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(Transmitted by Tirmidhi & Darimi)

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MESSAGE FROM THE PRESIDENT

Dear Readers,
Assalamualaikum wrm wbr and Warm Greetings,

Planning Malaysia has achieved another major milestone for the Malaysian Institute of Planners. It reaches out today beyond the circulation of MIP Members and beyond the boundaries of our country. It is now circulated to various libraries, planning and related professions organisations, planning schools and universities all across the globe.

Every article in this journal is refereed by distinguished panel of local and international professionals related to the planning profession. This adds credibility to the journal and ensures that every article published achieves the desired level of quality as well as meets the international standards of publication.

Planning Malaysia has come a long way from its first inaugural publication. Much credit must be given to the effort and continuous passion of the Chief Editor – Professor Dr Alias Abdullah and his dedicated editorial team. They have continued to enhance the quality of the journal as well as increase its level of circulation. This is part of MIP's mission for continuous effort in knowledge sharing and promotion of town planning and its professionals.

It is my deepest aspiration that Planning Malaysia becomes a household name to the planning community. Thus it is hoped that all members take this opportunity to contribute articles to the journal as its widespread circulation will enable members to disseminate ideas, share new findings or planning theories or share experiential planning to the industry at large.

Thank you to all writers, editorial board as well as the referees of the articles. I pray that the contribution that you all have made to the journal will shower all with greater wealth of knowledge and contentment.

Wassalam

Thank you

Norliza Bt. Hashim

PRESIDENT
(2007-2009)

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URBANIZATION, ENVIRONMENTAL PLANNING AND MANAGEMENT: A CHALLENGE FOR JAMAICA

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Abstract

The rapid pace of urbanization has presented numerous challenges for developing countries such as Jamaica. The effects of urbanization coupled with poor environmental and development practices have exerted tremendous pressure on the country's fragile and limited natural resources. This issue is exacerbated by poverty, poor urban planning and management and lack of enforcement of existing land use regulations. The purpose of this paper is to critically examine the challenges in reversing negative environmental trends and practices which is increasing the vulnerability of the population, economy, infrastructure and other vulnerable elements of the society to the devastating impacts of natural hazards. The growing threats from hurricanes and tropical storms has have occurred over the last 10 years have highlighted the need for more sustainable development. The report concludes with a number of recommendations that are critical to address the never ending cycle of environmental degradation.

Keywords: Urbanization, environmental planning, management, Jamaica

INTRODUCTION

Urbanization (the process through which cities and towns develop and grow) today is extraordinary with the world undergoing the largest wave of urban growth in history. The United Nations Population Fund 2008, highlighted that for the first time, more than half of the world's population will be living in towns and cities. They further highlight that by 2030 this number will swell to almost 5 billion, with urban growth concentrated in Africa and Asia. In the case of Small Island Developing States (SIDS), the United Nations Human Settlement Programme noted that of the 52 million people in SIDS, 30 million (or 58 percent) live in urban areas, with Caribbean SIDS being the most

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urbanized. Urban areas in Caribbean SIDS are located on the coast of these islands, and as noted by Rakodi and Treloar (1997), natural and coastal resources are always under threat from rapid development and population increase within the coastal zone. This continued growth of urban areas is attributed to the fact that cities are often seen as the engine for economic growth, however, governments' abilities to manage the unprecedented wave of urbanization has proven to be a challenge for many countries.

Leitmann *et al* (1992), pointed out that the immediate and most critical environmental problems facing Third World cities (including SIDS) encompass what is referred to as the 'brown agenda'- lack of safe water, inadequate waste management and pollution control, accidents linked to congestion and overcrowding, occupation and degradation of sensitive lands and the interrelations between these problems. In the case of Jamaica, which is the focus of this paper, urbanization, land use planning and environmental management continues to be a major challenge as population growth, coupled with agricultural, tourism, commercial and industrial expansion, has resulted in increase competition for local resources. This competition has exerted significant pressure on the country's fragile ecosystems. Added to this pressure, land use planning as an activity has been marginalized as there is little or no adherence and compliance to planning standards by developers, the lack of enforcement of said regulations and the use of outdated Development Orders (instruments that regulate the development of land), have gravely impeded attempts of achieving sustainable development.

This paper first presents a background of the case study of Jamaica and then an overview of urbanization trends in the country. This is followed by an analysis of the environmental problems and issues stemming from the impact of urbanization on land use and natural resource management. The last section of the paper discusses the main challenges plaguing environmental planning and management and also presents a number of recommendations which are germane to achieving sustainable development of land resources which meets people's needs and demands.

The empirical data for the case study comes from direct observation in the city of Kingston and Montego Bay, the two largest urban centres in Jamaica and from interviews with land use planners and other stakeholders involved in the planning process. A plethora of literature was reviewed to ascertain urbanization trends and practices, the planning and legislative framework geared towards the conservation and sustainable use of resources as well as the main challenges affecting effective environmental planning and management in Jamaica. The information collected was analyzed and is summarized in this

paper. Additionally, to aid in the analysis and discussion, this paper is guided by three (3) research questions:

1. What are the impacts of the process of urbanization on land use and natural resources?
2. What are the challenges hindering effective environmental planning and management?
3. What mix of strategies/measures is essential to arrest environmental degradation in order to achieve sustainable urbanization?

BACKGROUND

Jamaica is the third largest island in the Caribbean with a landmass of 10,991 square kilometres. Approximately two-thirds of the land resources consist of a central range of mountains and hills, surrounded by a narrow coastal plain.

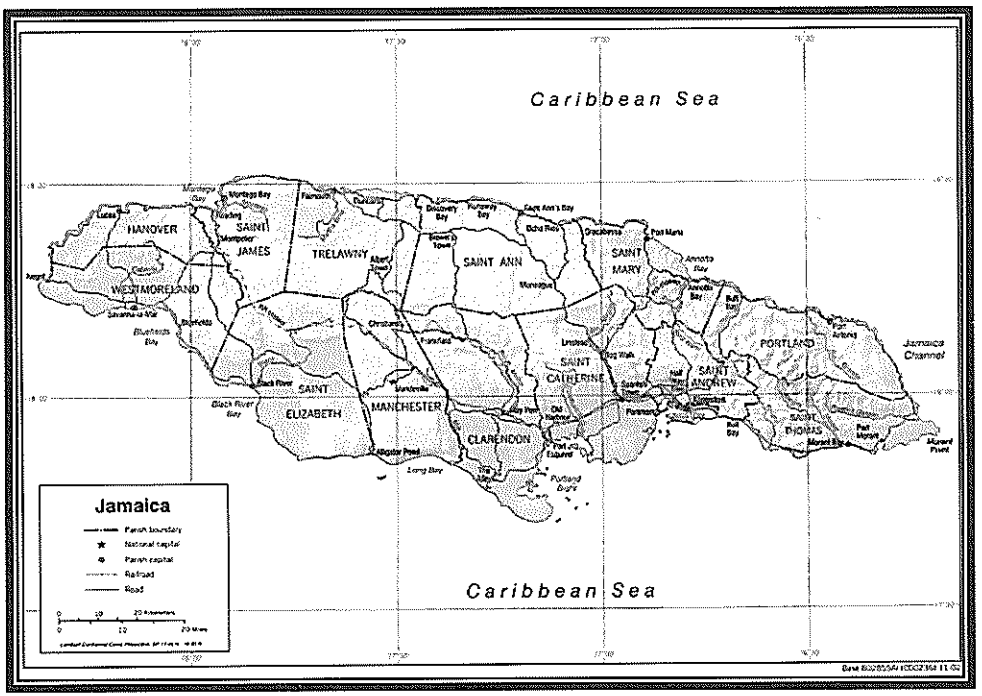

Figure 1: Spatial Context of Jamaica

Most major towns and cities are situated on the coast. Kingston, the country's capital, situated on the south-eastern coastline (Figure 1) is the main

urban centre and is the major hub for transport linkages, service type industries and public and private sector services, which has a direct sphere of influence over all the parishes. St. Andrew, though not the main service centre, has grown as an important support for public and private sector services and also the main residential urban areas.

Montego Bay is the second largest urban centre in Jamaica, and is also the second capital of Jamaica, providing similar services to Kingston, but to the western and north western end of the island (See Figure 1).

Urbanization Trends

The current population of Jamaica is estimated at 2.6 million with some 52 percent living in urban areas. According to the Statistical Institute of Jamaica, growing at an annual rate of 1.42 per cent between 1991 and 2001, the urban population moved from 1,192,000 to 1,354,900. This growth however, was only for four parishes; Kingston, St. Andrew, St. Catherine and St. James that the urban population was in excess of 50% of the total population of the parish. Furthermore, the population for the Kingston Metropolitan Area (KMA) alone in 2001 stood at 579, 137, representing 88 per cent of the total population of Kingston and St. Andrew combined and 22.2 per cent of the country's population.

Notwithstanding that, the parish of St. Catherine has been noted as the fastest growing peripheral area growing 26.3 per cent between 1991 and 2001. The expansion of St. Catherine has been described by Portes et al (1993), as that of "*the city of Kingston has stretched out a hungry arm into the adjacent parish of St. Catherine, reaching to embrace new residential areas in its overspill of population in the area know as Portmore*". Wade and Webber (2002) in their research found that Portmore, the satellite community of Kingston has experienced annual growth above 5 per cent.

Empirical data shows that since 1985 urbanization growth in Jamaica has been increasing steadily, a trend that is expected to continue to increase as shown in Figure 2 below. Moreover, it is estimated that, by 2020, the national population will reach 3 million, 60% of which are expected to reside in urban areas (United Nations Demographic Yearbook, 2003). Such data indicate a strong wave of urbanization, with most of the population pressures being exerted on the natural resources and also in the coastal zone of the country and presents a challenge.

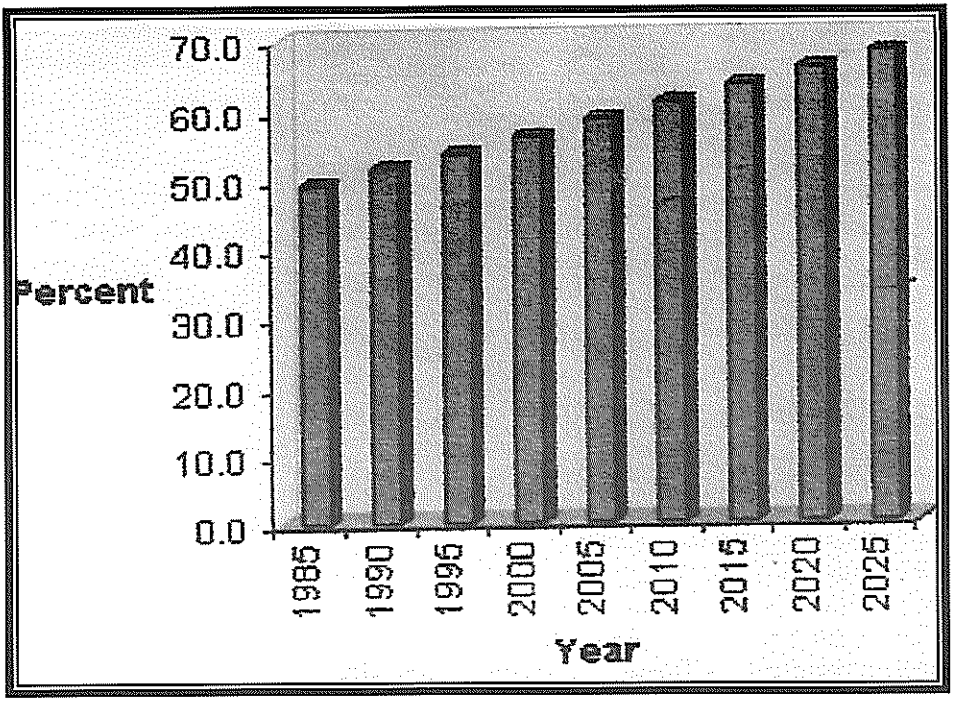

Figure 2: Urbanization Growth in Jamaica.
(Source: United Nations Demographic Yearbook, 2003)

URBANIZATION AND ENVIRONMENTAL CHALLENGES

The Jamaica National Assessment Report, 2003 highlighted that rapid urbanization has resulted in major problems such as squatting, inadequate housing and social services, inadequate infrastructure, traffic congestion and urban decay. This phenomenon is referred to as decapitalized urbanization whereby the rapid growth of the population has outpaced government's ability to provide basic services such as housing, physical infrastructure and social facilities.

One of the first signs of decapitalized urbanization in Jamaica is the proliferation of squatter settlements which has mushroomed in every urban centre in the country. The absence of a coherent urban housing plan and the disenchantment of many low income families have facilitated the growth of squatting (Tindigarukayo 2006). Moreover, the decade of 1991-2001 according to Ahmad, 2005 has witnessed "the utilization of narrow river valleys, faulted mountain fronts, and land – water interface as a preferred site for both formal and informal housing development". Many of these developments, especially

informal development, are located on marginal lands and/or on precarious sites that are vulnerable to natural and/or man-made hazards. This is compounded by poor environmental practices which perpetuate vulnerability and is often the factor that transforms the hazard into a disaster. A recent example of this is the devastation caused by Tropical Storm Gustav, 2008 which painted a grim picture of the reality that the poor are both victims and agents of poor environmental practice. Several informal settlements built in the Hope River watershed, for example, as well as along the Macgregor Gully (artificial drainage channel) in the Kingston Metropolitan Area were swallowed by the gushing waters of Tropical Storm Gustav, as shown in Figure 3. Drakakis-Smith (2000:89), rightly argued that the "consequence of so much poverty is a large and increasing number of urban residents who simply seek to survive as best as they can, seemingly oblivious of the cost of the environment". Similarly, the Red Cross (1999:19) describes this unwanted demarcation as the "social geography" of many towns and cities which .... "Reflects the vulnerability of different zones to natural hazards, often with disastrous consequences for the poor".

Tourism, though the major contributor to Jamaica's economy, is also contributing to the proliferation of squatter settlements, particularly in the resort areas, attracting a large influx of workers. As a consequence of inadequate housing and other related infrastructure to support the large influx of migrants, unplanned settlements have mushroomed in the hills and along the gullies Research has shown that nineteen (19) squatter settlements arose in Montego Bay because of hundreds of tourism workers and no housing arrangements for them. Additionally, the Government of Jamaica has embarked on a Tourism Expansion Programme in which 21,639 room stocks will be added to the current stock and it is feared that more unplanned settlements with associated environmental challenges will develop.

It should be noted, however, that it is not only the poor that is contributing to environmental degradation. The Long Mountain Housing project, for middle and upper class elites, completed in 2004, destroyed the last remaining piece of dry tropical forest this side of the world which had 10 endemic species of trees including three (3) rare ones and one (1) new species. This development threatens the Long Mountain watershed that contributes to the recharge of four wells that supply potable water to the Kingston Metropolitan Area (Neufville, 2001). The Jacks Hill Housing Development in upper St. Andrew is another example of housing development by affluent Jamaicans on steep slopes, an area that is prone to land slippages. Ahmad (2005), in his research found that the processes of rock fracturing and weathering have resulted in relatively weak bedrock, where both earthquakes

and rainfall have triggered many landslides in the past and the process continues. The net result he argues is severe denudation of hill slopes.

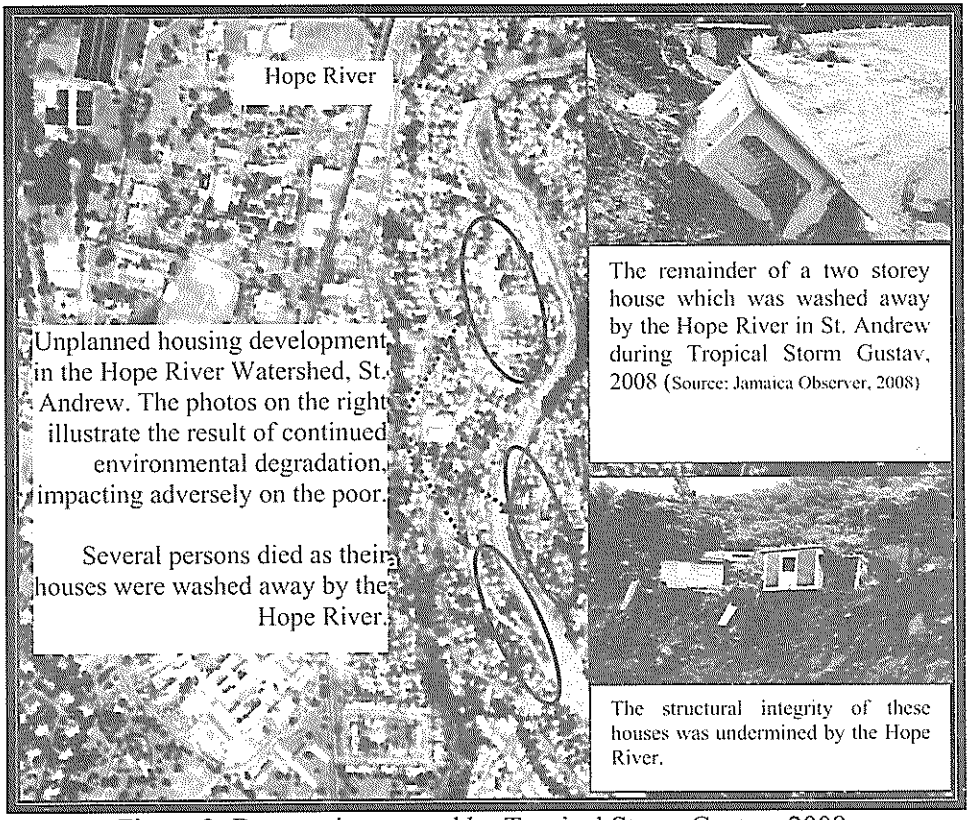

Figure 3: Devastation caused by Tropical Storm Gustav, 2008

Poor agricultural practices, quarrying, mining and the indiscriminate removal of forest cover for lumber and charcoal have also contributed to environmental degradation. Farming activities on the hillsides have long been recognized as one of the main causes of the degradation of watersheds in Jamaica. The Jamaica National Environment Action Plan (JaNEAP) noted that seventeen (17) out of twenty-six (26) watershed areas have been degraded as a result of deforestation and slash and burn farming (JaNEAP, 1999). Watershed degradation results in a reduction of freshwater resources, increased erosion and siltation of rivers, increased marine and coastal contamination and degradation adversely affecting the country's tourism industry and increased flooding. The World Bank in their research in 2000 also found that between 1990 and 1995, the annual average rate of deforestation for Jamaica was 7.2 per cent. The report further revealed that the country's annual average

rate of deforestation was proceeding at a rate that would see the country devoid of all forest in less than 25 years. The key concern that arose, is that Jamaica being an island state, has an unusually high level of endemism and has been ranked among the world's most important islands for endemic species.

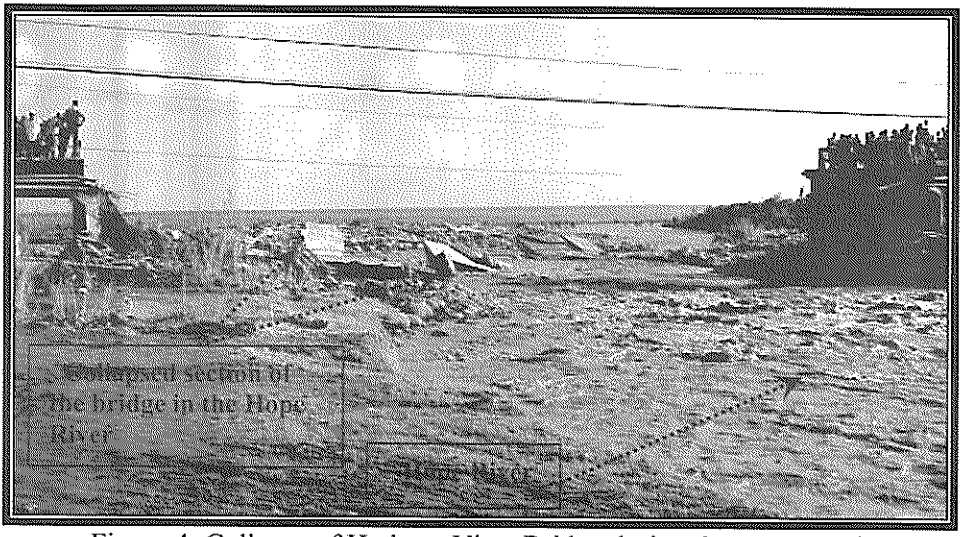

Figure 4: Collapse of Harbour View Bridge during the passage of Tropical Storm Gustav, August, 2008.
(Source: Rodriguez[2], 2008)

Jamaica's awareness of the need for soil conservation and watershed protection dates back to the 1930s. Croucher and Swabey (1937), Wakefield (1941), and the first annual report of the Soil Conservation Division (1944) all stress these needs. Nonetheless, there does not seem to exist a clear understanding that inappropriate actions, such as deforestation, housing development and poor agricultural practices, taken within the upper regions of the watersheds can negatively impact on downstream areas including the coastal zones. Additionally, rapid urban growth and the disenchantment of low income families over the years have led to an increase in the number of unplanned settlements in the watershed areas of Kingston and Montego Bay. This has resulted in poor water quality of the rivers, severe erosion of the river banks and decreased resilience to withstand flood hazards. For example, the poor state of the Hope River Watershed transported large volumes of flood waters downstream during Tropical Storm Gustav, 2008 which contributed to the collapsed of the Harbour View Bridge (Figure 4), several landslides, flooding,

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damaged roadways and loss of lives and property. Preliminary assessments by the Office of Disaster Preparedness and Emergency Management (ODPEM) indicate that an estimated JA$11 billion in damages were sustained island-wide during the Tropical Storm, $6 billion of which is associated with infrastructure damage.

Inadequate waste management both solid and liquid is another manifestation of the challenges of urbanization negatively impacting on the environment and the coastal zone. Approximately 70 per cent of the waste generated is collected by the National Solid Waste Management Authority primarily from the urban centres (Davis-Mattis,2005). The remaining 30 per cent of uncollected waste results in "foul odours, vermin and flies (Ministry of Local Government, 2001:3), and is either burnt or dumped in waterways and gullies which is a major source of point pollution of the coastal zone. In some of these gullies, "rubbish plies up as nearly high as the walls", and in other cases "raw sewage flows several feet high" (Jamaica Gleaner, 2003). Uncollected waste spoils the aesthetic vista of the city, a common trend in Montego Bay, the principal resort area of Jamaica. During periods of heavy rainfall, large quantities of waste from the North Gully in Montego Bay, deposits wastes into the coastal zone, creating an eye sore.

Sewage treatment and effluent quality is another concern whereby sewage plants "often do not generate effluent that meet acceptable standards for disposal", (National Environment Planning Agency (NEPA), 2001:15). The consequence of this according to NEPA is that an estimated 20 million gallons of mostly untreated sewage is discharged daily into the Kingston Harbour from several malfunctioning sewage treatment plants. The most visible symptom of this is the frequent recurrence of eutrophication which leads to depletion of oxygen, causing deterioration of water quality and a decline in biodiversity. This has drastically affected the condition of the Kingston Harbour, the seventh largest natural harbour in the world to be classified as a "Heavily Contaminated Bay" by the United Nations Office of Project Services (UNOPS), 1998. The United Nations Environment Programme (UNEP), also noted eutrophication is a growing problem in the Caribbean, threatening human health and coastal ecosystem, including coral reefs, mangroves and the fishing marine environment. These coastal ecosystems are important in mitigating the impact of natural hazards by providing protection of the coastline and beaches from hurricanes and associated storm surge which Jamaica is well acclimatized to. Figure 5 highlights the relationship between environmental degradation, natural disasters and vulnerability. Environmental degradation compounds the impacts of hazards, limits an area's ability to absorb those impacts, and reduces the

overall resilience and coping mechanisms to hazard impacts (International Strategy for Disaster Reduction, 2004).

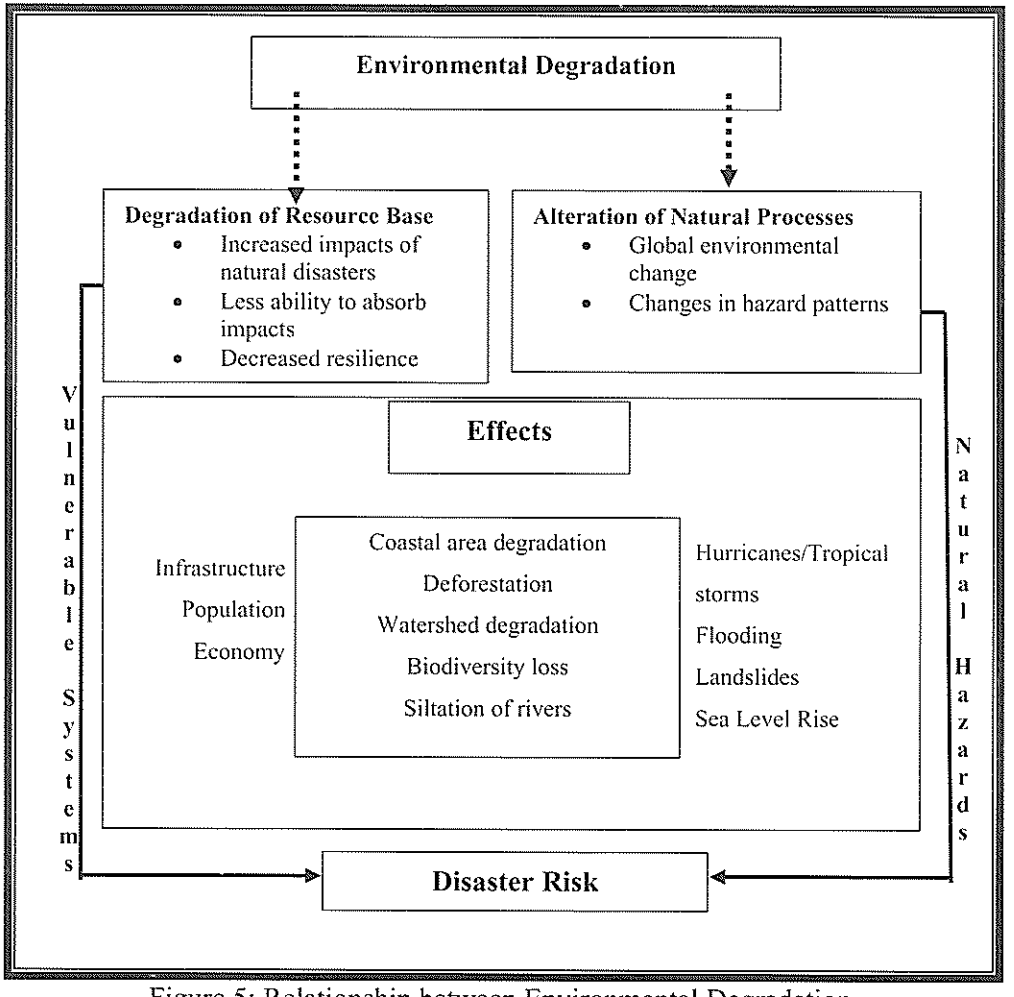

Figure 5: Relationship between Environmental Degradation, Natural Hazards and Vulnerability.
(Source: Adapted UN/ISDR, 2004)

ENVIRONMENTAL PLANNING

Over the years the Jamaican Government has embarked on a number of initiatives geared towards the proper management and conservation of the country's natural resources. The government recognizes that urban and rural

planning must be done within the context of the wider thrust of environmental management, and to this end the government established the NEPA (Davis-Mattis, 2002). NEPA represents an amalgamation of the Natural Resources Conservation Authority (NRCA), mandated to ensure the proper management and use of the natural resources of Jamaica; the Town and Country Planning Authority is mandated to ensure the orderly development and planning of the country and the Land Development and Utilization Commission is mandated to ensure "that prime agricultural lands are kept in agricultural production in the interests of *inter alia* food security and self sustainability"(Davis-Mattis, 2002).

Table 1 summarizes the legal and policy framework for the conservation and sustainable use of resources in Jamaica. However, very few of these statutes according to NEPA and Ministry of Land and the Environment (2003:16), "deal comprehensively with the protection, conservation and sustainable use of biodiversity, as they are primarily sectoral in nature".

Table 1: Summary of the main Legislation/Policies aimed at the protection and management of natural resources.
(Source: Compiled by Author from various sources)

Legislation/Policy	Summary of Instruments
Natural Resources Conservation Act (1991)	This Act provides for the management, conservation, and protection of the natural resources of Jamaica.
The Beach Control Act, 1956	Ensures the proper management of coastal and marine resources by a system of licencing of activities on the foreshore and the floor of the sea. It also addresses issues such as access to the shoreline.
The Forest Act (1995) and Forestry Regulation (2000)	Addresses the sustainable management of forests.
Endangered Species Act, 2000	Provides for the conservation, protection and regulation of trade in endangered species. A Scientific Authority is appointed under the Act to determine whether a species is at risk, vulnerable or threatened.
The Natural Resources (Marine Parks) Regulations (1992)	The object of the regulations is the establishment of marine protected areas, primarily for the conservation of marine resources.

The Wildlife Protection Act	Concerned with the protection of specified species of fauna.
Coral Reef Protection and Preservation Policy (1997), Draft	Ensures the conservation of coral reefs in order to sustain their ecological and socio-economic functions.
Watershed Protection Act (1963)	Provide for the protection of watersheds and areas adjoining watersheds and promote the conservation of water resources.
The National Solid Waste Management Act (2001)	Ensures effective management of solid waste in order to safeguard public health.
The Wetlands Policy *(Draft)*	Sets out a management strategy for the protection of wetlands.
The Town and Country Planning Act (1957)	The objective of this Act is to ensure the orderly development of land. This is achieved through Development Orders which are the main means of control of land use in Jamaica.
National Land Policy	Established for the proper planning, management and development of the use of land, recognizing the need to balance land use management and development with agriculture, mining, tourism and natural resource management.

Despite the various initiatives in the form of policies, legal instruments and institutional arrangements, sustainable urban development, holistic and integrated environmental planning and management remain elusive. It is therefore essential to explore the main reasons accounting for this shortcoming. Based on interviews with planners and other stakeholders in the planning process, this is a result of several factors which can be classified as:

a. Limited Compliance and Weak Enforcement
b. Policy and Institutional Overlap
c. Political and Governance Issues

a. *Limited Compliance and Weak Enforcement*

This has been identified as the primary factor contributing to environmental degradation and development in hazard prone areas. The PIOJ (1997) pointed out that weak enforcement is as a result of inadequacy of funds, low technical capacity, and poorly developed capacities for operational and fiscal management. This situation is compounded by outdated development orders which have made it difficult to exercise effective control over development in the country. The issues that subsequently arose are the proliferation of unplanned settlements, destruction of natural resources and conflicting and non-conforming land uses. However, the Manager of the Planning Division at NEPA was of the opinion that even though the development orders are outdated, they still remain a useful instrument to guide development. This reasoning can be challenged by questioning how effective can a regulatory instrument be if it is archaic and unable to arrest the never ending cycle of the annihilation of the country's natural and coastal resources.

A related issue and concern is that the Environmental Impact Assessment (EIA) process has been criticized for not being comprehensive, especially with regards to tourism development. It is argued that EIAs have failed in many instances to address the full scale impact of tourism and other major developments in Jamaica. This process has been inadequate in several respects, notably, identification of the impacts on the terrestrial and marine vegetation, shoreline modification, inadequate monitoring of activities on construction site, limited time in which the public has to review EIAs and assessment of cumulative impacts, among others. This is seen as a major shortcoming and failure as the EIA decision making support tool forms the basis for mitigating and monitoring impacts in sensitive environments, argues Mycoo, 2006.

b. *Policy and Institutional Overlap*

Policy and institutional overlap is another over-arching challenge of achieving sustainable urban planning and management in Jamaica. There are several pieces of legislation, regulations and guidelines pertaining to the terrestrial environment, watersheds and the coastal zone. This has resulted in several lead agencies being responsible for similar functions leading to confusion and conflict, the waste of limited resources and perpetuation of environmental degradation. For instance, the Draft Watershed Policy noted that there is considerable overlap between six (6) agencies in authority over the handling of watershed areas and requires clarification.

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The legislation for the current planning system has resulted in duplication of functions, mainly in the development approval process, which is considered to be partially accountable for 75 per cent of development that takes place outside the formal planning system (Mchardy, 2002). These statistic highlight a high percentage of non-compliance to environmental and planning regulations which translate into the mushrooming of unplanned settlements and other illegal developments in environmentally sensitive and vulnerable areas, an appropriate example is the devastation in the Hope River Watershed in August, 2008.

c. *Political and Governance Issues*

Strong urban governance is critical to making progress but it is often the resource in short (Linden, 1996), and in the case of Jamaica, poor accountability of policymakers for their decisions, and failure to enforce environmental laws and regulations is a manifestation of the challenges of poor governance and political issues. For instance, the continued expansion of planned and unplanned settlement in sensitive zones such as the Hope River Watershed has continued for years even in the face of mounting evidence of negative environmental effects and high environmental costs. The academic literature asserted that the lack of political will to enforce regulations is because of fear of losing support from the electorate. Henry-Lee (2005) revealed that the significance about Garrison constituencies (is one in which electoral process is directly influenced by social and economic processes) in Jamaica is that there is a strong political capital. They become very important at election times, and the level of activity surrounding the politicians is remarkably high.

Even when there is a genuine attempt by the government to effect change, Jamaica's onerous debt burden is an obstacle that hinders the provision of the full range of investment in basic services, environmental management and disaster reduction strategies. The International Monetary Fund (IMF) reported that at the end of the fiscal year 2007/2008, the country's debt will reach over 1 trillion Jamaica dollars (Jamaica Gleaner, 2007), which has absorbed resources at the expense of economic and social investments. This has impeded the implementation, monitoring and review of plans and policies that are critical to the proper management and use of land resources in the country. In turn, many of these policies and strategies become difficult to implement and are relegated to the shelf.

This situation is heightened by the fact that until recently most development planning initiatives were specifically intended for economic benefits mostly to developers, with little or no regard to other critical concerns such as social and ecological sustainability (Henry and Heinke, 1996). This has

been and is still manifesting in Jamaica in areas such as tourism and industrial development. The Tourism Expansion Programme is a prime example. An unreleased study commissioned by the Planning Institute of Jamaica (PIOJ), 2005 painted a grim picture of the current Tourism Expansion Project and its hotel development programmes. The study concluded that building more hotels will grow the economy and provide much valued short-term benefits for the country, but these benefits will not be sustainable at the proposed rate of development rationed for the Expansion Programme and there are risks if building does take place as proposed in certain environmentally-vulnerable areas (Jamaica Gleaner, 2006). Sango, 2007 argued that the heavily indebted governments of Third World countries are desperate for foreign currency revenue to an extent that they are prepared to risk allowing foreign investors and local industries to degrade the environment for as long as they satisfy the production targets desired by the state.

