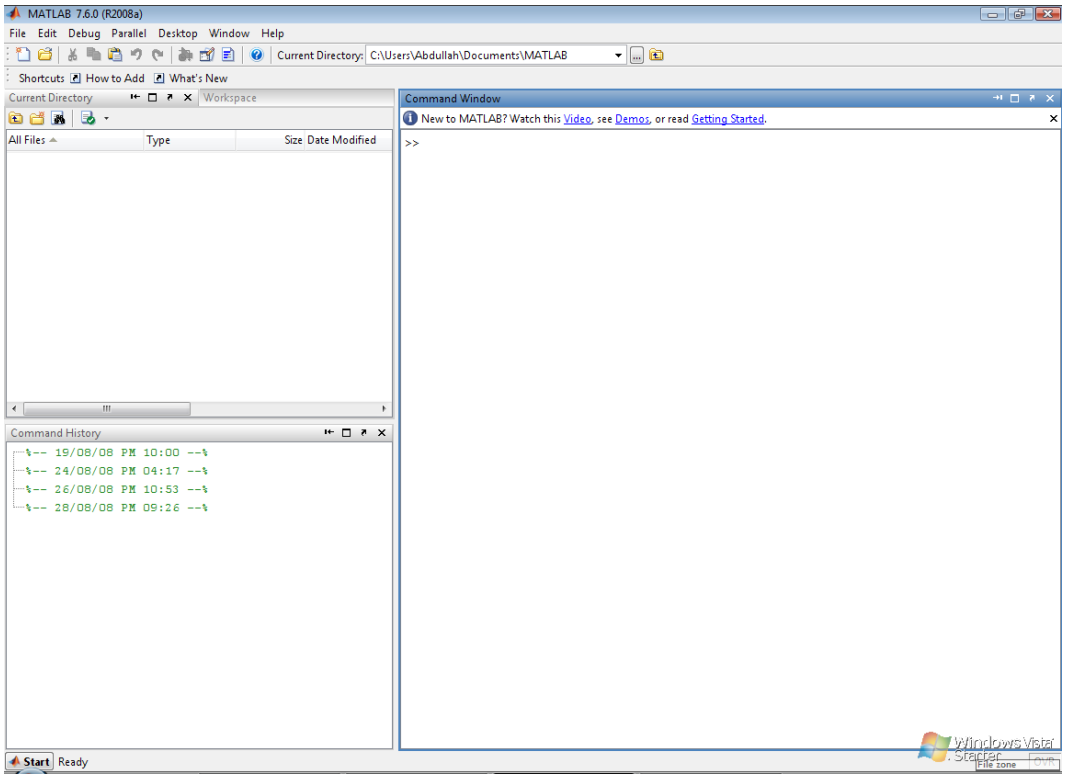
For this model the simplest measure is the output-input ratio using appropriate weights for the inputs and for outputs. The major limitation of the

method is the arbitrary nature of the fixed weights and the inability of discriminate the weather difference in transformation is due to change in weights or in the observations (Cooper, et.al, 2000). Another framework is the estimation of the Meta Production Function using the regression analysis.

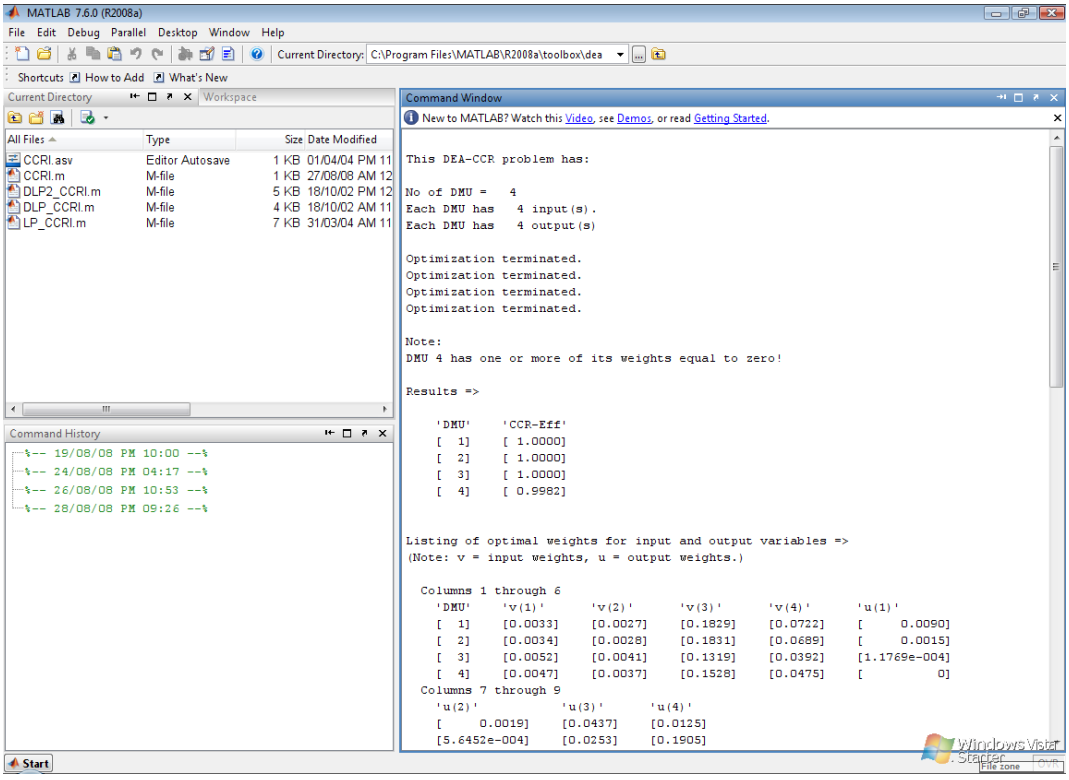
The production function approaches assumes, it is well known, uniform functional relationships and is messy in the case of multi input-multi output case. This model overcomes both the problems. The weights are decided on the basis of optimality condition and do not assume any functional relationship between the inputs and outputs. It also measures the comparative or relative efficiency of decision making units (DMUs). The first step is to identify the DMU, the unit assessment for this research purpose. In this case, the selected cities are taken as the DMUs judging the quality and reliability of data available on input and output on urban quality of life.

The second decision is whether to use input orientation model or output orientation model of DEA. Input orientation model is preferred if inputs are controllable and output orientation if output are controllable (Thanassoulis, 2001).

In this case, the characteristics are controllable compared with achieved capabilities. Hence input orientation model of DEA is taken for this analysis. So this task is to specify and estimates the input orientation model first developed by Charnes et. al, 1978 which is the CCR model with some modifications.



a. Before



b. After

Figure 9: User Interface for Analysis Result (a. before and b. after) in MATLAB R2008a Software

There are two (2) main steps taken for this model solution before it comes with slack values (recommendation values). Below is the detail description about this model;

STEP 1: Primal Linear Program - DEA CCR Input Model (LP_CCRI)

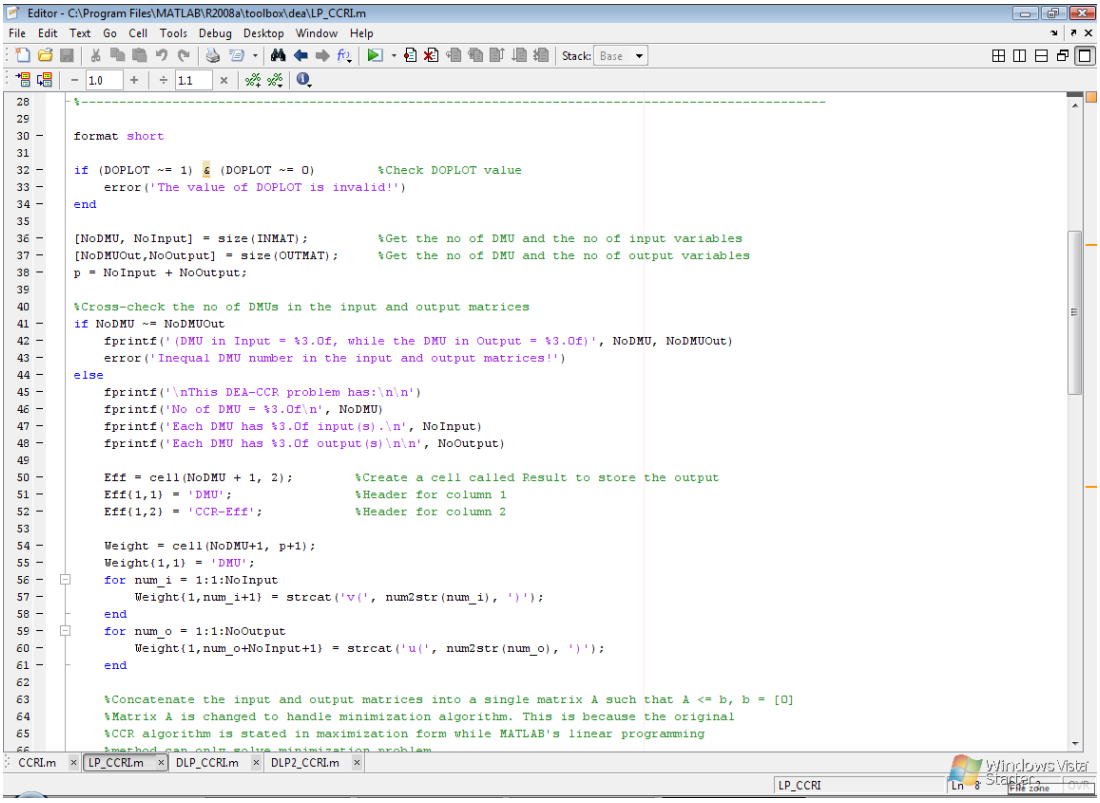


Figure 10: The Programming Command Interface for Step 1 Solution

[CCREff, Input Weight, Output Weight] = LP_CCRI (INMAT, OUTMAT, DOPLOT)

Function parameters:

1. INMAT - the matrix that contains the input values for all the DMUs. It has the m x n dimension, where m = the no. of DMU and n = the no. of input variables

2. OUTMAT - the matrix that contains the output values for all the DMUs. It has the m x k dimension, where m = the no. of DMU and k = the no. of output variables

3. DOPLOT - 1 to plot the CCR-efficiency, or 0 to suppress the plot of CCR-efficiency.

Other values will produce an error

Function output:

1. CCREff - A (m x 2) matrix where m = No of DMU and n = 2. The first column identifies the DMU and the second column contains the CCR efficiency for these DMUs

2. Input Weight - An (m x n) matrix where m = No of DMU and n = the no of input variable + 1. The first column identifies the DMU while the rest of the columns contain the weights for each of the input variables for all the DMUs.

3. Output Weight - An (m x k) matrix where m = No of DMU and k = no of output variable + 1. The first column identifies the DMU while the rest of the columns contain the weights for each of the output variables for all the DMUs.

STEP 2: Dual Linear Program - DEA CCR Input Model (DLP_CCRI)

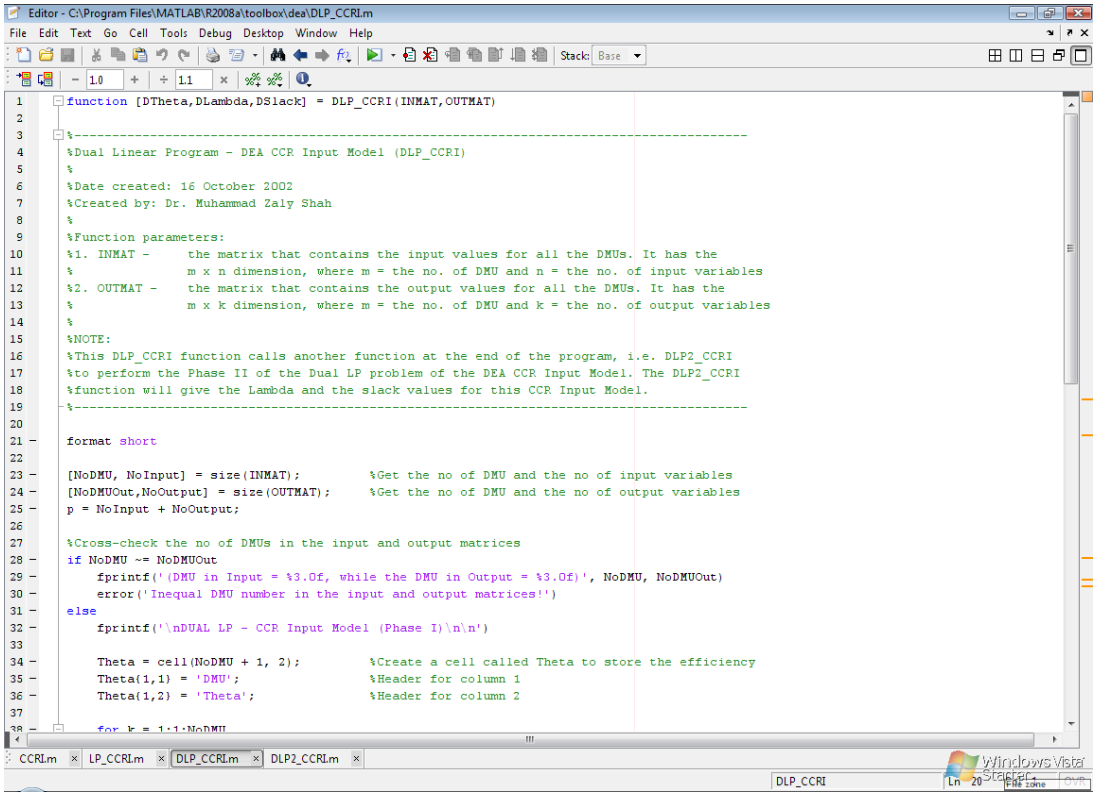


Figure 11: The Programming Command Interface for Step 2 Solution

Function parameters:

1. INMAT - the matrix that contains the input values for all the DMUs. It has the m x n dimension, where m = the no. of DMU and n = the no. of input variables

2. OUTMAT - the matrix that contains the output values for all the DMUs. It has the m x k dimension, where m = the no. of DMU and k = the no. of output variables

NOTE:

This DLP_CCRI function calls another function at the end of the program, i.e. DLP2_CCRI to perform the Phase II of the Dual LP problem of the DEA CCR Input Model. The DLP2_CCRI function will give the Lambda and the slack values for this CCR Input Model.

For this model, ‘DMU CCR-Eff’ table is considered as the main point of this analysis. This table means the most efficient decision making unit (DMU). However, this model will round up the efficiency values to 1 if those values are nearest to it such as 0.9999.

In this analysis, most of the variables used are output variables but at certain issues such output can become the input. This happened if the smaller number of these variables the better result it produced such as unemployment rate and poverty rate. And to benchmark the performance efficiency, guidelines standard will be the input variables but in certain issues these input can become the output variables just likes the output variables before (refer appendix I for guidelines standard by Town and Country Planning Department, Malaysia).

However, as the input orientation model it will calculate any measurement units without the needs to standardize DMUs and produced the most efficient DMUs and the best practiced to become an example to the others.

