Visualizing the application of GIS in transformation towards a sustainable development and a low carbon society

M H Ahmad¹, A Ariffin² and T A Malik³,⁴
¹ Institute Sultan Iskandar, Universiti Teknologi Malaysia, Skudai, Johor, 81310, Malaysia
² Faculty of Geoinformation and Real Estate, Universiti Teknologi Malaysia, Skudai, Johor, 81310, Malaysia
³ Department of Architecture, Universiti Teknologi Malaysia, Skudai, Johor, 81310, Malaysia,
Email: drmedan@gmail.com

Abstract. A strategy for sustainable development is a significant milestone on the road to a more socially, economically and environmentally responsible society. It creates a framework within which the stakeholders can make a strong contribution to a better future. Because of the merits and growing interest in sustainable development, the race is on for researchers and stakeholders in the construction sector to initiate actions to reduce the negative impacts of development and sharpen their competitive edge. The cities should be created with a vision which supports harmonious communities and living conditions through sustainable urban development. The resources must be used efficiently while reducing the development impact on human health and environment during the buildings’ life cycle. Environmental auditing and pressure-state response based models to monitor sustainable development in Malaysia should be developed. A data availability and sharing system should be developed and implemented to facilitate for the use in the establishment of sustainable development and low carbon society. Ideas which affect millions of people and guide the policies of nations must be accessible to all. Only thus can they permeate the institutions from the local to the global level. Creating sustainable development and low carbon societies depends on the knowledge and involvement of all stakeholders in the industry. So what is our level of understanding of GIS and its application? The development of geospatial data in Malaysia is important because the successful implementation of sustainable development and low carbon projects depend largely on the availability of geospatial information. It would facilitate the stakeholders and resolve some of the problems regarding the availability, quality, organisation, accessibility and sharing of spatial information. The introduction of GIS may change the way for better sustainable urban development and low carbon society performance. The use of GIS is to improve decision making to implement development methods, awareness for the need for sustainable development and in development control to provide the information on the distance from the proclaimed objective. Malaysia should not fall in its attitude on sustainable development, green design, sustainable construction and a low carbon society. Literature review on GIS is carried out to understand the philosophy, concept, principles, challenges and advantages of using GIS for sustainable urban development and low carbon societies. This paper would encourage our understanding about the state of geographical information system (GIS) in sustainable development and its application which would further stimulate actions and strategies towards a sustainable built environment.

⁴ To whom any correspondence should be addressed.

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1. Background

A sustainable city is a city that can retain economic development, social development and environmental development success and indefinitely (UNCHS 1996).

According to Peterson et al. (1999), sustainable city has various dimensions; apart from environmental dimensions, there are dimensions of economic growth, protection, reach, security, administration, transparency and involvement. It is quite impossible for a city that does not contain all these dimensions and be recognized as a sustainable development or a low carbon society. The efforts to measure the level of sustainability of a city are infinitely complex because city systems are interrelated and constantly changing.

According to literature review, a sustainable development is one that fulfils the human and environmental well-being. The people and environment of a development are the two main stakeholders who have shaped and will continue to shape the development. The socio-economic condition in a city is closely related to its inhabitants, on the other hand, a city’s quality of life effects its socio-economic level. The environmental condition of a city is always related to its ecological support and environmental management. Several policies, strategies, guidelines and indicators are proposed and these are often interrelated. Indicators imply measurement; measurement implies the theoretical definition of concepts to measure (Harris 2000). Indicators are usually illustrated as diagrams, maps, graphs, schemes, tables and figures that enable the users to see the information or data in the simplest and fastest way. Indicators have long been used as tools to obtain information on economic, social and environmental aspects towards sustainable development. Indicators are useful tools for decision makers, and provide information on major issues of development, and distinct image on the progress towards sustainability (Choon et al. 2011). Moreover sustainable decision making involves political decisions at local, national and regional levels that create and promote a balanced social-environment system (Huang et al. 2008). Within this setting the measurement of sustainable development and a low carbon society becomes crucial and sustainability indicators must therefore not only integrate, but also be forward looking, distributional and ideally be the result of inputs from multiple stakeholders.

The Department of Town and Country Planning, Peninsular Malaysia (DCTP) developed urban indicators (MurniNet) for Malaysia in March 1997. MurniNet comprises 11 sectors, namely demography, housing, economy, utility and infrastructure, community facilities and recreation, environment, sociology and social impacts, land use, tourism and heritage, transportation and accessibility, management and finance (Choon et al. 2011). It assumes equal weight for all the sectors. There are 55 proposed indicators. MurniNet is a foundation for Malaysia to measure sustainable development in the urban areas.