RECOMMENDATIONS

Changing urban development from its present unsustainable forms and patterns is a very challenging process (Kenworth, 2006). Notwithstanding that, if well managed, according to Cohen (2006), cities offer important opportunities for economic and social development. To realize the potential contribution of urbanization to sustainable development in Jamaica, a number of challenges have to be tackled in order to attain any measure of success. Issues such as poverty reduction, environmental degradation and governance failures must be pushed at the forefront of the policy agenda to reverse negative environmental trends and practices.

i) Strengthen Legislative and Institutional Capacity

Strengthening the legislative and planning machinery is a key step for mitigating the impacts of tourism and urbanization on environmentally fragile resources. Outdated development orders and environmental statutes should be revised and updated to transform current negative trends and practices. For example, even though Jamaica has a Watershed Protection Act which was passed in 1963, to date, no regulations have been promulgated for this act to come into effect, despite falling under the administration of NEPA and NRCA – the lead agencies mandated to protect the country's natural resources. This is a major shortcoming that has led to the continued degradation of the country's watershed areas. To cite another example, the St. James Development Order, dates back to 1982 and has not been revised or updated since despite the fact that Montego Bay is Jamaica's principal resort area.. An

Refereed Article: MIP-PMJ 05/09

updated instrument(s) is therefore fundamental to guide the development process in a sustainable manner.

Bartone *et al* (1994) also recognized that institutional strengthening is a critical pre-requisite for improving urban environmental problems as well as reducing some of the challenges facing planners in the decision-making process. Such institutional strengthening is important to identify, understand and evaluate complex urban environmental issues that aggravate risk to natural hazards. Improved sectoral and inter-agency coordination is also an important element of institutional strengthening to resolve issues associated with fragmentation and institutional overlap in the decision-making process. Without adequate institutional capacity, plans are never effectively realized, nor can enforcement be properly executed. Moreover, strengthening of institutional capacity must be complemented by improved governance with greater transparency and accountability, as outlined in the United Nations Millennium Project, 2005.

ii) Integrated Watershed Management

Poorly managed activities in the watershed areas have led to their degradation which have in turn intensified flood hazard by increasing the quantity and velocity of run-off, increasing flood risk downstream, a manifestation of the detrimental effects of Tropical Storm Gustav, 2008. Added to the negative effects, the country's freshwater resource is also threatened. To this end, an integrated approach to watershed management involving all the relevant stakeholders is paramount. The Asian Disaster Preparedness Centre, 2005 defined integrated watershed management as a "multi-resource management planning process, involving all stakeholders within the watershed, who together as a group, cooperatively work towards identifying the watershed's resource issues and concerns as well as develops and implements a watershed plan with solutions that are environmentally, socially and economically sustainable".

It is evident that the adoption of an integrated watershed programme is needed to stem the impacts of human activities on watershed quality in Jamaica. As part of the watershed programme, a zero tolerance approach should be adopted to restrict and prevent inappropriate land use activities such as intensive agriculture and residential development in watersheds and floodplains in order to restore the integrity of the degraded watersheds. Additionally, coastal zone management should form part of the wider goals and objectives of the integrated watershed programme.

An important part of such a programme will be monitoring the state of the watersheds and progress towards achieving specific objectives in order to identify gaps and revise strategies where necessary and track progress toward achieving the objectives. The application of Geographic Information System (GIS) can play a critical role in the watershed management programme by assessing watershed conditions through modeling impacts of human activities, on water quality and watershed restoration. The GIS tool would supplement better planning, decision-making, execution and monitoring of the watershed areas.

It should be noted, however, that the government has made several attempts to improve watershed management by the implementation of several projects such as the Trees for Tomorrow Project, a project focused on forest management and conservation, the USAID-GOJ Coastal Water Improvement Project and Ridge to Reef Watershed Project, for community-based projects aimed at improved practices in watersheds as well as outreach and enforcement, Despite these scattered successes, Bass and Geoghegan (2002) highlighted that constraints such as limited resources, an incomplete legal framework for watershed management and an uninformed citizenry are major challenges to overcome.

iii) Incorporate Disaster Management in the Planning Process

Incorporating disaster management in the overall planning process is a practical strategy which would take account of prevailing hazard risks and allow for the formulation of mitigation measures where development already exists and the discouragement of development where it has not yet taken place. Only by integrating hazard mitigation into all policies, programmes and plans at both the national and community levels can vulnerability be reduced and protect the environment. In addition, there needs to be more commitment to the kinds of research that can help fill data gaps and identify risk reduction policies.

iv) Environmental Education and Public Awareness

Public awareness and knowledge to overcome indifference to unsustainable land use practices as well as sensitizing the public on land management issues and the important role they can play in reducing environmental degradation is crucial. Central to the education programme must be to educate the public about the direct connection and domino effect of dumping solid and liquid waste in gullies, destruction of coral reefs and other coastal resources and degradation of watersheds because these activities decrease the resilience of natural ecosystems thereby increasing vulnerability to natural hazards.

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An informed citizenry may be "one of the most effective ways to move expeditiously toward environmental sustainability; while it is an insufficient condition for achieving environmental sustainability, without it, there is little hope that significant change will occur" (United Nations Millennium Project, 2005:70). Perhaps the strategy with the greatest long-term impact is to focus on the youngest generations in society. Environmental education based on life experiences should begin during the earliest years of life. These experiences play a critical role in shaping life-long attitudes, values and patterns of behavior toward natural environments (Tilbury, 1994).

v) Political Commitment

Political support and commitment is essential to the success of changing entrenched negative environmental practices in Jamaica that are draining national budgets and hampering all attempts of achieving sustainable development. The United Nations Development Program and Global Water Partnerships (2005) noted that political support and commitment is an important first step in creating awareness and drawing support to the process of environmental management. Unwavering political support is also needed to transform policies into action by ensuring the adoption and implementation of plans and commitment of government funds to effect change in Jamaica.

A high priority issue that requires strong political will and commitment is the alleviation of poverty as well as containing the mushrooming of squatter settlements, especially on marginal lands which perpetuate the cycle of urban environmental degradation and contribute to greater economic and environmental vulnerability. The government has made great strides to regularize and improve the lives of many squatters through the Operation Programme for Resettlement and Integrated Development Enterprise (PRIDE) programme; however, it failed because of charges of mismanagement and corruption. Henry-Lee (2005), from his research strongly argued that any strategy to eradicate poverty in the Garrison constituencies in Jamaica is subject to failure, as there are many people who have a vested interest in the perpetuation of poverty. The United Nations Development Programme Human Development Report, 1997 highlighted that "The poor can be politically convenient... They can also serve as a useful pool of voters for politicians who claim to serve their interests... Any strategy to eradicate poverty must therefore take into account the fact that many people have a vested interest in the perpetuation of poverty." A concerted effort is needed to change the political landscape of Jamaica, only then can sustainable development can be achieved.

CONCLUSION

Managing urban growth has become one of the most important challenges of the 21st century (Cohen, 2006). For Jamaica, managing urban growth along with associated environmental problems continues to be a daunting task hampering the effective management and protection of eco-systems and the services they provide. This has resulted in the degradation of the country's natural resources rendering the population, economy and infrastructure vulnerable to the effects of natural hazards. This is critical because environmental degradation increases vulnerability to the effects of natural hazards and reduce overall natural resilience, a prime example of the detrimental effects caused by Tropical Storm Gustav, 2008.

The proliferation of unplanned settlements on marginal lands, poor agricultural practices, mining, quarrying and deforestation have all led to the degradation of more than half of the country's watersheds as well as inadequate waste management are the visible symptoms of a city on the brink of destruction. Despite the evidence of attempts to improve environmental planning and management through legislative and policy framework and institutional reform, there are still shortcomings. Limited compliance and weak enforcement of regulations, policy and institutional overlap, political and governance issues are the major weaknesses that are hindering progress towards holistic environmental planning and management.

Moving towards sustainable development requires achieving economic and social systems which encourage environmental stewardship of resources for the long-term (Satterthwaite,1999). As such, a clearer understanding of the interface of economic development and the environment is necessary if the problems are to be effectively gauged and resolved. Moreover, there needs to be better synergy between the effects of urbanization and environmental planning and management by addressing the root cause of the common problems. Critical to the transformation process must be legislative and institutional strengthening, integrated watershed management, incorporation of disaster management in the planning process, public awareness and education and strong political commitment. As aptly highlighted by the United Nations (UN) Millennium Declaration, we must "spare no effort to free all of humanity, and above all our children and grandchildren, from the threat of living on a planet irredeemably spoilt by human activities, and whose resources would no longer be sufficient for their needs."

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STRUCTURAL CHANGES OF THE MALAYSIAN ECONOMY AND ITS SPATIAL INCIDENCE ON REGIONAL ECONOMIC GROWTH

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Abstract

The economy of Malaysia has undergone changes from its agricultural base to import-substitution during the 1960s and finally to export-orientation after 1968, associated with an influx of significant amount of direct foreign investment (DFI). These changes of the production base of the country led to concomitant changes in the structure of employment from agriculture to manufacturing and finally to services. Studies so far undertaken mostly concentrate on the macro aspect of this transformation process. No attempt has been made to study the structural changes of the national economy through analyzing the production/ employment structure of the regions/states of Malaysia. In spit of adopting and implementing a number regional development policies and strategies from 2MP, it is anticipated that the structural transformation has not been uniform across the different regions of the country. Therefore, this paper provides a spatial analysis of the structural changes in the structure of production and employment that has occurred across fourteen states of Malaysia. The study found that the economic growth process has been unequal across the 14 states of Malaysia, accentuating the regional disparities in income and employment growth. Both federal government development expenditure and private investments in different states of Malaysia have not been proportionate to their shares of national population and this partially explains the reason for the interregional differences of economic growth in the country.

Keywords: Structural Transformation, Import Substitution, Export orientation, Direct Foreign Investment (DFI), Gross Domestic Product (GDP), *Theil* Index, Free Trade Zone (FTZ)

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INTRODUCTION

The economic structure of Malaysia has undergone dramatic changes since Independence in 1957. The production base of the economy was broadened from the processing of primary commodities (particularly rubber), small scale food industries and handicrafts during the early 1960s to manufacturing (import-substitution) which accounted for a growing share of national output and employment. However, the need to extend industrialization upstream, especially the manufacturing of intermediate goods, was stressed in the First Malaysia Plan 1966-70.

A radical shift from an inward-looking, defensive industrialization strategy of import substitution to an outward-looking, aggressive strategy of export promotion took place after 1968 when it became obvious that import substitution could no longer provide a viable basis for sustained industrial expansion, given the small domestic market. Indeed, both export orientation and import substitution were pursued in a somewhat parallel fashion although stronger emphasis was placed on the former. Accordingly, investment incentives were restructured so as to offer a variety of export incentives under the Investment Incentives Act 1968, including export allowances and accelerated depreciation, tax holidays, investment tax credit and other fiscal incentives were aimed at export-oriented industries. Pre-shipment and post-shipment export credit refinancing facilities were also introduced. At the physical infrastructural level, 12 Free Trade Zones (FTZs) were established where nearly three-quarters of the firms were foreign-owned and they accounted for more than 90% of the total direct employment within the FTZs.

The changing structure of the Malaysian economy is reflected in the changing composition of the country's gross domestic product (GDP). Fig.1 shows that the share of the agricultural sector in the GDP has declined from 30.8 per cent in 1970 to 8.2 per cent in 2005, while that of manufacturing sector has grown rapidly from 13.4 percent to 31.4 over the same period.[i]

Structural changes in the Malaysian economy have also been reflected in the changing pattern of sectoral employment as presented in Fig.2 where it can be seen that there is a rising proportion of the labour force in the manufacturing sector, while the share of government services in total employment declined from 1985 onwards due mainly to the privatization of some public sector activities in the country.

Studies so far undertaken mostly concentrate on the macro-economic aspect of this transformation process (Onn, 1986; Ariff, 1991). A few studies

have attempted to analyze the phenomena through industrial concentration (Aiken, et al. 1982). Okposin et.al., (1999) did a comprehensive study on the changing phases of the Malaysian economy covering macroeconomic policies, framework and management, industrialization policies and strategies, agricultural and tourism development, financial sector and privatization, manpower and environmental development, including Vision 2020 and Multimedia Super Corridor development.

Tan and Ariff (2001) reviewed the industrial structure and policies of Malaysia from late 1960s until up to 1990s. Salih, et al., (2000) documented the dramatic changes of the Malaysian economy over the past three decades (1960 to 1990) and examined the long term outlook of the Malaysian in the context of post-1990 external and domestic environment. The various five-year Malaysia Plans provide data and analysis on the inter-state distribution of GDP, per capita GDP, unemployment rate and employment by sectors. Nevertheless, a few fragmentary attempts have been made to study the spatial incidence of the structural changes of GDP through changes in the production/ employment structure of the regions / states of Malaysia. Ghaffar (1987) identified three causes of regional disparities; first, the impact relief, climate and distribution of natural resources; second, the impact of colonial rule on the social, economic and spatial structure; and third, insufficient attention to the spatial aspects of resource allocation. Although it has been admitted that the problems of regional inequalities in development and poverty are the major issues of the country (Salleh, 2000, p.5), systematic studies highlighting the relationships between national and regional economic growth through production and employment changes are lacking and hence, the present paper intends to fill in the gap. It is anticipated that the structural transformation of the national economy has not been uniform across the different regions[ii] of the country. Hence, from welfare perspective, there is a need to study the spatial matrix of the structural transformation through the changing structure of production and employment of the regional economies of Malaysia.

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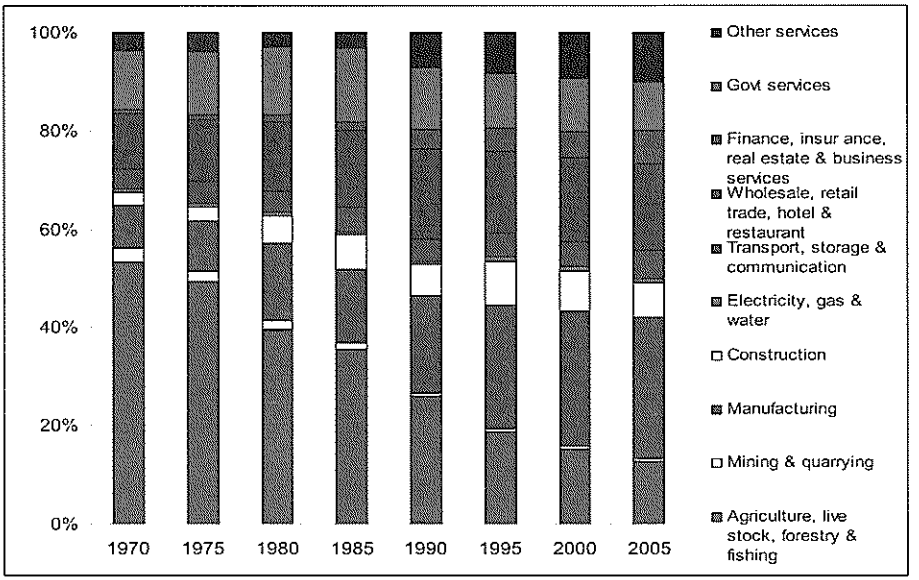

Figure 1: Changes in the Composition of GDP of Malaysia during 1970-2005.
(Sources: Compiled from Various Five-Year Plans of Malaysia.)

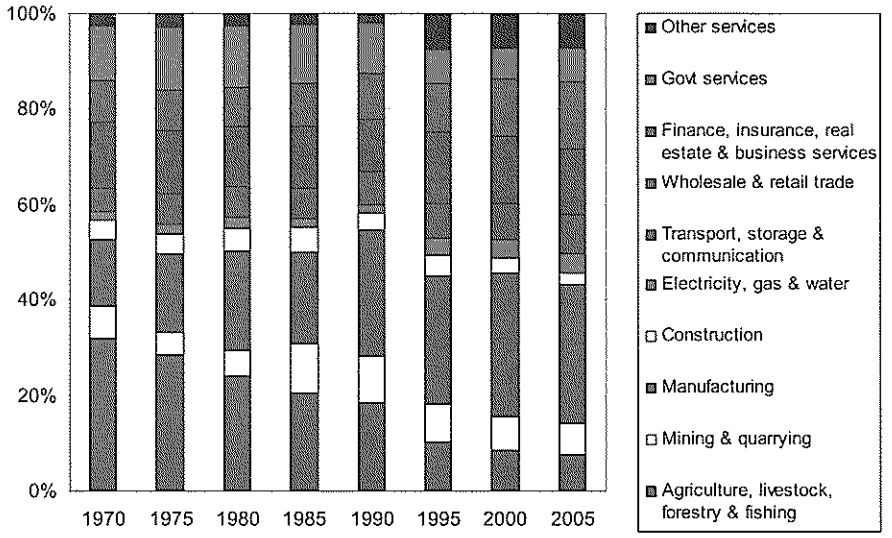

Figure 2: Changes in Employment Structure of Malaysia during 1970 2005.
(Sources: Compiled from Various Five-Year Plans of Malaysia.)

LITERATURE REVIEW

The spatial impress of economic development has always been uneven and hence regions grow at different levels within the national development process. Despite a good deal of research by economists, economic historians and economic geographers, there is still no generally accepted explanation as to why regional differences of growth occur. Although there is no single integrated theory that can explain the regional development process, there are a number of theories and concepts that can provide explanations to the regional growth process (Choguill, 1979). Three theories – neoclassical growth model, export-base approach and cumulative causation model, partially explain the phenomena. The neoclassical models stress supply-side influences on growth; export base approach stresses the importance of the demand for regional exports in the growth process and cumulative causation models stress the self-perpetuating nature of the growth process. Recently, attempts have been made to incorporate the principle of self-perpetuation into all growth theories, including new growth theory based upon endogenous growth. But these models are still in their infancy and require further development if they are to prove successful in explaining regional growth disparities and in identifying the major determinants of growth. Regional growth theory still has a long way to go and therefore a long future lies ahead of it (Armstrong and Taylor, 2004, p.117-8).

The theoretical perspective of the regional growth process, particularly based on the cumulative causation model (Myrdal, 1957) and Hirschman's (1958) theory, can be conceptualised into the divergence-convergence formulation which states that in the early stages of development, the developed centres enjoy the existence of external economies and other urbanising forces which lead to polarization and divergence of regional per capita incomes. However, at a later stage of growth, a process of convergence starts through the spread or trickle down of growth impulses to other areas and eventually, this will lead to a decrease of the regional income disparities. This process has been designated as β-convergence[iii] and σ-convergence[iv] (Armstrong and Taylor, 2004, p.82).

Empirical evidences on the validity of divergence-convergence syndrome are numerous. Williamson (1965), based on cross-sectional data of 24 countries, found that nations with intermediate levels of per capita income exhibit the largest regional inequalities than the highly developed and least developed nations. Based on time series data of 10 countries, he observed that increasing inequalities is associated with the early stages, while decreasing inequality is associated with mature stage of development. Empirical studies by Mera (1973; 1978) and later by Tabuchi (1988) seem to support the above findings, while

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others like Gilbert and Goodman (1976) are critical of Williamson's findings. According to them, regional disparities are unlikely to diminish unless national governments adopt strong regional development programmes. Their view is shared by Hansen (1981) and Nicols (1969). Ficsh (1984) calculated a dissimilarity index of US income for the years 1950, 1960 and 1970, as a measure of regional inequality and found that there was no clear empirical pattern emerging from his research. Barro and Sala-i-Martin (1995) examined the growth rates across the US states from 1880 to 1988 and found evidence of convergence of roughly 2% per year. Armstrong (1995) finds a similarly slow rate of convergence across regions of the EU. International studies of convergence by Sala-i-Martin (1996) indicate that regional convergence of per capita incomes has generally been slow in industrialised countries. Lall and Yilmaz (2001) examined the convergence across US states covering 1969-95 period when there were transformation of the economy from manufacturing to service base in the early 1980s and found that the concentration of those activities in a few states negatively affected the convergence tendencies.

According to Armstrong and Taylor (2002), "there is evidence that slow convergence of regional per capita incomes also appears to have occurred within individual EU member states as well as within many other countries around the world such as Japan, Canada, Australia and India". Similarly, Terrasi (2000) found a converging trend of regional per capita income and other variables, while she was comparing regional per capita income convergence of Italy and Spain on a comparative plane. On the contrary, Gezici and Hewings (2004) found little evidence of convergence of GDP growth per capita across the provinces and functional regions of Turkey during 1980-97.

Several regional development strategies and policies such as growth centre, urbanization, industrial dispersal, *in situ* development, resource frontier development, growth triangle development, have been adopted and implemented in Malaysia.[v] However, the outcome of those policies has not been very encouraging. It has been remarked that despite a strong state intervention in the planning and implementation of regional development programmes, the performance had been unsatisfactory (Mohd Yusof Kasem, 1992, p.55), and the impact of the government's efforts in reducing the growing regional disparities is marginal (Salleh, 2000, p.56). Even, the regional growth objectives and strategies adopted in various five year plans to enhance economic growth of lagging regions as well as decentralize the concentration of production and some commercial activities from core regions, have proved to be elusive (Hamzah Jusoh, 1992, p.22).

From the theoretical perspective and empirical studies, it appears that the divergence-convergence issue of regional growth is still open for further research both nationally and internationally. The present paper intends to fill in the gap of research that currently exist in Malaysia, where spatial incidence of structural changes of the national economy has led to the growth of imbalances in regional economic development in the country.

OBJECTIVES AND METHODOLOGY

The aim of the paper is to analyze the spatial incidence/connotation of the structural changes of the Malaysian economy from the regional perspective and as such the following objectives have been set:

a) Investigate the pattern of economic growth of Malaysia through employment and production changes;
b) Analyze the regional/state economic development through income and employment changes;
c) Identify and analyse the regional imbalances/disparities following from the national development process; and
d) Suggest policy directions to reduce regional imbalances of development.

The general hypothesis tested in the study is based on the fact that the regional growth resulting from or commensurate to the structural transformation of the Malaysian economy has not been uniform across the fourteen states of the country as can be observed from Figure 3 which shows state-wise variations of monthly household incomes in 2005.

Data source

The paper is based on secondary data. Data/information published by government, semi-government and private agencies were intensively utilized for deriving conclusions for the study. Four main sources were used to collect data/ information the following:

a) Data/information contained in the various five-year national development plans;
b) Statistical data/reports published by the Department of Statistics Malaysia.
c) Books, articles, conference proceedings.
d) Unpublished materials like dissertations and theses.

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Data Analysis

Simple statistical techniques such as charts, tables, were used to make the data meaningful and derive conclusions from thereon. XCEL, SPSS PC+ Software were used for data analysis. MapInfo GIS was used to make the analysis spatially focused and meaningful.

Analysis Techniques

Four analysis tools were adopted for the study. These are narrated as follows:

Theil Index

Theil (1967) coefficient of concentration which is apt for comparing inequalities of different regional systems was applied in the study. The index is calculated by using the following formula:

$$IC = \Sigma\ Yi \log (Yi / Xi)$$

Where *IC* is the *Theil* index, *Yi* is the share of GDP for region *i* and *Xi* is the share of national population for the same region. The index is standardized by dividing the equation by its maximum value, which is *log (P),* where *P* is the national population (Walsh and O'Kelly, 1979). The value of the index of regional inequality ranges between zero (0), corresponding to perfect equality and one (1) corresponding to maximum inequality. Theil index has been used by many authors (Terrasi, 2000; Gezici and Hewings, 2002) in regional studies.

Per Capita Regional GDP

From economic welfare perspective, output per capita is considered an important variable. Hence, regional disparities in GDP per capita have figured strongly in defining regions in need of special assistance through the EU's Structural Funds. The increasing interest of policy makers in regional disparities in output per capita has been one of the primary motivating forces behind the recent spur of empirical studies which attempt to explain these disparities (Armstrong and Taylor, 2004, p.88).

Shift-Share Analysis (SSA)

Shift-share analysis (SSA) is a technique which provides some insights into the pattern of regional employment changes. The analysis divides the growth of regional employment over a period of time into three constituent parts; (1) the

part that is due to the region's share in national growth, that is, if the national economy is growing the region should experience growth; (2) the part that is due to the region's specific mix of industry, that is, if the region has above average representation of growth industries it should benefit accordingly; and (3) the part that is due to residual influences not included above, that is, regional growth not explained by industrial structure. SSA would therefore predict that a region with a favourable mix of industry would experience higher employment growth than a region with an unfavourable mix of industry. The formula used for calculating the shift-share components for a single sector/ industry is expressed as follows:

Share Component: $SH = e_i [(N^*/N) - 1]$.
Mix Component: $MIX = e_i [(N_i^*/N_i) - (N^* - N)]$.
Competitive Component: $COM = e_i [(e_i^*/e_i) - (N_i^*/N_i)]$.

Where:
e_i = local employment in sector/industry $_i$ at the beginning of the period.
e_i^* = local employment in sector/industry $_i$ at the end of the period.
N^* = total national employment at the end of the period.
N = total national employment at the beginning of the period.
$_i$ = indicates reference to industry/sector.

Despite being criticised as an approach that is easy to use and understand, the analysis has been widely used by planners and economic development officials to help them understand the economic performance of regions (Blair, 1991, p.190).

Federal Government Development Expenditure and Private Sector Investment

Federal Government development expenditure in the form of infrastructural grants can impact the regional growth process through providing attractions to the investors. Similarly, the private sector's industrial investment in different states or regions can increase the regions' ability to generate employment and income in their territories. Gezici and Hewings (2002) and Hamzah Jusoh (1992) have used this technique in regional analysis.

NATIONAL ECONOMIC GROWTH AND REGIONAL DISPARITIES

In the last four decades, Malaysia has made striking progress in economic development when measured by using such criteria as growth rates, stability of

internal prices, and balance of payment strengths. However, development conceived in these terms is a value laden fraud which means that while gross indicators portray a bright picture, there may be an extreme distribution of development in spatial and human terms (Aiken, S.R. et. al., 1982, p.92).

In order to unravel the regional disparities of development among the fourteen (14) states of Malaysia (Figure 3), the *Theil* coefficient of concentration has been presented in Figure 4 with the real per capita GDP growth rate of the country during 1970-2005. Both real Per Capita GDP[vi] and the *Theil* index of regional disparity have increased concurrently with a rank (*rho*) correlation coefficient of 0.90 significant at 0.001 level[vii]. However, the annual growth rate of per capita real GDP was 5.8 percent compared to the disparity indices which grew at a rate of 1.5 per cent during the same period.

NATIONAL ECONOMIC AND REGIONAL PER CAPITA GDP GROWTH

Malaysia's spectacular economic performance has led to an increase of the per capita real GDP from RM[viii] 1,939 in 1970 to RM 13,546 in 2005. However, the increase in the per capita income has not been uniform across the 14 states of the country.

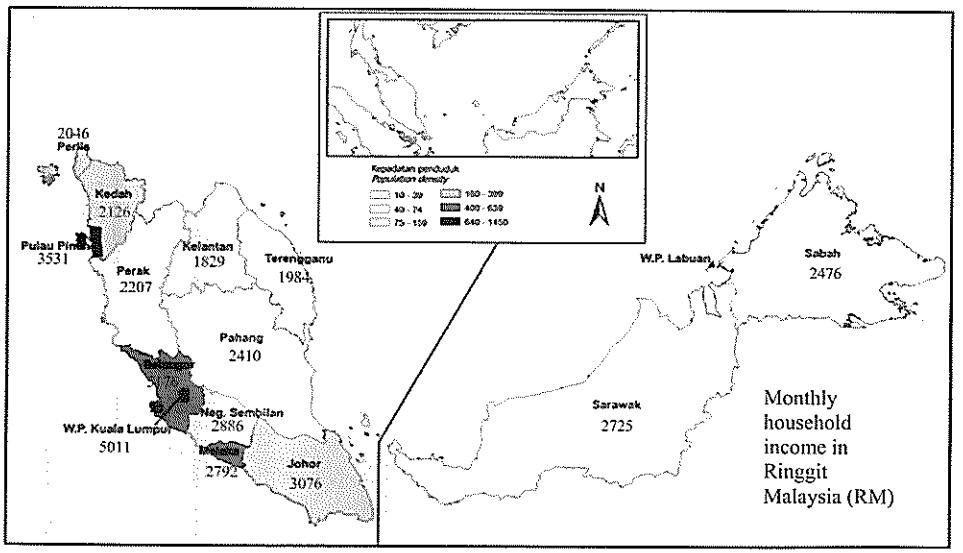

Figure3: Population Densities and Household Monthly Incomes by States of Malaysia
(Source: Dept. of Statistics Malaysia, 2005)

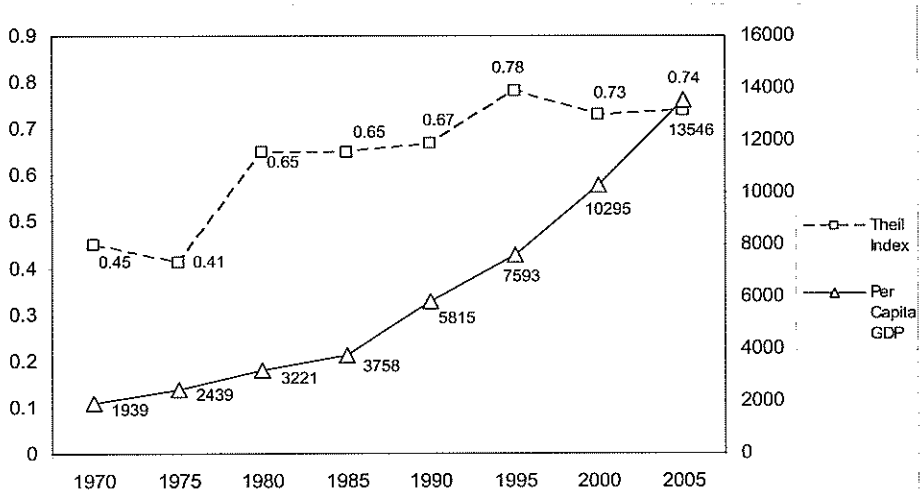

Figure 4: *Theil* Index and Real per capita GDP Growth of Malaysia during 1970-2005.
(Source: Author's Calculations based on data from various Five-Year Plans of Malaysia)

The Third Malaysia Plan (1971) stated that "as a result of historical patterns of development, the different states and regions of Malaysia have shown very different rates of development, resulting in very unequal distribution of income, amenities and opportunities. Not only does output growth vary greatly between regions; there are also substantial regional variations in the growth of output per capita as well" (3rd Malaysia Plan, 1971, p.210). Even the National Physical Plan (2005) has admitted that in Peninsular Malaysia, imbalances in economic growth exist between the West and East Coasts, within the West Coast, imbalances also occur between the more developed states such as Pulau Pinang and Perak with the northern states like Kedah and Perlis - reducing these imbalances is important towards enabling Malaysia to achieve national integration (JPBD, 2005, p.5-6). To investigate the spatial impress of the national growth process, per capita regional GDP of 14 states have been calculated with national per capita GDP (as a base of 1.00) for a period of 35 years beginning from 1970 to 2005. In Figure 5, the figure shows that there have been northern-southern, central-eastern differences in the growth of regional per capita income in Malaysia.[ix] The northern region comprises of four states of the country - Perlis, Kedah, Pulau Pinang and Perak; 3 (75%) of the states had per capita income less than the national average over the 35-year period. The central region comprising of three states – Selangor, Negeri Sembilan, Melaka and the federal territory of Kuala Lumpur; 3 states or 75% of the region had maintained their per capita GDP growth above the national

average during the same period. The eastern region has three states – Kelantan, Terengganu and Pahang, only one state (33.3%) had per capita GDP above the national average. The southern region – the state of Johor, and east Malaysia region of the states of Sabah and Sarawak, have their per capita income below the national average.

Nine states (64%) of Malaysia, out of 14, were low achievers in terms of per capita income, of which two states – Sabah and Negeri Sembilan have experienced continual declines in their per capita GDP. Five states (36%) of Malaysia are high achievers of per capita GDP, of which three states – Pulau Pinang, Terengganu and Melaka have shown increasing trend in their per capita GDP achievements. Among the high per capita GDP achieving states, FT Kuala Lumpur has the highest achievement followed by Terengganu, Pulau Pinang and Selangor. Three states – Kelantan, Kedah and Perlis, have continually remained low achievers of per capita GDP over three and a half decades. The per capita GDP gap between lowest and highest achieving states – FT Kuala Lumpur and Kelantan, declined marginally in 1980 and then onwards it started increasing and from 1985 the gap almost remained parallel.

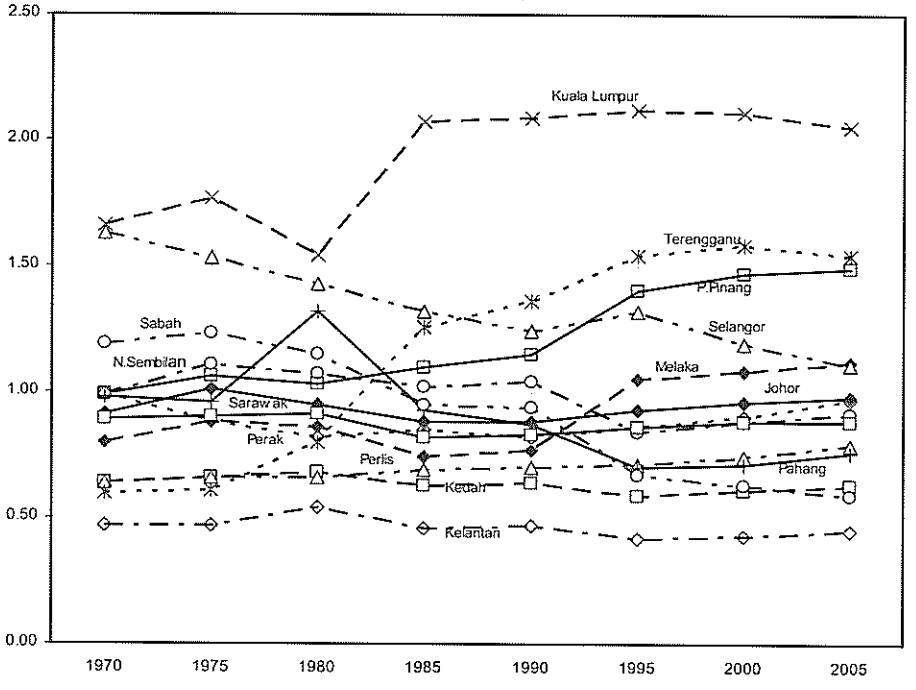

Figure 5: Distribution of Per Capita State GDP to National GDP Ratios during 1970 -2005.