4.3 ANALYSIS OF URBAN QUALITY OF LIFE BY SECTOR

This analysis will be divided based on sector. It will help to recognize the most efficient indicator and selected cities for good practiced of urban quality of life in Malaysia. From this analysis, it will help to benchmark the analysis outcome with quality of life index.

4.3.1 Analysis for Demography Sector

There are four (4) variables analyzed in this sector. Those variables are urbanization rate, population density, average population growth rate and average household size. Table below shows the analysis result for demography sector;

Table 15: Input Efficiency Analysis Result for Demography Sector

CITY	INPUT EFFICIENCY
Johor Bahru	**1.0000**
Kuantan	0.9882
George Town	0.9880
Melaka	**1.0000**

Source: Research Analysis, 2008

From the analysis, it shows that Melaka and Johor Bahru city are efficient for demography sector. Both score 1.0000 (100%) but Kuantan and George Town are not far from that with both score 0.9882 (98.82%) and 0.9880 (98.80%). Although Melaka city urbanization rate is lower than other cities, at certain aspects such average population growth rate and population density it is better and become a good practice to the other cities.

4.3.2 Analysis for Housing Sector

For housing sector, there are two (2) variables used for analysis. These variables are residential floor area to population ratio and percentage of housing stock unsold.

And form the analysis, it shows that Johor Bahru city is the most efficient city with score 1.0000 (100%) while Kuantan score 0.2473 (24.73%), George Town 0.0124 (1.24%) and Melaka 0.2221 (22.21%).

This shows that George Town city is the lowest score in housing sector although it shows the best city in percentage of housing stock unsold. This is because it has to improve the residential floor area to population ration more than 90% to score similar amount with other cities.

Table 16: Input Efficiency Analysis Result for Housing Sector

CITY	INPUT EFFICIENCY
Johor Bahru	**1.0000**
Kuantan	0.2473
George Town	0.0124
Melaka	0.2221

Source: Research Analysis, 2008

4.3.3 Analysis for Economics Sector

In economic sector, there are two (2) variables used for analysis. These variables are unemployment rate and poverty rate. This is the most valuable variables that must be tackling in urban areas as it was mentioned in any economic development reports.

Table 17: Input Efficiency Analysis Result for Economic Sector

CITY	INPUT EFFICIENCY
Johor Bahru	0.8500
Kuantan	0.7500
George Town	**1.0000**
Melaka	**1.0000**

Source: Research Analysis, 2008

From the analysis, it shows that both George Town and Melaka city score the efficient cities. For Johor Bahru, it scores 0.8500 (85%) and Kuantan with 0.7500 (75%) as the lowest.

4.3.4 Analysis for Utility and Infrastructure Sector

For utility and infrastructure sector, there are five (5) variables used for analysis. These variables are daily water consumption rate per person, water loss rate, flood-prone area development rate, average daily garbage collection per person and percentage of residential units serviced by centralized sewerage.

And the analysis shows that there are three (3) cities score the efficient value except Kuantan with 0.8752 (85.72%). Although Kuantan scores good numbers in daily water consumption rate per person variable, but at other variables Kuantan has to improve its services more than 80% to catch up the other cities.

Table 18: Input Efficiency Analysis Result for Utility and Infrastructure Sector

CITY	INPUT EFFICIENCY
Johor Bahru	**1.0000**
Kuantan	0.8725
George Town	**1.0000**
Melaka	**1.0000**

Source: Research Analysis, 2008

4.3.5 Analysis for Public Facilities and Recreation Sector

Public facilities and recreation sector is an important sector to produce healthy and active community lifestyle. So in this sector, there are five (5) variables used for analysis. These variables include doctor to population ratio, public open space to population ratio, primary school children to teacher ratio, kindergarten to population ratio and civic hall to population ratio.

And the analysis shows that Melaka city scores the most efficient city with 1.0000 (100%). While Kuantan town scores 0.9752 (97.52%), George Town city scores 0.9242 (92.42%) and Johor Bahru city with 0.8696 (86.96%).

Table 19: Input Efficiency Analysis Result for Public Facilities and Recreation Sector

CITY	INPUT EFFICIENCY
Johor Bahru	0.8696
Kuantan	0.9752
George Town	0.9242
Melaka	**1.0000**

Source: Research Analysis, 2008

4.3.6 Analysis for Environment Sector

Environment as the part of main sectors in achieving towards sustainable development has six (6) variables for this research. These variables are percentage of budget allocation for landscape program, river water quality index, percentage of area that received waste disposal services, number of complaint case on noise, water borne and through food disease to population ration and air pollution index.

And from the analysis, it shows that Melaka city scores the most efficient city. For George Town and Johor Bahru city, both score 0.9988 (99.88%) and 0.9841 (98.41%). Kuantan town scores the lowest with 0.8562 (85.62%). This happened because it scores the lowest in three environmental elements which are river water quality, air quality and noise cases.

Table 20: Input Efficiency Analysis Result for Environment Sector

CITY	INPUT EFFICIENCY
Johor Bahru	0.9841
Kuantan	0.8562
George Town	0.9988
Melaka	**1.0000**

Source: Research Analysis, 2008

4.3.7 Analysis for Social Sector

For social sector, there are four (4) variables used for analysis in this research. These variables are crime index cases to population ratio, juvenile cases to

population ratio, social problem cases to population ratio and divorce rate per 1000 households.

From the analysis result, it shows that Melaka city scores the most efficient city again. And follows by Kuantan town with 0.9899 (98.99%), George Town city with 0.7251 (72.51%) and Johor Bahru city with 0.6389 (63.89%).

From this result it shows that there is a link between urbanization rates with the social problems. The analysis result shows the most urbanization cities score the lowest marks. It means urbanization activities give impacts on community lifestyle.

Table 21: Input Efficiency Analysis Result for Social Sector

CITY	INPUT EFFICIENCY
Johor Bahru	0.6389
Kuantan	0.9899
George Town	0.7251
Melaka	**1.0000**

Source: Research Analysis, 2008

4.3.8 Analysis for Land Use Sector

Land use is an important element in patterning the urban landscape. In this analysis, there is only one (1) variable used in land use sector. This variable is the percentage of Certificate of Fitness (CFO). This variable is important in showing the development rate in a city.

Based on the analysis, it shows that Johor Bahru, Melaka and Kuantan have scored 1.0000 (100%) in approving CFO in a year except George Town city with 0.7333 (73.33%). It shows that George Town city needs to improve their approving efficiency with many problems in land matters.

Table 22: **Input Efficiency Analysis Result for Land Use Sector**

CITY	INPUT EFFICIENCY
Johor Bahru	**1.0000**
Kuantan	**1.0000**
George Town	0.7333
Melaka	**1.0000**

Source: Research Analysis, 2008

4.3.9 Analysis for Urban Design and Heritage Sector

Urban design and heritage is a major sector to be taken consideration in development especially in Melaka and George Town city as these cities already recognized under UNESCO on July 2008 as Malaysia heritage cities with conservation area. Under this sector there is only one (1) variable used for analysis which is percentage of maintenance and beautification on tourism attraction area in urban areas.

From the analysis result, it shows that only George Town city score the efficient result. However, Melaka city is not far from that with 0.3655 (36.55%) while Kuantan and Johor Bahru score 0.1160 (11.60%) and 0.0327 (3.27%).

Maybe by 2008 and after, the percentage value for this variable will increase for Melaka city especially after the reorganization from UNESCO to similar with George Town city in building conservation as tourism product.

Table 23: Input Efficiency Analysis Result for Urban Design and Heritage Sector

CITY	INPUT EFFICIENCY
Johor Bahru	0.0327
Kuantan	0.1160
George Town	**1.0000**
Melaka	0.3655

Source: Research Analysis, 2008

4.3.10 Analysis for Transportation and Accessibility Sector

As an important sector in generates activities and connectivity for urban area, transportation and accessibility sector has two (2) variables used in this analysis which are road accident cases to population ratio and percentage of fatal road accidents cases.

The analysis result shows that Johor Bahru and George Town score the most efficient cities with 1.0000 (100%) input efficiency. However, for Kuantan town and Melaka city, both cities score 0.9317 (93.17%) and 0.7493 (74.93%).

Although George Town city scores higher than other cities at road accident cases to population ratio variable, however at percentage of fatal road accidents cases it scores the lowest value rather than Kuantan and Melaka city.

Table 24: Input Efficiency Analysis Result for Transportation and Accessibility Sector

CITY	INPUT EFFICIENCY
Johor Bahru	**1.0000**
Kuantan	0.9317
George Town	**1.0000**
Melaka	0.7493

Source: Research Analysis, 2008

4.3.11 Analysis for Finance and Management Sector

To generate efficient governance administrative, financial and management elements in a local authority is important sector that should be taken consideration. For this analysis, there are six (6) variables have been used for evaluation. These variables are local authority per capita revenue, tax collection rate, cash flow to emoluments ration, development expenditure per capita, professionals and management officers to population ratio and percentage of operating expenditure as compared to revenue.

The analysis result shows that only George Town city scores the efficient value with 1.0000 (100%). For Melaka and Johor Bahru city, both score 0.9886 (98.86%) and 0.9560 (95.60%) while Kuantan scores the lowest with 0.8637 (86.37%). However, Kuantan town is not far towards these cities as it can increases its local authority per capita revenue and development expenditure per capita about 80% from current amount.

Table 25: Input Efficiency Analysis Result for Finance and Management Sector

CITY	INPUT EFFICIENCY
Johor Bahru	0.9560
Kuantan	0.8637
George Town	**1.0000**
Melaka	0.9886

Source: Research Analysis, 2008

As overall from the analysis result, in each sector there is an efficient city at least but in certain sector such as land use and transportation and accessibility there are more than a city. It means that such mentioned in chapter 2, some decision making units located under the frontier line and maybe there is only a decision making unit. For better result of this analysis, a benchmarking of analysis outcome and urban quality of life index will be a better solution to find the best performance measurement. An addition it also a good step to find the advantage and disadvantage of using Data Envelopment Analysis (DEA) in measuring efficiency performance.

4.4 BENCHMARK WITH CURRENT URBAN QUALITY OF LIFE INDEX

As a new method of measuring urban quality of life performance in Malaysia, the Data Envelopment Analysis result is benchmarked with urban quality of life index to ensure the quality and outcomes of the analysis. For urban quality of life index, a new numbers recalculate as there are certain indicators which are not included in this analysis such in Murninet index. However, for the best score it is still referred to Murninet guidelines standard score such in Appendix I.

Matrix below shows the benchmarking between the Data Envelopment Analysis results with new urban quality of life index. In this matrix, it will show the similar or differences result for both method. And from here, it will help in defining the most significant indicator/s which influenced the urban quality of life.

Table 26: Data Envelopment Analysis (DEA) result and Quality of Life Matrix by Sector for Research Study

SECTOR	JOHOR BAHRU		KUANTAN		GEORGE TOWN		MELAKA	
	DEA	QOLI	DEA	QOLI	DEA	QOLI	DEA	QOLI
Demography	**1.0000**	1	0.9882	2	0.9880	**3**	**1.0000**	**3**
Housing	**1.0000**	2	0.2473	**3**	0.0124	1	0.2221	**3**
Economic	0.8500	**3**	0.7500	**3**	**1.0000**	**3**	**1.0000**	**3**
Utility and Infrastructure	**1.0000**	**3**	0.8725	1	**1.0000**	2	**1.0000**	2
Public Facilities and Recreation	0.8696	2	0.9752	**3**	0.9242	1	**1.0000**	**3**
Environment	0.9841	2	0.8562	1	0.9988	2	**1.0000**	**3**
Social	0.6389	1	0.9899	**3**	0.7251	1	**1.0000**	1
Land Use	**1.0000**	**3**	**1.0000**	**3**	0.7333	2	**1.0000**	**3**
Urban Design and Heritage	0.0327	1	0.1160	1	**1.0000**	**3**	0.3655	2
Transportation and Accessibility	**1.0000**	**3**	0.9317	**3**	**1.0000**	**3**	0.7493	**3**
Finance and Management	0.9560	1	0.8637	1	**1.0000**	1	0.9886	**3**

Source: Research Analysis, 2008

Note: ***DEA*** *– Data Envelopment Analysis Result*

QOLI *– Quality of Life Index Result*

And from the matrix it shows that there are significant differences between the Data Envelopment Analysis results with urban quality of life index. The result significant when handling multi variables in a sector but there is no significant result when handling a variable only in a sector. This can be seen at land use and urban design and heritage sectors.

4.5 FINDINGS AND RECOMMENDATIONS

Based on this research result, Melaka city has been identified as the most efficient city than the others. Table 26 shows that Melaka city is efficient in seven (7) sectors out of eleven (11) sectors. These sectors are demography, economic, utility and infrastructure, public facilities and recreation, environment, social and land use. Meanwhile, Johor Bahru and George Town city are equal with both efficient in five (5) sectors and Kuantan with one (1) sector only.

For the recalculation of urban quality of life index, the same result happened with Melaka city as the best city among the others. However, in this index Melaka city score the best marks in eight (8) sectors which are demography, housing, economic, public facilities and infrastructure, environment, land use, transportation and accessibility and finance and management. The significant result happened for Kuantan town as the second best city with six (6) sectors while Johor Bahru and George Town city come third with four (4) sectors only. This issue happened because in index the outputs value already been ranked based on standardization format such in appendix I. It means that the individual values of decision making units (DMUs) have been put aside while in Data Envelopment Analysis method each decision making units (DMUS) have unique values which must be considered in analysis.

Based numbers of efficient cities in a sector, the Data Envelopment Analysis results shows that there are two (2) sectors that significantly influenced the urban quality of life for selected cities. These sectors are utility and infrastructure and land use. It means that three (3) cities have done an excellent and successful works in serving their community. However there are still lots of works to be done as there are nine (9) sectors more to be improves in the future to achieve better urban quality of life for the community. And for this, the recommendation activities already mentioned in urban report at local authority level. And detailed programs are planned and discussed between the technical departments.

As recommendation for enhancing this research in future, there are few issues that should be taken consideration before preceding the analysis; such as below;

i. Choosing input and output variables

In this research, choosing the right input and output is already critical at first stage. This is because for Data Envelopment Analysis method as mentioned earlier in Chapter 2 is critical with input and output data as it is about measuring performance. For this research, most of indicators used are output variables and this make the analysis difficult to define the input variables. However, solution finally will use the guidelines standard as the input to ensure the output variables are efficient and fulfill the guidelines standard.

ii. Using the right DEA models

There are four (4) models in DEA method such mentioned in chapter 2. Using the right models is important such as choosing the right input and output variables. Different models have different variables needed for the analysis. In this research, input based model has been selected which is CCR model that is the first model developed by Charnes et. al (1978).

iii. Using the right software

Recently, there is a lot of DEA softwares which can be downloading or purchase from the internet. But one thing should be considered before using this software is different software using different method of analyzing data. However, the basic calculation is still based on early CCR model by Charnes et. al (1978). In this research, MATLAB R2008a software is part of the model modification as it using command interface for analysis.