2. Introduction

In the context of sustainable development and a society that is low carbon, ideas which affect millions of people and guide the policies of a nation must be accessible to all, not just to an elite or a specific group or department. Only thus can they permeate institutions from the local to the state, national, regional and global levels, and become part of the human landscape, part of sustainable development, part of a low carbon society, part of the fabric within which we define our lives. Naturally, this process requires the availability of a very specific type of information which is generated from different sources framed by an information pyramid composed of indexes-> indicators-> information-> data (WRI, 1995), as shown in Figure 1.
The 7th Malaysia Plan states that there is a need to strengthen environmental database and information systems to “…clearly delineate the relationship between the environment and sustainable development.” (7th Malaysia Plan: page 615). Although Malaysia participates in UN sponsored initiatives to develop sustainable and low carbon societies, it has chosen to pursue the goals in its own way so that methodologies used and the indicators chosen reflect closely the capability and actual needs of the country. Indicators and indices must be matched with the needs of nations in order to manage the environment and development within defined policy frameworks (LESTARI 1995).

3. Geographical Information System

GIS is a multidisciplinary tool that brings together information and experts from diverse and disparate backgrounds for achieving sustainable development. It is a powerful software technology that allows a virtually unlimited amount of information to be linked to a geographic location. It incorporates powerful tools to analyze the relationship among geospatial data. It portrays important information graphically which is the way the human brain works. Geospatial information answers the question, “where on earth is it”? It defines the locations of things that can be described in terms of space- buildings, roads, highways, railways, land use, administrative boundaries and various areas.

GIS application is as a sustainability impact assessment tool for environmental, social and economic effects of multifunctional land use. It is applied in Overarching policy issues/initiatives, Land Management, Land Administration and Land Information Systems. Such as, shelter, food, production, environmental, economic, social, ecosystem, nature conservation, transport infrastructure, tourism, energy, agriculture, forestry, green and blue infrastructure, rural resources, urban growth, energy systems and many more. All of the above are components of sustainable development and a low carbon society.

Geographical Information System (GIS) is a Multi-component technology for problem solving. It’s main components are: GIS Hardware, GIS Software, GIS Data, GIS Community, GIS Processes.

Laurini (2001) especially points out the prominence of multi-media and geographical information system (GIS), which effect the extreme processing precision, presentation and information use in urban systems and e-government applications. GIS enables a detailed analysis and automatic overlay, classification and presenting data at the neighborhood’s and at the city levels inside the boundary of the built-up area.

4. Geographic Data Infrastructure (GDI) or Spatial Data Infrastructure (SDI) is defined as:

"...data infrastructure implementing a framework of geographic data, metadata, users and tools that are interactively connected in order to use spatial data in an efficient and flexible way." (Wikipedia)

"...provides a basis for spatial data discovery, evolution and application for users and providers within all levels of government, the commercial sector, the non-profit sector, academia and by citizen in general." (SDI Cookbook, 2004)
"..... a coordinated series of agreement on technology standards, institutional arrangements and policies that enable the discovery and use of geospatial information by users and for purposes other than those it was created for." (Kuhn 2005)

5. Geospatial Data: Objective, what and why?
Objective: The main objective of availability of geospatial data is to save time, effort and money in accessing spatial data and using it responsibly, to avoid wasteful duplication of effort and promote effective and economical management of resources by federal, state and local governments (MaCGDI, 2012)

What: To create an environment in which stakeholders cooperate and apply technology to achieve objectives across all levels of government.

Why: To drive Economic Development, to support better Governance and to promote environmental sustainability

6. Digital Malaysia Initiatives
GIS can contribute towards government services to the society such as:
- e-government and c-government, Economic Development, Land Administration, Public Works, Urban & Regional Planning, Real Estate and Facilities Management, Policy and administration through cost reduction, Environmental sustainability, Policy safety through more efficient emergency service, Improved utilities infrastructure, Better management of health services and many more as discussed further.

7. Current Policies
The National Centre of Infrastructure and Geospatial Data (MyGDI) under the Ministry Natural Resources and Environment (NRE, 2009) issued the guidelines for development and implementation of Geospatial Data Centre (GDC) as:
- Policies and guidelines are developed that aim to lower barriers to information flow.
- Facilitate all organizations moving in the same direction on policy issues.
- Resolve some of problems regarding the availability, quality, organization, accessibility and sharing of spatial information.
- Develop policies and guidelines to define how the spatial data should be stored, made available and maintained at the most appropriate level.
- Directives through MyGDI circulars should be followed to easy discover availability of spatial data.

8. Good information is good decision making and good governance
A geospatially enabled government is one that has ready access to the geospatial or geographic or location based information and its associated technologies. The application of these productively to all areas of government endeavors (MaCGDI 2012). Geospatial enablement leads to;
- Improved decision making
- Reduction of administrative costs
- Whole of government outcomes
- Enhanced research and industries
- Development opportunities

9. Geospatial information and sustainable development
Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

All definitions of sustainable development require that we see the world as a system- a system that connects space and time.
Geospatial solutions are necessary to support decision making for sustainable development. Any sustainable development or a low carbon society needs to link social, economic and environmental issues. To minimize any conflicts between the stakeholders, multi criteria decision-making is required. Geospatial or Geographic information supports decision making and management of growing national, regional and global issues such as climate change, pollution, deforestation and environment protection.