(Sources: Author's Calculations Based on Data from various Five-Year Plans of Malaysia)

REGIONAL EMPLOYMENT GROWTH AND CHANGES

The overall growth rate of a region's activity as measured by total employment is a weighted average of the growth rates of the separate sectors or activities making up the region's economy. If a region's growth rate is compared with that of another region, it is possible to explain the difference of growth rates statistically in terms of two components – mix and competitive. Quantitative analysis of comparative regional growth rates can be done by using the "Shift-share" approach. If a region contains mainly fast-growing activities and relatively few slow-growing activities, it can be said to have a favourable growth mix of activities and its overall percentage growth rate will exceed the nation. On the other hand, if slow-growing industries are more than proportionally represented in the region's mix, the region's overall growth rate will be slower than the national growth rate. If a region has same mix of activities as does the nation, and its percentage share of the national total is the same for all activities, the region will have an overall growth rate higher than that of the nation if it increases its shares (that is, if most activities grow faster in the region than in the nation). Such a case represents the competitive component in isolation. In any real situation, it is nearly certain that the relative growth rates of the region and nation will show the effects of some combination of mix & competitive components. The effect and the net result can be either positive or negative.

In order to explain the comparative regional growth process of Malaysia, regional employment data of 22 years starting from 1982 to 2004 were analysed by using share-shift technique. The result of the analysis presented in Table-1 shows that three states (21.5%) – Johor, Pulau Pinang, and Selangor, out of 14, had experienced employment growth above the national rate and they achieved positive shares and positive mix and competitive shifts. Among the three, Selangor followed by Pulau Pinang, and Johor had achieved a favourable economic environment in which regional activities and employment have been positive. Eight states (57%) - Kelantan, Melaka, Negeri Sembilan, Pahang, Perak, KL, Terengganu, and Perlis, had a positive mix but a negative competitive component, which stand to indicate that these regions had a favourable growth mix compared to the nation. But the existence of a negative competitive shift indicates that these regions lost out to that extent in competitive position vis-à-vis the rest of the country. Three states – Sabah, Sarawak and Kedah experienced a negative mix with negative competitive components, except for Sabah, which indicates that the industries of these states are of types that are less competitive nationally. Table-1 also shows the incidence of poverty and unemployment rates by the states of Malaysia. We did a correlation analysis and found that the coefficient is significant with the MIX

component only stands to suggest that both unemployment and incidence of poverty can be reduced by enhancing the mix component of regional employment.

The aggregate share-shift components need to be decomposed by sectors to get a better understanding of the regional economies. Three broad sectors have been considered - agriculture, industry and services.[x] Table-2 presents sector specific shift-share analysis of state economies. The table shows that the agriculture sector has achieved negative regional growth, mix and competitive components almost in all the states except Sabah where the regional employment has been higher than the national share and the competitive component is positive, which indicates the competitiveness of local industries of agriculture sector vis-à-vis the national sector.

Table 1: Shift- Share Analysis of Regional Employment Changes in Malaysia, 1982-2004 (in 000s)

State/ Region	Regional Employment Growth	Components			Incidence Of poverty (2004)	Unemplo-ment rate (%) (2005)
			Shift			
		National Share	Mix	Competitive		
Johor	721	612	89	108	2.0	2.1
Kedah	357	417	-69	-80	7.0	2.6
Kelantan	149	309	22	-37	10.6	3.1
Malaka	121	157	74	156	1.8	2.0
N. Sembilan	177	209	30	-32	1.4	2.4
Pahang	220	310	32	-89	4.0	2.7
Perak	222	693	132	-471	4.9	3.0
Perlis	27	61	4	-34	6.3	1.9
P. Pinang	425	361	237	65	0.3	1.6
Selangor	1427	635	371	792	1.0	1.7
Terengganu	127	207	25	-80	15.4	3.0
Kuala Lumpur#	216	334	233	-118	1.5	1.4
Sabah#	987	384	-80	603	23.0	5.0
Sarawak#	368	433	-196	-64	7.5	3.4
Rank correlation coefficient with MIX component		-	-	-	-0.82**	-0.71**

(Source: Calculations are based on State/District Data Book – Malaysia 1987 to 2005, published by the Department of Statistics Malaysia)
*Note: **Significant at 0.01 level. # Employment data covers 1990- 2004.*

The table also shows that all the state economies have positive shares and mix components for the industry sector except Kuala Lumpur, Sabah and Sarawak, in which case, the mix component is negative. The competitive components of industries of Perak, Terengganu and Kuala Lumpur are negative,

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implying that regional industries in these states are composed of units which are less competitive than the national industries. The performances of service sector of all the state economies have been good except Kelantan, Melaka, Perak, and Kuala Lumpur, in which case the achievement of a positive mix shift component along with a negative competitive component is indicative of the fact that these economies lost out to that extent in competitive position vis-à-vis the rest of the country. The analysis from the table appears to indicate that the employment growth of the state economies have highly depended on two sectors – industry and service rather than on agriculture. Sector-wise calculation of shift-share by states of Malaysia is given in Table 4.

FEDERAL GOVERNMENT DEVELOPMENT EXPENDITURE AND PRIVATE SECTOR INVESTMENT

Data on federal government development expenditure which accounts for 70% of total by the states of Malaysia during the period of 1976-2005 presented in Table 2 shows that Kuala Lumpur followed by Sarawak, Pahang, Terengganu, Negeri Sembilan and Perlis have received higher percentage share of development expenditure than their percentage share of population. The low percentage recipients of federal fund have been Selangor followed by Sabah, Perak, Pulau Pinang and Kelantan. Similarly, the percentage share of industrial investments during 1986-2005 have been high in Terengganu followed by Pulau Pinang, Melaka, Sarawak, Selangor, Negeri Sembilan and Kedah, whilst Sabah, Kuala Lumpur, Kelantan, Perak and Pahang have received low shares of the private industrial investment.

Both the allocation of the federal development fund and the private sector investment were favourable to some states and at the same they were disproportionate to some other states of Malaysia and this provides the partial reasons for regional disparities of development among the states of the country.

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Table 2: Federal Government Development Expenditure by States of Malaysia during 1976-2005

State	Expenditure (RM bl.)	Percentage	Population % ('05)
Johor	26.04	9.0	11.9
Melaka	7.55	2.6	2.7
N.Sembilan	11.91	4.1	3.6
Perak	19.92	6.9	8.5
Selangor	37.84	13.0	18.2
P.Pinang	12.41	4.3	5.6
KL	41.40	14.3	6.1
Kedah	20.43	7.0	6.9
Kelantan	13.48	4.6	5.6
Pahang	20.91	7.2	5.4
Perlis	4.787	1.6	0.9
Sabah	30.12	10.4	12.0
Sarawak	29.14	10.0	8.8
Terengganu	14.39	5.0	3.8
MALAYSIA	**290.332**	**100.0**	**100.0**

(Source: 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, and 9th Malaysia Plans)

Table 3: Approval of Manufacturing Projects by States of Malaysia during 1986-2005

State	Number	%	Employm-ent (000)	%	Investment (RM bl.)	%	Popun % ('05
Johor	3694	22.8	438.9	21.4	59.98	13.5	11.9
Melaka	634	3.9	89.9	4.3	28.59	6.4	2.7
N.Sembilan	652	4.0	89.7	4.3	22	4.9	3.6
Perak	1006	6.2	132.8	6.4	25.57	5.7	8.5
Selangor	4670	28.8	457.5	22.2	88.35	19.9	18.2
P.Pinang	2128	13.1	298.4	14.5	41.85	9.4	5.6
KL	430	2.6	34.5	1.7	3.93	0.9	6.1
Kedah	952	5.9	153.6	7.4	35.17	7.9	6.9
Kelantan	135	0.8	19.7	1.0	2.2	0.5	5.6
Pahang	349	2.1	60.6	2.9	20.89	4.7	5.4
Perlis	75	0.5	9.2	0.4	3.94	0.9	0.9
Sabah	631	3.9	94.8	4.6	17.03	3.8	12.0
Sarawak	629	3.9	121	5.9	48.06	10.8	8.8
Terengganu	232	1.4	62.9	3.0	46.44	10.5	3.8
MALAYSIA	**16217**	**100**	**2063.5**	**100**	**444**	**100**	**100.0**

(Sources: 4th, 5th, 6th, 7th, 8th, and 9th Malaysia Plans)

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Table 4: Shift-and-Share Analysis of Employment Types by States of Malaysia, 1982-2004 (in 000s).

Sectors /States	Agriculture				Industry				Service				Total			
	RG	SH	MIX	COM	RG	SH	MIX	COM	RG	SH	MIX	COM	RG	SH	MIX	COM
Johor	-46	220	-294	-267	368	147	3	225	399	249	381	150	721	612	89	108
Kedah	-66	214	-286	-280	185	62	1	123	238	141	215	97	357	417	-69	-80
Kelantan	-61	126	-168	-187	112	60	1	52	98	124	189	-25	149	309	22	-37
Malaka	-10	37	-49	-46	55	41	1	14	75	80	122	-5	121	157	74	156
N. Sembilan	-12	80	-106	-91	70	41	1	29	119	89	130	30	177	209	30	-32
Pahang	19	128	-171	-109	50	50	1	0	152	132	201	20	220	310	32	-89
Perak	-99	248	-330	-347	123	145	3	-22	119	301	460	-102	222	693	132	-471
Perlis	-10	26	-34	-36	11	10	0	1	27	25	38	2	27	61	4	-34
P. Pinang	-2	35	-47	-37	209	141	3	68	218	185	282	33	425	361	237	65
Selangor	-20	113	-151	-133	469	183	3	286	978	339	518	639	1427	635	371	792
Terengganu	-8	75	-101	-83	39	50	1	-11	95	82	125	13	127	207	25	-80
FT KL#	0	3	-5	-3	5	91	-30	-87	211	240	268	-29	216	334	233	-118
Sabah#	259	167	-251	92	241	48	-16	192	487	168	187	318	987	384	-80	603
Sarawak#	-33	229	-344	-262	142	55	-18	88	259	149	166	110	368	433	-196	-64

(Source: Calculations based on data from State/ District Data Bank (All States) of Malaysia -1987; State/ District Data Bank – Malaysia- 2005, published by the Department of Statistics Malaysia, (1987) & (2005))

Notes: RG = Regional Growth; SH = National Share Component; MIX = Mix (Shift) Component; COM = Competitive (Shift) Component.
 # Employment data covers between1990-2004.

CONCLUSION

This paper has examined the economic growth of the state economies as regional entities of Malaysia over a period of three and a half decades in the case of production and more than two decades in the case of employment, within the context of the structural changes of the national economy. In spite of implementing several regional development strategies and policies from second Malaysia Plan (1971-1975), the spatial matrix of national growth shows that the economic growth process has been uneven across the 14 states of Malaysia, giving rise to regional disparities in income and employment growth. Both federal government development expenditure and private investments in different states of Malaysia have not been proportionate to their shares of national population and this partially explains the reason for the growth of regional imbalances in the country despite that the national economy has undergone transformation.

The findings of the paper have the following policy implications:

- Federal government development expenditure should at least be equity based if it does not favour the lagging regions;
- Effective fiscal policies are necessary to encourage private investments in less developed states and at the same time discourage it in the more developed states;
- Regional economies should try to improve their industrial mix component for fast growing national industries;
- Regional economies should try to develop more specialized industries.

Recently, Malaysia has formulated a National Physical Plan with 36 policies which provide a spatial dimension to national economic policies by coordinating sectoral allocation of resources within the framework of regional, state and local planning. The first fifteen policies are directed towards reducing regional imbalances in the country. Among these, the most important ones are – selective concentration in strategic urban centres for all states in P. Malaysia (NPP2, p.5-7), adoption of industrial clusters in selected urban conurbations and resource-based clusters and craft-based clusters in less developed states to serve as a catalyst for growth ((NPP5, p.5-10), developing a rational land use strategy to support the Third National Agricultural Policy (NAP3). Furthermore, it has been stated that land and natural resources of the less developed regions which still remain not fully utilised, should be further used to increase the productivity of those regions and therefore, help reduce regional imbalances. Resource-based industries, forestry-based activities and industries, downstream agriculture-based activities, resort tourism, in particular eco-tourism, craft-based industries

and other niche activities – in other words, economic activities that are not subject to the same degree of competition as the activities that are being attracted to conurbations should be directed in the less developed regions" (JPBD-NPP, 2005, pp. 4-6). The NPP policies are supportive of the policy implications suggested in this paper. These policies when implemented effectively are expected to contribute towards ameliorating regional imbalances in Peninsular Malaysia, if not for the whole of Malaysia, because NNP is for P. Malaysia only.

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[i] Athukorala (2001) has identified a few factors to the impressive economic performance of Malaysia (p.21).

[ii] If not otherwise mentioned, the terms 'region' and 'state' have been used interchangeably in this paper.

[iii] β (Beta)-convergence occurs when poor regions grow faster than rich regions, implying a negative relationship between the growth of per capita income over several decades and the level of per capita at the start of the period (Armstrong and Taylor, 2004, p.82).

[iv] σ (Sigma)-convergence occurs when the dispersion of per capita income between regions falls over time. It is a more conventional measure of regional inequality (Armstrong and Taylor, 2004, p.82).

[v] For elaborate discussion on these regional strategies and policies, see Mohd Yusof Kasem (1992), Hamzah Jusoh (1992) and Salleh (2000).

[vi] Real Per Capita GDP has been calculated at 1978 prices.

[vii] Salleh (2000) has calculated regional inequality for Peninsular Malaysia during 1960-1990 and derived a similar tend (p.54).

[viii] The exchange rate between US$ and Ringgit Malaysia is, US$ 1.0 = RM 3.75.

[ix] In the Fourth Malaysia Plan & also Ninth Malaysia Plan, states of Malaysia were grouped into five regions – Northern, Eastern, Central, Southern and East Malaysia states of Sabah and Sarawak. (4MP, 1986, p.81; RMK9, 2006, pp.358).

[x] Agriculture comprises of farming, fishery, forestry, mining and quarrying; Industry consists of manufacturing and construction; and service is composed of finance, insurance, commerce, transport, storage, communication, government, utility and other services.

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URBAN SUSTAINABILITY AND GROWTH MANAGEMENT IN SOUTH-EAST ASIAN CITY-REGIONS: THE CASE OF KUALA LUMPUR AND HONG KONG

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Abstract

Major South-East Asian city-regions have experienced considerable physical, economic and social transformations during the past three decades. The rapid pace of globalisation and economic restructuring has resulted in these city-regions receiving the full impact of urbanisation pressures. In an attempt to ease these pressures, city-regions such as Bangkok, Seoul, Tokyo, Taipei, Hong Kong, Singapore and Kuala Lumpur have advocate growth management approaches giving particular interest to urban sustainability. These approaches promote efforts to achieve the triple bottom line sustainability by balancing economic and social development, and environmental protection, and putting more emphasis on compact and optimum development of urban forms. This paper evaluates the case of two South-East Asian city-regions, Kuala Lumpur and Hong Kong, and assesses their experiences in managing their urban forms whilst promoting sustainable patterns of urban development. The findings show that sustainable urban development initiatives employing a top down approach has yielded encouraging results in these case study city-regions. However the need for a more concerted effort towards the overall sustainability agenda still remains vital.

Keywords: Sustainable urban development, growth management, compact urbanisation, city-regions, Kuala Lumpur, Hong Kong, South-East Asia

INTRODUCTION

For about three decades ago the green agenda of sustainable development started to garner interest from almost every corner of the world. This agenda was initiated by the World Commission on Environment and Development

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(WCED), with its much quoted definition of sustainable development as the "development that meets the need for the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, 43). Although this rather vaguely descriptive statement raises some questions, so far it remains the most adequate definition of sustainable development (Jepson, 2004). Since early 1980s, policy-makers have been looking for ways to move city-regions towards more sustainable forms (Sorensen, Marcotullio, & Grant, 2004). The continued expansion of city-regions makes sustainability an issue of significant concern because of scarce world resources (Lindsey, 2003). This continued growth, both in population and consumption, is now putting our ability to a test in managing urban regions more sustainable and effective ways.

This paper explores the implementation of growth management efforts in the South-East Asia city-regions of Kuala Lumpur and Hong Kong. The methodology employed in this paper is a thorough policy evaluation with a comparative analysis of selected indicators of both city-regions. The paper first reviews the concept of urban sustainability, focusing on the nature and trends of urban development, and its consequences. The second section looks at solutions for addressing problems of urban growth by introducing concepts and strategies for promoting urban sustainability through compact urbanisation. The third section explores the experiences of two fast-growing South-East Asia city-regions, Kuala Lumpur and Hong Kong, and analyses their approaches in dealing with problems related to promoting compact urbanisation. For each case study, the research identifies the development pressures affecting their urban environments and the strategies adopted towards achieving sustainable urban growth management. The final section summarises the findings from the case city-regions and discusses the implications of growth management strategies for the South-East Asia region.

URBANISATION, SUSTAINABILITY AND GROWTH MANAGEMENT

For the past three decades, the notion of sustainable urban development has become central in planning and managing urban areas in Europe and North America. This notion was promoted in response to the problems associated with urban sprawl that has plagued cities in these continents during the past decades. Intense urbanisation has transformed cities in Europe and North America into mega-cities and metropolises. The associated economic development and prosperity experienced by these European and North American cities have prompted Asian cities to emulate these achievements. The industrial revolution that swept through the Asian continent has resulted in a rapid urbanisation process, fuelled largely by unprecedented population growth.

There is a strong belief that urbanisation is crucial to the process of development, and an inevitable process of creating a modern state (McGhee, 2008). Indeed, the rapid urbanisation of Asian cities in general has brought about rising income and living standards to the cities' population. The world development indicators data compiled by the World Bank, for example, shows that developing countries in South-East Asia have been experiencing a significant growth of their GDP over the last 10 years and their share of the global economy has risen from 13 percent in 1995 to 19 percent in 2005 (World Bank, 2007). However, Asian cities, cities in South-East Asia in particular, are struggling to keep up with the rapid urbanisation pressures caused by rapid population increase and expanding city sizes. These pressures have created what is generally known as urban sprawl, characterised by low density suburban development patterns. Urban sprawl takes three main forms: suburban expansion into the countryside, commercial expansion along arterial roads, and residential sprawl outside existing settlements (Daniels, 1999).

The consequences of sprawl have been viewed differently by planning scholars. Benefits of sprawl include private and social benefits to new residents and the community, for example in terms of housing costs (Kahn, 2001), potential for population growth accommodation (Brueckner, 2000), and symbol of economic prosperity (Nelson & Duncan, 1995). However, this phenomenon has also been associated with an array of undesirable physical and socio-economic effects (Nelson & Duncan, 1995; Boyle & Mohamed, 2007). These include: scattered development, excessive commuting and transportation costs, infrastructure and services provision costs, socio-economic segregation through inequitable land and housing markets, increasing consumption of natural open space, and other 'quality of life' problems (Nelson & Duncan, 1995; Brueckner, 2000; Carruthers & Ulfarrson, 2001; Carruthers, 2002).

URBAN MANAGEMENT STRATEGY OPTIONS

The problems associated with rapid urbanisation have prompted city governments to introduce a variety of approaches to control sprawl and limit further damage to the limited resources that they have. These measures have been extensively explored in scholarly research (Nelson & Duncan, 1995; Brueckner, 2000; De Roo & Miller, 2000; Choguill, 2008). The term urban management or urban growth management has been used interchangeably to reflect these efforts, and a variety of growth management techniques have also been introduced to apply growth management concepts into practice. The reason for adopting growth management approaches in cities was coming from the need to achieve a balanced and sustained urban development. Urban

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sustainability has long and flourishing roots in Europe and North America, where urban sprawl was first identified. Calls for adoption of sustainable urban development and management were at its height at the Rio Summit in 1992 following the World Commission on Environment and Development report on sustainable development.

While it is widely agreed that no single approaches can solve the problems of urban sprawl (Nelson & Dawkins, 2004), many believe that compact urban development contributes to urban sustainability, which is one of the key aims of growth management initiatives (De Roo & Miller, 2000; Wassamer, 2006). A number of strategies have been developed and employed to achieve compact urban development (Nelson & Duncan, 1995). Containment-based management supported by sustainable urban transport has been one of the most successful compact urbanisation strategies (Nelson & Dawkins, 2004; Yigitcanlar et al., 2007). This strategy attempts to promote the following: compact and contagious urban development patterns with easy access to public services; travel-self containment with reliable public transport options and integrated land use and transport planning, and; preservation of rural and agricultural land and natural resources (Nelson & Duncan, 1995; Duvarci & Yigitcanlar, 2007; Yigitcanlar et al., 2008). Compact urbanisation strategies determine the direction of public infrastructure investment, execute development regulation and shape the nature and intensity of development. Containment scales vary between sub-metropolitan (development shaped to take a specific form), unbounded (development within urban service boundary), bounded (development within a designated growth boundary), and natural containment (development restricted by geographical constraints) (Nelson et al., 2004). Around the world many cities implemented a variety of containment techniques that range from urban growth boundary to urban service area, and from land taxation to open space preservation. Successful implementation of containment techniques and experiences from North America and Europe provide invaluable insights to many city-regions seeking sustainable urban development.

The implementation of strict development regulations associated with containment techniques enables local authorities to encourage development in existing urban cores and dilapidated inner areas through infill and redevelopment projects, including not only prestigious but also affordable residential development. The promotion of higher residential densities in these infill areas helps to offset the high development costs resulting from urban containment and to minimise public infrastructure provision. Zoning is commonly used for such a purpose. It allows for higher density development on

the land used to accommodate low-rise dwelling units, hence making the properties more affordable to a majority of urban dwellers.

SUSTAINABILITY INDICATORS

The increased environmental agenda has brought about the need to employ indicators as a key mechanism for assessing environmental impacts (Hemphill, 2004) and as policy instruments in the transition toward urban sustainability (Hezri, 2005). There is a common view that sustainability indicators can be meaningful provided they are applied at the appropriate level (Brownhill and Rao, 2002, cited in Hemphill, 2004). Such indicators can be crucial in developing an awareness of urban problems and advocating the need for the achievement of sustainable development (Stanners and Bourdeau, 1995). They can contribute to the assessment of the performance of individual agencies/interventions, and of the overall effectiveness of partnerships to improve economic, social and environmental wellbeing of urban settings. However, most indicator-based approaches only highlight issues; they do not provide answers as to why differences exist. Key indicators must be supplemented by qualitative and quantitative information on impact and performance from the perspectives of users and beneficiaries. In recent years, the best starting-point for assessing sustainable practices has been the Bellagio principles developed by the International Institute of Sustainable Development (IISD) (Hemphill, 2004). These principles serve as guidelines for the assessment process, including the choice and design of indicators, their interpretation, and the communication of results, to provide a link between theory and practice.

SUSTAINABLE URBAN DEVELOPMENT IN SOUTH-EAST ASIA

The dynamic South-East Asia region is home to many fast growing city-regions. During the past three decades, cities in this region have undergone massive transformations (Marcotullio, 2004). Major cities experienced vibrant population growth, and major physical and functional urban transformations. The rapid pace of globalisation and economic restructuring has resulted in these city-regions receiving the full impact of urbanisation pressures. In an attempt to ease these pressures, major cities have advocated growth management approaches giving particular interest to balanced economic and environmental sustainability and put more emphasis on compact and optimum development of urban forms (DeGrove, 2005). This paper, therefore, evaluates the case of two South-East Asia city-regions, Kuala Lumpur and Hong Kong, and assesses their

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experiences in managing their urban forms whilst promoting sustainable patterns of urban development.

KUALA LUMPUR'S SUSTAINABLE URBAN GROWTH MANAGEMENT STRATEGIES

Located midway along the west coast of Malaysia and within the rapidly growing central region of the Klang Valley, Kuala Lumpur is a federal territory and its whole area (243 square kilometres) is entirely urbanised (Figure 1). The capital city of Malaysia is home to around 1.6 million people, and with a density close to 5,700 persons per square kilometres, it is the most urbanised and densely populated area in the country (Government of Malaysia, 2005). Famous for its modest beginning as a tin-mining town in the mid 19th century, Kuala Lumpur has progressed itself into a commercial core and has become one of the most prominent, modern and sophisticated cities in South-East Asia. However, the continued suburbanisation process has inevitably led to sprawl of population and industries towards the southern part of Kuala Lumpur, leaving most parts of the city centre with employment and entertainment centres only. With increasing affluence and the changing lifestyle, the city has witnessed a reduction in its population base due to out-migration to the more prosperous environment and affordable residential districts of Gombak and Petaling, in the neighbouring State of Selangor (Syafie, 2004). In addition, the relatively lower living costs and the availability of a good road network and public transportation, in particular the LRT and the KTM commuter train services, have attracted city workers to live in areas outside the city in the neighbouring satellite townships of Petaling Jaya, Subang Jaya or even further afield in Klang or Seremban (Kuala Lumpur City Hall, 2003). These patterns of development have led to high travel demand and increasing transportation cost, worsening congestion and environmental degradation, inner city dilapidation and population decline, and lack of affordable housing. As the problems worsen, the City administration (Kuala Lumpur City Hall) had to carry the burden of providing for extra infrastructure and public facilities, and tackle the consequences of sprawl.

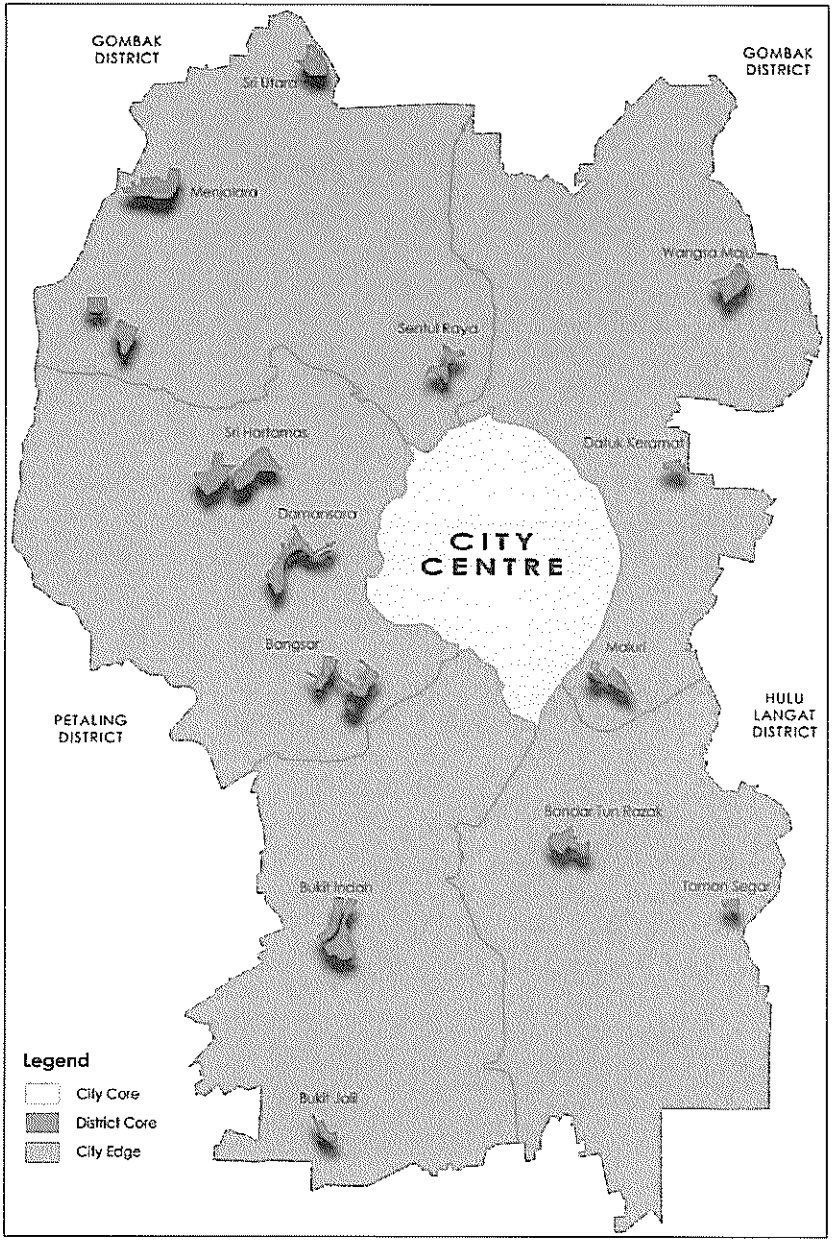

Figure 1: Kuala Lumpur city-regions and strategic zones
(Kuala Lumpur City Hall, 2008)

Kuala Lumpur's urban management strategy follows a top-down approach, starting with the federal government's countrywide National Physical Plan (NPP), and the regional administrative policies envisioned in the National

Urbanisation Policy (NUP). The City administration (Kuala Lumpur City Hall), in collaboration with the Federal Town and Country Planning Department, reinforces these policy-based growth management strategies with statutory planning measures incorporated in the city's structure plan, the Kuala Lumpur Structure Plan 2020 (Kuala Lumpur City Hall, 2003) and the recently publicised draft local plan, the Kuala Lumpur City Plan 2020 (Kuala Lumpur City Hall, 2008). The NPP's primary goal is to create a sustainable national spatial framework to guide the country's overall development whilst its policies related to land use put an emphasis on the planning of sustainable economic activities based on the concept of 'selective concentration' for strategic urban centres. It also emphasises the concentration of urban growth in existing and planned conurbations. This includes the conurbation of Kuala Lumpur, which is to be planned and developed as an integrated region through the preparation of a regional plan (Government of Malaysia, 2007).

Kuala Lumpur benefited highly from the establishment of the NUP in 2006, which forms a fundamental framework for the Draft KL City Plan 2020. The NUP promotes liveable communities as well as sustainable urban development of the city by coordinating and guiding the planning and development in a more efficient and systematic way (Government of Malaysia, 2006). Greater emphasis is put into creating a balanced social, economic and physical development and encouraging racial integration and solidarity for those who will reside in urban areas over the next 20 years. The NUP emphasises six main directions that outlines strategies for the creation of a city that is safe, efficient, modern and attractive. These include the achievement of an efficient and sustainable urban development, provision for integrated and efficient urban transportation system, quality urban services, infrastructure and utility, and for the creation of effective urban governance structures, all of which will contribute to a more sustainable urban management for Kuala Lumpur.

At the local level, the Kuala Lumpur Structure Plan 2020 is the cornerstone of the urban management strategy envisaged by the City administration. This statutory plan spells out the vision, goals, policies and actions which will guide the development of Kuala Lumpur towards its goal of becoming a 'world class city' by the year 2020 (Kuala Lumpur City Hall, 2003, 2008). The Kuala Lumpur Structure Plan 2020 also provides the framework for another more detailed local development plan, the Kuala Lumpur City Plan (Kuala Lumpur City Hall, 2008). The local plan, which is divided into six strategic zones covering the entire city, further enhances urban sustainability efforts by emphasising liveability and quality of life for its local communities with quality urban services, provision of public housing, improved urban transportation, and environmental sustainability (Kuala Lumpur City Hall,

2008). Zoning remains the main mechanism to guide and contain development, with more room for mixed-development patterns, especially in inner city areas, to encourage liveability (Figure 2).

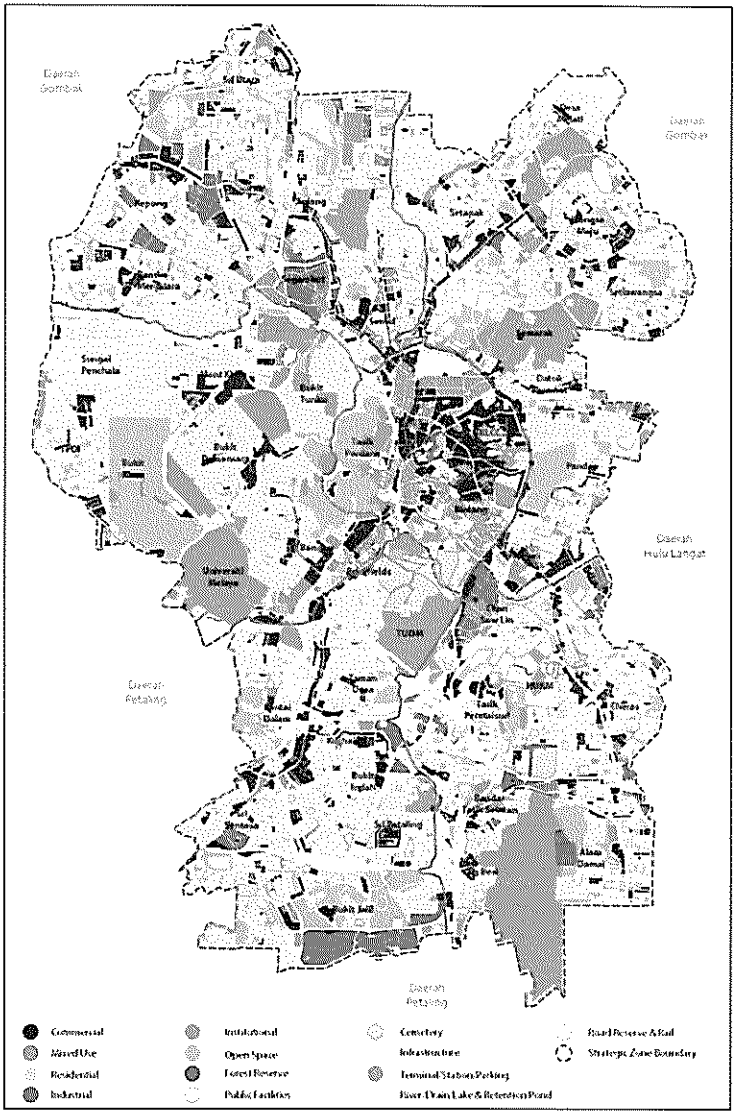

Figure 2: Kuala Lumpur 2020 Draft City Plan
(Kuala Lumpur City Hall, 2008)

The out-migration from the city centre which has created blight in core areas is partly due to the shortage of affordable housing (Kuala Lumpur City Hall, 2003). With emphasis on optimum and balanced land development, the

local plan gives priority for infill development in these areas. Developers are encouraged to redevelop dilapidated housing areas with high density and high quality residential development, and where possible, affordable housing. Mixed commercial and residential developments are also encouraged to regenerate urban blight areas to ensure that the city is safe, healthy and sustainable (Kuala Lumpur City Hall, 2008). Such infill development also helps containing urban growth within central areas and counter-balancing sprawl. One successful example is the Kuala Lumpur Sentral project (KL Sentral), a mixed residential, commercial and office development as well as a public transit hub.