As conclusion from this research, Data Envelopment Analysis method has a lot of advantages than traditional methods such index. As a non-parametric method, the analysis is become easier for researcher to measure performance without considering the measuring units. The capable in handling multi-input and output at the same time make it convenience and easy for analyzing data. However there are limitations in using this method such mentioned in Chapter 2.

4.6 CONCLUSION

In this research, DEA input based model has been presented to analyze the urban quality of life at selected cities. The first step of the study is identifying the urban quality of life indicators. There are total of eleven (11) sectors with thirty eight (38) indicators. The second step of study is benchmarking of urban quality of life for selected cities. The research finding that Melaka city has been identified as the most efficient city than the others. At the same time this research also identifies the significant sector/s influencing the urban quality of life for selected cities in Malaysia are demography and land use sectors. However there are still a lot of issues and problems that have to be taken into consideration for future research in order to improve this research result. Findings also showed that the frontier cities indicates

that the DEA method seems to be effective for generating benchmarks for efficient cities. This may be done in terms of inputs and outputs of the reference cities. In doing so, each city is to be evaluated will be given a unique combination of reference cities. From the analysis, the reference city may be used as a stimulation for the other cities to improve their performances.

I. APPENDIX

THE MURNInet INDICATORS

Sector	Indicator
P01. Demographic	**P01- 1** Urbanization Rate. **P01- 2** Population Density. **P01- 3** Average Population Growth Rate. **P01- 4** Median Age. **P01- 5** Average Household Size.
P02. Housing	**P02-1** Housing Price and Income Ratio. **P02-2** Housing Rental and Income Ratio. **P02-3** Ratio of Floor Space Area Per Person. **P02-4** Ratio of Housing Output Per 1,000 Population.
P03. Urban Economics	**P03-1** Unemployment Rate. **P03-2** Employment Growth Rate. **P03-3** Labour Force Growth Rate. **P03-4** Poverty Rate. **P03-5** Income Distribution (Gini Coefficient).
P04. Utility and Infrastructure	**P04-1** Daily Water Consumption Rate of Every Population. **P04-2** Water Loss. **P04-3** Percentage of Flooding Prone Area. **P04-4** Average Garbage Collection Per Day Per Population. **P04-5** Percentage of Residential Units Serviced by Centralised Sewerage.
P05. Public Facilities and Recreation	**P05-1** Doctors and Population Ratio. **P05-2** Ratio of Public Open Space Per 1,000 Population. **P05-3** Primary Schoolchildren and Teacher Ratio. **P05-4** Kindergarten and Population Ratio.

	P05-5 Civic Hall and Population Ratio.
P06. Environment	**P06-1** Percentage of Financial Budget for Environmental Management. **P06-2** Ratio Of Asthmatic Cases Per 10,000 Population. **P06-3** Percentage of Budget Allocation for Landscape Program. **P06-4** River Water Quality Index (WQI). **P06-5** Percentage of Area That Received Waste Disposal Services. **P06-6** Percentage of Solid Waste That Has Been Recycle. **P06-7** Number Of Complaint Cases On Noise. **P06-8** Ratio of Water Bone and Food Diseases Per 10,000 Population. **P06-9** Air Quality Index.
P07. Sociology and Social Impact	**P07-1** Percentage of The Population Involved In Community Program. **P07-2** The Quality Levels of Health Services. **P07-3** Ratio Of Crime Index Case Per 10,000 Population. **P07-4** Ratio of Juvenal Case Per 1,000 Population. **P07-5** Ratio of Arrests Due to Social Ills Per 1,000 Population. **P07-6** Divorce Rate Per 1,000 Marriages
P08. Land Use	**P08-1** Percentage of C.F.O Approvals. **P08-2** Percentage of Total Land Area for Public Facilities. **P08-3** Percentage of Residential Floor Space Area in City Centre.
P09. Tourism and	**P09-1** Percentage Expenditure On Maintenance Of Heritage Elements and Urban Beautification.

Heritage	**P09-2** Percentage of Tourism Attraction Area.
P10. Transportation and Accessibility	**P10-1** Percentage of Public Bus Users. **P10-2** The Quality Level of Public Bus Services. **P10-3** Percentage of Expenditure To Enhanced Accessibility System. **P10-4** Percentage of Single Occupancy Vehicle (SOV) Entiring City Centre During Morning Peak Hour Period. **P10-5** Ratio of Road Accident Cases Per 10,000 Populations. **P10-6** Percentage of Fatal Road Accident Cases.
P11. Finance and Management	**P11-1** Local Authority Per Capita Revenue. **P11-2** Tax Collection Rate. **P11-3** Cash Flow Ratio As Compared To Emoluments. **P11-4** Development Expenditure Per Capita. **P11-5** Ratio of Population Per Professionals and Management Officers. **P11-6** Percentage of Administration Expenditure As Compared to Revenue.

URBANIZATION RATE

Definition

Percentage of urban residents within the study area. Urban area is defined as a gazette urban area and areas which agglomerate.

Justification

Urbanization rate shows the levels of urban development in the study area. It also refers to the quality of life's levels and the types of facilities provided for the population in the study area.

Relationship with other Sectors

Housing, Urban Economics, and Utility & Infrastructure

Data Source

- Department of Statistics - Census
- Structure Plans (Local Planning Authorities)

Data Items

- Total urban population in the study area.
- Total population in the study area.

Formula

$$P_{01-1} = \left(\frac{P_{bandar}}{P_{kajian}} \right) x\, 100$$

Where:

P_{bandar} = Total urban population in the study area

P_{kajian} = Total population in the study area

Standard	Score	Standard Targets
< 30% (Low)	2	30% – 60%
30% - 60% (Medium)	3	
> 60% (High)	1	

POPULATION DENSITY

Definition

Population density is defined as the density levels of population in an area. The density level depends on the density control practiced by the Local Planning Authority.

Justification

The population density is important because it shows the density of an area. Areas that are too dense are not suitable as residential areas and it could cause social problems. Population density can also be used to measure the balance between population and the environment, which is an objective that is targeted within the urban sustainability concept.

Relationship with other Sectors

Housing, Utility & Infrastructure, and Sociology & Social Impact.

Data Source

- Department Of Statistics - Census.
- Structure Plans (Local Planning Authorities).

Data Items

- Total population in the study area.
- Size of the study area (hectares).

Formula

$$P_{01-2} = \frac{P_{kajian}}{L_{kajian}}$$

Where:

P_{kajian} = Total population in the study area

L_{kajian} = Size of the study area (Hectares)

Standard	Score	Standard Targets
< 75 Person Per Hectare (Low) 75 – 310 Person Per Hectare (Medium) > 310 Person Per Hectare (High)	3 2 1	< 75 Person Per Hectare

AVERAGE POPULATION GROWTH RATE

Definition

The average rate of population growth is an indicator that shows the urban population growth trend in a study area.

Justification

Closely related to the threshold levels for planning purposes and to ensure quality of life, level of comfort, health facilities and adequate infrastructure.

Relationship with Others Sectors

Housing, Urban Economics, Utility & Infrastructure, and Sociology & Social Impact.

Data Source

- Department Of Statistics– Census.
- Future data derived from cohort survival method and to be added with new population triggered through new developments.

Data Items

- Total population in the study area at the year of study.
- Total population in the study area at comparative year.

Formula

$$P_{n..1} = \frac{1}{(Tk - Tb)} \left(\ln \frac{Pk}{Pb} \right) x100$$

Where:

Pk = Total Population in the study Area at Year of Study
Pb = Total Population in the study Area at Comparative Year
Tk = The year of study
Tb = The comparetive year
$Tk > Tb$

Standard	Score	Standard Targets
< 1.5% (Low)	2	
1.5% - 2.5% (Moderate)	3	1.5% - 2.5%
> 2.5% (High)	1	

AVERAGE HOUSEHOLD SIZE

Definition

Average Household Size is the average number of persons that dwell in a house.

Justification

Household size reflects the number of persons in a house and it can relate to problems overcrowding.

Relationship with Other Sectors

Housing, and Land Use

Data Source

- Department Of Statistics – Census.
- Questionnaire Survey.

Data Items

- Total population in the study area.
- Total household in the study area.

Formula

$$P_{01\text{-}5}=\frac{P_{kajian}}{H_{kajian}}$$

Where:

P_{kajian} = Total population in the study area

H_{kajian} = Total household in the study area

Standard	Score	Standard Targets
< 4.5 (Low)	3	
4.5 – 5.5 (Moderate)	2	< 4.5
> 5.5 (High)	1	

RESIDENTIAL FLOOR AREA TO POPULATION RATIO

Definition

Floor space area for every dweller. The floor space covers all areas in the house including the bathroom, bedroom, kitchen, living area and other coverage used privately or domestically.

Justification

Reflects the overcrowding level.

Relationship with Other Sector

Urban Economics, Sociology & Social Impact, Demographic, and Land Use.

Data Source

- Questionnaire Interview.
- Local Planning Authority.

Data Items

- Total floor space dwelling area (m^2).
- Total Population of the Study Area.

Formula

$$P_{02-3} = \frac{R}{S}$$

Where:

R = Total floor space dwelling area (m^2).
S = Total Population in the study area.

Standard	Score	Standard Targets
< 10 m^2 (Low)	1	
10 m^2 – 20 m^2 (Moderate)	2	> 20 m^2
> 20 m^2 (High)	3	

PERCENTAGE OF HOUSING STOCK UNSOLD

Definition

Housing units completed but unsold in the study area

Justification

To ensure a balance between demand and supply of residential units.

Relationship with Other Sector

Urban Economics, and Sociology & Social Impact.

Data Source

- Questionnaire Interview.
- Local Planning Authority.

Data Items

- Total housing units unsold in the study area.
- Total housing units built in the study area.

Formula

$$P_{02-4} = \left(\frac{R_{takjual}}{R_{siap}} \right) \text{ x } 100$$

Where:

$R_{takjual}$ = Total housing units unsold in the study area.

R_{siap} = Total housing units built in the study area.

Standard	Score	Standard Targets
< 15 % (Low)	3	< 15 %
15% – 30% (Moderate)	2	
> 30% (High)	1	

UNEMPLOYMENT RATE

Definition

Unemployment rate refers to the average ratio of the population within the working age group (15-64 years) that are unemployed during the study period.

Justification

A strong urban economic base normally provides its ability to generate employment opportunities. A high unemployment rate will threaten the economic sustainability of the population and urban areas as a whole.

Relationship with Other Sector

Sociology & Social Impact, Housing, and Public Facilities.

Data Source

- Questionnaire Interview
- Statistics Department– Population Survey in the study area (aged 15-64 years old).

Data Items

- Total unemployment in the study area.
- Total working age population in the study area.

Formula

$$P_{03-1} = \left(\frac{U}{E}\right) x100$$

Where:

U = Total unemployment in the study area

E = Total working age population in the study area

Standard	Score	Standard Targets
< 5% (Low)	3	
5% – 10% (Moderate)	2	< 5%
> 10% (High)	1	

POVERTY RATE

Definition

Percentage population in the study area falls below the poverty line.

Justification

Indicates the number of population whom are poor. It provides information on the needs to provide social facilities and other aids.

Relationship with Other Sector

Sociology & Social Impact, Housing, and Public Facilities.

Data Source

- Questionnaire Interview.
- District Office.
- Social and Welfare Department.

Data Items

- Total number of poor (income that falls under the poverty line) population in the study area.
- Total population in the study area.

Formula

$$P_{03-4} = \left(\frac{P_{miskin}}{P_{kajian}} \right) x100$$

Where:

P_{miskin} = Total number of poor (income that falls under the poverty line) population in the study area

P_{kajian} = Total population in the study area

Standard	Score	Standard Targets
< 2.0% (Low)	3	
2.0% – 4.0% (Moderate)	2	< 2.0 %
> 4.0% (High)	1	

DAILY WATER CONSUMPTION RATE PER PERSON

Definition

Water consumption of every population in the study area.

Justification

To ensure water consumption at a minimal level and adequate water supply.

Relationship with Other Sector

Demographic, Public Facilities and Urban Economics.

Data Source

- Water Management Agency.
- State Water Department.

Data Items

- Total Annual Domestic Water Consumption.
- Total Population in the study area.

Formula

$$P_{04-1} = \frac{W}{T_{hari} P_{kajian}}$$

Where:

W = Total annual domestic water consumption (Liter)

P_{kajian} = Total population in the study area

T_{hari} = No. of day in a year (365 days)

Standard	Score	Standard Targets
< 300 Litre Per Day (Low)	3	

300 - 400 Litre Per Day(Moderate) > 400 Litre Per Day (High)	2 1	< 300 Litre Per Day Per Person

WATER LOSS RATE

Definition

Total volume of water loss.

Justification

Effective water management is needed to reduce water loss.

Relationship with Other Sector

Urban Economics and Public Facilities.

Data Source

- Water Management Agency.
- State Water Department.

Data Items

- Total volume of water generated in the year of study
- Total Volume of water consumption in the year of study

Formula

$$P_{04-2} = \left(\frac{J-G}{J}\right) x100$$

Where:

J = Total volume of water generated in the year of study (liter)
G = Total Volume of water consumption in the year of study (liter)

Standard	Score	Standard Targets
< 10% (Low)	3	
10% - 20% (Moderate)	2	< 10%
> 20% (High)	1	

FLOOD-PRONE AREA DEVELOPMENT RATE (%)

Definition

Total development area within flood-prone area.

Justification

To ensure the study area free from flooding by provision of appropriate drainage system and development planning.

Relationship with Other Sector

Environment, and Land Use.

Data Source

- Drainage and Irrigation Department.
- Local Planning Authority.

Data Items

- Total size of flood prone area.
- Total size of the development area within flood prone area.

Formula

$$P_{04-3} = \left(\frac{L_{Banjir}}{L_{kajian}} \right) x100$$

Untuk:

L_{Banjir} = Total size of the development area within flood prone area (hectares)

L_{kajian} = Total size of flood prone area (hectares)

Standard	Score	Standard Targets
< 1% (Low)	3	
1% - 10% (Moderate)	2	< 1%
> 10% (High)	1	

AVERAGE DAILY GARBAGE COLLECTION PER PERSON

Definition

Total domestic garbage generated by every population.

Justification

To increase the awareness on proper garbage disposals.

Relationship With Other Sector

Environment, and Land Use.

Data Source

- Local Planning Authority.
- Solid Waste Disposal Agency.

Data Items

- Total domestic solid waste disposal.
- Total Population in the Study Area.

Formula

$$P_{04-4} = \frac{S_{kg}}{T_{hari} P_{kajian}}$$

Where:

S_{kg} = Total domestic solid waste disposal in the study area (kg)
P_{kajian} = Total population in the study area
T_{hari} = No. of in a year (365 days)

Standard	Score	Standard Targets
< 0.5 kg (Low)	3	
0.5 kg – 0.6 kg (Moderate)	2	< 0.5 kg
> 0.6 kg (High)	1	

PERCENTAGE OF RESIDENTIAL UNITS SERVICED BY CENTRALIZED SEWERAGE

Definition

Number of housing/Residential units connected to the centralized sewerage.