10. Geospatial Data Infrastructure (GDI)
Stakeholders, both users and producers of spatial information can cooperate with each other in a cost efficient, cost effective and timely way to achieve better outcomes from spatially related economic, social and environmental decision making. The available data can be harmonized to facilitate appropriate decision making for sustainable development and low carbon societies. The Figure 2 below shows the hierarchy of geospatial data infrastructure (MaCGDI 2012).

![Figure 2. Hierarchy of Geospatial Data Infrastructure (GDI)](source: Modified based on Fauziah Abu Hanifah (Mac GDI 2012))

11. Benefits of application of GIS
The benefits of improved access, sharing and use of geospatial data are summarized below:

- Improved agency and organization service delivery
- Better management of geospatial information
- Enhanced public access to geospatial information
- Improved public image for all participants--maximizing resources, being efficient and more effective
- Broader sense of community
- Mutual benefits of GIS knowledge and communication
- Increased use of GIS technology by organizations that have not traditionally used them.
- Growth and expansion of resources, capabilities and knowledge based
Decision making methods are established which are convincing
Increased respect and trust among all stakeholders
Increased willingness to cooperate and share

12. Problems faced by GIS users
- It was found unnecessary to develop spatial data
- Knowing what data is available
- The existing data is unstructured and inaccessible
- The existing data is incompatible and lack quality
- The data available is not specific to the requirement of user
- The stakeholders need to USE the data, not just to view it
- No expertise to handle the data

13. Challenges to GIS sharing
- Majority of the organizations are motivated by their own mission and do not subscribe to national policy objectives
- Sharing information in a fully transparent manner is not the main characteristic of our culture
- An organization do not want to lose control of the data
- Misuse of shared data is the main concern of data providers
- The existing spatial data systems often are not technically linked
- Differences in data structure and incompatibility in facilitating data exchange
- Lack of application on national standards for spatial data and incompatible classification schemes
- Lack of documentation or metadata
- Information is handled in a strictly vertical direction, following hierarchies

14. Strengthening Coordination
Geospatial information resources need to be efficiently coordinated and managed for a sustainable society and in the greater interests of a nation. Data is a national capital asset and it should be generated, maintained and distributed. The time is ripe for the urgent need to coordinate the collection and transfer of current geospatial information between the different government levels. This is so that quality and accurate information can be disseminated, shared and contribute to sustainable urban development and low carbon society performance at local, state and national levels. Ways should be formulated to engage different agencies through awareness program and improve the coordination between agencies. The range of GIS services can be widened and finally to strike a balance between data sharing and focused applications. Geospatial data contributes to economic growth, environmental quality and social stability. The use of Geospatial information should be strongly promoted in decision making and applied in social, economic and environmental development. This would further stimulate actions and strategies towards a sustainable development and low carbon built environment.

Table 1. The uses of GIS in sustainable development and a Low Carbon Society

| Economic Benefits | Social Benefits | Environmental Benefits |
|-------------------|-----------------|------------------------|
| Increased efficiency at public and private sectors | Improved national, state and local governance | Promoting sustainable and low carbon development |
| Integrated transportation | Community engagement | Better natural resource monitoring, protection and management |
| Improved energy systems | More effective national security | |
| Green built environment | Faster emergency response | Improved environment |
| geoinformation products and services | Opportunities to target groups and areas with special needs | monitoring and management |
|------------------------------------|-----------------------------------------------------------|---------------------------|
| New opportunities for geoinformation business applications | Sustainable and low carbon lifestyle | Better air and built environment |
| Better land information systems | Better overarching policy issues or initiatives | Better catchment management |
| Better land administration | | Better land management |

It can be seen from the summary above the greater benefits of adopting and application of GIS according to the Triple Button Line (TBL) pillars of sustainable development.

**15. Conclusion**

Geospatial data infrastructure development processes at all levels in Malaysia is important because the successful implementation of sustainable projects depend largely on the availability of geospatial information. The relevant organizations need to focus on the integration of geospatial data and analysis in the mission-critical business processes, work flow and on increasing the return of investment (ROI) in geoinformation technology and geodatabases by improving interoperability, decision making and service delivery.

The GIS covers wide ranging aspects and specific measures that the stakeholders can adopt and implement directly. Through the awareness, knowledge and application of GIS can open avenues for further action towards performance improvement of sustainable development and low carbon society. The use or application of GIS in transformation towards sustainable development and low carbon society has many merits but applying this concept is not easy as it requires changes to the old ways. Delivering sustainable development and low carbon society requires action from all engaged in sustainable development with regards to economic, social and environmental aspects. It is almost impossible to grasp the potential of Geospatial Information, its use by the wider community and opportunities for the Government, semi-government and private sectors.

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