The integration of land use with transport networks forms the backbone of the city's sustainable urban development framework. The urban and suburban rail network for example, has expanded since 1990 and now covers over 200 km of electrified double-tracked service connecting major districts of the city-region and many locations in between (Bunnel et al., 2002). Along these rail and road networks, 66 Transit Planning Zones locations have been proposed (Kuala Lumpur City Hall, 2008). These planning zones encourage intensification of development within a 400 metre radius of a transit station (Light Rail Transit or LRT, KTM Commuter, Monorail, or Bus Rapid Transit) to enhance public transport use by city workers and the general public.

Urbanisation pressures are also accommodated through the creation of new growth areas within the six strategic zones. These growth centres absorb most of the residential, commercial and industrial demand as a result of the suburbanisation process of Kuala Lumpur. However, earlier commercial strip sprawl along major roads leading towards and out of the city remains a legacy of earlier sprawl. This is also evident in other cities within the South-East Asia region (i.e. Bangkok, Manila and Jakarta). The Federal government took growth management initiative a step further by relocating the government's administrative centre from Kuala Lumpur to Putrajaya. The decision was made on the basis of decongesting the city centre (Bunnel et al., 2002), in order to relieve development pressures, especially in terms of affordable housing for middle classes. This decision, along with the relocation of the airport terminal for passenger services from the fringe of the city further away to Sepang, Selangor, have had a profound effect in reducing development pressures within and around the city.

In summary, growth management measures in Kuala Lumpur take the form of planning regulations as well as government interventions in key physical decisions. The policies outlined for promoting sustainable growth management in the metropolitan area appear to be incorporated into the central government's effort to achieve sustainable urban development and

management, including sustainable transport. However, as far as physical planning is concerned, the overall effectiveness of these efforts at the moment appears to depend on the limited opportunities provided by the statutory planning mechanisms. The zoning directives of the structure and local plans seem to be the only tools to direct and contain urban growth, and promote more compact patterns of development. Nevertheless, these measures illustrate efforts by the government and City administration to minimise the negative side effects of urbanisation and to enhance environmental quality, and livability of urban areas. It is a significant step towards a more concerted planning and implementation effort at all institutional levels. At the moment however, the need to ensure the realisation of all proposals envisaged in the development plan is all too obvious.

HONG KONG'S SUSTAINABLE URBAN GROWTH MANAGEMENT STRATEGIES

The former British colony of Hong Kong boasts a far more complex urban form that entails a delicate management approach. This city-state consists of three districts: the Hong Kong Island, Kowloon, and the New Territories on the mainland (Figure 3), which accommodates more than half of its population in the purposely-built new towns. During the last three decades, Hong Kong has seen rapid population growth (mainly due to immigration), which puts a great pressure on its urbanisation process. The pressures are imminent because unlike any other South-East Asian countries, with the exception of Singapore, planners in Hong Kong do not have the option of extending their ability to control urban growth over a large expanse of the countryside (Taylor, 1988). With a total area of 1,108 square kilometres and a current population of over 6.9 million (Census and Statistics Department, 2006; Hong Kong Planning Department, 2007), of which nearly 90 percent live in urban areas, Hong Kong has to accommodate all of its urban and suburban development inside the island and the new territories, with the mainland border to the north acting as a growth boundary. One notable consequence is that population densities in Hong Kong are among the highest in the world. Geographical constraints have made only 20 percent of the land developable, and this has resulted in densities of slightly over 30,000 people per square kilometre. Urban planners face difficulties not only in managing the city-state in terms of public housing and infrastructure provision, but also in addressing social and environmental challenges. The influx of immigrants during the 1960s has created acute shortages in housing stock, already depleted by the damage of the WWII. In Hong Kong infrastructure provision cannot cope with the demand, and with scarce land availability, it poses huge physical and economic challenges to the city-region and its planners and policy-makers.

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towards building high density public housing in new towns to accommodate increasing urban population. Currently, 49 percent of the Hong Kong population live in public housing either as tenants or as subsidised owners (Hong Kong Housing Authority, 2007). However, the conditions of a number of older public housing schemes in inner areas in particular have been worsening. These areas are now subject to a new sustainable development strategy announced by the government in 2005, emphasising the importance to speed up improvements in the older urban environment. This metro development core, one of the four strategic zones in the city's spatial development planning, will transform these blighted areas into vibrant commercial and urban style residential zones (Hong Kong Planning Department, 2008a).

Equipped with the vision to become 'Asia's first world city', Hong Kong's sustainable urban development agenda will be fulfilled with the adoption of the much anticipated strategic planning study called Hong Kong 2030: Planning Vision and Strategy, or in short HK2030. The study, currently in its draft form, will be an update to the TDS and will showcase the future direction of the city state's development to the year 2030 under the overarching goal of sustainable urban development. Based on a strategy called 'the preferred option' (Figure 4), it will indicate how Hong Kong spatial environment should respond to various social, economic and environmental needs (triple bottom line sustainability) for the next two to three decades (Hong Kong Planning Department, 2008a).

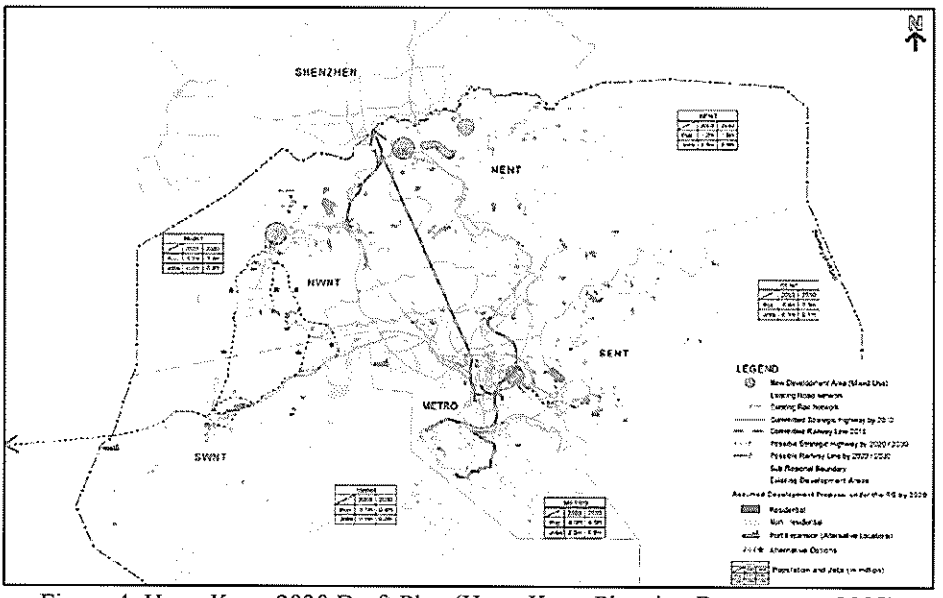

Figure 4: Hong Kong 2030 Draft Plan (Hong Kong Planning Department, 2008)

In summary, Hong Kong's experience in terms of growth management appears to have a strong foundation, backed by statutory planning regulations. The city-region's geographical constraints, acting as natural containment, combined with the concerted efforts towards promoting high frequency public transport, as well as the strict zoning regulations in place, have contributed to create a compact city-region with high density urban development. This is a desired result of sound planning by the central government, in pursuit of optimum land development in a constrained environment.

DISCUSSION AND CONCLUSION

The sustainability argument for urban growth management is inclined towards safeguarding of scarce resources and promoting social equity and economic development (Lindsey, 2003). Both case studies of Kuala Lumpur and Hong Kong display their concerns and efforts towards a more sustainable use of their resources. A number of parallels and differences can be identified as to how these efforts translate in practice and can be best compared in terms of the environmental, social and economic achievements of both city-regions towards a more sustainable urban future (see Table 1).

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Table 1: Comparison of the growth management strategies of Kuala Lumpur and Hong Kong (Teriman et al., 2008)

FACTS	KUALA LUMPUR	HONG KONG
City Type	Capital City	City State
Area (sq km)	243	1,108
Population (million)	1.62 (2005)	6.92 (2007)
Density (person/sq km)	6,667	6,250
Population Growth Rate (%)	1.39 (Year 2000)	0.8 (Year 2006)
OVERALL PLANNING FRAMEWORK		
Planning Legislation	Federal Territory (Planning) Act, 1982	Town Planning Ordinance, 1984
Planning System	2-Tier: Federal (City administration)	3-Tier: Territorial, Sub-Region & District
Planning System Mechanism	National Physical Plan (NPP) National Urbanisation Policy (NUP) Structure Plan Local Plans Development Control Plan (Guidelines)	Territorial Development Strategy (TDS) Sub-Regional Development Strategy District Statutory Plan (OZP & DPA) Planning Regulations Planning Guidelines
Regional Planning Framework	Voluntary through the NPP & NUP	Statutory through TDS
Growth Management Framework	Urban Containment (generally, through zoning approaches, infill development)	Urban Containment (statutory zoning, infill & redevelopment, green belt & country parks designation)
Containment Scale	Regional Unbounded (development within designated zones, but proliferation still occurs outside zones)	Natural Containment (development limited due to geographical constraints)
POLICY FEATURES		
Physical Containment	Yes, land use zoning-based containment boundary	Yes, strong land use zoning-based containment boundary
Open space preserved	Yes (enhancement of natural and man-made green spaces)	Yes (country parks, green belt)
Low density outside boundary	Yes (suburban development of adjacent state)	Yes (restrictions through zoning control)
Development Accommodation	Exclusive (single use) zones, with increasing number of inclusive (mixed-use) zones	Single and mixed-use zones
Provision for Future Development	Provided in zoning-based Structure and local plans	Provided in zoning-based District Plans
Range of Housing Supply	Yes (private sector provision)	Yes (Limited)
Affordable Housing	Continued provision, albeit limited rented public housing Provision of affordable housing for middle income group	Yes (existing and proposed new public housing in new towns)
Rigorous urban infill, redevelopment	Large mixed-use development of brown field (eg. KL Sentral)	Inner city areas and redevelopment of old public housing
Transport Oriented Development	Developments incorporating 'Transit planning zone' approach	Rail services incorporated into existing and future new town developments
SUSTAINABILITY INDICATORS		
ENVIRONMENTAL		
Clean Energy Strategy	Limited (most of the city's energy are generated outside from coal and oil)	Gradual coal to gas power generation. Clean energy sources developed (eg. wind and solar power stations)
Waste reduction & recovery	Continual efforts with limited success, but is now given more emphasis, with green infrastructure agenda, including waste management	Pursued through Municipal Solid Waste Management Framework Policy and Waste Reduction Framework Plan
Biodiversity & Ecological Balance	Conserving natural environment & residual forest, Designation of environmentally sensitive areas	Conservation of flora, fauna and natural habitat, marine parks and reserves
SOCIAL		
Compact development	Limited to city centre commercial development and strategic zones' centres	Compact form of residential & commercial development, and the promotion of 'urban living space'
Sustainable Transportation Strategy	Promotion of green urban transportation via bus and rail based public transport	High frequency rail based public transport approach Development option through 'land use-transport optimisation' model
Social Infrastructure and Housing	Promotion of sufficient social infrastructure in development plan, Adequate social housing	Adequate provision through inclusion in development plans
ECONOMICAL		
Sustainable Economic Development	Enhancing the city's role as leading centre of the Knowledge-Based Economy, linkages with MSC	Enhancement of economic competitiveness, with a strong service sector
Land Use Optimisation	Policy encouragement through development plans	Maintaining efficient intensity of land use and safe level of development
SUSTAINABLE URBAN DEVELOPMENT PERFORMANCE		
Overall Sustainable Urban Development Performance	Fair to Good, but improving constantly since the adoption of the Structure Plan and completion of its local plans, the KL City Plans 2020	Good to Very Good, particularly in terms of sustainable urban transport provision and urban development control. It is expected that under the HK2030 strategic plan might slightly improve this rating.

In terms of 'environmental aspects', both Kuala Lumpur and Hong Kong have different geographical contexts, with Kuala Lumpur sitting on a rather flat

geography and having more available land for development, whereas Hong Kong development is constrained between the steep terrain and the sea. Both city-regions are highly urbanised, with no specific delineation of their urban footprint. Urbanisation is accommodated and, where necessary, controlled via the use of statutory zoning plans. However, in terms of urban form, Hong Kong is a good example of a compact city-region served by efficient and sustainable public transport services. Kuala Lumpur is less compact, as the development of the city-region is not entirely a government matter, but rather responsive to market forces. Kuala Lumpur has no specific containment strategy, except for the use of statutory development plans, which guide the development within a specific area over a stipulated period of time. The plans are mandated by the City administration; however actual development still rests with the market forces. Even with the existence of such plans, the prevention of urban sprawl is not guaranteed, whereas the geographical setting of Hong Kong in itself contains urban growth naturally.

Both city regions are experiencing the impact of climate change due to global warming from greenhouse effect of human activities including rapid urbanisation. The level of per capita CO_2 emission in Hong Kong for example stood at 5.2 metric tonne while Kuala Lumpur at 6.3 metric tonne (World Bank, 2006), with vehicles emissions remains the highest contributor. Even though Malaysia is moving towards sustainable energy production (electricity sources: 64% natural gas, 26% coal, 7% hydro, 3% oil), this is yet to reflect the true environment in Kuala Lumpur. The new master plan for the city, the Kuala Lumpur City 2020, is expected to contribute positively to climate change with better traffic management measures to reduce private motor-vehicle use in the city, and green infrastructure agenda which includes waste management. Similarly, although Hong Kong is actively exploring alternative energy sources including solar and wind-based energy, fossil fuel currently remains the main sources of electricity (63% coal, 37% natural gas, 1% oil) (World Bank, 2006). The fact that per capita energy consumption is one of the highest in South-East Asia (EIU, 2008) and poses a greater challenge to sustainable energy use in the country.

Looking at the 'social aspects', both city-regions have evolved into high rise and high density residential and commercial entities. Social infrastructure and housing are given high degree of attention with their inclusion in the respective development plans. Conventional planning however has also been exercised with a high degree of success in Hong Kong, with the achievement of high standards of public housing, infrastructure and services. What contributes to this huge success is that Hong Kong's status as a city-state permits the nation's substantial resources to be channelled into urban development,

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including regenerating core inner areas. Kuala Lumpur on the other hand has to rely on funds sourced locally through rates and taxes, plus limited federal grant to finance most of its development and regeneration/renewal exercises. That is why provisions such as affordable housing and efficient public transport remain to be solved. It is only recently that the idea of transit oriented development started to gain recognition after its inclusion in the Kuala Lumpur Structure Plan and the draft Kuala Lumpur 2020 City Plan. Hong Kong, however, has had a very good track record with its efficient rail-based public transport system. Hong Kong residents also have realised that there is very limited land available for development, and therefore, are more willing to accept tougher controls over the land development/allocation. Hence, local authorities are able to manage the scarce resources effectively to ensure a sustainable development. In contrast, apart from expensive gated condominiums, a majority of the population in Kuala Lumpur still associated with high rise urban living with relatively low income. High rise living is still considered as 'have to' rather than 'sought after' phenomenon.

In terms of 'economic performance', Hong Kong adopted a strategy of enhancing its economic competitiveness through its strong service sector. Its superior economy thus makes urban management more effective. The fact that the government owning almost all the land in Hong Kong makes the formulation and implementation of (sustainable) development plans a much easier task. Land use optimisation has always been the key factor in its planning for development by maintaining an efficient intensity of land uses. Kuala Lumpur is also gearing itself towards the tertiary sector with a focus on enhancing its role as a knowledge-based economy, taking advantage of the Federal Government's Multimedia Super Corridor (MSC) project spanning over 50km from the city centre to Cyberjaya and then to Kuala Lumpur International Airport. In terms of land use optimisation, there seems to be limited success at the moment. However, the idea is being promoted in the Kuala Lumpur draft local plan. Whilst high density development is a must in the land-stricken city-state of Hong Kong, developers in Kuala Lumpur find low-rise suburban housing scheme very attractive, due to the low land prices and higher demand. This explains the reason of compact urbanisation being less successful in Kuala Lumpur compare to Hong Kong.

In conclusion, within the context of resource constraints, sustainable urban development has been a key factor in the adoption of urban growth management initiatives promoting viable use of scarce resources for urban expansion whilst at the same time minimising uncontrolled urban sprawl. Within this context, the use of a whole range of policies designed to control, guide, or mitigate the effects of urban growth is seen as a practical way to

promote compact development (i.e. see Nelson & Duncan, 1995). The rapid population growth and urbanisation in South-East Asia city-regions has indeed placed great pressures on their environments. Whilst a few cities in the region, as discussed in this paper, have adopted some form of urban management policies towards minimising or alleviating these pressures, many other cities within the region are still without suitable urban growth management strategies (i.e. Ho Chi Minh City, Bangkok, Manila, and Jakarta). In these cities, higher land consumption, expansive and discontinuous urban development will continue into the future. Local authorities and planners should, therefore, look into the possibilities of implementing sustainable urban growth/development management strategies for their cities. Both case studies investigated in this research display top-down approaches to ensure that planning at the district and local levels is properly guided to achieve state and regional standards and goals. In both Kuala Lumpur and Hong Kong cases, urban development is facilitated and governed by statutory planning legislation and flexible planning processes and approaches. This ensures that all development will have some degree of standardisation and will occur in harmony with existing development. It seems that from these cases, a top-down approach is a key factor to trigger sustainable urban management practices. However, these top-down approaches need to be balanced with bottom-up, collaborative strategies in order to provide a more transparent and democratic platform for citizen participation in the urban planning and development process.

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URBAN SPRAWL IN MALAYSIA: EVIDENCES FROM THREE LARGEST METROPOLITAN AREAS

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Abstract

Urban sprawl is a one of the most pressing issues confronting urban development in the developed as well as developing countries. Much research had been done on the trend of urban sprawl and its negative consequences in established cities in the United States, Europe and Australia. This paper analyzes the phenomenon in the three largest metropolitan areas in Malaysia, namely Kuala Lumpur, Penang and Johor Bharu Metropolitan Areas. Using population and land use as main variables, it argues that suburban expansion and the resulting urban sprawl has been occurring in these metropolitan areas since 1970 and has intensified since the late 1980s due to the rapid economic growth brought by industrialization. It calls for more sustainable approach in the planning and management of urban areas in Malaysia.

Keywords: Urban Sprawl, Metropolitan, Malaysia

INTRODUCTION

The topic of urban sprawl is one of the most pressing issues confronting the global urban world, Malaysia being no exception. Many researches have been conducted on this issue with almost all of them indicating that the problem is real and of great negative consequences. Early studies focused on cities of the United States which, due to post World War II economic boom, had abundant supply of land and a great dependence on private automobiles which led to a horizontal expansion of the cities. The term suburbanization came out of this process. Los Angeles, Houston and Atlanta conjure the image of the urban sprawl of American cities.

European cities, which tend to be more compact due to massive rebuilding of bombed out central cities, started to expand and began to follow the American trend of growing at the suburbs. Cities such as Madrid, Paris and

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London started to experience the urban sprawl phenomenon and began to resemble the American urban expansion. Economic policies associated with Ronald Reagan and Margaret Thatcher, which favour the role of the private sector in urban development, are partly the reasons for this development.

Much research has been done on sprawl especially in the United States. Most American metropolises have experienced massive urban sprawl with Los Angeles and Atlanta considered as poster child of sprawl. In Europe, a study of 24 cities by the European Environmental Agency in 2006 found that in majority of them, the growth of built-up areas were higher than those of the population and in a couple of Italian cities, more than doubled the population growth.

Sprawl is an environmentally unsustainable form of urban growth since it is characterized by a situation whereby built-up area increases faster that the population growth. Lower density in new suburban areas is taking up much more land for a smaller number of population as shown by Burchell, et al. (2002) and Galster, et al. (2001). This inefficient urban growth requires more investment for new infrastructure, more travel, especially automobile travel, which consumes energy and pollutes the air, gobbles up farmland and green areas, and leads to the decline of inner city. Sprawl is monetarily, environmentally and socially destructive to the built and natural environment.

The phenomenon of urban sprawl can be observed in Malaysia as well, albeit at a later period. This paper seeks to prove that the same type of urban expansion, i.e. horizontally rather that vertically, more intensive at the suburbs than the city centre, and a departure of the traditional colonial urban form are happening in the country. By using examples of the three largest metropolitan areas, i.e., the Kuala Lumpur, Penang and Johor Bharu, it shows that sprawl is the current dominant trend of urban growth in the country.

URBAN SPRAWL IN THREE LARGEST METROPOLITAN AREAS OF MALAYSIA

Malaysia is an urbanized country since the census of 1991, which revealed that 51 percent of her population lived in urban areas. The figure currently stood at about 65 percent. The trend is a result of the paradigm shift of the national economy whereby the Manufacturing sector overtook Agriculture as the largest contributor to the nation's economy in 1987. Currently the manufacturing sector contributes almost half of the GDP.

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With the growth of the Manufacturing sector, the urban areas became a magnet for the migration of people seeking employment in the new engine growth of the economy. While many thought that most of these people would migrate to city centres, evidences have shown that actually it is the peripheral areas that have been growing faster, sometimes at the expense of the city centres. There are various factors that led to this phenomenon, some of which include the location of the factories in the suburban areas, zoning regulations, lower price of land at the outskirts, the opening up of new highways and townships, and the overt dependence of Malaysians on private automobiles. The inefficiency of the public transport, higher per capita income and the national car policy had encouraged greater car ownership rate among Malaysians.

This paper seeks to find evidence of urban sprawl in the three largest metropolitan areas in Malaysia, namely the Kuala Lumpur Metropolitan areas (KLMR), the Penang metropolitan Area (PMR), and the Johor Bharu Metropolitan Areas (JBMR). Each of these is the prime urban area for its respective zone, KLMR in the central region, PMR in the north and the JBMR in the south of the Peninsular. The main variables used to evaluate the urban sprawl phenomenon in these metropolitan areas are population growth, density and land use.

Urban Sprawl in Kuala Lumpur Metropolitan Region (KLMR)

The phenomenon of the rise of the suburbs as well as the urban sprawl is best illustrated by the trend in the KLMR, perhaps due to the fact that it is the largest metropolitan areas in the country and many new townships had sprung out outside of Kuala Lumpur city boundary.

As shown vividly by Table 1 and Figure 1, the dominance of Kuala Lumpur as the main urban centre of KLMR, at least in terms of population, has diminished over the three decades of 1970 to 2000. In 1970, Kuala Lumpur commanded 48 percent of the total population in the KLMR; 30 years later its share had decreased to a mere 28 percent. During the same time, the share of Petaling District had increased from 14 percent to 24 percent. It was followed closely by Hulu Langat district.

In 1970, population size of Petaling district was only 40 percent of the size of Kuala Lumpur. By the year 2000, Petaling population size was 91 percent of Kuala Lumpur population. For Hulu Langat, the relative size of its population compared to that of Kuala Lumpur had increased tremendously from 19 percent to 66 percent during the same time period. The growth of Petaling

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District is due mainly to the rapid population growths in new townships such as Shah Alam, Subang Jaya and newer parts of Petaling Jaya, while that for Hulu Langat is due to the growth in Ampang, Kajang, Bangi and Semenyih.

The relative higher share of suburban districts population can be explained by higher average population growth rate experienced by these new growth centres. Average annual growth rate for Hulu Langat at 8.20 percent was more than 10 folds of that for Kuala Lumpur (1.39 percent) in the period of 1991-2000. Despite its already large population size, Petaling District grew at a very rapid 7 percent per year, making the district as significant as Kuala Lumpur as the population centre of the KLMR. Surprisingly, the trend is not a very recent phenomenon, it had occurred as early as the early 1980s. If the trend persists, Petaling District would have a larger population than that of Federal Territory Kuala Lumpur by 2010.

Table 1: Population and Average Annual Growth Rate, Selangor and Kuala Lumpur, 1980-2000.

State and District	Population			Average Growth	Annual Rate
	1980	1991	2000	1980-1991	1991-2000
SELANGOR	1,426,250	2,297,159	3,947,527	4.33	6.02
Gombak	166,059	352,649	553,410	6.85	5.01
Kelang	279,349	406,994	648,918	3.42	5.18
Kuala Langat	101,578	130,090	189,983	2.25	4.21
Kuala Selangor	110,366	123,052	157,288	0.99	2.73
Petaling	360,056	633,165	1,181,034	5.13	6.93
Sabak Bernam	103,261	99,824	110,713	-0.31	1.15
Sepang	46,025	54,671	97,896	1.56	6.47
Ulu Langat	177,877	413,900	865,514	7.68	8.20
Ulu Selangor	81,679	82,814	142,771	0.13	6.05
W.P. KUALA LUMPUR	919,610	1,145,342	1,297,526	2.00	1.39
MALAYSIA	13,136,109	17,563,420	22,202,614	2.64	2.60

(Source: Malaysia, Department of Statistic, 2000)

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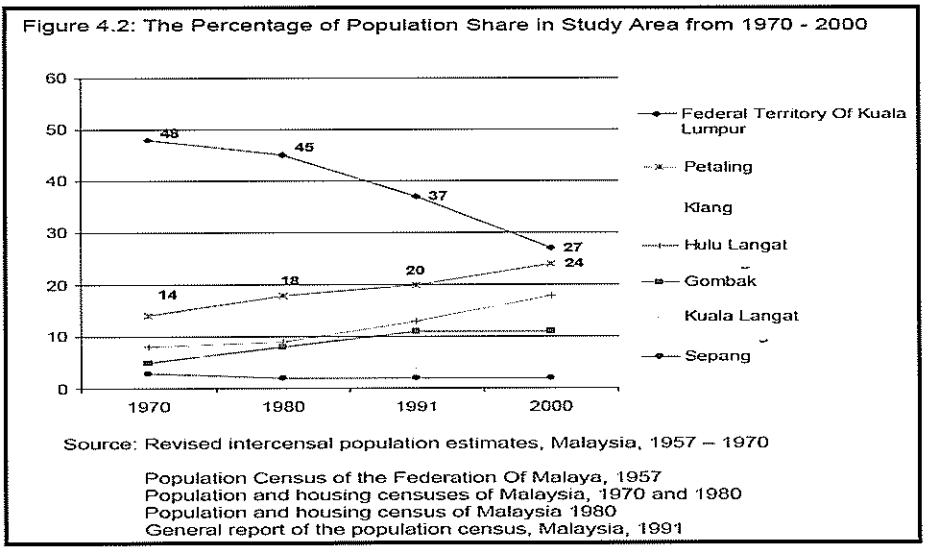

Figure 1: Share of KLMR Population by District, 1970-2000
(Source: Dept of Statistics, Population Census, 1970, 1980, 1991, 2000)

Figure 2 by Kuala Lumpur City Hall and Figure 3 by Ahris Yaakob illustrate the spatial built up of urban areas in KLMR pre and post 1991. The new built up areas after 1991 more than doubled the 1991 built up areas. New urban areas had sprouted after the construction of new highways, especially in areas leading to Putrajaya and Kuala Lumpur International Airport. While pre-1991 growths tend to concentrate along the Federal Highway, the post-1991 urban growths are along the NKVE, LDP, ELITE and KESAS Highways.

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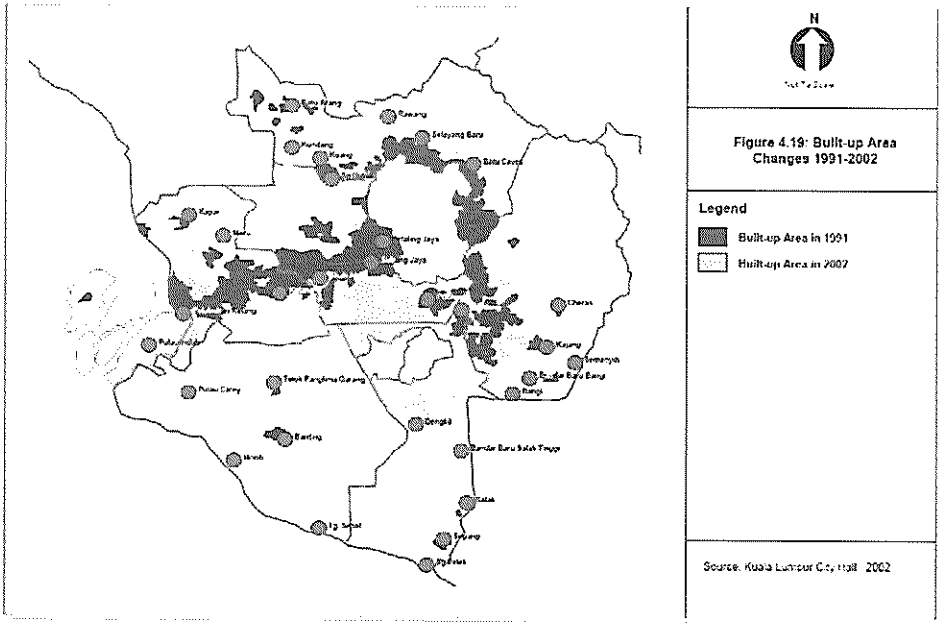

Figure 2: Built up areas in KLMR, 1991 – 2002

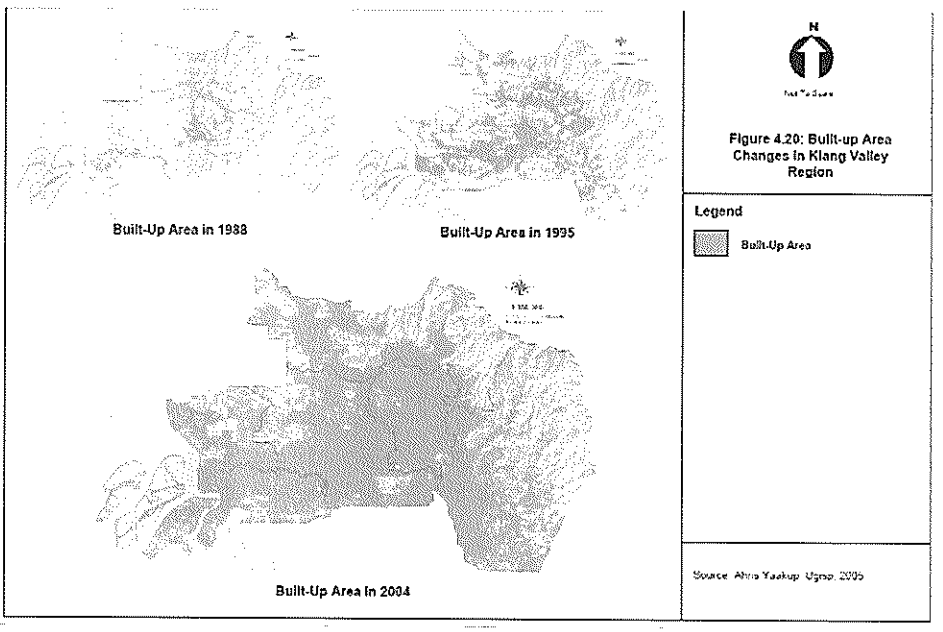

Figure 3: Built up Areas Changes in KLMR, 1988 -2004

Urban Sprawl in Penang Metropolitan Area (PMR)

To the north of the peninsular, the same phenomenon of suburbanization and urban sprawl can be observed in the Penang Metropolitan Areas. Timor Laut District, in which the City of Goergetown is part of, accounted for almost half of the state population in 1970; by the year 2000, its percentage had dropped to only a third. On the other hand, district adjacent to Timor Laut, i.e. Barat Daya (Southwest) and Seberang Perai Tengah had increased their share of the population; the former by 5 percent while the latter by almost 9 percent. It should be noted that while Kuala Lumpur increased its population only marginally in the period of 1970 to 2000, Georgetown actually had a population decline, i.e. its net out-migration figure was higher than its natural population increase.

This phenomenon is due to fact that districts other than Timor Laut had experienced high population growth rates between 1970 and 2000 (with the exception of Seberang Perai Utara). While the rate for Timor Laut had consistently been around 0.5 percent per annum since 1970, Seberang Perai Tengah grew by more than 3 percent per annum. In the 1980s, Seberang Perai Tengah and Barat Daya were the star performers, while the 1990s saw the emergence of Seberang Perai Selatan as the magnet of population growth in the state. Due to this, there was a population shift in the state. In 1970, a majority of the population in the state (55 percent) lived on the island; by the year 2000, those on island became a minority (47 percent).

Urban expansion on the mainland is due to its land being cheaper than that on the island as well as the opening up of more land after the completion of the North South Highway and the Penang Bridge, allowing people to commute to places of employment in Georgetown. In addition, the growth of industry based townships such as Bayan Lepas in Barat Daya and Kulim in the 1980s and Batu Kawan in the south recently had led to many people settling around these new areas. The dominance of Georgetown as the main population and urban centre of the state is slowly disappearing. Unlike Kuala Lumpur which seemed to manage to hold to its attraction, due to its role as the nation's administrative and commercial centre of the country and redevelopment of the KLCC area, Georgetown does not seem to hold strongly to its dominance.

A worrying trend of urban growth in Penang state is the rate of new land being taken up compared to population growth. As Figure 5 indicates, in all the districts, with the exception of highly urbanized Timor Laut District, the rate of built up area growth was higher than that of the population. In newly opened up areas of Seberang Perai Selatan, the growth rate for the built-up area was more

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than double that of the population. The abundance of land in that district had led to inefficient use of land, a major characteristic of urban sprawl. If the trend continues, the implications to sustainable urban planning will be dire.

Table 2: Population and Percentage of State Population by District, Penang State, 1970 – 2000.