Justification

A complete sewerage system will enhanced the cleanliness level and its environment.

Relationship with Other Sector

Environment, Housing, and Urban Economics.

Data Source

- Local Authority (PBT).
- Statistics Department.
- Indah Water Consortium.
- Sewerage Department.

Data Items

- Number of housing units connected to the centralized sewerage.
- Number of housing units in the study area.

Formula

$$P_{04-5} = \left(\frac{K_{pb}}{K_{kajian}} \right) x100$$

Where:

K_{pb} = Number of housing units connected to the centralised sewerage

K_{kajian} = Number of housing units in the study area

Standard	Score	Standard Targets
<60% (Low)	1	
60% - 80% (Moderate)	2	> 80%
> 80% (High)	3	

DOCTOR TO POPULATION RATIO

Definition

Number of population serviced by a doctor.

Justification

Adequate number of doctors will provide an effective services to the population.

Relationship With Other Sector

Sociology & Social Impact, and Urban Economics.

Data Source

- District and State Health Departments.
- Department Of Statistics.

Data Items

- Number of doctors in the study area.
- Total population in the study area.

Formula

$$P_{05-1} = \left(\frac{P_{kajian}}{D_{bil}} \right)$$

Where:

P_{kajian} = Total population in the study area.

D_{bil} = Number of doctors in the study area.

Standard	Score	Standard Targets
1 Doctor : > 20,000 Population (Low) 1 Doctor : 10,000 - 20,000 Population (Moderate) 1 Doctor : < 10,000 Population (High)	1 2 3	1 Doctor **:** < 10,000 Population

PUBLIC OPEN SPACE TO POPULATION RATIO

Definition

Open space reserves for public purposes.

Justification

Adequate total public open space area for leisure and recreational purposes .

Relationship with Other Sector

Sociology & Social Impact, Urban Economics, and Environment

Data Source

- Local Authority (PBT)

Data Items

- Total public open space areas (hectares) in the study area.
- Total population in the study area.

Formula

$$P_{OS-2} = \left(\frac{K_{LAwam}}{P_{kajian}} \right) x1000$$

Where:

K_{LAwam} = Total public open space areas (hectares) in the study area

P_{kajian} = Total population in the study area

Standard	Score	Standard Targets
< 1 Hectares : 1,000 Population (Low) 1 – 2 Hectares : 1,000 Population (Moderate) > 2 Hectares : 1,000 Population (High)	1 2 3	> 2 Hectares : 1,000 Population

PRIMARY SCHOOLCHILDREN TO TEACHER RATIO

Definition

Number of primary schoolchildren serviced by a teacher.

Justification

Adequate number of teachers will provide effective educational services to primary schoolchildren in the study area.

Relationship with Other Sector

Sociology & Social Impact.

Data Source

- State or/and District Education Department.

Data Items

- Number of primary schools teachers in the study area.
- Number of primary schoolchildren in the study area.

Formula

$$P_{05-3} = \frac{B_{murid}}{B_{guru}}$$

Where:

B_{murid} = Number of primary schoolchildren in the study area
B_{guru} = Number of primary schools teachers in the study area

Standard	Score	Standard Targets
1 Teacher : < 20 Schoolchildren (Low)	3	
1 Teacher : 20 – 30	2	1 Teacher **:** < 20
Schoolchildren(Moderate)	1	Schoolchildren
1 Teacher : > 30 Schoolchildren (High)		

KINDERGARTEN TO POPULATION RATIO

Definition

Measurement of preschool education that is available as compared with total population.

Justification

Early education is the base before formal education.

Relationship with Other Sector

Sociology & Social Impact.

Data Source

- KEMAS
- State or/and District Education Department

Data Items

- Number of kindergartens in the study area.
- Total population in the study area.

Formula

$$P_{05-4} = \frac{P_{kajian}}{T_{Bil}}$$

Where:

T_{Bil} = Number of kindergardens in the study area

P_{kajian} = Total population in the study area

Standard	Score	Standard Targets
1 : > 5,000 Population (Low)	1	
1 : 2,500 – 5,000	2	1 **:** < 2,500 Population
Population (Moderate)	3	
1 : < 2,500 Population (High)		

CIVIC HALL TO POPULATION RATIO

Definition

The level and availability on the provision of civic halls.

Justification

Civic Halls is the focal point of community activities and functions as one-stop service center.

Relationship with Other Sector

Sociology & Social Impact.

Data Source

- Local Authority (PBT).

Data Items

- Number of civic halls in the study area.
- Total Population in the study area.

Formula

$$P_{05-5} = \frac{P_{kajian}}{D_{serbaguna}}$$

Where:

$D_{serbaguna}$ = Number of civic halls in the study area

P_{kajian} = Total Population in the study area

Standard	Score	Standard Targets
1 : > 20,000 (Low)	1	1 : < 10,000
1 : 10,000 – 20,000 (Moderate)	2	
1 : < 10,000 (High)	3	

PERCENTAGE OF BUDGET ALLOCATION FOR LANDSCAPE PROGRAM

Definition

Percentage of the annual budget that is allocated for landscape and tree planting programs..

Justification

Evaluate the commitments of the Local Authority in implementing the landscape program and tree planting. Trees and greenery provides many advantages such as reduce air pollutants, reduce temperature, prevent erosion and surface run-off and others.

Relationship with Other Sector

Finance and Management.

Data Source

- Local Authorities (PBT).

Data Items

- Total financial allocations for landscape related programs in the study area (by Local Authority).
- Total Local Authority financial budget for the year of study

Formula

$$P_{06-3} = \left(\frac{B_{landskap}}{B_{total}} \right) x100$$

Where:

$B_{landskap}$ - Total financial allocations for landscape related programs in the study area (by Local Authority).

B_{total} - Total Local Authority financial budget for the year of study

Standard	Score	Standard Targets
< 5% (Low)	1	
5% – 10% (Moderate)	2	> 10%
> 10% (High)	3	

RIVER WATER QUALITY INDEX (WQI)

Definition

Levels of water quality of all major rivers in the study area

Justification

A good water quality contributes to a very high environment quality.

Relationship with Other Sector

Sociology & Social Impact and Finance & Management.

Data Source

- Department of Environment.
- Ministry of Health.

Data Items

- Water Quality Index of major rivers.

Formula

$$P_{06-4} - WQI$$

Where:
WQI = Average Water Quality Index of major rivers in study area recorded at the year of study

Standard	Score	Standard Targets
> 80 (Clean)	3	
60 – 80 (Moderate)	2	> 80
< 60 (Polluted)	1	

PERCENTAGE OF AREA THAT RECEIVED WASTE DISPOSAL SERVICES

Definition

Total area (size) that has received waste disposal services.

Justification

To ensure that the whole study area is provided with the waste disposal services.

Relationship with Other Sector

Environment, and Land Use.

Data Source

- Local Authority (PBT).
- Waste Disposal Management Agency.

Data Items

- Total area (size) received the waste disposal services.
- Size of the study area.

Formula

$$P_{06-5} = \left(\frac{L_{kutipan}}{L_{kajian}} \right) x100$$

Where:

$L_{kutipan}$ = Total area (size) received the waste disposal services

K_{kajian} = Size of the study area.

Standard	Score	Standard Targets
< 50% (Low)	1	> 70%
50% – 70% (Moderate)	2	
> 70% (High)	3	

NUMBER OF COMPLAINT CASES ON NOISE

Definition

Number of Complaint Cases on Noise Reported in the year of study.

Justification

Noise disturbance is a form of pollution which can cause damage to health.

Relationship with Other Sector

Sociology & Social Impact, and Utility & Infrastructure.

Data Source

- Local Authority (PBT).
- Department of Environment.

Data Items

- Number of cases reported on noise in the year of study.

Formula

$$P_{06-7} = B_{Adum}$$

Where:

B_{Adum} = Number of cases reported on noise in the year of study.

Standard	Score	Standard Targets
> 10 cases (Unsatisfactory)	1	
5-10 cases (Moderate)	2	< 5 Cases Reported
< 5 Cases (Very Satisfactory)	3	

WATER BORNE AND THROUGH FOOD DISEASES TO POPULATION RATIO

Definition

Number of water borne and food diseases reported in the year of study.

Justification

A good water quality can reduce water borne and food related diseases.

Relationship with Other Sector

Sociology & Social Impact and Utility & Infrastructure.

Data Source

- Hospital.
- Health Centre.
- State and District Health Department.

Data Items

- Number of cases related to water borne and food diseases reported in the study area.
- Total population in the study area.

Formula

$$P_{06-8} = \left(\frac{K_{kes}}{P_{kajian}} \right) x10,000$$

Where :

K_{kes} = Number of cases related to water borne and food diseases reported in the study area.

P_{Kajian} = Total population in the study area.

Standard	Score	Standard Targets
> 5 Cases : 10,000 Population	1	

(Unsatisfactory) 1 – 5 Cases : 10,000 Population (Moderate) < 1 cases : 10,000 Population (Very satisfactory)	2 3	< 1 cases **:** 10,000 Population

AIR POLLUTION INDEX

Definition

Level of air pollution in the study area.

Justification

A good air quality contributes to overall environment quality

Relationship with Other Sector

Sociology & Social Impact

Data Source

- Department of Environment

Data Items

- Air pollution index.

Formula

$$P_{06-9} = IPU$$

Where :

IPU = Average air pollution index recorded for the year of study

Standard	Score	Standard Targets
< 50 (Good)	3	

50-100 (Moderate) >100 (Bad)	2 1	< 50

CRIME INDEX CASES TO POPULATION RATIO

Definition

Number of crime index (high criminal offence) cases reported in the year of study.

Justification

A frequent crime index will threaten public safety. There is a need to consider safety characteristics in any development.

Relationship with Other Sector

Urban Economics, Utility & Infrastructure, Public Facilities and Housing.

Data Source

- Royal Malaysian Police.
- Department of Statistics.

Data Items

- Number of crime index cases reported in the year of study.
- Total population in the study area.

Formula

$$P_{07-3} = \left(\frac{J_{bilkes}}{P_{Kqian}} \right) x10,000$$

Where :

J_{bilkes} = Number of crime index cases reported in the year of study.

P_{Kqian} = Total population in the study area.

Standard	Score	Standard Targets
< 50 Cases : 10,000 Population (Low) 50 - 200 Cases : 10,000 Population (Moderate) > 200 Cases : 10,000 Population (High)	3 2 1	< 50 Cases **:** 10,000 Population

JUVENILE CASES TO POPULATION RATIO

Definition

Number of Juvenal cases reported in a year.

Justification

Frequent Juvenal cases will cause low moral among youth. Planning of community program should consider programs that can enhance youth personality.

Relationship with Other Sector

Urban Economics, Utility & Infrastructure, Public Facilities, and Housing.

Data Items

- Royal Malaysian Police.
- Welfare Department.
- Department of Statistics.

Data Items

- Number of Juvenal cases reported in the year of study.
- Total Population in the study area.

Formula

$$P_{07-4} = \left(\frac{K_{juvana}}{P_{kajian}} \right) x10,000$$

Where :

K_{juvana} = Number of juvenal cases reported in the year of study.

P_{kajian} = Total Population in the study area.

Standard	Score	Standard Targets
< 5 Cases : 10,000 Population (Low)	3	
5 - 10 Cases : 10,000 Population (Moderate)	2	< 5 Cases **:** 10,000
> 10 Cases : 10,000 Population(High)	1	Population

ARRESTS DUE TO SOCIAL ILLS TO POPULATION RATIO

Definition

Number of social ills/problems cases (other than crime index and Juvenal cases) recorded in a year.

Justification

High rate of social problems cases will reduce social sustainability.

Relationship with Other Sector

Urban Economics

Data Source

- Royal Malaysian Police.
- State/District Welfare Departments.

Data Items

- Number of social problems cases recorded in the year of study.
- Total population in the study area.

Formula

$$P_{07-5} = \left(\frac{K_{Sosial}}{P_{Kajian}} \right) x1,000$$

Where :

K_{Sosial} - Number of social problems cases recorded in the year of study.

P_{Kajian} - Total population in the study area.

Standard	Score	Standard Targets
< 5 Cases : 1,000 Population (Low)	3	
5 - 10 Cases : 1,000 Population (Moderate)	2	< 5 Cases : 1,000
> 10 Cases : 1,000 Population (High)	1	Population

DIVORCE RATE PER 1,000 HOUSEHOLDS

Definition

Number of divorce cases reported (Muslims and Non-Muslims) in the study area.

Justification

A harmonized family can contribute to sustainable social life.

Relationship with Other Sector

Urban Economics and Demographic.

Data Source

- Syariah Court/Kadi Office/Civil Court.
- Registrar of Marriage Department.
- Islamic Affairs Department.

Data Items

- Number of divorce cases reported in the study area.
- Number of households in the study area.

Formula

$$P_{07-6} = \left(\frac{K_{Cerai}}{H_{Kajian}} \right) x1,000$$

Where :

K_{Cerai} - Number of divorce cases reported in the study area.

H_{Kajian} - Number of households in the study area.

Standard	Score	Standard Targets
< 5 Cases : 1,000 Households (Low)	3	
5 - 10 Cases : 1,000 Households (Moderate)	2	< 5 Cases : 1,000
> 10 Cases : 1,000 Households (High)	1	Households

PERCENTAGE OF C.F.O. APPROVED

Definition

Numbers of C.F.O. applications approved by the Local Authority (PBT) in the year of study.

Justification

A shorter time period in C.F.O approvals reflects the competency and capability of the Local Authority.

Relationship with Other Sector

Urban Economics & Housing.

Data Source

- Local Authority (PBT).

Data Items

- Numbers of C.F.O approved in the year of study.

- Numbers of C.F.O. application received in the year of study.

Formula

$$P_{08-1} = \left(\frac{T_{CF}}{J_{Pelan}} \right) x100$$

Where :

T_{CF} - Numbers of C.F.O approved in the year of study.

J_{Pelan} - Numbers of C.F.O. application received in the year of study.

Standard	Score	Standard Targets
< 50% (Low)	1	
50% - 90% (Moderate)	2	> 90%
> 90% (High)	3	

PERCENTAGE OF MAINTENANCE AND BEAUTIFICATION EXPENDITURE ON TOURISM ATTRACTION AREA

Definition

Local Authority expenditure on building and heritage areas maintenance, and urban beautification.

Justification

Reflects the commitments of the Local Authority on building structure forms, heritage areas, urban morphology pattern and urban beautification in the study area.

Relationship with Other Sector

Land Use, and Urban Economics.

Data Source

- Local Authority (PBT)
- District Local Plan.

Data Items

- Total maintenance and beautification expenditure on heritage and tourism attraction area in the year of study (RM).
- Total Local Authority financial budget for the year of study.

Formula

$$P_{09\text{-}1} = \left(\frac{B_{tarikan}}{B_{total}} \right) x100$$

Where :

$B_{tarikan}$ = Total maintenance and beautification expenditure on heritage and tourism attraction area in the year of study (RM).

B_{total} = Total Local Authority financial budget for the year of study.

Standard	Score	Standard Targets
< 5% (Low)	1	
5% - 10% (Moderate)	3	5% - 10%
> 10% (High)	2	

ROAD ACCIDENT CASES TO POPULATION RATIO

Definition

Road accidents reported in the study area.

Justification

Indicates the level of road safety in the study area.

Relationship with Other Sector

Sociology & Social Impact.

Data Source

- Royal Malaysian Police.
- Department of Statistics.

Data Items

- Numbers of road accidents reported in the study area.
- Total population in the study area.

Formula

$$P_{10-5} = \left(\frac{K_{cedera}}{P_{kajian}} \right) x10,000$$

Where :

K_{cedera} - Numbers of road accidents reported in the study area.
P_{kajian} = Total population in the study area.

Standard	Score	Standard Targets
< 10 Cases : 10,000 Population (Low) 10 – 20 Cases : 10,000 Population (Moderate) > 20 Cases : 10,000 Population (High)	3 2 1	< 10 Cases : 10,000 Population

PERCENTAGE OF FATAL ROAD ACCIDENT CASES

Definition

Fatal road accidents in the study area.

Justification

Indicates the motorist level of awareness.

Relationship with Other Sector

Sociology & Social Impact.

Data Source

- Royal Malaysian Police.
- Department of Statistics.

Data Items

- Total cases of fatal road accidents in the year of study.
- Total cases of road accidents reported in the year of study.

Formula

$$P_{10-6} = \left(\frac{K_{maut}}{K_{jumlah}} \right) x100$$

Where :

K_{maut} - Total cases of fatal road accidents in the year of study.

K_{jumlah} - Total cases of road accidents reported in the year of study.

Standard	Score	Standard Targets
< 5% (Low)	3	
5% – 10% (Moderate)	2	< 5%
> 10% (High)	1	

LOCAL AUTHORITY PER CAPITA REVENUE

Definition

Distribution of income revenue of the Local Authority (accept development grant) on every population

Justification

High per capita income could finance development projects and the provision of quality urban services to the population.

Relationship with Other Sector

Demography and Urban Economics.

Data Source

- Local Authority (PBT).
- Department of Statistics.

Data Items

- Total revenue of the Local Authority (tax and non-tax) during the year of study.
- Total population in the study area.

Formula

$$P_{11-1} = \frac{H_{PBT}}{P_{PBT}}$$

Where :

H_{PBT} - Total revenue of the Local Authority (tax and non-tax) in the year of study.

P_{PBT} - Total population in the study area.

Standard	Score	Standard Targets
< RM100.00 (Not Satisfactory)	1	
RM100.00 – RM130.00 (Moderate)	2	> RM 130.00
> RM130.00 (Most Satisfactory)	3	

TAX COLLECTION RATE

Definition

Tax collected or received by the population.

Justification

High tax collection could finance development projects in order to enhance the quality of life of the study area.

Relationship with Other Sector

Urban Economics

Data Source

- Local Authority (PBT)

Data Items

- Total amount of tax collected by Local Authority in the year of study.
- Total amount of tax issued by Local Authority in the year of study.

Formula

$$P_{11-2} = \left(\frac{C_{Kutipan}}{C_{Taksiran}} \right) x100$$

Where :

$C_{Kutipan}$ - Total amount of tax collected by Local Authority in the year of study.
$C_{Taksiran}$ - Total amount of tax issued by Local Authority in the year of study.

Standard	Score	Standard Targets
< 60% (Not Satisfactory)	1	
60% - 80% (Satisfactory)	2	> 80%
> 80% (Most Satisfactory)	3	

CASH FLOW TO EMOLUMENTS RATIO

Definition

Local Authority financial/monetary reserves liquidity for emolument expenditure.

Justification

Local Authority (PBT) need to have sufficient financial/monetary reserves and not dependent on other resources.

Relationship with Other Sector

Urban Economics

Data Source

- Local Authority (PBT).

Data Items

- Total monetary reserves of the Local Authority
- Total emoluments expenditure of the Local Authority in the year of study.

Formula

$$P_{11-3} = \frac{R_{wang}}{E_{PBT}}$$

Where :

R_{wang} - Total monetary reserves of the Local Authority.

E_{PBT} - Total emoluments expenditure of the Local Authority in the year of study.

Standard	Score	Standard Targets
< 3 kali (Not Satisfactory)	1	
3 – 5 kali (Satisfactory)	2	> 5 time annually
> 5 kali (Most Satisfactory)	3	emoluments

DEVELOPMENT EXPENDITURE PER CAPITA

Definition

The distribution of development expenditure of Local Authority for every population

Justification

A high per capita expenditure relates to the commitments of the Local Authority to enhance the quality of life.

Relationship with Other Sector

Demographic and Urban Economics

Data Source

- Local Authority (PBT).
- Department of Statistics.

Data Items

- Local Authority total development expenditure.
- Total population in the study area.

Formula

$$P_{11-4} = \frac{B_{Pembangunan}}{P_{PBT}}$$

Where :

$B_{Pembangunan}$ - Local Authority total development expenditure.

P_{PBT} - Total population in the study area.

Standard	Score	Standard Targets
< RM60.00 (Not Satisfactory)	1	
RM60.00 – RM100.00 (Satisfactory)	2	> RM100.00
> RM100.00 (Most Satisfactory)	3	

PROFESSIONALS AND MANAGEMENT OFFICERS TO POPULATION RATIO

Definition

Number of population in the Local Authority serviced by the administration and professionals.

Justification

Adequate administration and professional Officers can provide an efficient service to the population.

Relationship with Other Sector

Demographic

Data Source

- Local Authority (PBT).
- Department of Statistics.

Data Items

- Numbers of administration and professional officers in the Local Authority.
- Total population in the study area.

Formula

$$P_{11-5} = \frac{P_{PBT}}{B_{Pegawai}}$$

Where :

P_{PBT} - Total population in the study area.

$B_{Pegawai}$ - Numbers of administration and professional officers in the Local Authority.

Standard	Score	Standard Targets
1 Officer : > 30,000 Population (Not	1	

Satisfactory) 1 Officer : 10,000 – 30,000 Population (Satisfactory) 1 Officer : < 10,000 Population (Most Satisfactory)	2 3	1 Officer **:** < 10,000 Population

PERCENTAGE OF OPERATING EXPENDITURE AS COMPARED TO REVENUE

Definition

Operating expenditure compared to the overall revenue of the Local Authority.

Justification

If the operating expenditure is more than revenue collected it shows the weaknesses of the Local Authority's financial administration.

Relationship with Other Sector

Urban Economics

Data Source

- Local Authority (PBT)

Data Items

- Total operating expenditure of the Local Authority.
- Total revenue collected by the Local Authority.

Formula

$$P_{11-6} = \left(\frac{B_{Mengurus}}{H_{PBT}} \right) x100$$

Where :

$B_{Mengurus}$ - Total operating expenditure of the Local Authority in the year of study.

H_{PBT} = Total revenue collected by the Local Authority in the year of study.

Standard	Score	Standard Targets
< 80% (Most Satisfactory)	3	
80% – 100% (Satisfactory)	2	< 80%
> 100% (Not Satisfactory)	1	

Source: a) Laporan Petunjuk Bandar Kuantan, 2005

b) Laporan Petunjuk Bandar Melaka, 2005

c) Laporan Petunjuk Bandar George Town, 2005

d) Laporan Petunjuk Bandar Johor Bahru, 2005

c) Website MURNInet (http://rsj.townplan.gov.my/MURNINet)

II. APPENDIX

TOWARDS NORM OF GOOD URBAN GOVERNANCE

Sustainability *in all dimensions of urban development*

Practical means of realizing this principle include, *inter alia*:

- Undertaking consultations with stakeholders within communities to agree on a broad-based, mission statement and long-term strategic vision for the city, using tools such as city development strategies;
- Engaging in consultative processes such as environmental planning and management (EPM) or Local Agenda 21s, that are geared to reach agreement on acceptable levels of resource use, applying the precautionary principle in situations where human activity may adversely affect the well-being of present and/or future generations;
- Integrating urban poverty reduction strategies into local development planning;
- Increase green cover and preserve historical and cultural heritage;
- Ensuring financial viability by promoting economic activity through the participation of all citizens in the economic life of the city;
- Promote the transfer of appropriate technologies.

Subsidiarity *of authority and resources to the closest appropriate level*

Practical means of realizing this principle include, *inter alia*:

- In consultation with local authorities, develop clear constitutional frameworks for assigning and delegating responsibilities and commensurate powers and resources from the national to the city level and/or from the city level to the neighbourhood level;
- Adopt local legislation to translate constitutional amendments in support of subsidiarity into practical means to empower civil society to participate

effectively in city affairs and which promote the responsiveness of local authorities to their communities;

- Creating transparent and predictable intergovernmental fiscal transfers and central government support for the development of administrative, technical and managerial capacities at the city level;
- Protecting financially weaker local authorities through systems of vertical and horizontal financial equalization agreed to in full consultation with local authorities and all stakeholders;
- Promoting decentralized cooperation and peer-to-peer learning.

Equity *of access to decision-making processes and the basic necessities of urban life*

Practical means of realizing this principle include, *inter alia*:

- Ensuring that women and men have equal access to decision-making processes, resources and basic services and that this access is measured through gender disaggregated data;
- Establish quotas for women representatives in local authorities and encourage their promotion to higher management positions within municipalities;
- Ensure bye-laws and economic development policies support the informal sector;
- Promote equal inheritance rights for land and property;
- Establishing equitable principles for prioritizing infrastructure development and pricing urban services;
- Removing unnecessary barriers to secure tenure and to the supply of finance;
- Creating fair and predictable regulatory frameworks.

Efficiency *in the delivery of public services and in promoting local economic development*

Practical means of realizing this principle include, *inter alia*:

- Delivery and regulation of public services through partnerships with the private and civil society sectors;

- Promote equitable user-pay principles for municipal services and infrastructure;
- Encourage municipal departments to find innovative means of delivering public goods and services through management contracts;
- Promote integrated, inter-sectoral planning and management;
- Improving the effectiveness and efficiency of local revenue collection;
- Removing unnecessary barriers to secure tenure and to the supply of finance;
- Developing and implementing fair and predictable legal and regulatory frameworks that encourage commerce and investment, minimize transaction costs, and legitimize the informal sector;
- Adopting clear objectives and targets for the provision of public services, which maximize the contributions all sectors of society can make to urban economic development; encourage volunteerism.

Transparency and Accountability *of decision-makers and all stakeholders*

Practical means of realizing this principle include, *inter alia*:

- Regular, organized and open consultations of citizens on city financial matters and other important issues, through such mechanisms as the participatory budget; transparent tendering and procurement procedures and the use of integrity pacts and monitoring mechanisms in the process; internal independent audit capacity and annual external audit reports that are publicly disseminated and debated;
- Regular, independently executed programmes to test public officials integrity response;
- Removing administrative and procedural incentives for corruption, including simplifying local taxation systems and the reduction of administrative discretion in permit processing;
- Promoting an ethic of service to the public among officials while putting into place adequate remuneration for public servants;
- Establishing codes of conduct and provision for regular disclosure of assets of public officials and elected representatives;

- Developing practically enforceable standards of accountability and service delivery, such as ISO, that will transcend the terms of public office holders;
- Creating public feedback mechanisms such as an ombudsman, hotlines, complaint offices and procedures, citizen report cards and procedures for public petitioning and/or public interest litigation;
- Promoting the public's right of access to city information;
- Providing access to city information to create a level playing field for potential investors.

Civic Engagement and Citizenship

Practical means of realizing this principle include, *inter alia*:

- Promoting strong local democracies through free and fair municipal elections and participatory decision-making processes;
- Establishing the legal authority for civil society to participate effectively through such mechanisms as development councils and neighbourhood advisory committees;
- Promoting an ethic of civic responsibility among citizens through such mechanisms as "City Watch" groups;
- Making use of mechanisms such as public hearings and surveys, town hall meetings, citizen's forums, city consultations and participatory strategy development, including issue-specific working groups;
- Undertaking city referenda concerning important urban development options.

***Security** of individuals and their living environment*

Practical means of realizing this principle include, *inter alia*:

- Creating a culture of peace and encouraging tolerance of diversity, through public awareness campaigns;
- Promoting security of tenure, recognizing a variety of forms of legal tenure and providing counseling and mediation for people at risk of forced evictions;

- Promoting security of livelihoods, particularly for the urban poor, through appropriate legislation and access to employment, credit, education and training;
- Implementing environmental planning and management methodologies based on stakeholder involvement;
- Creating safety and security through consultative processes based on rule of law, solidarity and prevention, and supporting appropriate indigenous institutions that promote security;
- Address the specific needs of vulnerable groups such as women and youth through women's safety audits and youth training programmes;
- Developing metropolitan-wide systems of policing as a means of realizing more inclusive cities;
- Raising awareness about the risk of disasters and formulating local emergency management plans, based on reduction of risk, readiness, response and recovery, for natural and human-made disasters and, where necessary, relocating residents of disaster-prone areas;
- Integrating emergency management among municipal departments and with national plans;
- Formulating strategies and action plans addressing all forms of abuse against the person, especially abuse against women, children and the family.

III. APPENDIX

CURRENT INDICATORS USED

Table 27: Indicators listed in Urban Indicators Database by HABITAT (1993)

Sector	Sub-Sector
Shelter	• Tenure types • Evictions • House price & rent • Access to water • Land price to income ratios • Household connections • Housing rights
Social development and poverty eradication	• Under - five mortality • Reported Crime rates • Poor households • Gross school enrolment ratios • Urban violence • Literacy • Life expectancy at birth • Urban violence
Environmental Management	• Population • Annual population growth • Water Consumption • Median water price

	• Waste water treated • Solid waste disposal • Travel time • Transport modes to work • Disaster prevention & mitigation • Local environmental plans
Economic Development	• Informal employment • City product • Unemployment • Public-private partnership
Governance	• Decentralization • Local government revenue & expenditures • Citizens participation • Transparency & accountability • International cooperation

Table 28: Indicators listed in Malaysia Urban Network Index (MURNInet) by Town and Country Planning Department, Malaysia (2003)

Sector	Sub-Sector
Demography	• Urbanization Rate. • Population Density. • Average Population Growth Rate. • Median Age. • Average Household Size.
Housing	• Housing Price and Income Ratio. • Housing Rental and Income Ratio. • Ratio of Floor Space Area per Person. • Ratio of Housing Output per 1,000 Populations.
Urban Economic	• Unemployment Rate.