District	1970		1980		1991		2000	
	Population	%	Population	%	Population	%	Population	%
SP Tengah	117,475	15.19	161,975	17.98	236,270	22.20	294,051	23.88
SP Utara	161,524	20.89	199,449	22.14	224,647	21.11	243,938	19.81
SP Selatan	63,626	8.23	71,558	7.94	84,771	7.97	117,722	9.56
Timor Laut	369,991	47.84	391,400	43.45	395,714	37.18	416,369	33.82
Barat Daya	60,711	7.85	76,390	8.49	122,764	11.54	159,129	12.93
Penang State	**773,327**	**100.00**	**900,772**	**100.00**	**1,064,166**	**100.00**	**1,231,209**	**100.00**

(Source: Department of Statistic, Malaysia, 2000)

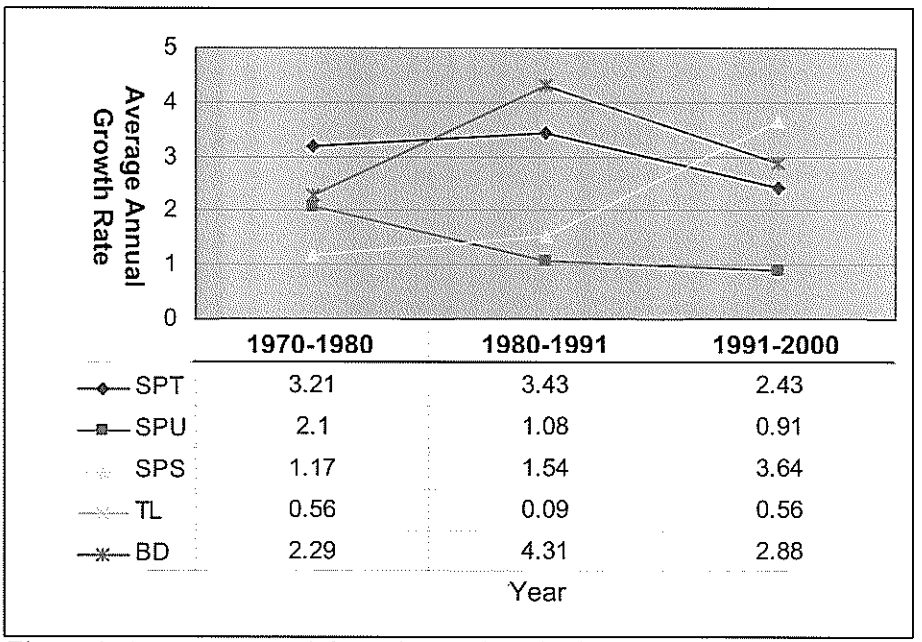

Figure 4: Average Annual Growth Rate by District, Penang State, 1970- 2000
(Source: Department of Statistic, Malaysia, 1970-2000)

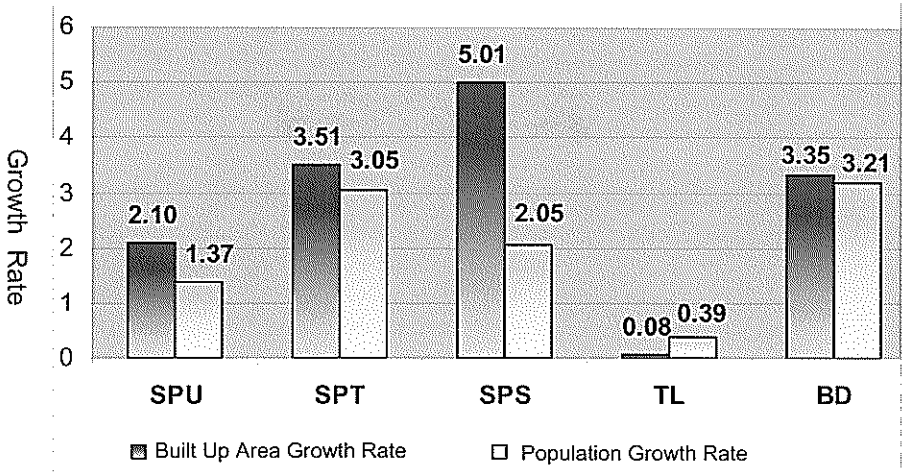

Figure 5: Growth Rates of Built up Areas and Population by District, Penang State, 1985-2000.
(Source: Laporan Pemeriksaan, Rancangan Struktur Negeri Pulau Pinang 2005 – 2020; Rancangan Struktur, MPSP, 1985; Rancangan Struktur MPPP, 1985)

Urban Spawl in Johor Bharu Metropolitan Region

To the south of the Peninsular, the Johor Bharu Metropolitan Area has been growing rapidly especially since the 1980s. During this period, Johor Bahru overtook Georgetown and Ipoh to become the second largest city in the country. However, a closer look at the trend reveals that most of the growth in this southern metropolitan occurred mostly outside the border of the city of Johor Bharu, the same trend as those in Kuala Lumpur and Penang metropolitan areas.

Unlike Georgetown which declined, and Kuala Lumpur which grew marginally since the 1970, the city of Johor Bharu grew at a respectable rate of more than 2 percent per annum from 1970 till 2000. In the 1970s, it was the fastest growth municipality in the region, averaging almost 8 percent per annum. Thus, its population grew rapidly from 130,000 in 1970 to almost half a million in 2000.

Since the 1980s, however, rapid growth had shifted to the suburbs of Johor Bharu, mainly in Johor Bahru Tengah, where Skudai is located, and the Pasir Gudang area, one of the main industrial and port areas in the metropolis. The growth of Johor Bahru Tengah since the 1980 has been phenomenal. In 1980, its population size was merely 6.5 percent of Johor Bharu City

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population; twenty years later its size was almost that of the city itself (90 percent of size of JB City). During the twenty years period, it grew at a whopping 15 percent per annum. Even the areas under the purview of Johor Bharu District Office, the most rural in the metropolitan areas, had been growing at respectable rates.

As in the other two metropolitan areas in central and northern regions of the peninsular, growth in the suburbs of JBMR is due to many large scale developments taking place outside the boundaries of the city. The building of Universiti Teknologi Malaysia and its surrounding township development as well as UDA new township had propelled urban growth in Johor Bahru Tengah. Growth of industries and the port in Pasir Gudang had shifted some development to the east of city; while to the west, the second link and new administrative township of Nusajaya will spur further rapid development.

In terms of density growth rate, JB tengah had the highest increase per annum in the 1990s due to its rapid population growth rate. Population wise it grew at an astounding 2600 percent between 1970 to 2000 while Johor Bahru City grew by 192 percent. As a matter of fact, during the last three decades (until 2000), all three municipalities outside the city grew much faster than the City of Johor Bahru with Pasir Gudang registering absolute growth of almost 1500 percent.

CONCLUSION

This paper has shown the evidence of rapid urban growth at the suburban areas of main cities in the three largest metropolitan areas of the country. The reasons are due to the opening up of more lands outside city centres which tend to be cheaper, the heavy reliance on private automobile and the opening up of more highways. These factors go hand in hand in encouraging the expansion of built areas in previously green fields. While currently the impacts may not be significantly felt, if the trend persists, urban development in Malaysia will be very likely to be unsustainable.

The present trends of suburban growth will lead to the problem of urban sprawl with its host of negative elements. It leads to the decline of the city centre as evident in Georgetown, inefficient use of the land as shown in Seberang Perai Selatan (PMR) , the loss of green areas which act as water catchment areas in Hulu Langat (in KLMR), and very rapid opening of green fields as illustrated in Johor Bahru. Opening up of more highways to ease congestion will only lead to greater reliance on private automobile which will

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lead to greater rate of urban sprawl. Kuala Lumpur has done rather well since the late 1990s in arresting its slow population growth rate by offering rapid rail transit which led to new transit-oriented development strategies. Penang and johor Bharu may need to look at KL strategy.

Table 3: Population and Average Annual Growth Rates of Local Authorities, JBMA, 1970-2000

Local Authorities	Populations				*Annual Growth Rates (%)*		
	1970	1980	1991	2000	1970-1980	1980-1991	1991-2000
Johor Bahru City Hall (MBJB)	138,600	247,700	328,436	404780	5.61	2.56	2.32
Johor Bahru Tengah Municipal Council (MPJBT)	13,357	16,567	120,352	364,887	2.15	18.03	12.32
Kulai City council (MPKu)	31,027*	47,067	70,237	113,171	3.79	3.64	5.3
Pasir Gudang Local Authority (PBTPG)	2,800	8,000	22,657	43,169	10.5	9.46	7.16
Johor Bahru District Office	83,300*	87,537*	162,789	233,072	1.00	5.64	3.99
Total	269,084	406,871	704,471	1,115,910	4.13	39.33	31.09

Local Authorities	Density Annual Growth Rates (%)			Absolute Growth Rate (1970-2000) (%)
	1970-1980	1980-1991	1991-2000	
Johor Bahru City Council (MBJB)	5.8	2.57	2.32	192
Johor Bahru Tengah Municipal Council (MPJBT)	2.05	22.14	12.32	2627
Kulai City council (MPKu)	6.73	3.63	5.29	265
Pasir Gudang Local Authority (PBTPG)	10.66	9.48	7.18	1471
Johor Bahu District Office	0.49	5.69	3.95	18
Johor Bahru	7.28	7.16	5.55	651

(Source: Statistic Department, 1980, 1991, 2000
JPBD, Report of Survey Johor Bharu, Mukim pelentong and pasir Gudang
JPBD, Johor Bharu Local Plan 2020)

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The urban sprawl phenomenon in main urban areas in Malaysia requires planners and urban managers to look at alternatives to teh current trend and practices of urban planning. Rather than identifying only land available for development, planners should think a step further in guiding development to areas where sprawl can be contained more effectively. The relatively new concepts and stragies of *Sequential Approach* which is practiced in the United Kingdom and *Smart Growth* which has been in existence in the United States for the past two decades should be implemented in Malaysia. These strategies actively encourage mixed land uses, take advantage of compact building design, strengthen and direct development towards existing communities, preserve open space, farmland and critical environmental areas, provide a variety transportaion choices and foster distinctive, attractive communities with a strong sense of place.

Planners have to realize that the model that we have been following for the past decade, i.e. opening up of more land to meet demand, may need a paradigm shift in the new century. Land is scarce; efficient and effective management of existing urban areas through redevelopment and infill development rather than planning new layouts of green fields should be the new strategies of the day.

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AN INTEGRATED APPROACH FOR THE PREDICTION OF WATER QUALITY INDEX BASED ON LAND USE ATTRIBUTES USING DATA GENERATION METHOD AND BACK PROPAGATION NETWORK ALGORITHM

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Abstract

Malaysian experts have warned that several major cities, including the capital Kuala Lumpur, could face serious water shortages due to over-pollution of the country's rivers by problems brought about by over-development. As 97 per cent of Malaysia's water supply is sourced from surface water, the main aim of this study was to identify a relationship between water quality and land use attributes. The study which was conducted on Gombak River and its watershed in Malaysia, introduced data generation method for the prediction and forecast of LU/LC data within the watershed. The method used exponential model equation, Lagrange model equation third & fourth degree polynomial fit; saturation growth-rate model in order to generate the required data; and artificial neural network's back propagation network algorithm. The study also introduces the LA-WQI model. This model was developed by associating the appropriate loading factors to a set of sub indices. The findings revealed that as the activities increased throughout the watershed, the values of WQI quality decreased accordingly. The accuracy of prediction of the proposed LA-WQI ranged from 94.3% to 99.3% between Actual DOE-WQI and LA-WQI for station 18 in Gombak River. The results of predicted WQI obtained using LA-WQI, showed a continuous decrease of water quality. Despite the high accuracy attained by the application of LA-WQI model on Gombak River; it has not yet been tested on other rivers. It is recommended that future studies should be able to further test the current model on a regional scale.

Keywords: Water Quality Index, ANN, Gombak River, Back Propagation, Land-Use Data Generation

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INTRODUCTION

In Malaysia there are 189 river basins nationwide. Out of 189 river basins, 120 rivers are being monitored by the Department of Environment (DOE). There are 926 monitoring stations for these rivers. According to the Department of Environment (44.5% are clean, 48.4 % slightly polluted and 7.1% are polluted. Generally, stations located upstream are clean, while those located downstream are either polluted or slightly polluted. The main cause of pollution of these river basins is over-development on the rivers' catchment area. The growth of urban areas has led to many problems, and any attempt to plan and manage the urban environment will ultimately have to be concerned with the entire city system and its interdependence with its rural hinterland, other city systems and the outside world as a whole. A prime goal of planning is to achieve efficiency in the utilization of resources with the objective of creating a high level of environmental quality for healthy living. Where urbanization is unstoppable and useful most of the time, the best management practices (BMP) serves to match both the necessity of mankind to innovate and high level of environmental quality. Some of the essential factors for BMP are shown in Figure 1.

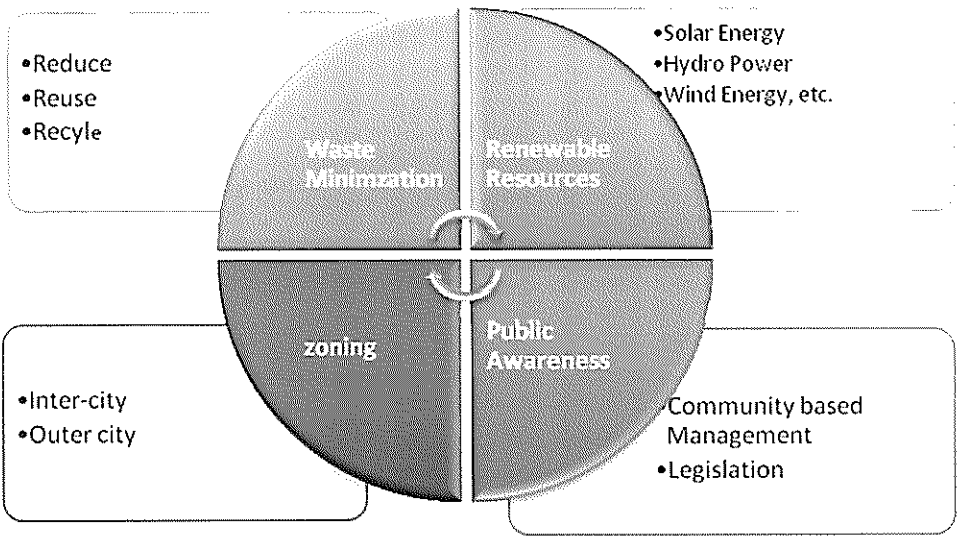

Figure 1: Suggested factors for improving best management practice in town planning

These factors constitute a necessary condition, but alone it is not enough. Usually decisions made at the upper level of the decision hierarchy, significantly change the land use zoning patterns[3]. Rapid development in peninsular Malaysia has begun to put a strain on existing water resources. Environmental problems such as flash floods and heavy sedimentation are often associated with development activities within the basin. Water pollution also arises due to intensive land clearing, uncontrolled earthworks, mining and logging activities in water catchments area. The state of Selangor can be considered as one of the fastest developing states in Malaysia. Rapid development is one of the major reasons in causing water pollution.

RELATED WORK

The study of the relationship between water quality and urbanization is not new. Wang (2001)[4] examined how the form and rate of urbanization influence water quality through examining the effect of density and industrial activities on a range of water quality classifications. Work in Evans & Miller (1988)[5] provided an examination of the spatial variation to water quality across an entire watershed. The findings of researches reveal a strong relationship between the degradation of water quality and urban land use. While a number of studies (Goodchild & Stevaert, 1993)[6], (Engel et al., 1993)[7], (Carr & Chamber, 1998)[8],

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[3]Alias Abdullah, Kazuhisa IKI and Morozumi Mitsuo, 1994. A study to evaluate change of zoning in GIS operation due to the diversification of the AHP judgment, *Proceeding of the Sixteenth Symposium on Computer Technology of Information, System and Applications*, AIJ, S-5-6, pp. 349-354.

[4]Wang X., 2001. Integrating Water-Quality Management and Landuse Planning in a Watershed Context, *Journal of environmental management*, 61, pp. 25-36.

[5]Evans, B. M. and D. A. Miller, 1988. Modeling Nonpoint Pollution at the Watershed Level with the Aid of a Geographic Information System, In *Nonpoint Pollution: 1988 - Policy, Economy, Management, and Appropriate Technology*, American Water Resources Association, pp. 283-290.

[6]Goodchild, M. F., B. O. Parks, and L. T. Steyaert, (eds.) 1993. *Geographic Information Systems and Environmental Modeling*, Oxford University Press, New York, pp. 231-237.

[7]Engel, B. R., R. Srinivasan, J. Arnold, C. Rewerts, and S. J. Brown, 1993. Nonpoint Source (NPS) Pollution Modeling Using Models Integrated with Geographic Information Systems (GIS). *Water Science and Technology*, Vol. 28, No. 3-5, pp. 685-690.

[8]Carr, G.M. and P.A. Chambers, 1998. *Spatial and temporal patterns of nutrients and algal abundance in Alberta rivers*. Report prepared for the Prairie Provinces Water Board, Regina, SK.

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(Corell et al., 2001)[9] and (Tong & Chen, 2002)[10] concluded that land use has a direct effect on the deterioration of water quality of rivers through point and non-point effluent discharges, few have dealt specifically with the relationship that defines this relationship. Generally, river systems are polluted by point and non-point sources. Currently, there are very little efforts directed towards monitoring non-point sources in Malaysia. Monitoring of all point and non-point is very difficult or impossible to achieve; whereas the procedure is costly, time consuming and needs a large body of manpower. Thus the need for indirect approaches has grown widely in the recent years. In order to obtain an accurate assessment of spatial and temporal variation of land use, using water quality as a key indicator, many studies of modeling using different approaches has been attempted in recent years. Hubert-Moy et al.[11] used Dempster-Shafer theory of evidence to predict land use and land cover, however the differences between prediction and reality were associated with uncertainties which is of great interest to the expert. Non predicted changes were due to unexpected transformation of land use. Generally, the model produced was unable to eliminate the anomalies associated with the prediction. In a later research, (Smith et al., 2003)[12] developed an approach using LandSat imagery, trained with high resolution data sets. These data sets identified the impervious surface area at sub-pixel resolution. The data were then used in a time series spatial predictive model using Monte Carlo's approach. The model simulated urbanization in four ways, as edge growth, spreading urban centers, road induced growth and spontaneous growth. The first look of the results taken from this model shows good monitoring techniques used, however the prediction model is limited to the probabilistic categorization and assumptions initiated by the author.

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[9]Correll, D.L., Jordan, T.E., and D.E. Weller. 2001. Effects of precipitation, air temperature, and land use on organic carbon discharges from Rhode River watersheds. *Water, Air and Soil Pollution*, 128, pp.139-159.

[10]Tong, S. T. Y. and W. Chen. 2002. Modeling the relationship between land use and surface water quality, *Journal of Environmental Management*, 66, pp. 377-393.

[11]Hubert-Moy, L., Cotonnec, A., Le Du, L., Chardin, A., and Perez, P. (eds), 2001. *A Comparison of Classification Procedures of Remote Sensed Data Applied on Different Landscape Units, Remote Sensing of the Environment*, Elsevier, Vol. 75, No. 2, pp. 174-187.

[12]Smith, A. J., Goetz, S.D., Prince, R. and Wright, B., 2003. Estimation of sub-pixel impervious surface area using a decision tree approach, *Remote Sensing of The Environment*, (in press).

W. Ren et al. (2003)[13] examined the water quality of Huangpu River in China, and land use of the same river watershed, their study revealed the correspondence of deterioration of water quality with respect to the rapid urbanization. The authors took a period of 50 years to analyze their data, and concluded that there is a strong indication of influence of the industrial land use on the changing of the water quality of the river. However the type and nature of industrial activities, changing technologies and the factors affecting the water quality were not explored in their study. In another study, Noorazuan et al. (2003)[14] applied GIS in evaluating the change in land use and its impact on the stream flow of Langat River in Malaysia. The study revealed the landscape diversity of Langat significantly altered the Langat's stream flow response. Although the study has given acceptable results of the change of stream flow which was 20.35% in 1983 – 1988 to about 31.4 in 1988 – 1994, the stream flow and characteristics were not included within the study scope.

Based on the complexity of the alteration of water quality, simulation Models have always been good practice to simulate real-time situations with controlled variables; However for water quality response the behavior of water quality characteristics changes is a non-linear one. Kadri, et al. (2004)[15] attempted a stochastically based approach model in order to predict daily maximum stream flow. Stochastic models can be used to predict water quality as well, but most of the conventional statistical models are based on the assumption that the observations are independently distributed in time. The occurrence of the event is assumed to be independent of all previous events. This assumption is not always valid for hydrologic time series. Chandra (2003)[16] used mass budget regression model in order to extract percentages of pollutants from point and non-point sources from the upstream to the downstream of Krishna River in India. Although the recent development on regression models for the prediction of pollutant loads can give more acceptable results, such models could only be useful in predicting the physical water

[13]Wenwei Ren, Yang Zhong, John Meligrana, Bruce Anderson, W. Edgar Watt, Jiakuan Chen, and Hok-Lin Leung, 2003. Urbanization, Land use, and Water Quality in Shanghai, *Environment International*, 29, Elsevier, pp. 649-659.

[14]Noorazuan M. H, Ruslan Rainis, Hafizan Huahir, Sharifuddin, M. Zain, and Nazari Jaafar, 2003. GIS Application in Evaluating Land use – Land Cover Change and its Impact on the Hydrological Regime in Langat River Basin, Malaysia, *Map Asia Conference 2003*, GISdevelopment.net.

[15]Kadri, Yurekli, Ahmet Kurunc, and Huseyin Simsek, 2004. Prediction of daily Stream Flow Based on Stochastic Approaches, *Journal of Spatial Hydrology*, Vol. 4, No. 2.

[16]Sekhar M. Chandra, and Sreenivasulu, 2003. Modeling Nutrients Contributed by Overland Flow From the Krishna River Basin, *Diffuse Pollution Conference*, Dublin, Water Resources Management, 1A, pp. 20 – 23.

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quality parameters. Other pollutants such as constituents that undergo chemical transformation, alteration, degradation and / or volatilization cannot be assessed using this approach as it will not give accurate segments unless the distance between the upstream and the downstream is negligible, which is impossible in practice.

The same author (Chandra, 1995)[17] had attempted earlier modeling of land use and water quality. In his study the author focused on the cause-effect principal. Using the mass budget from non-point sources discharges compared to existing land use. The results were concluded as percentage output. Theoretically this method could give good results in a controlled environment; however the application of this model on surface water could give a very false statuesque. This approach is an indicative one and needs more development. Most of land use change studies have mainly dealt with the analysis and modeling of land use change[18]. Simulation models had always been good practices to model a real time situation with controlled variables, however, due to the complexity of water response/behavior in rivers, analysis of data recorded or generated, suffer to understand this complexity. In a study on recreational zoning development, Alias et al., (1994)[19] concluded that zoning map and policy can be effectively developed through a quantitative spatial analysis.

In recent years, geographic information systems (GIS), artificial neural network (ANN) and fuzzy logic techniques have been used in several hydrological studies. However, few of these research studies have undertaken an extensive sensitivity analysis (Dixon, 2004)[20].

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[17]Sekhar, M. Chandra, and P. Anand. Raj, 1995. Land Use Water Quality Modeling, *Journal Of Water Science Technology*, Vol. 31, No. 8, IWA Publishing, pp.383-386.

[18]Ruslan Rainis, 2003. *Application of GIS and Landscape Metrics in Monitoring Urban Land Use Change,* "Urban Ecosystem Studies in Malaysia. A Study of Change", Noorazuan Md Hashim & Ruslan Rainis (eds.), Universal Publishers, pp 267 –278.

[19]Alias Abdullah, Kazuhisa IKI and Mitsuo Morozumi, 1994. An integrated approach of AHP and GIS application to analyze and develop recreational zoning, *Journal of Architecture Planning and Environmental Engineering,* AIJ, No. 463, pp. 213 – 222.

[20]Dixon, B., 2004. Applicability of Neuro-Fuzzy Techniques In Predicting Ground Water Vulnerability: A GIS-based sensitivity analysis, *Journal of Hydrology*, published by Elsevier B. V. doi:10.1016/jhydrol.2004.11.010. Retrieved online on 22/04/2005. http://www.sciencedirect.com

Artificial Neural Network (ANN)

The concept of artificial neurons was first introduced in 1943. Artificial Neural Network is a network of interconnected elements. These elements were inspired from studies to simulate the biological brain. The purpose of Artificial Neural Network is to learn to recognize patterns in ones data. Once the Neural Network has been trained on samples of data, it can make predictions by detecting similar patterns in future data ((Cormac, 1999)[21] and (Picton, 1994)[22]). Mostly used neural networks are SFAM algorithm, where one attempts to predict the class or category for a given pattern. The architecture of the network was better explained in a previous study by the authors[23]. Other widely used neural network is the Back Propagation Neural Networks and sometimes called Feedback Network. This method can predict the variable quantity with high precision, for example the concentration of a certain parameter. The algorithm makes its prediction as numeric values, not as class names. It is best suited for predicting continuous numerical values such as water quality data.

Training an ANN is a mathematical exercise that optimizes all of the ANN's weight and threshold values using some fractions of the available data. Neural networks serve to provide researchers with empirical models of complex system from which they can begin to unravel the underlying relationships and come to a more complete understanding of the environment. The most commonly used activation function within the nodes is the logistic sigmoid function, which produces output in the range of 0–1 and introduces non-linearity into the network, which gives the power to capture non-linear relationships between input and output values. The logistic function was used in this work in the form given below.

$$f(x) = \frac{1}{1 + e^{-x}}$$

While many statistical and empirical models exist for water quality prediction, artificial neural network (ANN) models are increasingly being used

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[21]Cormac Technologies Inc., 1999. *Manual, NeuNet Pro, Revision 2.2*. Cormac Technologies Inc. (http://www.cormactech.com/Neunet)

[22]Picton, P. D., 1994. *Introduction to neural network*, The Macmillan Press Ltd: London.

[23]Faris, F.G. & Alias A., 2008. A Study on the Water Quality of Gombak River Using Artificial Neural Network, *Al-Rissala Journal*, International Islamic University Malaysia (In press).

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for forecasting of water resources variables because ANNs are often capable of modeling complex systems for which behavioral rules are either unknown or difficult to simulate. Hafizan et al., (2004)[24] mentioned "*previous studies have shown that ANN models perform well in predicting short and long-term environmental data*". Loke et al., (1997)[25] concluded that ANNs can deal with problems that are traditionally difficult for conventional modeling techniques to solve. In recent years, artificial neural networks were successfully applied in the area of water quality modeling. The use of ANN model was to be better than other simulations and commonly used statistical models[26] due to the complex inter-related and non-linear relationships between multiple parameters. However, modeling applications for water quality response due to land use attributes are generally more difficult due to the complexities in environmental distribution, mobility and number of point and non-point sources of waste discharge.

Junaidah et al., (2004)[27] concluded that the model derived using MLR technique gave a better prediction than the model derived using ANN in a study on sediment prediction, However, this statement can be debatable depending on the complexity of the model itself. Water quality responds to myriad stimuli and reactions. Many chemical constituents are involved either naturally or synthetically. The model of which cannot be treated in a linear manner. ANN is intended to be used with problem of complexity. A later study by Stewart[28]

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[24]Hafizan Juahir, Sharifuddin M. Zain, Zainal Ahmad, Nazari M. Jaafar, 2004. An Application of Second Order Neural Network Back Propagation Method in Modeling River Discharge. In *Water Environmental Planning: Towards Integrated Planning and Management of Water Resources for Environmental Risks*, Alias Abdullah, Norio Okada, and Mohd Kamil Yusoff, eds., International Islamic University Malaysia, pp. 307–324.

[25]Loke, E., Warnaars E. A., Jacobsen P., Nelen F. and Ceu Almeida M., 1997. Artificial Neural Networks as a tool in Urban Storm Drainage, *Journal of Water Science and Technology*, Vol. 36, Issues 8-9, pp. 101–109.

[26]Diane M. L., David P. A., 2004. *Use of Artificial Neural Network Models to Predict Indicator Organisms Concentrations in an Urban Watershed,* AGU, 85(17), Joint Assembly Suppl., Abstract H53A-06 1330h POSTER.

[27]Junaida Ariffin, Aminuddin Abdul Ghani, Nor Azazi Zakaria, and Ahmad Shukri Yahya, 2004. Sediment Prediction Using ANN and Regression Approach, *Proceedings of the 1st International Conference on Managing Rivers in the 21st Century: Issues & Chanlenges, Malaysia*, pp. 168–174.

[28]Stewart A. Rounds, 2002. Development of a Neural Network Model for Dissolved Oxygen in the Tualatin River, Oregon, *Proceeding of the second Federal Interagency Hydrologic Modeling Conference,* Las Vegas, Nevada, July 29 – August 1, 2002 Subcommittee on Hydrology of the interagency Advisory Committee on Water Resources.

revealed that a multiple linear regression may be viewed as a special case ANN model that uses linear transfer functions and no hidden layers. If the linear model performs as well as a more complex ANN, then using the nonlinear ANN may not be justified; however the optimization of the ANN model revealed a markedly better prediction than the MLR model in a study to predict the concentration of dissolved oxygen in a river. In addition multiple linear regression models failed to capture the long term patterns; however ANN model was successful in predicting those patterns (Zou et al., 2002)[29].

A study done by Kamarul and Ruslan (2004)[30] concluded that ANN could become a useful modeling method, as alternative to actual data collection, thus is the best choice for the government to manage water resource issues. The study uses existing raw water quality data from official sources and related to eight land uses categories i.e. residential, industrial, commercial, public utilities, recreational, institutional, and forest. In this study the authors used the Simplified Fuzzy Adaptive Resonance Theory Map [SFAM]. The SFAM logic output was according to classes of water quality. Although the findings were well correlated, nevertheless, the wide range of water quality classes will not give an accurate forecast in terms of a particular water quality parameter. Using a different approach such as back propagation could have given more précised findings.

CASE STUDY

The study area of this research is Gombak River. Gombak River is situated mainly in the Gombak District in Selangor state and its lower zone is situated in the Malaysian Capital Kuala Lumpur. The River is a slow flowing one, which originates from many tributaries in the Gombak district. The river has several confluences with other streams such as Batu River, Untut River, and Kelang River in the Heart of Kuala Lumpur. Figure 2 shows a map of the Gombak River Catchment area. The catchment area within which the river passes through, has grown quite rapidly since early 1970s and is expected to continue growing in the future. The topography of the watershed area, as it is surrounded

[29]Zou, R., Lung, W.S., and Guo, H., 2002, Neural Network Embedded Monte Carlo Approach for Water Quality Modeling Under Input Information Uncertainty, *Journal of Computing in Civil Engineering*, ASCE, 16 (2), pp. 135–142.

[30]Kamarul Ismail, and Ruslan Rainis, 2004. Modeling River Water Quality Index Using Artificial Neural Networks and Geographical Information System. In *Water Environmental Planning: Towards Integrated Planning and Management of Water Resources for Environmental Risks*, Alias Abdullah, Norio Okada, and Mohd Kamil Yusoff, eds., International Islamic University Malaysia, pp. 307–324.

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by hilly mountains. Gombak river watershed is in the upper part of Klang river basin. About 60% of the catchment is steep mountains rising to a height of 1220m. The Gombak River drains a narrow elongated watershed that runs slightly west of south from the steep-sloped main range mountains down through more gently sloping foothills to the alluvial plain in the vicinity of north Kuala Lumpur[31]. Sungai Keroh, Sungai Pusu, Sungai. Rumput, Sungai. Salak, Sungai. Semampus and Sungai. Blongkong feed Gombak River.

Figure 2: Map of Gombak River catchment area.

The Gombak River traverses a vast spectrum of land use change within the Gombak River watershed area. The axial length of the drainage basin is 22.2 km, average width 5.5 km, and an area of 123.3 square km. The river confluence with Batu River at 28.3 metre altitude[32] Gombak River and Kelang River meet at a confluence point in the heart of Kuala Lumpur city. The watershed can be divided into three main sections. The upper zone, including

[31]Bishop, J. E., 1973. *Limnology of a Small Malayan River, Sungai Gombak*, The Hague., pp. 485.

[32]Lai, F.S., 1983. Biochemical Oxygen Demand Concentration of Two River Basins of Selangor, *Pertanika*, Vol. 6(3), pp. 32-43.

the upper tributary sub-zone, takes in the undisturbed forest reserve areas of the watershed and terminates at the point where the river leaves the steep sloped hills and enters the gentler foothill section. The middle and lower zones with gradients of 4.7% and 2.2% respectively.

RESEARCH APPROACH

A water index is a method of combining various water quality parameters into one concise and objective value representing the state of the water quality trends. The WQI (Water Quality Index) is used to compare water quality on rivers, on different locations on the same river, and to measure water quality changes over a period of time. There are many methods used for the calculation of WQI. The Department of Environment (DOE) has obtained an opinion-poll formula for the calculation of WQI. A panel of experts is consulted on the choice of parameters and on the weightage to be assigned to each parameter. The parameters, which have been selected, were: DO (Dissolved Oxygen), BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), AN (Ammonia-Nitrogen), SS (Suspended Solids) and pH (pH value). A more comprehensive description of the DOE-WQI and Harkins' method had been discussed in a previous study by Faris & Alias, (2008)[33].

The water quality parameters are accessible and can be made available as frequent as needed; however, land use and land cover are difficult or impossible to obtain in short frequent terms. To overcome this challenge, it was deemed necessary to develop a method for data generation that can mimic the actual land use and land cover. The proposed method will be able to predict the actual data then and to project (forecast) data for the future. The generation of land use or land cover data is essential for the ANN training of the river based on land use sub indices and for building the model that predicts and forecasts the WQI of the river.

Data Generation Models and Boundary Conditions for Gombak River Watershed

For the purpose of this study and in order to generate land use or land cover data, the following models and boundary conditions will be followed:

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[33] Faris, F.G. & Alias Abdullah, 2008. Prediction of Water Quality Index Using Back Propagation Network Algorithm. Case Study: Gombak River, *Journal of Engineering Science and Technology*, 2008 (In press).

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Exponential Model Equation: $y = a^{e^{bx}}$

Exponential model will be used to generate data for all ascending values. However if the values (according to the planner's decision) need to be stabilized based on maximum capacity of the watershed or the region, then another model (Lagarange Model) will be used in order to generate data for the converging values.

Lagrange Model Equation: *3rd degree Polynomial Fit*: $y=a+bx+cx^2+dx^3 \ldots\ldots$

Third degree polynomial model will be used in order to generate data that had reached the maximum capacity area allocated for the watershed/region. The data generation will continue until the value of the generated area reaches the capacity area.

In order to generate descending values such as forest area, the saturation growth model will be used.

Saturation Growth-Rate Model: $y = \frac{ax}{(b+x)}$

The data will be generated until a convergent point has been reach. At this point the maximum allocated capacity of the category will be reached. After the land use or land cover data were generated. Another neural network was set up to train the stations 18 and 24 based on LU/LC parameters only. The configuration of the network was not changed to ensure the consistency of the training. The network used WQI values that corresponds the same date of the generated LU/LC data.