	• Employment Growth Rate. • Labor Force Growth Rate. • Poverty Rate. • Income Distribution (Gini Coefficient).
Utility and Infrastructure	• Daily Water Consumption Rate of Every Population. • Water Loss. • Percentage of Flooding Prone Area. • Average Garbage Collection per Day per Population. • Percentage of Residential Units Serviced by Centralized Sewerage.
Public Facilities and Recreational	• Doctors and Population Ratio. • Ratio of Public Open Space per 1,000 Populations. • Primary Schoolchildren and Teacher Ratio. • Kindergarten and Population Ratio. • Civic Hall and Population Ratio.
Environment	• Percentage of Financial Budget for Environmental Management. • Ratio of Asthmatic Cases per 10,000 Populations. • Percentage of Budget Allocation for Landscape Program. • River Water Quality Index (WQI). • Percentage of Area That Received Waste Disposal Services. • Percentage of Solid Waste That Has Been Recycle. • Number of Complaint Cases on Noise. • Ratio of Water Bone and Food Diseases per 10,000 Populations. • Air Quality Index.
Sociology and Social Impact	• Percentage of the Population Involved In Community Program. • The Quality Levels of Health Services. • Ratio of Crime Index Case per 10,000 Populations. • Ratio of Juvenal Case per 1,000 Populations. • Ratio of Arrests Due to Social Ills per 1,000 Populations. • Divorce Rate per 1,000 Marriages.

Land use	• Percentage of C.F.O Approvals. • Percentage of Total Land Area for Public Facilities. • Percentage of Residential Floor Space Area in City Centre.
Urban design and Heritage	• Percentage Expenditure on Maintenance Of Heritage Elements and Urban Beautification. • Percentage of Tourism Attraction Area.
Transportation and Accessibility	• Percentage of Public Bus Users. • The Quality Level of Public Bus Services. • Percentage of Expenditure to Enhanced Accessibility System. • Percentage of Single Occupancy Vehicle (SOV) Entering City Centre during Morning Peak Hour Period. • Ratio of Road Accident Cases per 10,000 Populations. • Percentage of Fatal Road Accident Cases.
Management and Financial	• Local Authority per Capita Revenue. • Tax Collection Rate. • Cash Flow Ratio As Compared To Emoluments. • Development Expenditure Per Capita. • Ratio of Population per Professionals and Management Officers. • Percentage of Administration Expenditure As Compared to Revenue.

Table 29: Indicators used by Community University Institute for Social Research (2005)

Sector	Sub-Sector
Demographic and Background Information	• Population Growth • Household & Family Compositions • Average Income • Renters & Owners • Population Mobility • Foreign Born

	• New Immigrant Groups • Language Spoken at Home • Visible Minorities • Aboriginal Population
Affordable, Appropriate Housing	• 30+ Income on Shelter • 50%+ Income on Shelter • Core Housing Need • Substandard Unit • Changing Face of Homelessness • Vacancy Rates • Rental Housing Starts • Monthly Rent
Civic Engagement	• Voter Turnout • Women in Municipal Government • Newspaper Circulation • Volunteering • Charitable Donations
Community and Social Infrastructure	• Social Housing Waiting Lists • Rental-Geared-to-Income Housing • Social Assistance Allowances • Subsidized Child Care Spaces • Public Transit Costs • Social Services Professionals • Private Health care Expenditures
Education	• Education Levels • Literacy Levels • Adult Learning • Education expenditures • Classroom Size • Student/Teacher Ratio • Post-Secondary Tuition • Spending on Private Education
Employment	• Unemployment/Employment Rates • Quality of Employment

	• Long Term Unemployment • Labor Force Replacement
Local Economy	• Business Bankruptcies • Consumer Bankruptcies • Hourly Wages • Change in Family Income • Building Permits
Natural Environment	• Air Quality • Urban Transportation • Population Density • Water Consumption • Wastewater Treatment • Solid Waste • Ecological Footprint • Recreational Water Quality
Personal & Community Health	• Low Birth Weight Babies • Teen Births • Premature Mortality • Work Hours Lost • Suicides • Infant Mortality
Personal Financial Security	• Community Affordability • Families Receiving EI/Social Assistance • Economic Dependency Ratio • Lone Parent Family • Incidence of Low Income Families • Children Living in Poverty • Income Gap
Personal Safety	• Youth Offenders • Violent Crimes • Property Crimes • Injuries and Poisonings

REFFERENCES

Allen, R., A. Athanassopoulos, R. Dyson and E. Thanassoulis (1997). Weight Restrictions and Value Judgments in Data Envelopment Analysis: Evolution, Development and Future Directions. Annals of Operations Research..

Andersen, P. and N.C. Petersen (1993). A Procedure for Ranking Efficient Units in Data Envelopment Analysis. Management Science, Vol. 39, No. 10, pp. 1261–1264.

Farrell, M.J., 1957, The Measurement of Productive Efficiency, Journal of Royal Statistical Society A 120, 253-281.

Charnes, A., W.W. Cooper, and E. Rhodes, 1978, Measuring the Efficiency of Decision Making Units, European Journal of Operational Research 2.

Charnes A, Cooper WW & Rhodes E (1981) Evaluating program and managerial efficiency: application of data envelopment to program follow-through. Management Science 27:429–444.

Coelli, T., P.D.S. Rao and G.E. Battese (1998). An Introduction to Efficiency and Productivity Analysis. Kluwer Academic Publishers, Bosten/Dordrecht/London.

Cooper, W.W., L. Seiford, and K. Tone. (1999). Data Envelopment Analysis. Kluwer, Boston, MA.

Cooper, W.W., Seiford, L.M. and Zhu, Joe, A Unified Additive Model Approach For Evaluating Inefficiency And Congestion With Associated Measures In DEA. Socio-Economic Planning Sciences, Vol. 34, No. 1 (2000),

Førsund FR (1992) Comparison of parametric and non-parametric efficiency measures: the case of Norwegian ferries. Journal of Productivity Analysis 3.

Førsund FR & Hjalmarsson L (1974) On the measurement of productive Efficiency. Swedish Journal of Economics 76: 141–154.

Jabatan Perancangan Banda dan Desa Semenanjung Malaysia (2005), Pelaksanaan Petunjuk Bandar Malaysia: Laporan Bandar Bandaraya Johor Bahru 2005, Kementerian Perumahan dan Kerjaan Tempatan, Johor
http://rsj.townplan.gov.my/MurniNetWeb

Jabatan Perancangan Banda dan Desa Semenanjung Malaysia (2003), Pelaksanaan Petunjuk Bandar Malaysia: Laporan Bandar Bandar Kuantan 2003, Kementerian Perumahan dan Kerjaan Tempatan, Pahang
http://rsj.townplan.gov.my/MurniNetWeb

Neumayer, E. (2001). The Human Development Index and Sustainability — A Constructive Proposal. Ecological Economics, 39, pp. 101–114.

UNDP (1998). Human Development Report 1998. United Nations Development Program (UNDP), Oxford University Press 2000. Available on the Internet: http://www.undp.org/hdro/98.htm.

UNDP (2000). Human Development Report 2000. United Nations Development Program (UNDP), Oxford University Press 2000. Available on the Internet: http://www.undp.org/hdr2000/english/HDR2000.html.

Unit Perancangan Ekonomi, Jabatan Perdana Menteri (2005), Millennium Development Goals Report, Kuala Lumpu

Unit Perancangan Ekonomi, Jabatan Perdana Menteri (2002), Laporan Kualiti Hidup 2002, Kuala Lumpur

Zhu, J., 2000, Multi-Factor Performance Measure Model with an Application to Fortune 500 Companies. European Journal of Operational Research

Zhou, P., Ang, B.W., Poh, K.L., 2007, A Survey of Data Envelopment Analysis in Energy and Environmental Studies, Science Direct Journal, Department of Industrial and Systems Engineering, National University of Singapore, Singapore

DEA and benchmarks – an application to Nordic banks

Göran Bergendahl
School of Economics and Commercial Law, Göteborg University,
S-411 80 Göteborg, Sweden

In memory of Åsa Hallefjord

In this paper, Data Envelopment Analysis (DEA) is developed to analyze the efficiency of a single bank. The inputs are given in terms of cost of personnel, cost of material and expected cost of credit losses. Outputs concern lending, deposits and gross revenues (interest margins and non-interest income). The data covers 48 large Nordic banks during the two years 1992 and 1993. Fourteen banks are from Denmark, thirteen from Finland, twelve from Norway and nine from Sweden. For each of these banks, the DEA method is used to form a "reference bank", which is a convex combination of the best competing banks (those at the efficiency frontier). The three inputs and the three outputs of the reference bank will be used as benchmarks. This procedure implies that one can only say that one single bank is less efficient than its reference bank, not less efficient than another bank. The results show that 4–7 Nordic banks were situated at the efficiency frontier for those two years. These banks should then be used to form reference banks for other banks, and to set benchmarks for them. Such benchmarks would have been slightly different, dependent on the "window" to be used, 1992, 1993 or 1992 + 1993.

1. The DEA model

Charnes et al. [8] initiated the use of linear programming for evaluating managerial behavior in organizations with multiple inputs and outputs. Their method, called Data Envelopment Analysis (DEA), has been widely used and several applications are found in the banking sector.

In this paper, we will apply the DEA method to the Nordic banking sector. We will assume that a single bank wants to improve its performance in its own sector, which is banking. Such a procedure may include three steps for the bank to be evaluated:

(1) to identify and to quantify the outputs and inputs of the bank itself as well as of other competing banks in the sector;

(2) to generate a convex combination of banks, which will constitute its reference bank;

(3) to compare on the one hand inputs and outputs for the bank to be evaluated and on the other hand the corresponding benchmarks from its reference bank.[1)] The difference will state the potential degrees of improvement.

Let us formulate these three steps in more precise and mathematical terms. Set the following indices:

k = a bank $(k = 1, 2, \ldots, K)$,
i = an input $(i = 1, 2, \ldots, I)$,
j = an output $(j = 1, 2, \ldots, J)$,

and define the following data:

x_i^k = quantity of input i for bank k,
u_j^k = quantity of output j for bank k.

Certain benchmarks may concern items on the balance sheet. They will have the role to generate future income. Other benchmarks may concern the profit and loss accounts, with the task of stimulating present income and of discouraging present expenditures.

Then constitute for each bank κ to be evaluated a Reference Bank (the "Evaluator") named $R(\kappa)$ with inputs $x_i^{R(\kappa)}$ and outputs $u_j^{R(\kappa)}$. These inputs and outputs are given as convex combinations of those of the competing banks and are defined as follows:

$$x_i^{R(\kappa)} = \sum_k \lambda_k x_i^k, \tag{1}$$

$$u_j^{R(\kappa)} = \sum_k \lambda_k u_j^k, \tag{2}$$

$$\lambda_k \geq 0, \tag{3}$$

where λ_k stands for the weight bank k will have in this convex combination.

The DEA formulation fulfills the task of setting benchmarks $(x_i^{R(\kappa)}, u_j^{R(\kappa)})$, which will generate an efficiency score θ for bank κ according to the following model:

$$\text{minimize} \quad \theta \tag{4}$$

$$\text{subject to} \quad x_i^{R(\kappa)} = \sum_k \lambda_k x_i^k \leq \theta x_i^\kappa \quad (i = 1, 2, \ldots, I), \tag{5}$$

$$u_j^\kappa \leq u_j^{R(\kappa)} = \sum_k \lambda_k u_j^k \qquad (j = 1, 2, \ldots, J), \tag{6}$$

as well as to (3),

[1)] This may be called an external benchmarking (see Gustafsson [14, pp. 19–20]).

This analysis shows that DEA is a suitable *instrument for benchmarking*,[2] since

(a) it generates the best units in the branch ("best in class") in terms of those banks that are efficient;

(b) it forms a reference bank (a reference decision unit) as a combination of these efficient units;

(c) it defines benchmarks in terms of inputs, outputs and financial ratios based upon the reference bank.

There have been almost as many assumptions of inputs and outputs as there have been applications of DEA (see table 1). For example, Sherman and Gold [17] have chosen labor, office space and supply costs as inputs, and various loans and deposits as outputs (the "Production Approach"). On the other hand, Yue [26] has taken interest and non-interest income as well as total loans as outputs. Interest and non-interest expenses, transactions and non-transaction deposits are handled as inputs (the "Intermediation Approach").

The choice of inputs and outputs has to reflect the objective of the bank. For example, if the bank is assumed to maximize profit, then all types of costs should be treated as inputs and all types of revenues as outputs. On the other hand, in the case an efficient service management is viewed as the main objective, then the volume of services will become a relevant output and the cost to produce those services an appropriate input. If, alternatively, the efficiency in risk management is to be evaluated, risk is to become an input and the return from that risk-taking an output. From this, it follows that given a certain income, less risk is preferred to more. And given a certain risk, more income is preferred to less.[3]

Tulkens and Vanden Eeckaut [25, table 3.1] listed five approaches to efficient bank management, each with a certain objective and consequently with a certain set of inputs and outputs. The approaches are:

(1) profit maximization,

(2) service provision,

(3) intermediation,

(4) utility provision,

(5) risk management.

It is evident that the choice of inputs and outputs will depend first of all on which of these approaches is to be followed. Secondly, the way to measure inputs and outputs may depend on the availability of data. Berger and Humphrey (4, p. 23] observe that "output of financial institutions is best measured as a flow of services provided to

[2] For an analysis of benchmarks in terms of inputs, outputs, and financial ratios, see e.g. Bogan and English [5, pp. 51–57].

[3] For a rigorous analysis of inputs and outputs to a bank, see Humphrey [15, pp. 16–19].

Table 1

Inputs and outputs in certain applications of DEA for bank management.

Author(s)	Inputs	Outputs
Sherman and Gold [17]	Labor, office space, supply costs	Loan applications, new passbook loans, life insurance sales, new accounts, closed accounts, travelers checks sold, bonds sold, bonds redeemed, deposits, withdrawals, checks cashed, treasury checks issued, B5 checks, loan payments, passbook loan payments, life insurance payments, mortgage payments
Charnes et al. [7]	Interest expenses, non-interest expenses, provisions for loan sales	Interest expenses, non-interest income, allowance for loan losses, total loans
Berger and Humphrey [3]	Labor, physical capital, purchased funds	Demand deposits, time and savings deposits, real estate loans, commercial and industrial loans, installation loans
Oral and Yolalan [16]	Personnel, on-line terminals commercial accounts, saving accounts, credit applications	Time spent on service transactions, on credit transactions, on deposit transactions, and on foreign exchange transactions
Tulkens [23, 24]	Labor, windows, ATM	C/A and S/A operations, ATM operations, international operations, brokerage, credit operations, opening of new accounts, special service, miscellany
Yue [26]	Interest expenses, non-interest expenses, transaction deposits, non-transaction deposits	Interest income, non-interest income, total loans
Berg et al. [2]	Labor, material, rea capital	Loans to households, loans to other sectors, total deposits, guarantees, number of branches
Brown and Gardener [6]	Operating costs, cost of equity, reserve changes (–)	Reserve changes (+), gross profit

users, such as the number and type of transactions processed over a given time period. However, as such flow data are usually not available to researchers, the number of deposit or loan accounts (stock data) or the values of deposits and loans (balance sheet data) may be used as alternative output indicators".

In this paper, we assume that a bank has the twin input-saving objectives of an efficient service provision and of an efficient risk management. (Output-increasing objectives seem to be of less importance for setting benchmarks in a bank.) In the spirit of Tulkens and Vander Eeckaut [25, pp. 20–23], it is evident that the risk management objective may be expressed as one of minimizing risk for a given level of gross revenues (benefit). In the same way, the service provision approach (alternatively called the production approach) may be seen as to minimize inputs of personnel and material for desired levels of services such as loans and deposits. The task of evaluating bank efficiency will become rather complex when these two objectives of risk management and service provision are considered simultaneously.