The Proposed Land-Use Attributes WQI Model (LA-*WQI Model)*

This model was developed by associating the appropriate loading factors to a set of sub indices. The loading factors were obtained based on peak factor theorem by assigning weights to different categories of land use indices. These weights were primarily assigned based on the effect of each land use as well as the existence of each category within the watershed. Then they were corrected furthermore by trial and error until the required weights were assigned.

The proposed model:

$$\text{LA-WQI} = 100 - [0.15\ BU_{si} + 0.17\ R_{si} + 0.26\ C_{si} + 0.38\ I_{si} + 0.04\ F_{si}]$$

Where, BU*si* is the build-up area sub index; build-up area represents the effluents of storm and wash water from the build-up area, R*si* is the residential area sub index, C*si* is commercial area sub index, I*si* is Industrial area sub index and F*si* is the Forest area sub index. It has been thought earlier, that forest area within a river watershed does not degrade the water quality of the river; However, Mohd Kamil et al.[34] concluded in a study of water quality index and forest health, that a disturbed forest will degrade the water quality of the river within its catchments.

Assumptions and boundary conditions – The land use and activities within catchments area may vary from one river to another; however the main land uses and activities that constituted Gombak River catchment were the ones used as input parameters in the proposed model. These parameters were assumed to be the most effective ones after an extensive training process using the (leave-one-out) method. The input parameters represent the effluents discharged from each category and the physical area per se. The loading factors (associated weights) were obtained by ANN training and using peak factor theorem.

All the five categories are firstly generated as area measured in acres and converted to percentages of the watershed. These percentages are considered as the effects of these categories on water quality. They are then calculated using the logistic model and boundary conditions as shown on Table 1.

The calculation of the sub indices were based on the Logistic Model:

$$f(x) = \frac{1}{1 + e^{-x}}$$

The reason for choosing the logistic model is that it is based on the sigmoid function, a function of which is used internally for the training of artificial neural networks' back propagation algorithm. The model will be applied on the average values of the percentages of land use every year, and will be compared with average values of yearly WQI (actual and ANN predicted). The predicted WQI will include both water quality and land use sub indices.

[34]Yusoff, M.K., Heng, S.S., Majid, N.M., Mokhtaruddin, A.M., Hanum, I.F., Alias, M.A., & Kobayashi, S., 2001. Effects of different land use patterns on the stream water quality in Pasoh, Negeri Sembilan, Malaysia. In *Rehabilitation of Degraded Tropical Forest Ecosystems: Workshop Proceedings,* Kobayashi, S., Turnbull, J.W., Toma, T. Mori, T., Majid, N.M.N.A. eds., *2-4 November 1999*, CIFOR, Bogor, Indonesia, pp. 87-98.

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Table 1: Sub Index Equation and Boundary Conditions for the Proposed LA-WQI Model.

Parameter (%)	Boundary Conditions	Sub-Index (*si*) Equation
Build up Area	If $X \leq 1$	$BUsi = 0$
	If $1 < X > 88$	$BUsi = \frac{a}{1 - bx^{-2x}}$ where, a = 110.04386, b = 14.002778, c = 0.054011454
	If $X > 88$	$BUsi = 100$
Residential Area	If $X \leq 5$	$Rsi = 0$
	If $5 < X > 55$	$Rsi = \frac{a}{1 - bx^{-2x}}$ where, a = 110.71519, b = 21.502455, c = 0.093329354
	If $X > 55$	$Rsi = 100$
Commercial Area	If $X \leq 2$	$Csi = 0$
	If $2 < X > 50$	$Csi = \frac{a}{1 - bx^{-2x}}$ where, a = 110.71522, b = 16.378263, c = 0.097218005
	If $X > 50$	$Csi = 100$
Industrial Area	If $X \leq 0.5$	$Isi = 0$
	If $0.5 < X > 20$	$Isi = \frac{a}{1 - bx^{-2x}}$ where, a = 107.92071, b = 14.190819, c = 0.24676863
	If $X > 20$	$Isi = 100$
Forest Area	If $X \leq 20$	$Fsi = 0$
	If $20 < X > 80$	$Fsi = \frac{a}{1 - bx^{-2x}}$ where, a = 110.715, b = 63.881014, c = 0.077774785
	If $X > 80$	$Fsi = 100$

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RESULTS AND DISCUSSIONS

The water quality index sums up the overall quality of the three stations located along the Gombak River. As shown in Figure 3, the mean WQI for stations 24, 18 and 17 respectively were 91, 68 and 57 on the DOE WQI scale. This puts station 24 as clean river water; station 18 as slightly polluted and station 17 as polluted river water. Station 18 is considered the downstream of Gombak river watershed. The station was trained using ANN back propagation algorithm. The neural network was configured with 5 hidden nodes, 12125 iteration cycles and a momentum of 50. The results of the network produced normalized RMS error of 0.86 and Actual error of 0.36.

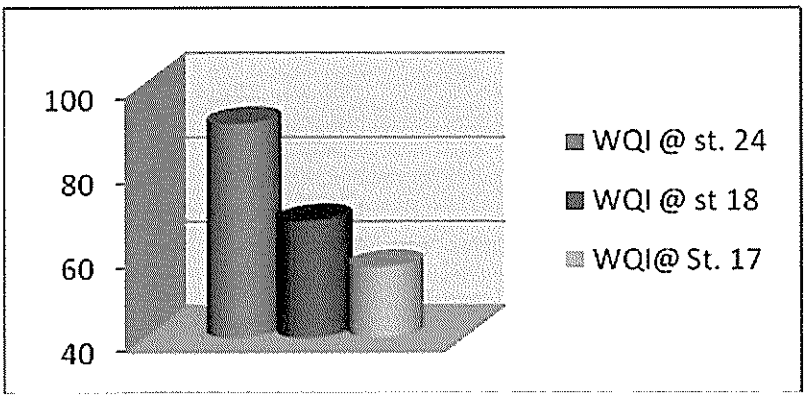

Figure 3: Average Annual Values of Gombak River for the period of 1999 to 2006.

The network later was able to produce its own minimum, maximum and mean values for predicted output. Based on the results (Please refer to Table 2) obtained by the network, back propagation algorithm was able to predict WQI with high accuracy. The number of tested WQI was equivalent to that of the predicted one. The time-series graph shown in Figure 4 indicates very high accuracy of prediction of WQI at station no. 18 of Gombak River. Values that appear less than the actual data is due to the learning process of the network. Water quality monitoring station no. 18 is the last monitoring point within the boundary of Gombak River watershed. Unlike station no. 24, the land use affecting the water quality of Gombak River is an extensive one as shown on Table 3 and Figure 5. The build-up area exceeds 80% of the total area of this part of the watershed. It is important to understand the evolution of land use within the watershed in order to generate data and to forecast data for future development. The build-up area increment has stabilized to a lesser value after the year 2000 as shown in Figure 6. This stabilization indicates that the capacity of the watershed has approached its peak.

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Table 2: Results of Actual vs. Predicted WQI using Back Propagation Algorithm of Station No. 18

Actual WQI	Predicted WQI	Actual WQI	Predicted WQI	Actual WQI	Predicted WQI
85.88	84.95	61.41	61.25	65.51	65.29
79.99	80.31	61.61	61.93	68.37	68.16
45.88	47.04	62.91	62.57	77.28	77.10
64.71	64.60	75.17	75.24	38.81	47.04
55.19	55.07	62.09	62.07	63.06	63.15
53.64	53.67	71.87	71.72	70.47	70.19
58.46	58.43	81.16	80.58	65.58	65.58
50.49	49.89	73.33	73.27	52.05	51.44
78.84	78.71	69.00	68.81	71.19	70.96
66.31	66.13	73.40	73.03	78.15	78.58
67.00	66.76	66.38	66.19	73.32	72.79
52.87	52.99	81.74	80.92	74.65	74.59
57.40	57.36	77.43	77.06	75.74	75.66
80.59	80.08	67.55	67.33	69.79	69.69
52.73	52.74	65.59	65.38	71.75	71.96
53.24	52.84	59.94	60.09	64.61	64.57
77.93	77.79	66.24	65.98	64.97	64.91
61.59	61.72	65.61	65.49	69.43	69.00
57.81	57.76	28.10	45.85	68.85	68.53
67.00	66.65	62.19	62.21	73.05	72.99
70.33	70.18	71.01	70.71	62.62	62.37
64.63	64.31	63.07	63.26	71.48	71.25
56.09	55.97	71.61	71.38	76.61	77.06
76.49	76.62	65.05	64.71	79.21	79.55

Table 3: Selected land use/land cover categories

No.	Year	Build Up Area	Forest	Residential	Industrial	Commercial
1	2003	6356.595	7.161	2802.5	77.552	620.625
2	2002	6334.512	7.186	2792.691	77.280	618.079
3	2000	6312.506	7.202	2782.917	77.010	615.916
4	1997	6298.492	7.217	2776.739	76.839	614.549
5	1990	5195.878	8.480	2290.531	63.385	506.9

The build-up area reaching its highest capacity and forest area is at its lowest values. The data were generated from 1984 until 2001; however, only the years 1998 until 2006 will be considered for the purpose of this study in order to match corresponding WQI data available. The data was generated for build-up Area, forest area, residential area, commercial area and industrial area.

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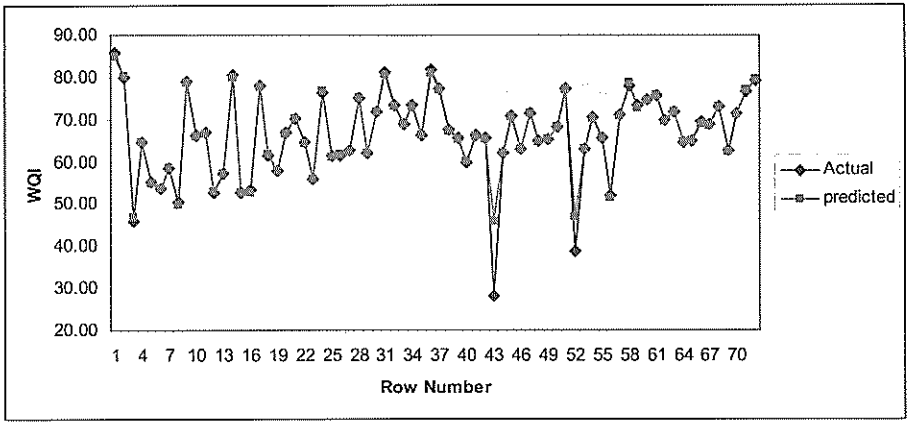

Figure 4: Time-Series Graph of Actual vs. Predicted WQI at Station 18 of Gombak River

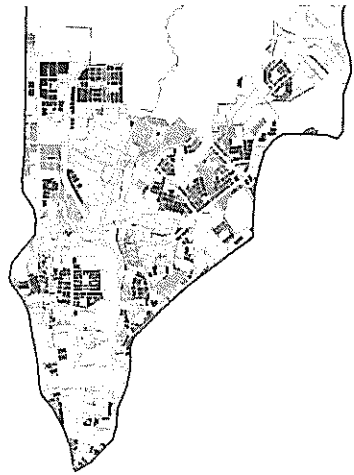

Figure 5: Land Use Map of Gombak River Watershed

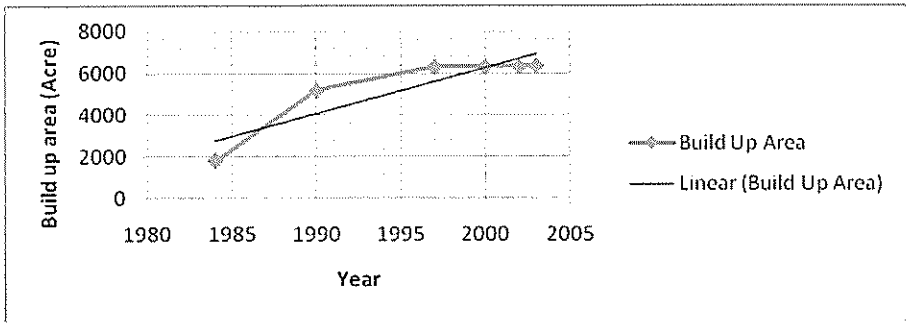

Figure 6: Build-Up Area of Station 18 from 1980 to 2005

Buildup Area Data Generation

Using the 3rd degree Polynomial model: $y=a+bx+cx^2+dx^3$.....
The initial curve for build up area as shown in Figure 7 was generated using the following coefficient data: $a = -7.312269e+009$, $b = 10961380$, $c = -5477.1702$ and $d = 0.9122745$. The model operated with few numbers of data at the initial stage of generation and yielded a standard error of 49.54, and with correlation coefficient of 0.99985.

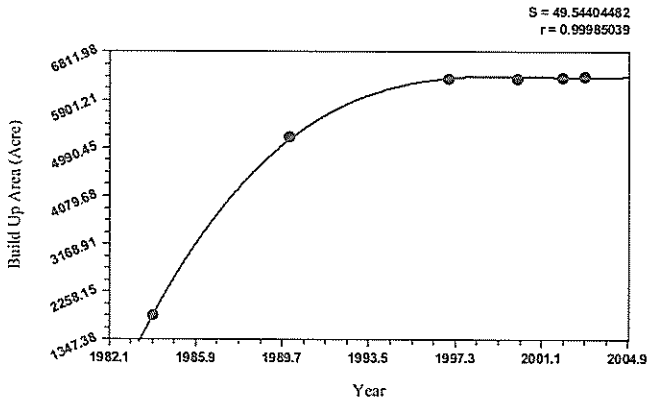

Figure 7: Data generation of Build-Up Area at Station 18 using Lagrange Model

Based on the data generated above, 4th Degree Polynomial model was used to generate the required build-up area from 1984 until 2010 on a monthly basis as shown in Figure 8. During the iteration process the following coefficient data were used: a = -4.64034e+009, b = 5692851.6, c = -1582.5807, d = -0.366894, and e = 0.00015750769

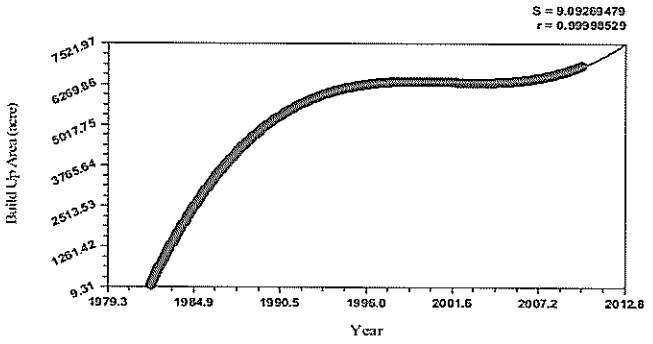

Figure 8: Build-Up Area Data Generation using 4th Degree Polynomial Model

The data exceeding the capacity of the watershed will not be considered as stated in the boundary condition of model applications.

Forest Area Data Generation

The forest area affecting station no. 18 of the watershed is decreasing in value; therefore a saturation growth-rate model was used to generate the area. To generate the initial data, the following coefficients were used: coefficient data: a = 0.11519198 and b = -1966.9875 and were applied on the model:

$$y = \frac{ax}{(b+x)}$$

The initial curve (Figure 9) for data generated produced acceptable results; however due to few numbers of data, the curve needed adjustment. The second stage of data generation solved this problem and produced the required data.

Based on the initial saturation growth-rate model the remaining required data were generated from 1984 until 2010 using the same model (Figure 10) and applying new coefficient data for the model obtained from a number of iterations. The coefficient data were a = 0.11519245, and b = -1966.9874.
As the second application was based the first model the second application produced much lower standard error 0.0011342

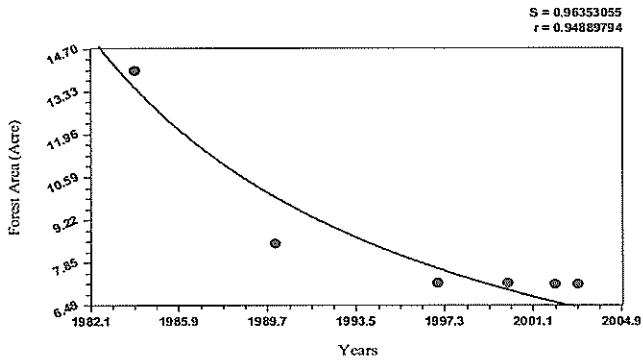

Figure 9: Forest Area Data Generation of Station 18 Using Therefore Saturation Growth-Rate Model

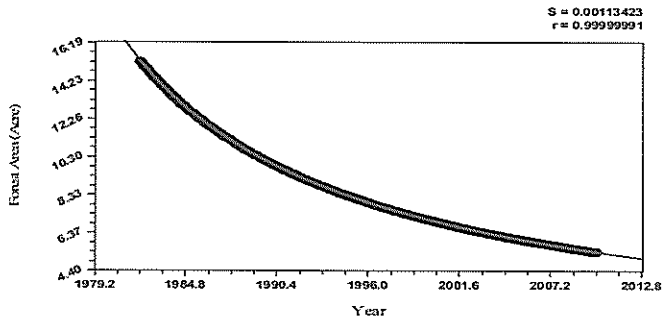

Figure 10: Application of Saturation Growth-Rate Model On Forest Area Affecting Station 18

Data Generation of Residential Area Affecting Station 18

Following the same method used for generating build-up area, the residential area was generated initially using 3rd degree Polynomial model with coefficient data of a = -3.0076658e+009, b = 4508008.2, c = -2252.2557, and d =0.37508435 as shown in figure 5.50. The standard error was 20.913 in the initial model application. After the initial data were generated, the remaining required data were generated using 4th Degree Polynomial model with coefficient data of a = -1.7159507e+009, b = 1990074.4, c = -413.14533, d = -0.22143343, and e = 7.2490844e-005. The residual curve gave better prediction ability with a standard error of 7.497584 as shown in Figure 11.

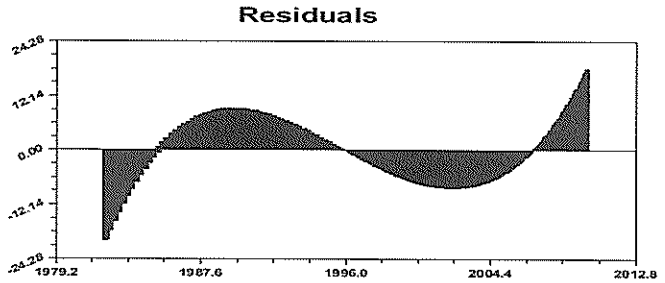

Figure 11: Residual Curve of Actual Versus Generated Data of Residential Area

Data Generation for Commercial and Industrial Area Affecting Station 18

Exponential model had been used for the generation of data for commercial and industrial area. The initial setup for data generation used a = 7.3704247e-046, and b = 0.055158363 data coefficient for commercial area and for industrial

area, a = 9.4973359e-047, and b = 0.055143224. Data generated for commercial and industrial areas represented the years 1984 through 2010. For commercial area, the best standard error was 115.2054407, with Correlation Coefficient of 0.8126092; while industrial area had best standard error of 14.4130782 with correlation coefficient of 0.8122768.

After data generation, exponential model was defined by new coefficient data of a = 7.3720831e-046, & b = 0.05515825 for commercial area, and a = 9.4985733e-047 and b = 0.055143159 for industrial area for further data generation, forecast and analysis. The standard error for commercial and industrial area was 0.0869008 and 0.0108680 respectively.

ANN Training of Gombak River LU/LC Parameters for Station 18

A neural network was set up in order to train the generated LU/LC data affecting station 18 of Gombak River. The network architecture consisted of 5 hidden nodes, and 94 rows. The network which used pack propagation algorithm carried out 125500 cycles of iterations as described in the training boundary conditions. The average predicted water quality index during this period (9 years) was 66.68. The normalized RMS error was 19.97% and actual error of 8.47. The high error value was expected at this part as the learning process is between a more stable LU/LC parameters and heterogeneous WQI that changes continuously. The network was able to identify a pattern while the training process continued. The pattern indicated that the WQI predicted based on LU/LC data was more linear than that of actual WQI as shown in figure time series of station 12 (Figure 12).

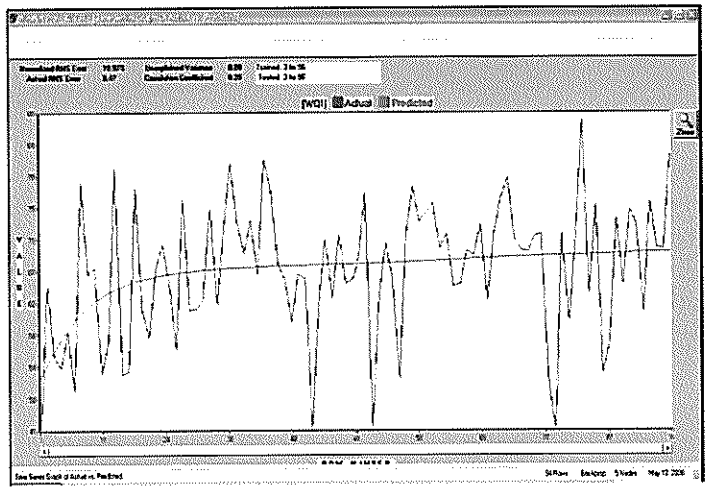

Figure 12: Time Series Graph of Actual vs. Predicted WQI at Station 18

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In order to predict the WQI using the LA-WQI the sub indices of selected LU/LC parameters had to be calculated. Using the method described previously in the research approach, the calculated sub indices were then multiplied by the weight factor of each category.

The LA-WQI was then calculated using the proposed model equation as follows:

$$LA\ WQI = 100 - [0.15\ BUsi + 0.17\ Rsi + 0.26\ Csi + 0.38\ Isi + 0.04\ Fsi]$$

The results of predicted WQI obtained using LA-WQI, shows a continuous decrease of water quality index from 66.825 in 1998 to 64.677 in 2006. As the activities increase throughout the watershed the values of WQI quality decreases accordingly. The values of predicted WQI using the mentioned methods are illustrated in Figure 13.

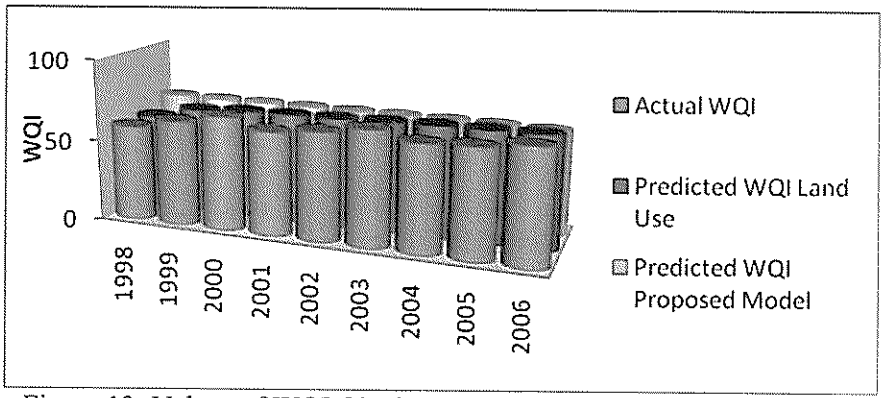

Figure 13: Values of WQI Obtained Using DOE-WQI, ANN-WQI and LA-WQI Models

The average mean results of WQI from each method were very near in value. The results showed an accuracy of 98% between Actual DOE WQI and LA WQI for station no. 18 of Gombak River.

As shown in Figure 14, average Values of WQI for Actual, ANN Predicted and LA WQI predicted are 66.299, 66.844 and 66.008 respectively which constitute an accuracy range of 97.9 to 99.5 %.

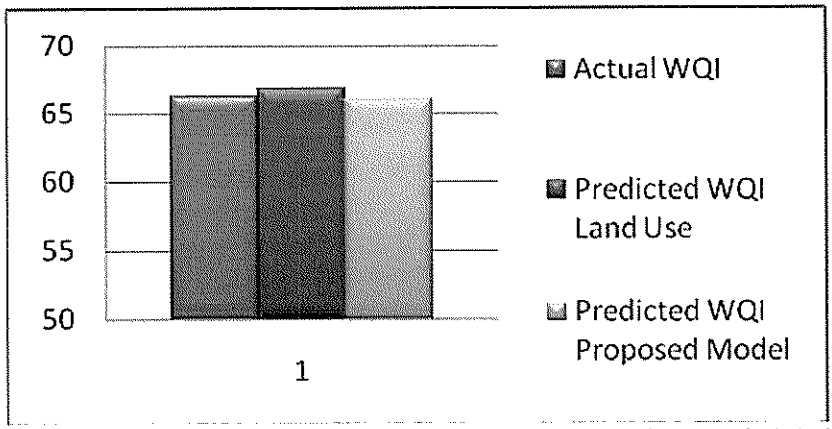

Figure 14: Average Values of WQI using DOE, ANN and LA-WQI Models

VALIDATION

In order to carry out a sensitivity test to validate the method for generating and forecasting LU/LC data, some of the obtained data were withheld and were not used in originating the models for data generation. These data represent LU/LC data for the year of 1984

The average area for the whole year was considered during the validation process, and it was compared to actual land use data for the same year as shown in Table 4. The land use area obtained using the method described in the methodology to generate and forecast data, had given a very high precision ranging from 91.862 to 95.902 when compared to actual data obtained from DOA.

Table 4: Comparison between Average Values of Actual vs. Predicted Data

	BU (Acre)	R (Acre)	C (Acre)	I (Acre)
Actual	1984.43	1229.6	17.569	4.837
Average	1899.234	1338.524	16.84918	4.621188
Accuracy %	95.706	91.862	95.902	95.538

The trends which were chosen to describe the pattern of development were very realistic, and succeeded to mimic the actual patterns of development. Furthermore, and in order to see the pattern of deterioration of the water quality of the Gombak River with respect to the increase of land use within the watershed, the LA-WQI model was applied on three stations. The average values of WQI obtained on the three stations were taken from the same dates to

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ensure the consistency of the results as shown in Table 4. The sub-indices were multiplied by their respective factor explained previously. The Values of WQI were 96, 91.9 and 65.7 respectively.

CONCLUSION

This study had focused on finding a low-end alternative for water quality monitoring techniques. It used data generation method coupled with ANN approach to provide an effective prediction model that suits environments with high heterogeneity. The proposed approach minimized most of anomalies associated with prediction methods and provided water quality forecasting and prediction with high accuracy. The study proposed a method that mimicked the actual development pattern in the watershed; however, it is recommended that for future planning, watershed development should follow an identified model fit for development. All developmental schemes should be conducted in accordance with a specific allocation of time and space which follows a certain model. This will help in producing more accurate forecasting of LU/LC sub-indices, which in turn will help in forecasting the WQI for the future years until the watershed is fully developed. After the watershed is fully developed, the activities of different categories of land use will produce a uniform discharge of effluents to the river. The study had also identified that the mid streams of Gombak River is deteriorating in quality due to rapid development within the vicinity of the watershed. Despite the high accuracy attained by the application of LA-WQI model on Gombak River; it has not yet been tested in other rivers due to the limitation of the scope of this study. It is recommended that future studies should be able to further test the current model on a regional scale.

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GROUNDWATER EXTRACTION MODELLING FOR KUALA LUMPUR WATER RESOURCE PLANNING

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Abstract

Potable water consumption in Kuala Lumpur and the surrounding area is expected to grow by 34% from 2005 to 2010. This increase in demand will be met by the construction of new reservoirs. However, reservoirs are dependent on rainfall and during prolonged periods of drought, as occurred in 1998, they could become empty. Therefore it is of great importance to develop alternative sources of water supply, including groundwater, to mitigate the effects of a serious water crisis. In this paper, results from a preliminary study on Kuala Lumpur's groundwater resources are presented. Modelling of the city's groundwater resources is extremely difficult given the limitations imposed by data availability and the karstic nature of some aquifers. Hence, the research presented here serves as a starting point for further studies rather than providing any definitive conclusions. In addition to the study results, the planning implications of groundwater extraction are discussed.

Keywords: Potable water, Kuala Lumpur, Groundwater, Extraction

INTRODUCTION

Kuala Lumpur, with a population of 1.4 million (2000), is the heart of the Kuala Lumpur conurbation (population of 4.2 million in 2000), Malaysia's most prosperous and most densely populated region. Kuala Lumpur is a major commercial and industrial centre in Southeast Asia (Kuala Lumpur City Hall, 2000).

Average per capita income in Kuala Lumpur is approximately double the national average (Kuala Lumpur City Hall, 2000). This means that average purchasing power of city residents (25,600 USD) is comparable to that of developed countries such as Greece (24,000 USD) and New Zealand (26,200 USD). Malaysian average purchasing power per capita (12,800 USD) exceeds

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that of Bulgaria (10,700 USD), a member state of the European Union. (Central Intelligence Agency, 2007)

By 2010 the water supply capacity in the Kuala Lumpur region from reservoirs will be 5.15 million m^3/day and the demand will be 5.0 million m^3/day, meaning excess capacity is just 3% of the demand (Economic Planning Unit, 2005). This means any disruption in supply can have an immediate and serious effect on supply. To prevent such an occurrence, reservoir capacity needs to be expanded further to create the needed excess capacity or an alternative source of water supply that is independent of rainfall needs to be found. It is herein that groundwater can play a role.

Groundwater is a common source of water supply across the world, which is unsurprising if one considers that it tends to be locally available, often just metres below the point of consumption, it is generally of high quality and it is reliable, being insensitive to short-term rainfall patterns (Custodio, 2002). The fact that groundwater has not been used extensively in Kuala Lumpur can be attributed to the availability of surface water captured by the many reservoirs surrounding the city and the generally poor quality of local groundwater due to local geological conditions (Institute of Environment and Development, 1997). The main obstacle in developing groundwater resources is a lack of knowledge. Conducting the necessary research to gain this knowledge takes up a very large share of the total investment needed to exploit groundwater resources. Uncertainty often makes it difficult for decision-makers to commit to a natural resources or environmental policy (Bressers, 2003).

This paper presents the results from a preliminary study on Kuala Lumpur's groundwater resources. The theory, methodology and data behind the study are only very briefly described as in-depth knowledge of these details is less relevant from a planner's perspective.

Important to planners are the unique features of the study area and how these features influence the planning process. Although a lack of groundwater data makes it impossible to make concrete recommendations, there is potential for groundwater extraction in Kuala Lumpur, especially for emergency purposes. However this requires planning to minimise environmental damage to recharge areas and to plan water supply infrastructure close to areas with groundwater potential so that groundwater can be used to make for a shortfall from reservoirs, should the need arise.

Kuala Lumpur has three important characteristics which pertain to groundwater: the area has a rapidly growing economy and population, it has a

highly complex geology and there are potentially significant environmental threats to groundwater that cannot be comprehensively assessed at present. These three issues will be addressed below and in that order.

THE GROWING DEMAND

Kuala Lumpur initially developed as a trading centre in the 1850's to service the nearby tin mining industry. Large rubber and palm oil plantations were established in the vicinity soon after. From the 1950's onwards the city started to industrialise and today all mines and most plantations around Kuala Lumpur have closed. Between 1995 and 2000 average per capita income grew by 6.1% per year. Population growth is projected at 2.2% per year for the period from 2000 to 2020 (Kuala Lumpur City Hall, 2000).

Kuala Lumpur's water infrastructure is strained and although expansion has generally kept up with fast-growing demand, parts of the system are in very poor shape. Although access to the public water supply is universal, non-revenue water[2] stood at 37% in 2005 which is worth more than RM[3] 1 million per day in lost revenue. Non-revenue water can explain the entire RM 449.1 million annual revenue shortfall of the Selangor water system (Lee, 2005).

Kuala Lumpur was hit by a severe water shortage in 1998 caused by an extended period of drought. Due to its dependence on rain-fed reservoirs for the city's water supply the city may be faced with a similar shortage in the near future (Hamirdin et al., 2004). On a smaller scale, accidents sometimes pollute rivers and reservoirs, temporarily disrupting water supply to parts of Kuala Lumpur. Such instances are regularly reported in local newspapers.

Following the 1998 water shortage, a controversial inter-basin water transfer scheme was constructed to supply water from the Selangor river basin, just north of Kuala Lumpur (Tan, 1999). In 2008 construction will start on another inter-basin transfer scheme from Pahang state, southeast of Kuala Lumpur, valued at RM 4 billion. A total of RM 8 billion has been allocated for all water supply projects nation-wide under the Ninth Malaysia Plan (Economic Planning Unit, 2005; Barrock, 2007). Under the Ninth Malaysia Plan, which is the Malaysian federal government's most important policy document: "...

[2] The Malaysian Water Association defines non-revenue water as water that is treated but lost due to leakages, theft, pipe bursts and meter under-registration and hence generates no revenue for the water supply company.
[3] Malaysia currency is Ringgit or RM.

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development of *groundwater* will be promoted as [an] interim measure[s] to address the anticipated shortage of water in Selangor, Kuala Lumpur and Putrajaya." (Economic Planning Unit, 2005). However, no significant groundwater plans have been presented, although groundwater has received some attention in the Malaysian media (Malaysian National News Agency, 2007a; 2007 b).

To put the water supply and demand numbers into perspective, note that total net rainfall (compensated for evapotranspiration) over the Klang basin alone is on average approximately 5.25 million m^3/day which is roughly equal to projected 2010 demand for all of Selangor and the federal territories (Stek, 2008; Rustam et al. 2000). So in theory, there is enough water to meet Kuala Lumpur's needs, the question is can it be captured?

THE STUDY AREA

Kuala Lumpur is located in the eastern part of the Klang River basin (total area of 1,278 km^2). The Klang, Gombak and Batu rivers originate in the densely forested foothills of the Titiawangsa mountain range, north of Kuala Lumpur and have their confluence near the old city centre (see Figure 1). The Klang River then continues its journey through the relatively flat and heavily urbanised valley floor before discharging into the Melaka Straits at Port Klang (Rustam et al., 2000).