Stewart [20] has given an extensive exposé over multiple-criteria decision making. In particular, he has presented descriptive methods in order "to develop an understanding of what can realistically be achieved and what are the constraints on performance imposed by the current decision set" [20, p. 581]. In a comment to Stewart's paper, Doyle and Green [11] have demonstrated that multiple objectives may be efficiently evaluated through the use of DEA. Following their argumentation, we will analyze the performance of a bank by including the dual objectives of an efficient risk management and of an efficient service provision. In so doing, *gross revenues* will become outputs and credit risk in terms of *credit losses* (measured in terms of loss provisions) will become inputs in risk management.[4)] In parallel, *lending volume* and *deposit volume* will become outputs and *cost of personnel* and *cost of material* will become inputs in evaluating the service provision. That leads up to an analysis based upon three outputs and three inputs for each bank.

In DEA, the financial benchmarks are generated by the procedure itself. First, each bank is specified in terms of inputs and outputs. Then, the procedure will calculate benchmarks for each bank in terms of inputs and outputs for its reference bank. If they match, no improvement may be found. If they do not match, this will imply that the benchmarks will indicate potential for improvement.

2. DEA and the cases of Nordic banks 1992 and 1993

The DEA model (3)–(6) has been tested for one sample of large Nordic banks over the two years 1992 and 1993. The sample covers 14 Danish, 13 Finnish, 12 Norwegian and 9 Swedish banks. They are identified with a code of one letter for country and two digits for the individual bank and year as follows:

[4)] Note that varying accounting standards in the four Nordic countries may result in loss provisions being measured somewhat differently between banks. In this paper, we assume that that effect is of minor importance for the efficiency evaluation.

Class (year)	1992	1993
Danish banks	D10–D23	D30–D43
Finnish banks	F10–F22	F30–F42
Norwegian banks	N10–N21	N30–N41
Swedish banks	S10–S18	S30–S38

The choice of bank data is based on official financial statistics. Examples of statistics that are excluded are the number of branches per bank, the size of manpower per bank, the number of customers per bank, etc.

Actual outputs and inputs have their origin in data presented in annual reports for the two years of 1992 and 1993 (see [9, 10, 12, 13, 18, 19, 21, 22]). The data have been made convertible into Swedish Kronor by the use of end-of-year exchange rates.[5] For each of the 48 banks, table 2 gives the three inputs: cost of personnel, cost of material and credit losses and the three outputs: loans, deposits and gross revenues.

The DEA model was operated in such a way that each bank (κ) was analyzed separately. The analysis of bank κ covers two tasks. First, the reference bank $R(\kappa)$ is determined among the convex combinations of the given set of 48 Nordic banks. Secondly, the outputs, inputs and financial ratios of bank $R(\kappa)$ may be used as benchmarks for bank κ. In the present case, there are *three* alternatives ("windows") to use in order to calculate reference banks, namely:

(a) to choose among the banks of 1992 – "Window 1992",

(b) to choose among the banks of 1993 – "Window 1993",

(c) to choose among the banks of 1992 and 1993 – "Window 1992–93".

The first reason to analyze windows from two consecutive years (1992 and 1993) was to illustrate the change of efficiency scores and benchmarks over time. The second reason was to demonstrate the use of shadow prices. Shadow prices of the first year (1992) were studied in order to indicate for each bank which would be the best strategy to improve efficiency for the following year. Through the study of the second year (1993), we could discover which banks had adopted a strategy to improve efficiency and to what extent they had been successful. Furthermore, a third window (Window 1992–93) was studied in order to make a "dynamic" comparison of the efficiency. In so doing, a bank of 1993 was compared to banks in both the preceding year (1992)

[5] For the class of 1992, those rates were given as 1 DKK = 1.135 SEK, 1 FIM = 1.345 SEK and 1 NOK = 1.0275 SEK. These data are taken from the market exchange rates of December 31, 1992. For 1993, they are were approximated to 1 DKK = 1.237 SEK, 1 FIM = 1.445 SEK and 1 NOK = 1.113 SEK (taken from market data of December 30, 1993).

Table 2

Outputs and inputs for the 48 Nordic banks in 1992 and 1993 [7)]
(outputs and inputs in million Swedish Kronor).

Bank 1992	Output 1 Loans	Output 2 Deposits	Output 3 Gross revenues	Input 1 Cost of personnel	Input 2 Cost of material	Input 3 Credit losses
D10	169919	156350	8715	4806	2685	2584
D11	134406	124775	9152	4188	2822	6349
D12	10206	11814	764	370	276	331
D13	6744	4885	402	173	128	257
D14	5901	5874	495	192	125	162
D15	7286	10803	537	406	200	230
D16	7103	4992	389	107	102	1045
D17	61234	59314	3945	1903	1334	1951
D18	11184	32939	2612	781	1653	53
D19	25767	36471	1581	880	522	821
D20	6386	5388	405	174	121	280
D21	14785	12633	960	415	244	280
D22	17676	16065	834	516	1016	726
D23	6895	7702	519	266	178	716
F10	88317	63775	4807	2027	1523	5252
F11	89573	64061	4734	1792	1318	3814
F12	55696	41271	4512	1338	1419	2324
F13	22059	3139	1851	261	1006	351
F14	15593	3096	171	239	790	4112
F15	11983	1219	393	315	200	390
F16	2841	2488	187	63	27	50
F17	584	4266	101	19	26	4
F18	1041	0	46	0	5	0
F19	463	1221	31	11	22	3
F20	77437	70822	3475	2378	1699	10387
F21	6888	8422	714	234	168	253
F22	5636	4171	1145	148	147	846
N10	117439	91976	6657	2104	1847	4133
N11	80325	68846	4485	1506	1167	2698
N12	29749	23250	1624	580	544	968
N13	18494	1396	378	33	38	92
N14	7852	6984	389	120	120	284
N15	5239	5970	323	77	105	89
N16	3548	3009	254	60	75	58
N17	3851	3005	135	26	30	50
N18	3313	3201	157	49	50	109
N19	2268	1687	122	26	31	44
N20	2781	2541	145	51	64	82
N21	1973	1916	67	14	17	16
S10	8431	6371	467	168	168	567
S11	63692	36162	4144	1156	4932	12480
S12	164217	121688	11138	2392	2383	7085
S13	528	421	587	246	45	230
S14	152104	154184	7238	1897	3861	17146
S15	1128	941	68	37	42	111
S16	225572	130619	10107	3158	2910	9587
S17	54519	57190	4645	1389	1390	3288
S18	167730	140131	12247	3995	3790	16633

continues . . .

Table 2 (continued)

Bank 1993	Output 1 Loans	Output 2 Deposits	Output 3 Gross revenues	Input 1 Cost of personnel	Input 2 Cost of material	Input 3 Credit losses
D30	191772	201369	16692	4902	2838	3393
D31	146518	157777	12688	4266	3008	4370
D32	8399	15415	1044	359	302	464
D33	6314	6815	602	186	130	370
D34	6275	6587	757	215	143	288
D35	7318	12230	967	444	209	161
D37	53779	69818	6331	2050	1377	3245
D38	37607	33473	3548	845	1731	122
D39	28472	46864	3020	967	553	996
D40	5832	6108	495	193	119	372
D41	15657	15684	1416	465	275	510
D42	17638	18529	1467	522	360	769
D43	4094	7344	601	250	171	1028
F30	115044	94119	5992	2029	2222	5199
F31	104154	89126	6104	1913	1685	5316
F32	71386	63342	5622	1261	1864	2715
F33	18366	3868	2201	260	1166	526
F34	10679	2066	707	199	400	2339
F35	1873	0	61	169	149	2448
F36	2763	2783	224	71	33	69
F37	1056	3738	123	25	35	39
F38	936	0	36	0	49	0
F39	516	111	88	12	38	19
F41	299	9034	603	207	150	270
F42	8703	6011	172	328	328	2007
N30	121748	92360	8784	2128	2136	2964
N31	88504	70234	5078	1626	1304	1715
N32	26797	23054	1749	505	463	503
N33	22733	3694	503	41	61	72
N34	8833	7237	618	135	154	191
N35	6144	7135	452	92	125	107
N36	4481	4255	315	70	104	21
N37	4985	4246	176	40	38	24
N38	1545	268	60	70	104	618
N39	2491	2180	135	31	43	47
N40	2981	3224	232	53	53	0
N41	3074	2173	144	31	33	16
S30	7956	8322	432	155	141	258
S31	34340	38791	2558	1058	3040	11982
S32	143943	126801	12351	2446	2211	5988
S33	581	646	336	123	62	8
S34	126606	159128	11179	1585	3758	3805
S35	1261	1307	101	44	47	77
S36	189723	141095	14106	3214	3056	8962
S37	49327	60170	4656	1197	1239	4012
S38	137123	138456	12174	3505	3410	9602

[6] Forty-eight banks were observed for 1992. Two of them (D16 and F20) were closed down in 1993. Consequently, no statistics are available for the corresponding banks of 1993 (D36 and F40).

and the actual year (1993). Then, the question to be posed was if the activities of 1993 were formed in such a way that (a) the knowledge of production in 1992 was considered, and (b) the technical progress in 1993 was reflected in the result.[7)]

Window 1992: The main results from this computation are demonstrated in table 3. Four banks were located on the efficiency frontier, namely F17, F18, N13 and S13. These four banks will then form the reference banks. As these four banks are relatively small, the reference banks will often be scaled up.

Window 1993: Table 4 shows that seven banks were on the efficiency frontier in 1993. They were F36, F37, F38, N33, N37, N40 and S33, where F36, N33 and N37 were those banks that were used more frequently. Also these banks were rather small.

Window 1992–93: Table 5 demonstrates the results for this window. Six banks were on the efficiency frontier over the two years, namely F17, F18, N13, N33, N40 and S13. Observe that no index (like the one of Malmqvist) has been used, as both inputs and outputs are given in million SEK (Swedish Kronor).

It is evident that windows of this type may be used in order to set benchmarks for a subsequent year. For example, "Window 1992" could have been a basis for benchmarks in year 1993 and "Window 1993" or "Window 1992–93" for benchmarks in year 1994.

The examples suggest that the DEA method seems to be suitable for benchmarking. The banks that form the efficiency frontier will not only set the benchmarks in terms of inputs and outputs, they may also be used to constitute benchmarks in terms of financial ratios. For example, banks F18, F38, N13 and N33 are outstanding in terms of lending per unit cost of personnel and material. Banks F17 and F38 are extremely good in terms of deposits per cost unit. Moreover, banks S13 and S33 are special in terms of gross revenues per cost unit.

Hitherto, the calculations have been made under the assumption of *constant* returns to scale. This implies that small banks may be scaled up a multiplicity of times in order to be comparable to large banks. An alternative assumption would be that any reference bank has to become a combination of *fractions* of other banks (e.g. see Banker et al. [1, pp. 1086–1088]). This implies that the sum of the factors λ_k in equations (5) and (6) must be equal to unity. Such an assumption will stand for a *variable* return to scale.

Example 1. In the foregoing, bank S12 has been used as an example of how to form a reference bank in a rather arbitrary way. Bank S12 will now be used to illustrate how to form a reference bank that is efficient, and to use that reference bank to set benchmarks.

[7)] For a window analysis, see e.g. [26, pp. 38–39].

Table 3

Efficiency ratios and reference banks for the class of Nordic banks in 1992. (The reference banks are identified in terms of shares of the efficient banks F17, F18, N13, and S13. For example, the reference bank *R*(D10) to bank D10 will become a convex combination of 34.25 times bank F17, 27.11 times bank F18, 6.55 times bank N13, and 2.61 times bank S13.)

Bank	Degree of efficiency	Reference banks as shares of the efficient banks			
		F17	F18	N13	S13
D10	51.86	34.25	27.11	6.55	2.61
D11	44.70	25.25		10.96	4.19
D12	41.16	2.58	2.48	0.48	0.36
D13	41.63	0.94		0.60	0.14
D14	53.82	1.30	2.92	0.14	0.30
D15	44.17	2.41	0.38	0.29	
D16	52.10	0.94		0.68	0.06
D17	42.66	12.40	2.49	4.05	1.78
D18	58.27	7.72	152.50		
D19	53.58	8.13		1.12	0.57
D20	45.77	1.08		0.52	0.17
D21	55.77	2.79	5.49	0.39	0.47
D22	15.33	3.67	9.91	0.28	
D23	41.57	1.60		0.56	0.25
F10	43.26	12.58		6.73	1.69
F11	49.57	12.76		6.36	1.77
F12	39.36	6.85	7.39	8.49	
F13	20.49	0.56	33.60	0.49	0.11
F14	9.29	0.62	9.05	0.31	
F15	20.10	0.11	2.41	0.51	0.14
F16	93.24	0.52		0.14	0.14
F17	100.00	1.00			
F18	100.00		1.00		
F19	49.44	0.29	0.69		
F20	34.08	15.31		3.68	0.92
F21	56.72	1.71	1.98	0.71	0.31
F22	77.78	0.02		2.91	0.08
N10	50.51	18.00		10.42	1.53
N11	55.94	14.14		5.64	1.58
N12	42.54	4.57		2.61	0.30
N13	100.00			1.00	
N14	51.04	1.45		0.54	0.06
N15	50.18	1.26	0.72	0.43	
N16	47.99	0.62	1.90	0.28	
N17	79.52	0.64		0.19	
N18	52.55	0,69		0.19	0.03
N19	55.73	0,32		0.23	0.00
N20	35.52	0,52		0.24	0.00
N21	84.91	0,42		0.09	
S10	38.94	1,22		0.81	0.06
S11	13.93	8,48	93.35		
S12	60.37	21.28		21.75	1.31
S13	100.00				1.00
S14	38.34	35.65	99.18	1.52	
S15	22.90	0.18		0.13	0.00
S16	47.52	24.81		17.19	1.88
S17	45.03	10.54		8.57	0.58
S18	42.34	25.22		22.75	1.88

Table 4

Efficiency ratios and reference banks for the class of Nordic banks in 1993. (The reference banks are identified in terms of shares of the efficient banks F36, F37, F38, N33, N37, N40 and S33.)

Bank	Degree of efficiency	Reference banks as shares of the efficient banks						
		F36	F37	F38	N33	N37	N40	S33
D30	86.66	15.59			19.01	20.67		
D31	62.78	25.26			9.73	12.14		
D32	56.17	1.15			0.80	2.18		
D33	65.99	1.23			0.53	0.34		
D34	67.88	0.90			1.10			
D35	74.05				1.17	1.47	0.53	
D36								
D37	64.71	14.18			5.42	2.43		
D38	72.81			12.66	1.23		10.65	
D39	90.39	9.65			0.08	4.64		
D40	61.51	1.33			0.28	0.33		
D41	72.42	4.09			0.92	0.21		
D42	61.07	3.08			1.04	1.44		
D43	51.85	1.29			0.45	0.50		
F30	45.45		0.16		5.99	16.82		
F31	58.57	5.55			5.16	12.86		
F32	45.55		7.80	0.24	9.25			
F33	58.50			9.30	3.71			
F34	28.08			0.60	1.36			
F35	4.96				0.12			
F36	100.00	1.00						
F37	100.00		1.00					
F38	100.00			1.00				
F39	57.47			0.24	0.15		0.01	
F40								
F41	65.64	1.09			0.32	1.14		
F42	17.28		0.06		0.10	1.28		
N30	57.06	5.98			12.31	7.13		
N31	61.17	6.87			4.06	8.51		
N32	58.09	1.23			1.89	2.98		
N33	100.00				1.00			
N34	58.50	0.12			0.87	0.87		
N35	70.00		0.57	0.19	0.48	0.77		
N36	82.44			0.53	0.13	0.32	0.74	
N37	100.00					1.00		
N38	7.00				0.12			
N39	57.48		0.36	0.00	0.16	0.05		
N40	100.00						1.00	
N41	83.20			0.01	0.10	0.27		
S30	57.66	0.22			0.18	1.66		
S31	28.41		7.88	8.85	2.52			
S32	76.61	12.92			16.27	7.24		
S33	100.00							1.00
S34	80.79		29.45	24.40	13.28			
S35	32.81	0.03			0.12	0.18		
S36	62.66	12.56			19.70	7.86		
S37	57.31	1.89			5.59	8.07		
S38	51.26	8.82			15.65	13.21		

Table 5

Efficiency ratios and reference banks for the class of Nordic banks in 1992 and 1993. (The reference banks are identified in terms of shares of the efficient banks F17, F18, N13, N33, N40, and S13.)

Bank	Degree of efficiency	Reference banks as shares of the efficient banks					
		F17	F18	N13	N33	N40	S13
D10	51.68	29.18			8.33		2.69
D11	44.70	25.25			10.96		4.19
D12	41.01	2.13			0.70		0.33
D13	41.63	0.78		1.11	0.02		
D14	53.54	0.82			0.62		0.17
D15	44.12	2.33		0.12	0.15		0.30
D16	52.10	0.94		0.68			0.06
D17	42.63	11.94		3.47	0.76		1.78
D18	37.13	4.92	57.86			3.71	
D19	53.58	8.13		1.12			0.57
D20	45.77	1.08		0.52			0.17
D21	55.48	1.87			1.23		0.26
D22	15.15	3.53	9.12		0.27		
D23	41.57	1.60		0.56			0.25
F10	43.26	12.58		6.73			1.69
F11	49.57	9.40		14.35			
F12	39.27	1.14		0.40	12.11		
F13	20.44		30.40		0.84		0.05
F14	8.94	0.46	6.39		0.31		
F15	20.04		1.91	0.29	0.20		0.16
F16	93.22	0.52		0.12	0.01		0.14
F17	100.00	1.00					
F18	100.00		1.00				
F19	49.44	0.29	0.69				
F20	34.08	15.31		3.68			0.92
F21	56.53	1.35		0.31	0.57		0.30
F22	77.78	0.02		2.91			0.08
N10	50.51	15.51		15.82			
N11	55.94	14.14		5.64			1.58
N12	42.54	5.07		4.13			
N13	100.00			1.00			
N14	51.04	1.45		0.54			0.06
N15	50.11	1.19	0.35	0.35	0.11		
N16	47.71	0.39	0.70		0.36		
N17	79.52	0.64	0.19				
N18	52.55	0.69		0.19			0.03
N19	55.73	0.32		0.23			0.00
N20	35.52	0.52		0.24			0.00
N21	84.91	0.42		0.09			
S10	38.94	1.22		0.81			0.06
S11	13.93	8.48	93.35				
S12	60.37	26.53		37.84			
S13	100.00						1.00
S14	38.07	34.89	94.92		1.45		
S15	22.90	0.18		0.13			0.00
S16	47.52	8.43		26.05			
S17	45.03	10.54		8.57			0.58
S18	42.34	25.22		22.75			1.88

continues . . .

Table 5 (continued)

Bank	Degree of efficiency	Reference banks as shares of the efficient banks					
		F17	F18	N13	N33	N40	S13
D30	80.50	27.08			22.75		4.28
D31	57.19	25.90		3.41	10.87		5.65
D32	49.68	3.10		1.49			0.29
D33	59.69	1.28		0.89			0.23
D34	62.89	1.03		1.04	0.17		0.30
D35	66.44	1.66	2.14		1.39		
D36							
D37	58.62	13.12		9.13			2.65
D38	29.07	7.80	59.37		0.06		
D39	78.66	10.08		2.15			2.03
D40	54.95	1.22		0.58			0.26
D41	65.68	2.86		1.24	0.39		0.79
D42	54.61	3.64		1.95			0.62
D43	46.51	1.43		0.82			0.25
F30	40.14	18.72		10.05			0.52
F31	51.91	17.75		9.18			1.44
F32	40.99	11.98	23.89	8.76			
F33	20.84		34.27	0.49	0.86	0.01	
F34	18.91	0.24	7.38	1.66			
F35	4.04			0.15		0.01	
F36	88.37	0.59		0.14			0.19
F37	74.19	0.85	0.22	0.07			
F38	9.17		0.90				
F39	25.08		1.44	0.02	0.02		0.01
F40							
F41	57.75	1.86		0.72			0.25
F42	15.04	1.27		0.43			
N30	53.48	12.40		8.64	10.29		
N31	55.15	12.22		2.43	3.78		1.75
N32	53.54	3.30			2.39		0.37
N33	100.00				1.00		
N34	54.36	1.01		0.47	0.61		0.06
N35	55.41	1.15		0.15	0.55		0.01
N36	46.78	0.92	3.89		0.09		
N37	87.58	0.86		0.10	0.12		
N38	6.26		0.26	0.08	0.04		
N39	48.32	0.45	0.34	0.20			
N40	100.00					1.00	
N41	68.01	0.40	0.85		0.13		
S30	49.69	1.78		0.50			0.11
S31	16.33	9.09	52.00				
S32	70.43	21.83		23.48			2.17
S33	61.89	0.10	6.40		0.06		
S34	46.96	36.87	151.15	1.33			
S35	29.56	0.24		0.19			0.01
S36	57.81	12.35		36.93			
S37	51.62	11.26		8.54			0.50
S38	46.72	24.76		23.02			1.66

For the class of Nordic banks in 1992, and based upon the use of the DEA formulation, bank S12 is given the following reference bank (see table 3):

$$[21.28 * \text{Bank F17} + 21.75 * \text{N13} + 1.31 * \text{S13}].$$

The degree of efficiency for bank S12 was calculated to be $\theta = 0.6037$.

Bank S12 of year 1992 is identical to bank S32 of year 1993. When bank S32 is compared to the class of Nordic banks in 1993, the DEA model will show a degree of efficiency of $\theta = 0.7661$ (see table 4). The corresponding benchmarks for the inputs and outputs of bank S32 can also be found in table 6 (see *R*(S32)–DEA 1993).

Table 6

Benchmarks for bank S12 and bank S32 based upon the classes of Nordic banks in 1992 and 1993.

Bank	Output			Input		
	1	2	3	1	2	3
S12	164217	121688	11138	2392	2383	7633
R(S12)–DEA 1992	415297	121688	11138	1444	1438	2387
S32	143943	126801	12351	2446	2221	5988
R(S32)–DEA 1993	441607	126801	12351	1874	1694	2236
R(S32)–DEA 1992-93	448062	126801	12351	1723	1557	2745

Bank S32 may also be compared to the extended class of banks in both 1992 *and* 1993. This reduces the DEA efficiency to $\theta = 0.7043$ (see table 5). The corresponding benchmarks for the inputs and outputs of bank S32 are given in table 6 (see *R*(S32)–DEA 1992–93).

Finally, observe that if bank S12 is compared to the extended class of banks of both 1992 and 1993, there will be no change in efficiency (see table 5).

The assumption of a variable return to scale will imply that more banks will become efficient (see table 7). Some of these banks may become efficient just because they are large in terms of outputs, (e.g. D10, D30, D11, S34 and S36) or have the smallest inputs (e.g. F18 and F38).

It is obvious that the choice of model has a substantial effect on the efficiency scores. For the case of a constant return to scale, just a few and mainly small banks were on the efficiency frontier. This result should be compared to the study of Berg et al. [2], who found several large Nordic banks as being efficient. One explanation for the difference in results compared to those of this study seems to depend upon different assumptions of inputs and outputs. For example, Berg et al. used the number of branches as an output "representing the availability of banking services" [2, p. 376]. In that respect, many large banks may have shown to be efficient just because they operated a large number of branches.

Table 7

Efficient banks under the assumption of a variable return to scale.

Window	Efficient banks
1992	D10, D11, D18, D19, F13, F17, F18, F22, N11, N13, S12, S13, S14, S16, S18
1993	D30, D38, D39, F33, F36, F37, F38, F39, N30, N31, N33, N37, S34, S36
1992–93	D10, D18, D30, D38, D39, F17, F18, F22, F33, N13, N30, N31, N33, N40, S12, S13, S14, S16, S32, S33, S34, S36

3. Conclusions

In this paper, Data Envelopment Analysis, DEA, was developed for efficiency analyses of banks. It was then applied to a data set of Nordic banks in the years 1992 and 1993. Outputs were measured in terms of loan volumes, deposit volumes and gross revenues. Inputs were given as costs of personnel, costs of material and the volume of credit losses. The efficiency boundary was first supposed to follow a constant return to scale. This implied that two Finnish banks, one Norwegian bank and one Swedish bank were on the efficiency boundary for 1992. The same banks remained efficient in the year 1993, now together with another Finnish bank and two other Norwegian banks.

Then the assumption of a constant return to scale was replaced by one of a variable return to scale. In doing so, more banks become efficient. In certain cases, this was caused by their having the largest inputs or outputs.

The banks at the frontier seem to have had different qualities that made them efficient. Four of them were outstanding in terms of lending per cost unit.[8)] Two of them were excellent in terms of deposits per cost unit, and two others good in terms of gross revenues per cost unit.

The excellency of the frontier banks indicates that the DEA method seems to be perfect for generating benchmarks for non-efficient banks. This may be done in terms of inputs and outputs of the reference banks. In so doing, each single bank to be evaluated will be given a unique combination of reference banks. As a consequence, the reference banks may be used as a stimulation for the other banks to improve their performances.

Acknowledgements

Thanks are due to Dr. Stefan Sjögren for constructive comments and to the Nordbanken, Stockholm, which provided financial support for this study.

[8)] Volume of lending divided by the costs of personnel and material.

References

[1] R.D. Banker, A. Charnes and W.W. Cooper, Some models for estimating technical and scale inefficiencies in Data Envelopment Analysis, Management Science 30(1984)1078–1092
[2] S.A. Berg, F.R. Førsund, L. Hjalmarsson and S. Suominen, Banking efficiency in the Nordic countries, Journal of Banking and Finance 17(1993)371–388.
[3] A.N. Berger and D.B. Humphrey, The dominance of inefficiencies over scale and product mix economies in banking, Working Paper, Board of Governors of the Federal Reserve System, Washington, DC, USA, May 1990.
[4] A.N. Berger and D.B. Humphrey, Efficiency of financial institutions: International survey and review, Draft Report, Department of Finance, Florida State University, Tallahassee, FL, November 1995.
[5] C.E. Bogan and M.J. English, *Benchmarking for Best Practice*, McGraw-Hill, New York, 1994.
[6] M. Brown and E.P.M. Gardener, A DEA approach towards evaluating bancassurance strategies: A preliminary note, European Association of University Teachers in Banking and Finance, Modena, Italy, Sept. 1994.
[7] A. Charnes, W.W. Cooper, Z.N. Huang and D.B. Sun, Polyhedral cone-ratio DEA models with an illustrative application to large commercial banks, J. of Econometrics 46(Oct./Nov. 1990).
[8] A. Charnes, W.W. Cooper and E. Rhodes, Measuring the efficiency of decision making units, European Journal of Operational Research 2(1978).
[9] Den Norske Bankforening: Forretningsbankenes Årsregnskaper 1992 (Annual Reports for the Banks 1992), Oslo, 1993.
[10] Den Norske Bankforening: Forretningsbankenes Årsregnskaper 1993 (Annual Reports for the Banks 1993), Oslo, 1994.
[11] J. Doyle and R. Green, Data Envelopment Analysis and multiple criteria decision making, Omega, Int. J. of Mgmt Sci. 21(1993).
[12] Finanstilsynet: Pengeinstitutter m.v., Statistisk materiale, 1992 (Financial Institutions, Statistics 1992), Copenhagen, Sept. 1993.
[13] Finanstilsynet: Pengeinstitutter m.v., Statistisk materiale, 1993 (Financial Institutions, Statistics 1993), Copenhagen, Sept. 1994.
[14] L. Gustafsson, Bäst i klassen. Benchmarking för högre effektivitet (Best in the class. Benchmarking for higher efficiency), Idéer, erfarenheter och råd från svenska och utländska företag, Sveriges-Verkstadsindustrier, Stockholm, 1992.
[15] D.H. Humphrey, Productivity in banking and effects from deregulation, Economic Review, Federal Reserve Bank of Richmond, March/April 1991.
[16] M. Oral and R. Yolalan, An empirical study on measuring operating efficiency and profitability of bank branches, European Journal of Operational Research 46(1990)282–294.
[17] H.D. Sherman and F. Gold, Bank branch operating efficiency, J. of Banking and Finance 9(1985) 297–315.
[18] Statistiska Centralbyrån: Bankerna 1992 (Banks 1992), Official Statistics of Sweden, Örebro, Sept. 1993.
[19] Statistiska Centralbyrån: Bankerna 1993 (Banks 1993), Official Statistics of Sweden, Örebro, Dec. 1994.
[20] T.J. Stewart, A critical survey on the status of multiple criteria decision making theory and practice, Omega, Int. J. of Mgmt Sci. 20, no. 5/6(1992).
[21] Tilastokeskus (Statistikcentralen): Pankit, Bankerna, The Banks 1992, pankkikohtaisesti-enligt bank, Rahoitus 1993:27, Helsinki, 1993.
[22] Tilastokeskus (Statistikcentralen): Pankit, Bankerna, The Banks 1993, Rahoitus 1995:5, Helsinki, 1995.

[23] H. Tulkens, Non-parametric efficiency analyses in four service activities: Retail banking, municipalities, courts and urban transit, CORE Discussion Paper No. 9050, Université Catholique de Louvain, Louvain-la-Neuve, Belgium, 1990.
[24] H. Tulkens, On FDH efficiency analysis: Some methodological issues and applications to retail banking, courts and urban transit, Journal of Productivity Analysis (1993).
[25] H. Tulkens and Ph. Vanden Eeckaut, How to measure efficiency and productivity with special reference to banking, Draft Report, CORE, Université Catholique de Louvain, Louvain-la-Neuve, Belgium, September 1995.
[26] P. Yue, Data Envelopment Analysis and commercial bank performance: A primer with applications to Missouri banks, Federal Reserve Bank of St. Louis, Jan./Feb. 1992.