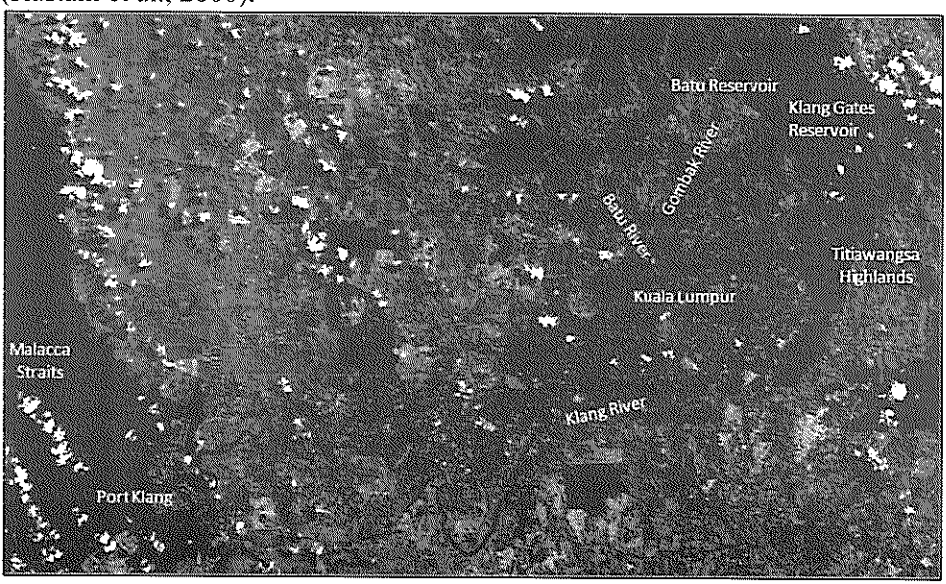

Figure 1: Colour composite satellite image (Landsat) of the Klang basin.

The Klang basin has a tropical climate with abundant rainfall of 2700 mm per annum. The maximum precipitation occurs in October and November and in April, coinciding with the southeast and southwest monsoon seasons respectively (Rustam et al., 2000). Rainfall is also the primary source of the basin's two main drinking water reservoirs (Klang Gates reservoir and Batu reservoir).

On a smaller scale, tin ponds are one of the most important hydrogeological features of Kuala Lumpur. Limestone, being easily erodible, traps mineral deposits (especially tin) in its extensive networks of fractures, conduits and cavities. Tin deposits were mined from the 1850's until the 1980's in open-cast mines. These mines have since been closed and flooded, creating Kuala Lumpur's characteristic tin ponds (Yin, 1986). Because of the high permeability of the limestone formations, the tin ponds play an important role in regulating Kuala Lumpur's water balance, providing water storage during heavy rains and being a major source of groundwater recharge. The groundwater table in the valley is quite shallow at around 5 metre below the surface, making it sensitive to pollution (Binnie dan Rakan, 1980).

The irregular limestone formations also pose geotechnical engineering challenges. If groundwater levels fall and cavities and tunnels are drained, this can lead to sudden catastrophic land subsidence (sinkhole formation) as illustrated in Figure 2. The sudden loss of support provided by the groundwater has caused the collapse of buildings in the past. Often these occurrences were related to the draining of tin mines or major construction projects (Tan, 2006).

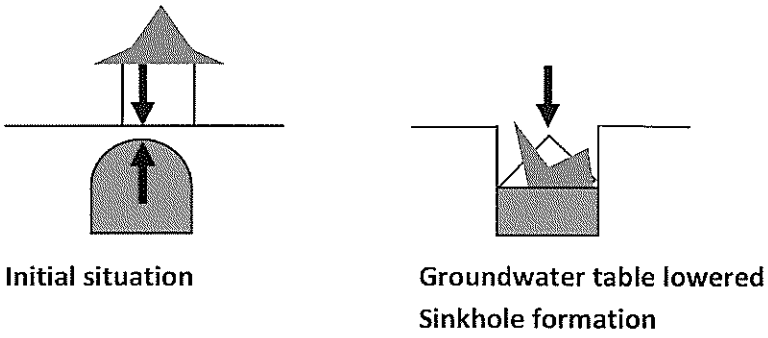

Figure 2: Simplified illustration of sinkhole formation mechanism.

Other geotechnical challenges are posed by the steep hills that surround most of Kuala Lumpur. Some of these hills have been cleared from natural vegetation to make way for development. Here, heavy rains occasionally induce landslides, some of them involving loss of life (Institute of Environment and

Development, 1997). These landslides are usually caused by inadequate local drainage which causes the soil to become saturated and lose its carrying capacity. However, it is a very local problem; whereas sinkholes can be induced by groundwater extractions hundreds of metres away (Tan, 2006; Craig, 1997).

ENVIRONMENTAL RISK

In addition to the risks posed by an unstable subsurface, there is a significant risk of severe pollution from other sources, including poorly constructed landfills. Leachate[4] is a known problem near landfills, and given that the groundwater table is shallow at approximately 5 metre deep, the entire water system is susceptible to pollution. Leaching in tropical climates is often more severe than in temperate climates because heavy rainfall generates more effluent from landfills.

The protection of groundwater recharge zones, one way of eliminating environmental risks, is the responsibility of the Department of Town and Country Planning and the local authorities. It delineates and classifies Environmentally Sensitive Areas into 3 ranks. Rank 1 is the most stringent and absolutely no development is allowed there. Rank 2 allows development only under special circumstances. Rank 3 permits for development, but insists that it be monitored carefully by local authorities. The upper part of the Klang basin is Rank 1 because it is a part of Peninsular Malaysia's central forest spine and a catchment area for the Klang Gates and Batu reservoirs (Federal Department of Town and Country Planning Peninsular Malaysia, 2005).

The valley floor on which most of Kuala Lumpur is built is classified as Rank 3 and hence it still poses a significant environmental risk. This is due to the limestone subsurface which is prone to sinkhole formation and the threat from pollution, erosion and flooding. Kuala Lumpur City Hall recognises its responsibility in monitoring development, but also states in its Strategic Plan that there is no policy at the moment to deal with these environmental issues (Kuala Lumpur City Hall, 2000; Federal Department of Town and Country Planning Peninsular Malaysia, 2005).

Another component in environmental risk reduction is adequate environmental protection legislation. Under the Environmental Quality Act (1974), only 'large scale' developments need to submit an Environmental

[4] Leachate is the product of water percolating through polluted soil or a landfill that reaches and pollutes the groundwater system.

Impact Assessment to the Department of Environment. 'Small scale' developments, including shopping centres, office towers and apartment buildings, do not require an Environmental Impact Assessment but only a building permit issued by the local authority. In some cases projects are deliberately split into smaller pieces to circumvent the Environmental Quality Act (Perunding Zaaba, 1999; Neergaard, 2003).

Although new landfills do require an Environmental Impact Assessment, the enforcement of the legislation on this issue can also be circumvented. Datuk Shahrir Abdul Samad, a senior National Front member of parliament, noted that for the Kundang landfill, operated by the Selayang Municipal Council, no preliminary Environmental Impact Assessment report was submitted. Because there is no Environmental Impact Assessment, the Department of Environment has no ground for enforcement (Mutadir, 2006). It must be noted that such behaviour by municipalities is not the norm. For example, Kuala Lumpur City Hall recently invested RM 24 million to properly decommission the Taman Beringin landfill (Lim, 2008).

To evaluate the results of these policies, groundwater monitoring data provided by the Department of Environment provides some indicators. Near landfills groundwater is polluted, especially by Manganese. Manganese is a heavy metal commonly found in batteries and other industrial chemicals. Manganese leaching is a known problem and has been reported at least since the late 1970's (Binnie dan Rakan, 1980). Monitoring also takes place at other sites, such as golf courses. Here, groundwater quality seems to be fair (Department of Enviornment, 2007). Casual observation of tin pond in Kuala Lumpur suggests that their water quality is also fair, as they are popular fishing spots with local residents.

Nevertheless, one must conclude that large-scale groundwater pumping may cause unexpected groundwater flows, especially near polluted sites, which can have disastrous consequences for a groundwater pumping project and the general environment. Responsible groundwater development cannot proceed without adequate knowledge of these threats.

GROUNDWATER MODEL

Due to the fact that this article is aimed at town planners rather than engineers or hydrogeologists, this section only addresses some aspects of the groundwater modelling process. The modelling aspects that are addressed in this section are: the reasons for modelling, the assumptions on which the model is based, the

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simulation results and the limitations of the model. For a more comprehensive description of the modelling process, a discussion of the relevant theory and more detailed descriptions of the input data and the results, please refer to Stek, 2008.

WHY MODEL?

The quantification of groundwater resources often proves to be a formidable challenge. It is difficult to quantify groundwater resources because required data acquisition can be prohibitively expensive. Just like the exploitation of oil and gas reserves, exploration costs account for a large part of the investment needed to safely exploit groundwater resources. Hence it is important to quantify groundwater resources accurately and cheaply early on in the development process so that the necessary information is available for timely decision-making.

There are several different methods of groundwater quantification, one of them is modelling. Groundwater models can be used to study the sensitivity and dynamics of the groundwater system and to organize available field data (Anderson and Woessner, 1992). This gives modelling a significant advantage when analysing Kuala Lumpur's very inhomogeneous hydrogeology over other quantification methods such as pumping tests and groundwater potential mapping.

Pumping tests[5] are primarily influenced by local hydrogeological conditions and therefore, if the hydrogeology is highly variable, the results are not valid for a wider area and therefore of limited value in larger-scale groundwater studies (Lubczynski and Gurwin, 2005). Groundwater potential mapping[6] is a very powerful tool for estimating groundwater recharge in large vegetated areas. However in urban areas recharge is heavily influenced by factors such as leaking pipes and complex land use for which groundwater potential mapping methods are ill-suited (Lerner, 2002).

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[5] Pumping Test: a method for determining the transmissivity (hydraulic conductivity x aquifer thickness) and storativity (volume of water released from storage per unit decline in the hydraulic head) of an aquifer and to establish the reliable yield of a well and to find out if the well affects other wells and springs.

[6] Groundwater Potential Mapping: a method for estimating groundwater recharge using climate (e.g. rainfall, evaporation), geophysical (e.g. slope, soil type) and land-use data (e.g. vegetation type). Recharge is then used to estimate the *potential* amount of groundwater that can be extracted.

Gaining knowledge about the dynamics of the groundwater system, i.e. how it will react to certain changes, is of great importance to assess potential environmental risks. This assessment must occur at different scales: from the perspective of the water balance of the entire hydrological system and from the local impact of pollution. From the planning perspective it is now most important to uncover the larger, hydrological system perspective because data for modelling on smaller scales is unavailable.

The question that the model needs to answer is: What are the physical effects of groundwater extraction? The answer that town planners and decision makers specifically seek is: How much water can safely be extracted? If this quantity is fairly large and the environmental impact seems mild, then there is a strong case to be made to develop groundwater resources in Kuala Lumpur and to enforce more stringent planning rules to protect groundwater recharge zones. The quality of the answer the model provides depends on the validity of the assumptions on which it rests.

MODEL ASSUMPTIONS

There are three areas in which assumptions must be made: (1) the data used in the model, (2) the theory underlying the model and (3) the criteria defining what constitutes environmental damage. These matters, in addition to some details about the available data and model, are discussed in this section.

First off, the groundwater model uses the Modular Finite-Difference Groundwater Flow (MODFLOW) code to simulate groundwater flows. MODFLOW is a finite difference code based on the ground flow water equation which is based on uniform laminar groundwater flow (Anderson and Woessner, 1992). In the case of Kuala Lumpur's hydrogeology, both of these assumptions are violated. The fractured limestone aquifers are not uniform and non-laminar flow occurs through the fractures.

The MODFLOW model is instead based on the assumption that on a large scale, say with model cells of 300 m by 300 m, the groundwater system behaves as if it were a porous medium with uniform laminar groundwater flows. This allows the hydraulic conductivity, the most important parameter in the groundwater flow equation, to be calculated. However, this hydraulic conductivity is artificial and describes flow through a completely theoretical 'equivalent porous medium'. The success of this approach lies not in its theoretical beauty but in the fact that it has been applied successfully to model

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groundwater flows in many other studies, across the world (Anderson and Woessner, 1992; Scanlon et al., 2003; Lubczynski and Gurwin, 2005).

The second model assumption is that the groundwater system in Kuala Lumpur is steady-state; that inflows equal outflows and that both are constant. This statement is based on the casual observation that tin ponds have near-constant water levels throughout the year and the assumption that these ponds play a dominant role in regulating the water table, which must therefore also be near-constant. This assumption also allows data to be used from different periods in time as water levels are assumed to be constant. Since there is no continuous monitoring of groundwater levels in Kuala Lumpur, this assumption cannot be confirmed.

In order to construct a reliable model, the data used must be representative for the entire study area: it simply is not. Although there are 1305 measurement points for a model area of 42 by 31 km, there is a deficit in measurement points from the mountainous areas surrounding the valley floor. This causes several problems for interpolation and modelling (Stek, 2008). If certain assumptions (or rather, 'educated guesses') are made about the water table in these mountainous areas, a reasonable model can still be calibrated; nevertheless these assumptions should be confirmed through additional measurements.

To calculate the inflows and outflows of water in the groundwater model, a water balance is constructed that relies on satellite observations to measure evaporation and assumptions about pipe leakage. Both of these methods can be called into question, but they nevertheless give the best available estimate of the current situation. Because large parts of the local hydrogeology remain unexplored, the depth of the model (limited to 300 metre) and the exact location and nature of the hydrological boundaries are still uncertain.

Third, because Kuala Lumpur had tin mining until the 1980's, which lowered local groundwater tables far in excess of 5 metre in the most sensitive limestone areas, it is assumed that a fall of 5 metre or less in the local water table does not pose an environmental threat (Yin, 1986). This assumption is posited here without providing any strong, empirical evidence.

All these assumptions leave the model open to a multiplicity of outcomes: if the assumptions are changed, the outcomes will be different. Even the outcomes generated from the same assumptions may not be the same. Nevertheless, if the assumptions and outcomes are deemed to be reasonable, simulations results should be accepted in the absence of better data. Naturally,

the above assumptions should be verified to confirm the validity of the model results.

SIMULATION RESULTS AND MODEL LIMITATIONS

The model is used to simulate two extreme extraction alternatives: a permanent extraction of 8,000 m^3/day at 12 locations in Kuala Lumpur and a temporary extraction of 80,000 m^3/day at 12 locations that lasts 3 months after which there is a 3-year recovery period. The purpose of these simulations is to test the limitations of two approaches to using groundwater in Kuala Lumpur's water supply. The first simulation considers groundwater as a permanent additional source (yielding 96,000 m^3/day, 1.9% of 2010 projected demand), the second as a source to make up for a temporary shortfall in reservoir storage (yielding 960,000 m^3/day, 19% of 2010 projected demand).

Both alternatives, when simulated in the model, cause a maximum drawdown of 5 m. To get a better appreciation of the model output, please refer to Figure 3. The model is able to simulate where most drawdown is likely to occur (caused by the pumping locations in the limestone aquifer) and how groundwater flows as the water table recovers following the end of groundwater extraction. If the model assumptions can be confirmed using additional measurements, then the model clearly offers valuable simulation results.

Figure 3: Sample model output for 3 month drawdown followed by 3 year recovery.

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It must be noted that the model only provides a rough simulation of the study area: it cannot be used to predict the local effect of groundwater extractions because these are influenced by factors that act on a much smaller scale and therefore cannot be taken into account by the present, large-scale model.

Groundwater modelling, monitoring and extraction are a process of continuous improvement not dissimilar to the Japanese *kaizen* philosophy of industrial process improvement that has been formalised in the ISO 9001:2000 standard. Hence, as more data becomes available, which is generated as pumping gets underway, groundwater modelling efforts and simulation results should be further improved (Von Storch, 2004).

DISCUSSION OF PLANNING IMPLICATONS

The primary argument in favour of groundwater extraction is financial. Adding additional water supply capacity to the Kuala Lumpur water system by developing groundwater resources is cheaper than the main alternative: expanding reservoir capacity. It is this comparison that the first part of this section focuses on, followed by a brief consideration of the current institutional barriers to the implementation of comprehensive groundwater planning. In the last part of this section, physical planning implications are touched upon again, and several points that have already been made in previous sections are briefly revisited.

Financial

To meet Kuala Lumpur's growing demand for water, large investments are being made. The Malaysian government has earmarked RM 8 billion for investment in water supply infrastructure for the period of 2006-2010. Of this, RM 4 billion will be invested in the Pahang Selangor Water Transfer Scheme which, when completed, will provide the Kuala Lumpur Conurbation with 2.2 million m^3/day (Economic Planning Unit, 2005; Ministry of Energy, Water and Communications, 2007).

In this analysis, the Water Transfer Scheme serves as an indicator of the Malaysian government's "willingness to pay" for new water supply infrastructure. The cost of the Water Transfer Scheme is compared to a permanent groundwater extraction project and a temporary groundwater extraction project in Table 1. Although this is an imperfect analysis, as costs are based on rough estimates and the price of the Water Transfer Scheme may be

somewhat inflated because it is financed by soft loans provided by the government of Japan (Barrock, 2007), the cost comparison does provide a starting point to consider the financial implications of groundwater extraction projects in Kuala Lumpur.

Table 1 – Cost comparison of expanding water supply infrastructure.

Cost of expanding water supply capacity with 1 m^3/day	Water Transfer Scheme	Permanent Extraction (100,000 m^3/day)	Temporary Extraction (80,000 m^3/day on average in 10 years)
Sourcing water (i.e. dam or tube well)	1,800 ringgit	600 ringgit	750 ringgit
Treatment	2,200 ringgit	2,200 ringgit	0 ringgit
Total	4,000 ringgit	2,800 ringgit	750 ringgit
Price relative to Transfer Scheme	same	1,200 ringgit less	3,250 ringgit less

All costs are calculated as a price per m^3 of daily water supply capacity. The costs of the Water Transfer Scheme consist of two parts, the construction of a large reservoir (55%) and the construction of water treatment facilities (45%) (Ministry of Energy, Water and Communications, 2007; The Edge, 2007). The cost of the groundwater projects include the construction of tube wells, monitoring wells, some piping and land acquisition at 12 extraction sites and is estimated at a total sum of RM 60 million. In addition to this, there is a cost for constructing treatment capacity, estimated at RM 2,200 per m^3 for all scenarios (Stek, 2008). Note that for the Temporary Extraction scenario there are no treatment costs because in this scenario, unused treatment capacity created by a water shortage is utilised, hence the RM 0.00 investment. Also note that the cost per m^3 of extracted water for the Temporary Extraction scenario is higher (RM 750/m^3) because extraction (800,000 m^3/day during that period) only takes place for three months every 10 years (hence 80,000 m^3/day on average), increasing the cost per m^3 of capacity because the required investment (RM 60 million) does not change.

Essentially this cost analysis suggests that groundwater projects are between RM 120 to 260 million cheaper than obtaining the equivalent water supply capacity from reservoirs. Nevertheless, there are some caveats. First, the Temporary Extraction scheme does not provide regular water supply capacity; it provides extra capacity during water emergencies. This means that decision makers will look at this option differently; they may instead choose to impose water rationing which brings with it minimal investment costs but could cause significant economic disruptions and popular discontent.

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Second, the groundwater extraction schemes carry significant environmental risk. A groundwater extraction program may have to be closed down and the investment written off if environmental problems occur.

These are two kinds of environmental risk: the risk from groundwater extraction itself (mainly the lowering of the water table and induced flows) and the fact that groundwater recharge areas may be inadequately protected due to inadequate or poorly enforced land use planning rules. Kuala Lumpur is largely classified as an Environmentally Sensitive Area, yet local authorities lack the capacity to plan appropriately for this fact.

Institutional

To gain insight into why there has been very little policy or planning with regards to groundwater extraction in Kuala Lumpur, we view the decision-making process from the perspective of Bressers, who stresses the importance of policy coherence between different actors (Bressers et al, 2003). Bressers' theories were developed by studying decision making in European Union water management projects and there are many parallels between this situation and the complex interaction between actors of Malaysia's local, state and federal governments.

Bressers maintains that policy coherence between all relevant policy actors is absolutely necessary to manage water in a sustainable way. This is because it entails policy actors adapting to each other, stabilising the water management regime and ensuring the commitment and cooperation necessary to carry out sustainable water policies. Policy coherence cannot simply be imposed, because there is no policy actor that has full control and is able to do it. Even a powerful government agency will need to respect property rights, legal jurisdictions and prevailing interests (Bressers, et al, 2003).

Bressers also observes that there are several key barriers to making groundwater policy that prevent a win-win situation or profitable trade-offs between policy actors. Uncertainty, along with the problem's complexity, the long-term time-scale of groundwater changes and pluralism (i.e. the presence of multiple policy actors) can prevent effective decision making (Bressers, et al., 2003).

Regulation of groundwater in Kuala Lumpur is highly fragmented as more than 13 government actors dealing with groundwater can be identified (see Table 2). These institutions are discussed below, starting with the

distribution of state and federal responsibilities, a description of state agencies, federal agencies and then the role of local authorities and private parties.

Table 2: Overview of organisations dealing with groundwater in Kuala Lumpur Conurbation.

Federal Agencies	Ministry of Natural Resources and Environment • Department of Environment • Department of Minerals and Geoscience • National Hydraulic Research Institute Malaysia Ministry of Federal Territories • Kuala Lumpur City Hall Ministry of Energy, Water and Communications • National Water Services Commission Treasury (Ministry of Finance) • Water Asset Holding Company Ministry of Health
Federal and State Agencies	Ministry of Natural Resources and Environment • Department of Irrigation and Drainage Ministry of Housing and Local Government • Town and Country Planning Department Ministry of Public Works • Department of Public Works
Selangor State Agencies	Selangor Waters Management Authority Kumpulan Darul Ehsan Berhad (Selangor State Investment Company) Local Authorities of Selangor State such as Ampang Jaya Municipal Council, Petaling Jaya City Council, etc.
Private Companies	Selangor Water Supply Corporation

Malaysia is a federation in which state governments have significant autonomy. Under article 73 of the federal constitution, state governments have jurisdiction over water and land resources, whereas the federal government can legislate on interstate issues such as pollution control, mining and public health (Perunding Zaaba, 1999). However during the past decades financial resources and decision making have increasingly moved towards the Federal Government, making states more dependent on it to fulfil their constitutional obligations (Jomo and Wee, 2003).

Selangor state has created a single agency, the Selangor Waters Management Authority, to manage its key responsibilities in the fields of water resources and water supply. In Selangor and Kuala Lumpur the water supply system is operated by the Selangor Water Supply Corporation, a private company which has a concession granted by the Selangor state government and which is part-owned by the Selangor State Investment Company – Kumpulan Darul Ehsan Berhad (KDEB).

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The Selangor Waters Management Authority relies on expertise from the federal government's Department of Minerals and Geoscience and the Department of Environment to carry out its duties. At the state level, the Selangor Waters Management Authority interacts with the Department of Irrigation and Drainage and the Public Works Department. These two agencies are involved in the design and construction of physical infrastructure. The Town and Country Planning Department is responsible for land use planning at the national and state levels, which includes gazetting sensitive riparian areas and groundwater recharge zones.

The Selangor Water Supply Corporation, being a private water utility, is regulated by the federal government's National Water Services Commission. The Commission regulates water prices, piped water quality and water delivery. The Selangor Water Supply Corporation buys water from water treatment plants which are operated by other companies. Some of these plants are privately owned, others are owned by the state government or the federal government's Water Asset Holding Company. Because the Selangor Water Supply Corporation supplies drinking water, it is also supervised by the Ministry of Health which operates small-scale water supply projects in some rural areas, but not in Kuala Lumpur.

The Department of Irrigation and Drainage, the Department of Public Works and the Department of Town and Country Planning are federal departments but the state governments hold significant powers over their state level operations. The Department of Environment and the Department of Minerals and Geoscience are pure federal agencies who assist state governments but are not controlled by them.

Local authorities such as Kuala Lumpur City Hall are required to monitor development in Environmentally Sensitive Areas and withhold building permits if it is deemed prudent to do so (Institute of Environment and Development, 1997). Local authorities fall under the control of the state government (there are no local elections), and in the case of Kuala Lumpur, which is a federal territory, under the Ministry of Federal Territories.

It is important to note that the Selangor Waters Management Authority faces several 'holes' in its jurisdiction, notably Kuala Lumpur. In Kuala Lumpur, the Selangor state government is required to supply water (a duty carried out by the Selangor Waters Supply Corporation) but it has no jurisdiction over the city's water resources. Research on water management issues is conducted by the National Hydraulic Research Institute Malaysia, an institute of the Ministry of Natural Resources and Environment.

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To fully appreciate the problems this fragmentation brings, it is important to note that the Malaysian government is very legalistic and hierarchical. This can prevent cooperation between different levels of government. This legalistic nature of the government is evident from the following example about groundwater monitoring activities. The Department of Environment monitors groundwater quality as part of its tasks to control pollution under the Environmental Quality Act (1974). The Department of Minerals and Geoscience monitors groundwater levels because it has to study hydrogeology as instructed by the Geological Survey Act (1974). This leads to the peculiar situation where both departments operate completely separate groundwater monitoring networks. At Department of Environment wells only groundwater quality is measured. At Department of Minerals and Geoscience wells only groundwater levels are measured. However both departments fall under the same Ministry of Natural Resources and Environment.

In terms of hierarchy, federal ministers and state chief ministers have roughly the same level of authority. So for a comprehensive groundwater policy to be initiated in Kuala Lumpur, the chief minister of Selangor and eight federal ministers must reach agreement. This fragmentation of authority makes regulation of water resources in Malaysia ineffective (Zakaria, 2001; Madsen, et al., 2003; Mutadir, 2006).

Only the Prime Minister, backed by the federal parliament and the treasury, has a higher standing than the federal ministers and the chief ministers. The Economic Planning Unit of the Prime Minister's department establishes 5-year plans which direct policy for all ministries and state governments. The current 5-year plan (2006-2010) is the Ninth Malaysia Plan.

The hierarchical structure of Malaysia's government is very suitable for pushing through large projects such as the Pahang Selangor Water Transfer Scheme, the Kuala Lumpur International Airport or the Kuala Lumpur Light Rail Transit but it makes coordination of small-scale projects much more difficult as many issues, including jurisdiction and funding, need to be resolved. To solve this problem, the federal Treasury could instead allocate grants for groundwater development, but leave government agencies or consortia of government and private agencies to come up with a plan, forcing them to work together. The advantage of the grant system is that it leaves the current institutional landscape intact while giving the federal government the ability to direct water policy, without micro-managing it. This is an advantage, considering that the Economic Planning Unit or the Treasury cannot and should not know enough about water management.

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By forcing agencies to work together, enforcement and monitoring activities can be rationalised and expertise combined. The federal Treasury could then appoint a committee of experts to select the best plan. Such procedures are also used by the European Union to disburse nearly 347 billion euro in grants via the European Structural Fund and the European Cohesion Fund to finance infrastructure and socio-economic developments in its 27 member states (European Commission, 2006).

Physical

Although a comprehensive description of how groundwater development in Kuala Lumpur should be planned is far beyond the scope of this paper, but there are several criteria that can be formulated based on which groundwater related land-use planning should take place. Tin ponds have an important role to play in regulating the groundwater table, especially in the fractured limestone aquifers. City Hall is also constructing many flood retention ponds that could double as infiltration ponds. However, in all cases, land use planning must ensure that polluted runoff does not reach the ponds to protect the groundwater system (Kuala Lumpur City Hall, 2000).

Groundwater recharge areas have already been delineated by the Department of Town and Country Planning as protected areas, however appropriate environmental management by local authorities remains a problem that must be addressed through better planning at the municipal level. Infrastructure that may influence groundwater quantity and quality, such as large-scale urbanisation, the construction of reservoirs and land-fills and the location of potentially hazardous industrial facilities, must take into account the possible use of groundwater in the future as the rehabilitating groundwater systems is a long-term and potentially very expensive process.

At a more macro land use planning level, having access to a safe and reliable supply of groundwater may make certain areas more attractive to residents and certain industries. A high technology manufacturer that uses large quantities of water or a five star hotel must have access to a reliable water supply to operate. Hence zones where high-value activity takes place should be planned in areas where the water supply can be guaranteed, either by diverting water from other areas or providing locally available groundwater.

At the micro-level, land-use planners should also consider possible locations of pump sites in the design and planning of new water supply infrastructure. Optimum locations for tube wells are (1) close to water treatment facilities, (2) close to recharge areas to minimise potentially adverse

groundwater flows, (3) far away from environmental risks and (4) easily accessible for monitoring and maintenance.

CONCLUSIONS

The motivation for exploring groundwater as a potential source of potable water is clear: groundwater stored underneath Kuala Lumpur is independent of short-term rainfall patterns and it can thus make up for a shortfall from rainfall-dependent reservoirs when Kuala Lumpur faces another water crisis.

Some planning criteria have been outlined above; however the main obstacle facing engineers, environmental scientists and town planners alike is a lack of data. It is impossible to make good planning decisions without adequate information. Therefore, the iterative process of groundwater planning: research, decision making and then providing funding for additional research, is exceptionally important. It requires cooperation between different parts of the government which is very difficult under current circumstances.

In a world of dwindling water supply and growing water demand, careful water and land use planning may ensure that Kuala Lumpur is able to meet demand even during periods of reduced supply. This is as much a social issue as an economic one, as scarcity will increase the value of the city's water resources.

But this value can only be tapped through comprehensive and long-term planning which protects groundwater recharge areas while exploiting the available groundwater resources sustainably and efficiently, adding to the city's competitive advantage and prosperity.

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POWERS OF THE LOCAL AUTHORITY IN REGULATING LAND PLANNING AND DEVELOPMENT CONTROL: WHITHER CONTROL

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Abstract

Land use planning in Malaysia as regulated by the Town and Country Planning Act 1976 ("Act 172") vests in the local authorities' wide powers and responsibility for managing and carrying on the daily administration of land use planning decision making and development control regime. This article examines the powers of the local authority in regulating land planning and development control and the power of the courts in exercising control over the exercise of the discretionary powers of the local authority.

Keywords: Local authority, Land planning and development control, indemnity, judicial supervision

INTRODUCTION

Local authorities assume an extremely important role in the administration of local authority areas. A local authority is a unit within the system of local government and is established to manage its affairs[3]. The local authority administration is a politico-administrative system, constituted by law, and having devolved powers. The United Nations has defined it as a political subdivision of a nation or (in a federal system) state which is constituted by law

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[3] The United Nations considers both the terms local government and local authorities as synonymous and as such can be used interchangeably.

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and has substantial control over local affairs, including the power to impose taxes[4].

The local authority construct, operate, and maintain economic, social and environmental infrastructure, oversee land planning and development control processes, establish local environmental policies and regulations, and assist in implementing national and sub-national environmental policies. As the level of government closest to the people, they play a vital role in educating, mobilizing and responding to the public to promote sustainable development.[5] Towards realizing this, the local authorities are vested with wide discretionary powers by the empowering legislation o as to enable it to manage the local authority area's planning and development control matters for the principal purpose of ensuring comfort for the residents. It is thus useful to examine the powers of the local authority in administering the land planning and development control regime and the extent of its discretionary powers as well as the role of the courts in supervising the exercise of the discretionary powers.

INSTITUTIONAL AND ADMINISTRATIVE FRAMEWORK

The hierarchy of administration of the local authority is the creation of the Federal Constitution Malaysia 1957 ("Federal Constitution"). The Federal Constitution delineates the mandates, responsibilities and jurisdictions of the Federal and State Governments[6]. This is the essence of federalism that has been described as "the establishment of a single political system, within which, general and regional governments are assigned to coordinate authority (rights and powers) such that neither level of government is legally or politically subordinate to the other"[7].

Land is listed in the State List together with agriculture, forestry and water. Thus, this effectively places the State Authority[8] as the ultimate authority

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[4] United Nation, 1962 p. 89

[5] Chapter 28 of Agenda 21: "Local Authorities' Activities in Support of Agenda 21"

[6] See articles 74, 95B and Schedules 9-10 of the Federal Constitution of Malaysia of 1957; see also Item 2, State List, Ninth Schedule, Constitution of Malaysia.

[7] Watts, R.L, *New Federations: Experiments in the Commonwealth,* (Oxford, Clarendon Press, 1966) at p.13.

[8] State Authority, refers to the Ruler or *Yang di-Pertua Negeri* of a State and includes, in Negeri Sembilan, the *Yang di-Pertuan Besar* acting on behalf of himself and the Ruling Chiefs (see Section 3 of the Interpretation Acts 1948 and 1967). The term includes the decision making body in the highest hierarchy in a State. Refer *Sentul Murni Sdn. Bhd. v Ahmad Amiruddin Bin Kamaruddin & Ors.*[2000] 4 MLJ 503.

for matters related to all land dealings, including alienation, subdivision, type of land use, extraction or minerals, compulsory acquisition and reservation of land. Local government is a matter listed in the State List, thus empowering the State Authorities to organise local governments and municipal services.[9] Local governments established under the Local Government Act 1976 ("Act 171") are primarily responsible for health, sanitary condition, amenities and the general well being of its residents, and administration of matters relating to land planning and development control by the powers conferred by Act 172. The administration of the planning system and development control is within the exclusive powers of the state and local governments despite of their relying heavily on the Federal government for funds and other resources.[10]

The State Authorities are responsible for organising the local government and municipal services and assume the position of "central government" to the local authority. The local authority in Malaysia is the principal government agency empowered to exercise control at the local level. This gives rise to lack of uniformity in the administration of town and country planning laws in the states of Malaysia, despite Act 172 manifesting its aim of promoting uniformity in the planning law in the West Peninsular Malaysian states.[11] Sensing the lack of uniformity in the implementation of the planning legislation and rules in the States, the National Physical Planning Council was established in 2002, to ensure some form of coordination in implementing and enforcing of planning laws in all the states as envisaged by the Federal government principally to promote sustainable development and also overcome regional economic imbalances.[12] However, the Council's power to control the States' or the local planning authority in regulating land use planning has yet to be tested in a court of law.

LEGAL REGULATORY FRAMEWORK

The Act 171 provides various powers for local authority for regulating local authority areas for ensuring proper administration of affairs of local authority areas to ensure comfort of the residents in the area. The local authorities in

[9] Local Government Act 1976 s 3

[10] For a detailed discussion on the historical aspects related to organisation of the Malaysian Local Government System, can refer Taylor W.C., *Local Government in Malaya,* (Alor Setar, Kedah Government Press, 1949).

[11] Town and Country Planning Act 1976 Preamble

[12] The provision on the National Physical Planning Council was inserted into the Town and Country Planning Act 1976 by the Town and Country Planning (Amendment) Act 2001 (Act A1129) s 7 wef on 1st March 2002.

Malaysia have been vested with discretionary powers by Act 171. The functions not only include mandatory functions but discretionary functions as well. The mandatory functions include all critical functions such as refuse collection, street lighting and activities pertaining to public health. Discretionary functions include all development functions such as providing amenities, recreational parks, housing and commercial activities. The provisions of the Local Government Act grant the local authorities the roles of local planning authority; licensing authority; taxation authority with power to impose certain kinds of taxes; Undertake building, housing and commercial construction (markets, hawker stalls etc.); Power to perform urban planning and management functions; Traffic management and control (manage urban public transport systems); and Power to plan and provide public utilities.

Act 171 provides local authorities in Malaysia with a very comprehensive set of functions and responsibilities. Two other major legislations are Act 172, and the Street, Drainage and Building Act (1974), help local governments to perform their functions under the Act 171. The legislation allows the local authorities to assume developmental functions in the field of urban management and play a more dynamic role in national development. According to Mohamed Afandi, the provision of the related local government laws empowers the local authorities to carry out a whole range of functions, limited only by their own ambitions and resources.[13] The major functions of local authorities can be summarized as environmental, public, social and developmental. The functioning of local authority is based on the principle of *ultra-vires* and general competence as such it may perform those functions as specifically enumerated in the legislation, bylaws and rules. It has no general competence to undertake any activity according to affordability, it cannot undertake any activity that is beyond its powers or else it can be declared as *ultra-vires*. It is a body corporate that can sue and be sued.

Act 172 confers on the local authority the powers to control land use planning, control and conservation of all lands and buildings within their local authority area.[14] In areas within a State, which does not come under the jurisdiction of any local authority area, the State Director will assume the role of the local planning authority. Act 172 is applicable to all the local planning authorities in the states of Peninsular Malaysia with the exception of the Federal Territory. The Federal Territory planning authority is governed by the Federal

[13] Mohamed Afandi, *Local Government Restructuring in Peninsular Malaysia: A Review of the Local Authority Function and Capacity, in Planning and Administration*, Volume 16 No. 2, Autumn, IULA, The Hague, 1989 at p. 125.
[14] Town and Country Planning Act 1976 s 5.

Territory (Planning) Act 1982 (Act 267). The East Malaysian states of Sabah and Sarawak are regulated by other legislation and are not bound by Act 172.[15]

The local authority assumes the functions of a local planning authority as conferred by section 5 of Act 172 and carries out the following functions:[16]

(a) To regulate, control, and plan the development and use of all lands and buildings within its area;
(b) To undertake, assist in, and encourage the collection, maintenance, and publication of statistics, bulletins, and monographs, and other publications relating to town and country planning and its methodology; and
(c) To perform such other functions as the State Authority or the Committee may from time to time assign to it.

The local planning authority can perform all other functions that are supplemental, incidental, or consequential to any of its specified functions and do all such things as may be necessary or expedient for carrying out its planning functions under Act 172.[17]

LAND PLANNING AND DEVELOPMENT CONTROL FUNCTIONS

The local planning authority is required to prepare a local plan for the whole of its area for purposes of guiding it in planning development in its area.[18] A local plan is a written statement prepared to elaborate the policies and proposals set out in the structure plan. It comprises of written statement and diagrams setting out the detailed planning, and manner of executing and implementing the proposals set out in the structure plan of a local planning authority area. The principal aim of the local plan is to prepare a land use plan in accordance with the procedural requirements set out in of Act 172 and the Development Plans Rules taking into consideration all the national and state land use and development policies. The local plan will be a reference for the local planning authority, government departments and agencies as well as the private sector in the process of planning of land development activities. The functions of the local plan is to interpret the policies and representations from the public

[15] Law applicable to the State of Sabah is the Town and Country Planning Ordinance 1950 of Sabah [Sabah Cap.141] and law applicable to Sarawak is the Town and Country Planning Ordinance 1952 of Sarawak [Sarawak Cap.87];
[16] Functions as prescribed in Town and Country Planning Act 1976 s 6(1)
[17] Town and Country Planning Act 1976 s 6(2)
[18] Town and Country Planning Act 1976 s 12(2)

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incorporated in the structure plan and to implement such aspects in line with the social development, economic and use of resources in a local planning authority area. The local plan is also important in setting out the basic guidelines for the local planning authority, and to identify the aspects related to the action areas which are in need of urgent attention. A local plan in respect of a local planning authority area may be prepared by the local planning authority before the approval of a draft structure plan if they consider it worth having.

In formulating its proposals in a draft local plan, the local planning authority is required to confirm that the proposals conform generally to the structure plan for the State, irrespective as to whether the plan has come into effect, and is required to have regard of any information and other considerations that appears to it to be relevant, or prescribed,[19] or that the Committee can in any particular case direct it to take into account.[20] The local planning authority, upon being directed by the Committee as soon as practicable is required to prepare for that part a draft local plan of such nature as may be specified in the direction.[21]

Act 172 does not expressly provide that planning permission must be granted if the development in respect of which permission is applied for would not contravene any provision of the development plan. Planning permission could be refused even if the development in respect of which permission is applied for would not contravene any provision of the development plan. In *Chong & Co. Sdn Bhd v Majlis Perbandaran Pulau Pinang*[22] it was decided that even if the development in respect of which permission was applied would not contravene any provision of the structure plan, planning permission could be validly refused on account of the provisions that the planning authority thinks are likely to be made in any development under preparation or to be prepared, or the proposals relating to those proposals. The development plan was definitely not the only matter to be taken into consideration.

It is the responsibility of the planning authority to plan and enforce laws to ensure managed and orderly growth of their local authority areas. Local authority is also entrusted to realise the government's development policies and assist in revitalising the economy of their local authority area. The planning authority exercises control over land development activities by making it

[19] Prescribed by the Committee pursuant to the powers vested on it by the Town and Country Planning Act 1976
[20] Town and Country Planning Act 1976 s 12(8)
[21] Town and Country Planning Act 1976 s 12 (6)
[22] *Chong & Co Sdn Bhd v Majlis Perbandaran Pulau Pinang* [2000] 5 MLJ 130

compulsory to obtain planning permission prior to carrying out any land development activity.[23]

The planning authorities have powers to issue directions for developments involving the erection of a building.[24] However, issuance of such directions cannot be deemed as approval of an application. The local planning authority reserves the right to reject any application even if an application has complied with the required directions. In *Tetuan Sri Bangunan Sdn Bhd v Majlis Perbandaran Pulau Pinang,*[25] the court held that directions made by the local planning authority under section 21(3) of Act 172 are not a decision made under section 22(3) of Act 172.

This powers could possibly be used to impose absurd, unjust and inequitable directions, which may leave the applicant aggrieved and without any course of appeal. Act 172 is silent as to the recourse that is available to an applicant who does not agree with the directions imposed pursuant to section 21 of Act 172. The applicant must amend the building plan to ensure they take abroad all the directions made by the local planning authority. If the applicant fails to amend and resubmit the application within the specified time, then he is deemed to have withdrawn the application.[26] Appeal against the issuance of directions cannot be made to the Appeal Board established pursuant to section 36 of Act 172. Appeal can only be made against a decision made under section 22(3) of Act 172 where the local planning authority makes a decision on the application for planning permission either approve, approve subject to conditions or reject altogether the application.

The planning authority is required to consult other related government agencies and statutory bodies to obtain their views and recommendations on a proposed development.[27] This is important to ensure such all development will comply with stipulations prescribed by other statutes and relevant government regulatory agencies.[28]

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[23] Town and Country Planning Act 1976 S 19(1)
[24] Town and Country Planning Act 1976 s 21(3)
[25] *Tetuan Sri Bangunan Sdn. Bhd. v Majlis Perbandaran Pulau Pinang* [2006]
[26] Town and Country Planning Act 1976 s 22(5); See *Tetuan Sri Bangunan Sdn. Bhd. v Majlis Perbandaran Pulau Pinang* [1998] 2 AMR 1053.
[27] Town and Country Planning Act 1976 s 22(1)
[28] Rule 9 Town and Country Planning Act 1976 Planning Control (General) Rules 1990

In *Bencon Development Sdn. Bhd. v Majlis Perbandaran Pulau Pinang,*[29] the court held that the Majlis Perbandaran Pulau Pinang as the approving authority should obtain technical advises from other relevant government departments. Act 172 has not provided the mode of consultation and the authorities to be consulted. This also gives the local planning authority the discretion on deciding the mode of consultation and consideration of the input.

The local planning authority is also required to notify applications for planning permission to provide an opportunity for the adjoining neighbour of the proposed development to make objections.[30] This is an important process wherein it provides, the adjoining neighbour (landowner) with the opportunity to put forward their views on the proposed development that may pose adverse impact to their property or person. However, such right to participate is only available if there is no local plan for the area involved.[31] It is suggested that it would be useful for ensuring proper planning practice if adjoining neighbour can be permitted to participate in the decision making process irrespective if there is a local plan in existence or not.

PROTECTION AND INDEMNITY IN PERFORMANCE OF FUNCTIONS

Local authority and its agents are deemed to be public servants. Every member and agent of the local planning authority, every authorized person, and every assistant or workman accompanying or assisting an authorized person in the performance of his functions under Act 172 will be deemed to be public servants for the purposes of the Penal Code.[32] The Public Authorities Protection Act 1948 (Act 198) is applicable to any action, suit, prosecution, or proceeding against the local planning authority, every member and agent, every member of the Appeal Board, every authorized person, and every assistant or workman accompanying or assisting an authorized person in the performance of his functions under Act 172, in respect of any act, neglect, or default done or committed by the authority, member, person, assistant, or workman in his

[29] *Bencon Development Sdn. Bhd. v Majlis Perbandaran Pulau Pinang* [1999] 2 MLJ 385; See also *Chong & Co v Majlis Perbandaran Pulau Pinang* [2000] 5 MLJ 130
[30] Town and Country Planning Act 1976 s 21(6): Refer also case of *Ah San @ Goh Ah Soon v Majlis Bandaraya Ipoh & Ors* [2000] 1 MLJ 615
[31] In *Leila Dulcie Allana Labrooy & 9 Ors. v Majlis Bandaraya Ipoh & Anor* [1995] 4 CLJ 727.
[32] Town and Country Planning Act 1976 s 53

capacity as such.[33] Section 54 of Act 172, provides protection for the officers who, in administering the planning functions as provided in Act 172, carry out their duties in good faith in accordance with their statutory powers. The court interpreted the term local authority to exclude the government of Malaysia, where it said that local authorities and Government of Malaysia are distinct bodies.[34]

No matter or thing done and no contract entered into by any State Authority and no matter or thing done by any officer employed in the administration of the the planning functions,[2] or other persons acting under the direction of the State Authority will if the matter or thing was done or the contract was entered into in good faith (*bona fide*) for the purpose of executing the functions entrusted by law, subject them or any of them personally to any action, liability, claim or demand whatsoever[3].

The State Authority, local authority[4] and any public officer or officer or employee of the local authority may not be subject to any action, claim, liabilities or demand whatsoever arising out of any building[5] or other works carried out in accordance with the provisions of the Act or any by- laws[6] made under it or by reason of the fact that such building works or the plans thereof are subject to inspection and approval by the State Authority, local authority or such public officer or officer or employee of the State Authority or the local authority and nothing in the Act or any by- laws made under it may make it obligatory for the State Authority or the local authority to inspect any building, building to ascertain that the provisions of the Act or by-laws are complied with or that plans, certificates and notices[7] submitted to him are accurate[8]. Any expenses incurred the State Authority, officer or other person acting in accordance with the above provisions will be borne by the local authority[9].

The court in *Steven Phoa Cheng Loon & Ors v Highland Properties Sdn Bhd & Ors.*[35] when asked to decided on the liability of the officer of the local authority held that by the provisions of sections 5, 6(1), 6(4), and 18 of the Government Proceedings Act, the particular officer or officers in the Government who committed the tortuous wrong must be identified otherwise the claim against government will fail. Section 5 of the Government

[33] Town and Country Planning Act 1976 s 54; Refer *Baltim Timber Sdn Bhd v Director of Forests & Ors* [1996] 4 MLJ 103 for related discussion on the protection of public authorities in performing their official functions.
[34] see Lee Hun Hoe CJ in *Government of Malaysia & Anor v Akasah Bin Ahad* [1986] 1 MLJ 396 at p.399.
[35] *Steven Phoa Cheng Loon & Ors v Highland Properties Sdn Bhd & Ors* [2000] 4 MLJ 200

Proceedings Act 1956[36] provides that, subject to the Act, the Government shall be liable for *any wrongful act done or any neglect or default committed by any public officer* in the same manner and to the same extent as that in which a principal, being a private person, is liable for any wrongful act done, or any neglect or default committed by his agent, and for the purposes of this section and without prejudice to the generality thereof, any public officer acting or purporting in good faith to be acting in pursuance of a duty imposed by law shall be deemed to be the agent of and to be acting under the instructions of section 6(1) of the Government Proceedings Act 1956 that provides that no proceeding can be brought against the Government by virtue of section 5 in respect of *any act, neglect or default of any public officer*, unless proceedings for damages in respect of such act, neglect or default would have *lain against such officer personally*. The Court decided that the local authority is protected by virtue of the provision of section 95(2) of the Street, Drainage and Building Act 1974.

The local authorities are also protected by sections 123-126 of the Local Government Act 1976. In *Dr Abdul Hamid Abdul Rashid & Anor v Jurusan Malaysia Consultants,*[37] the Court supporting the concept of economical loss is recoverable said that, "If there is any fear that this approach may encumber the local authorities to pay out substantial claims due to their negligence in granting approvals or inspecting building works, there is section 95 of the Street, Drainage and Building Act 1974 which prohibits such authorities to be sued.

JUDICIAL AUTHORITY OVER LOCAL PLANNING AUTHORITY

The statute confers wide discretionary powers to the planning authorities. Judicial control and central government policy is available in Malaysia to ensure some form of control over the decisions. However, judicial control of the discretionary powers to impose planning conditions in Malaysia is relatively undeveloped. Thus, reference is often made to the English courts, which have developed legal tests for the validity of planning conditions over the years. Malaysian courts have accepted the reasonableness test pronounced by Lord Greene MR in *Associated Provincial Picture Houses Limited v Wednesbury*

[36] Government Proceedings Act 1956 s 5
[37] *Dr Abdul Hamid Abdul Rashid & Anor v Jurusan Malaysia Consultants* [1997] 3 MLJ 546

Corporation[38] (*'Wednesbury case'*) where his Lordship said that what needs to be determined is as to whether the local planning authority in imposing a condition had acted reasonably.

The local planning authority has power "to impose such conditions[39] as it thinks fit to impose" on a grant of planning permission. The conditions are stipulated in section 21(3) of Act 172. In *Dr Benjamin George & Ors v Majlis Perbandaran Ampang Jaya & Ors*,[40] it was held that the conditions that can be imposed on an application for planning permission by the local planning authority are pursuant to provisions of section 21(3) of Act 172. The conditions that may be imposed by the local planning authority can also be based on the matters related to the development proposal report and the layout plans.[41] In *Chong & Co. Sdn. Bhd. v Majlis Perbandaran Pulau Pinang*,[42] the court affirmed the rights of the local planning authority to impose such conditions as it "thinks fit."

The directions imposed by the local planning authority pursuant to the provisions of section 21(3) of Act 172 cannot be made subject to an appeal to any other authorities since right to appeal is only in respect of the decision made pursuant to section 22(3) of Act 172. The provisions of s 23(2) of Act 172 cannot be circumvented by directions under s 21 or by indecision. A local planning authority must decide on an application for planning permission. It is the intention of Act 172 that there is a speedy disposal of applications for planning permission and a right of appeal to aggrieved applicants. The application of the words in Act 172 must produce that result and that result would be produced only by construing the word 'decision' not only in the literal sense (grant or refusal of planning permission) but also in the wider sense (no decision on the application), so that a local planning authority could not refuse to decide on an application, and also so that an applicant who would be aggrieved by no decision could appeal to the Appeal Board. The Planning Appeal Board is also not empowered to entertain appeals against the decision of the local planning authority to give directions pursuant to the provisions of section 21(3) of Act 172.

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[38] *Associated Provincial Picture Houses Limited v Wednesbury Corporation* [1948] 1 KB 223.

[39] "Subject to such conditions", see Town and Country Planning Act 1976 s 22(5) as to the conditional grant of planning permission.

[40] *Dr Benjamin George & Ors. v Majlis Perbandaran Ampang Jaya & Ors.* [1995] 3 MLJ 665.

[41] Town and Country Planning Act 1976 s 21B on preparation of layout plans and s 21A on development proposal report and matters to be included in such plans.

[42] *Chong & Co. Sdn. Bhd. v Majlis Perbandaran Pulau Pinang* [2000] 5 MLJ 130.

The statutory guidance appears to be rather limited, thus conferring wide powers to the planning authorities. Judicial control and central government policy is available in Malaysia to ensure some form of control over the decisions. However, judicial control of the discretionary powers to impose planning conditions in Malaysia is relatively undeveloped. Thus, reference is often made to the English courts, which have developed legal tests for the validity of planning conditions over the years. Malaysian courts have accepted the reasonableness test pronounced by Lord Greene MR in the *Wednesbury case*[43] where his Lordship said that what needs to be determined is as to whether the local planning authority in imposing a condition had acted reasonably.

Suffian L.P. in *Pengarah Tanah dan Galian Wilayah Persekutuan v Sri Lempah Enterprise Sdn. Bhd.*[44] (*"Sri Lempah case"*) was approached to decide as to whether the condition imposed on the landowner by the planning authority is valid. The court expounded the following principles could be followed in determining the validity of planning conditions:[45]

a. the approving authority does not have an uncontrolled discretion to impose whatever conditions it likes;
b. the conditions to be valid, must fairly and reasonably relate to the permitted development;
c. the approving authority must act reasonably and planning conditions must be reasonable;
d. the approving authority is not at liberty to use its power for an ulterior object, however desirable that object may seem to be in the public interest.

Therefore, in exercising its discretion in approving an application for planning permission, the planning authorities is required to have regard to all relevant considerations, disregard all improper considerations and produce a result, which does not offend against common sense as decided by Lord Greene in *Associated Provincial Picture Houses Ltd v Wednesbury Corporation.*[46]

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[43] *Associated Provincial Picture Houses Limited v Wednesbury Corporation* [1948] 1 KB 223.
[44] *Pengarah Tanah dan Galian Wilayah Persekutuan v Sri Lempah Enterprise Sdn. Bhd.*[1979] 1 MLJ 135.
[45] Followed *Fawcett Properties v Buckingham County Council* (1950) Ch 543 (CA) and (1961) AC 636 (HL).
[46] *Associated Provincial Picture Houses Ltd v Wednesbury Corporation*[1948]1 KB 223

In *Majlis Perbandaran Pulau Pinang v Syarikat Bekerjasama-sama Serbaguna Sungai Gelugor dengan Tanggungan,*[47] (*"Syarikat Bekerjasama"*) the Federal Court had to decide whether it was permissible for a planning authority to impose a planning condition relating to affordable housing accommodation and used the following tests:

a. they must be imposed for a planning purpose and not for an ulterior motive;
b. they must fairly and reasonably relate to the development permitted; and
c. they must not be perverse ("so unreasonable that no reasonable authority could have imposed them").

On the first point, the court determined whether affordable housing was a permissible planning purpose. After considering the Structure Plan policies containing stipulations as to affordable housing and section 8(4) of Act 172 as to the relevancy of current policies in formulating the Structure Plan, the court held that the appellant has the power to impose a planning condition to give effect to affordable housing.[48] The court decided on the second point that the imposition of the condition was not *ultra vires* the powers of the planning authority.

In *Rethina Development Sdn. Bhd. v Majlis Perbandaran Seberang Perai, Butterworth,*[49] Rethina Development (plaintiff) applied for and obtained planning permission to build flats and shophouses in a housing scheme. In the layout plan approved by the Council, it required the developer to carry out landscaping and tree planting. The developer agreed to the requirement and to pay monetary contribution to the Council at the fixed rate. The issue before the court was whether the Council was empowered to impose monetary contributions in lieu of complying with an agreed planning condition. The court in deciding in favour of the developer granted the orders. The court held that any direction to a developer for carrying out landscaping and planting of trees in a housing scheme does not come within the meaning of 'any other matter' in section 21(3) of Act 172 which the local planning authority considers necessary for the purposes of planning. The local planning authority is not empowered in law to demand for payment of monetary contribution for landscaping and tree

[47] *Majlis Perbandaran Pulau Pinang v Syarikat Bekerjasama-sama Serbaguna Sungai Gelugor dengan Tanggungan* [1999] 3 MLJ 1
[48] *Ibid* at p.54.
[49] *Rethina Development Sdn. Bhd. v Majlis Perbandaran Seberang Perai, Butterworth* [1990] 2 MLJ 111

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planting in lieu of the requirement imposed on the developer. In the circumstances the Council was ordered to refund all the monies collected from the developer.

The authorities are not at liberty to use their powers for an ulterior object; however, desirable that object may seem to them to be in the public interest. If they mistake or misuse their powers, even in good faith, the Court can interfere by declaration and injunction. Thus, the powers of the local planning authorities to impose planning conditions are not uncontrolled. The Malaysian courts, however, often refrain from reviewing the decision of the planning authorities because such decisions involve policy consideration and 'the courts do not possess knowledge of the policy considerations which underlie such decisions'.[50] In *Sri Lempah* case,[51] it was held that the court is not an appellate authority that has more powers than the approving authority but merely a judicial authority is authorized to examine as to whether the approving authority has acted outside the statutory powers. Further, no court should pretend that it knows more or better about town planning than town planners themselves. Courts are concerned with law, not planning.

CONCLUSION

The law enacted to regulate affairs of local authority vests wide discretionary powers on the local authorities in the course of exercising its functions related to administration, planning and development control in local authority areas. These powers are necessary to help them execute the vast responsibilities entrusted upon them. The power to indemnify local authorities against losses arising from negligence is a necessary evil. However, this power must not be left unchecked since it can lead to abuse of discretion. The courts very often refrain from controlling the powers of the local planning authorities. Analysis of case law amplifies the fact that the discretionary powers are not absolutely free from judicial check and control. Similar to any other administrative or government agent, the local authority must use their powers judiciously and within the limits of the powers prescribed by law to prevent the court from questioning their decisions.

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[50] *Datuk Bandar Kuala Lumpur v Zain Azahari bin Zainal Abidin* [1997] 2 MLJ 17.
[51] *Pengarah Tanah dan Galian Wilayah Persekutuan v Sri Lempah Enterprise Sdn.Bhd.* [1979] 1 MLJ 135 (FC).

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AUSTRALIA PLANNING REPORT CARD – TELLING IT LIKE IT IS!

Liz de Chasterl[1]
National Policy Manager
PLANNING INSTITUTE OF AUSTRALIA

OVERVIEW

Are we doing what is needed in the critical areas for creating effective, functional and sustainable cities, towns, neighbourhoods and regions? Every year Australian planning professionals are asked by the Planning Institute of Australia (PIA) for their expert opinions on how we are performing in key areas critical to the health and wellbeing of our cities.

The first poll was conducted in 2006. The results, released on World Town Planning Day, 8 November, attracted considerable media, political and community interest. In 2007 over 740 planners responded to the survey 'telling it like it is' and more respondents are expected in 2008.

This article provides an overview of the Planning Report Card and more detailed information can be found at the PIA web site at http://www.planning.org.au/index.php?option=com_content&task=view&id=547&Itemid=485.

WHY IS THE PLANNING INSTITUTE OF AUSTRALIA DOING THIS REPORT CARD?

Planners and PIA want to work with planning decision makers and industry to support best practice, highlight what is important, congratulate those responsible for a job well done, and ensure everyone knows where more work is needed.

PIA is concerned about planning in Australia and about the health and wellbeing of our cities, towns and neighbourhoods. It wants to raise the profile of planning and the importance of sound planning to our lives. PIA also wants

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to be part of identifying solutions and doing things better in partnership with all the other players that help create great communities and places.

Planners cannot achieve improvements alone. We work in a collaborative system with government decision makers, local councilors, developers and the community all have a role to play. How well the planning system operates relies on all those players pulling together to produce A+ performances.

There are some big issues facing Australian cities and towns. Australia is one of the most urbanized countries in the world. Over 85% of the people live within 50 kilometres of the coastline and most of these in the 7 major cities. These cities, towns and regions are where most Australians live, do business, get educated and participate in community life. They generate 85% of our nation's GDP.

Australia has some great challenges to face in the next 20- 50 years. We need to tackle them effectively to ensure that future generations are able to enjoy the same levels of prosperity as we do.

We all know that climate change is expected to impact on our cities and towns in a variety of ways – such as an increase in severe weather events, rising sea levels, inundation and drought conditions. Many regions of Australia are already feeling the effect of these impacts, through tough water restrictions or property damage from severe storms.

Our ageing population is also placing pressure on our health and transport systems and demands are increasing for alternative forms of housing to meet the need of our elderly population.

Public transport will become increasingly important if the likely trend for increased fuel prices continues. The affordable housing crisis is now causing social and economic stress on a large part of the community.

To ensure we are ready to meet the challenges facing our cities and towns we need to have effective planning and investment in infrastructure and a commitment to sustainable, liveable cities, regions and neighbourhoods.

We must have effective planning to integrate land use, transport, water, growth pressures and housing. Without effective planning systems we are losing opportunities to keep our cities competitive and vibrant.

GOVERNMENT INPUT

In 2007 following feedback from the 2006 survey we approached all State and Territory Planning Ministers and, given the Federal Election that was held in November 2007 all the political parties at the federal level, to detail policy plans and initiatives underway against the 12 Report Card criteria.

Responses received from Governments and political parties before the survey was released, were made available to planners to ensure they knew the strategies underway when rating performance. These responses, and those received after the survey, were made available on the PIA website.

Most Governments and political parties took the opportunity to respond and it is uplifting to see the positive initiatives being taken in so many states against the Report Card criteria

TWELVE CRITERIA

This year we added climate change and urban design to last year's 10 critical planning criteria that we believe should be in place for effective planning. We derived these criteria from PIA's Sustainable Communities policy platform and the priorities identified by PIA's members – 4500 professionals from around Australia.

The survey asked planners to rate performance against these 12 criteria

1. **Growth Management**
   How is your state/territory performing in developing and approving growth management plans for regions that integrate social, economic, environmental and transport issues?

2. **Sustainability Indicators**
   How is your state/territory performing in developing sustainability indicators that can be used to measure the performance of plans?

3. **Governance**
   How is your state/territory performing in having governance structures that support the development and implementation of effective growth management plans?

4. **Infrastructure**
   How is your state/territory performing in having a timetable and funding commitment for major social and physical infrastructure in accordance with a growth management plan?

5. **Transport**
   How is your state/territory performing in having a commitment to fund improvement and expansion of public transport integrated with a growth management plan?

6. **Demographic Change**
   How is your state/territory performing in developing a sea change/tree change strategy to address the impacts of population shifts?

7. **Housing**
   How is your state/territory performing in developing a housing strategy that addresses affordability, housing choice and sustainable design?

8. **Public Participation**
   How is your state/territory performing in having effective mechanisms for public participation in developing planning strategies?

9. **Planning Workforce**
   How is your state/territory performing in having a well resourced and skilled professional workforce to provide expertise to the planning process?

10. **Streamlined Assessment**
    How is your state/territory performing in having a streamlined planning assessment in place?

11. **Urban Design**
    How is your state/territory performing in having clear policies that promote quality buildings and urban spaces?

12. **Climate Change**
    How is your state/territory performing in having a strategy to mitigate and adapt to climate change?

Respondents were asked to rate the above criteria using the following scores:

A	Performing well against this criterion (80–100%)
B	Doing well against this criterion with some initiatives underway (70–79%)
C	Evidence of some initiatives with improvement required to reach this criterion (60–69%)
D	Inadequate progress in this criterion (50–59%)
E	No progress (<49%)

PIA is also developing national position statements on all of the above 12 criteria, outlining what it believes are essential elements and action for effective performance of each criteria.

THE 2007 RESULTS

This survey tool is intended to illustrate how Australia, state by state, is performing in planning terms. This assessment is intended to be constructive, highlighting our successes as well as identifying where we can do better.

The frustrations of the planning community with the speed of progress, the impediments to change and the lack of investment in planning, shows through again this year in the comments provided by respondents.

The survey results are summarised in the table below (Table 1). The results indicate that overall Australia has scored a C. This means there is evidence of some initiatives being taken in the 12 key areas nationally, but that improvement is needed to meet the levels of commitment, activity and funding needed to produce effective outcomes. Australia-wide we are performing reasonably well (with some caveats) in three of the twelve criteria:

- Growth Management
- Public Participation
- Streamlined Assessment

Australia is also doing moderately well in terms of Urban Design and Governance. We are doing less well, however, against the remaining seven criteria. Some states and territories are continuing to take positive steps to get it right. The strong performances which rated C+ on the national table include:

- Western Australia —Transport Planning and Public Participation
- South Australia—Streamlined Development Assessment
- Victoria—Public Participation
- Queensland and Australian Capital Territory—Growth Management
- Australian Capital Territory—Public Participation

In terms of the positives, no more than 60% of respondents rated their state A or B against any criterion and some states/ territories received no A scores at all against any criteria. So, there is still a lot more to be done. (The Northern Territory had a low respondent rate and its results have therefore not been included.)

CONCLUSION

Many people influence the built environment—state and federal politicians, local government councilors, professionals, community, public servants, developers and many others. They impact on our cities, towns and regions through their decisions in terms of funding, regulation, development proposals and design.

This opinion poll gives the profession an opportunity to reflect on the current state of our planning systems and outcomes. Planners are qualified and well placed to tell us how well we are doing.

The Planning Institute of Australia believes that an annual, honest look at the way our planning systems are operating is an important way to remind us all of the importance of these issues.

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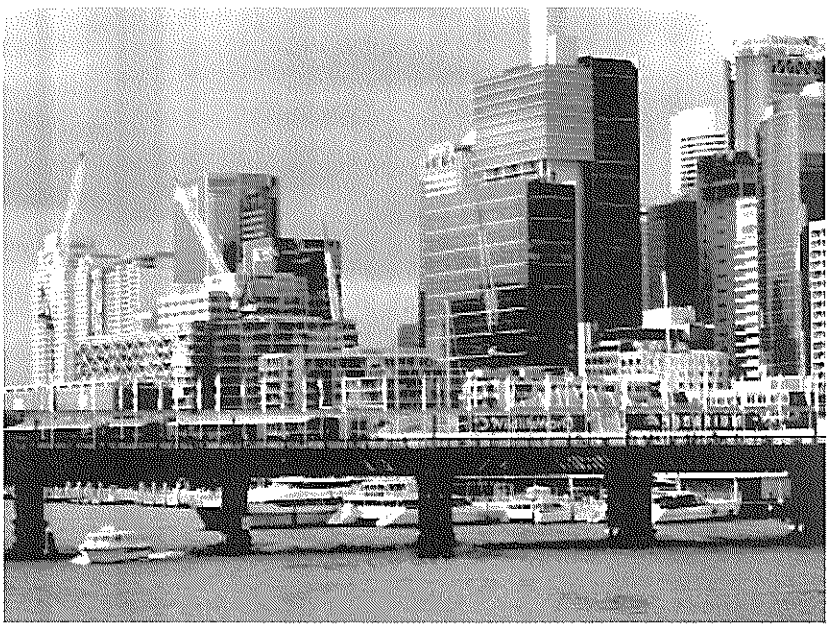
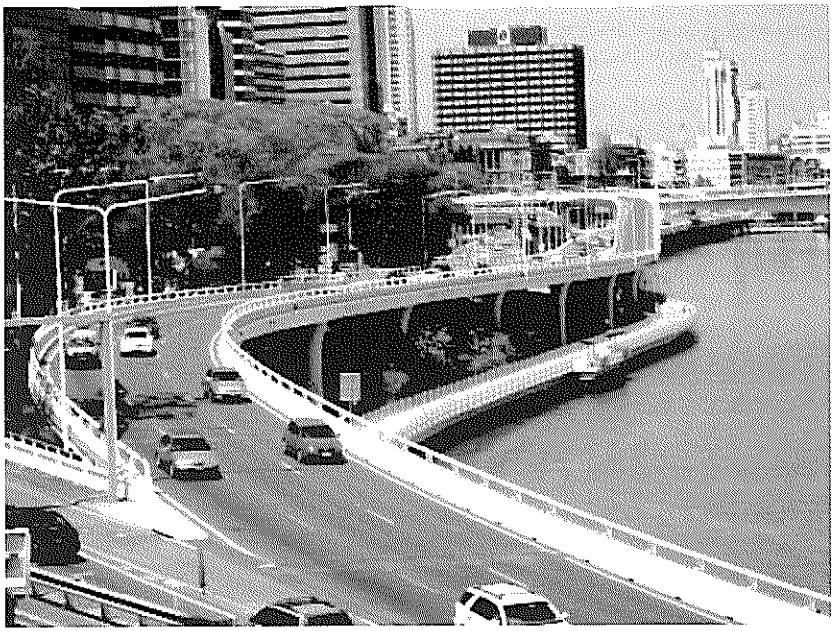
Table 1: Planning Report Card – National results

STATE	NSW	ACT	QLD	VIC	SA	TAS	WA	NATIONAL
Growth management	C	C+	C+	C	C	D	C	C
Sustainable Indicators	C-	C	C-	C	C	D+	C	C-
Governance	C-	C	C	C	C	D	C	C
Infrastructure	D	C	C	C-	D+	D	C	C-
Transport	D	D+	C	D	D+	D-	B-	C-
Demographic Change	D+	C-	C	C	C-	D	C-	C-
Housing	D+	C	C-	C-	C	D+	D+	C-
Public Participation	C-	C+	C	C+	C	C	B-	C
Planning Workforce	D-	C-	D+	C-	C-	C-	D+	C-
Streamlined Assessment	D+	C	C-	C	C+	C	C-	C
Urban Design	C	C	C-	C	C-	D	C	C
Climate Change	D+	C	D+	C-	C	C-	D+	C-
AVERAGE GRADE	D+	C	C	C	C	D+	C	C

Picture 1: Bondi Junction Mall2, February 2008



Picture 1: Darling Harbour Bridge Sydney, April 2008



Picture 3: Express Freeway1 Brisbane, October 2007

Picture 4: Maroochydore foreshore, 2006

NOTES TO CONTRIBUTORS AND GUIDELINES FOR MANUSCRIPT SUBMISSION

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The objective of the journal is to promote the activity of town planning through dialogue and exchange of views concerning professional town planning practice. PLANNING MALAYSIA will welcome any news, feature articles, or peer reviewed (including book reviews, software review, etc.) articles for publication. All articles should be original work by the authors. **Articles, views and features will not be taken to be the official view of the Malaysian Institute of Planners (MIP) unless it carries the name of MIP as the author.** This is to encourage open discussion on diverse issues and opinion for the advancement of town planning practice. Articles and contributions will be accepted from MIP members and non-members worldwide.

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