Factors of Building Climate for Remote Sensing Urban Mapping

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ABSTRACT

Mapping of an urban area can be done by many ways and based on many factors. Lately, the usage of remote sensing data for this purpose has been widely used since the data is more flexible and easy to manage. However, the data used must be high in spatial and spectral resolution to ensure the reliability of the analysis. There are a lot of factors involved in identifying the climate of a building. These factors are obtained based on the contributing factors to the building climate. The building climate factors varies from location of the building (climate of the country), materials used to build the building, as well as orientation of the building towards the sun etc. This paper investigates and discusses the factors involved in building climate, by using remote sensing data to produce an urban map. The results of the study revealed the building climate factors namely, building materials, building design, building surrounding climate and building orientation towards the sun.

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INTRODUCTION

Satellite remote sensing technology using optical and radar remote sensing techniques have been used successfully in various applications related to earth resources studies and environmental monitoring. Some advantages of these techniques are cost effectiveness, wide coverage, near real-time data acquisition and frequent revisit capability (Wahid et al., 2005). The most frequently used conventional remote sensed data were either satellite images or airborne colour infrared (CIR) photos and images. The satellite data mostly have not enough high spatial resolution to differentiate detailed ground information. Although the airborne CIR photos and images may have enough spatial resolution, they may have too broad spectral wavebands to identify two similar colour looking species. Therefore, as to model the building climate, a base map of a remote sensing data, either airborne or space-borne would fit the needs in terms of both spatial and spectral resolutions.

There are many functions related to a building such as structure, climate control, energy savings, aesthetical values, user comfort etc that related to the purpose of the building being built in the first place. Building climate is one of the main thing in determining the effectiveness of the function of the building. To know the building climate is an advantage in this century. The information obtained can be used for many purposes. From planning a new building structure and infrastructure, or even a new regional area, to compare with building of rural area in order to obtain the best energy saving building and to follow the government’s suggestion by building green building are to name some of the advantages.

An urban area is defined as an area with minimum population of 1000 persons and with population density of at least 400 persons per square kilometer. The territory outside urban area is called rural area (Statistic Canada, 2011). Mapping an urban area is one of a complicated thing to do, yet important since to know how does the area being covered with is really important in a developed country like Malaysia. Urban land is usually defined as areas being characterized by buildings, asphalt, concrete, suburban gardens, and systematic street pattern. There are several classes of urban development as well. They includes residential, commercial, industrial, transportation, communications, utilities and mixed urban. Undeveloped land on the other hand being used as cemeteries, golf courses and urban parks is recognized within urban areas (USGS, 2013).

Remote sensing is the measurement or acquisition of information of an object or phenomenon, by a recording device that is not in physical or intimate contact with the object. In practice, remote sensing is the utilization at a distance (as from aircraft, spacecraft, satellite, or ship) of any device for gathering information...
about the environment. Thus an aircraft taking photographs, Earth observation and weather satellites, monitoring of a fetus in the womb via ultrasound, and space probes are all examples of remote sensing. In modern usage, the term generally refers to techniques involving the use of instruments aboard aircraft and spacecraft, and is distinct from other imaging-related fields such as medical imaging or photogrammetry (Schowengerdt, 2007 & Schott, 2007). The human eye has three colour receptors for red, green and blue. Multi-spectral images are images that are taken with additional receptors sensitive to other frequencies of the visible light, or to frequencies beyond visible light, like the infrared region of electromagnetic continuum. This can allow extracting additional information that the human eye fails to capture (Harold, 1991).

Multi-spectral images are the main type of images acquired by remote sensing radiometers. Multi-spectral is the opposite of panchromatic. Usually satellites have 3 to 7 or more radiometers (France's SPOT has 3, Landsat has 7). Each one acquires one digital image (in remote sensing, called a scene) in a small band of wavelengths, ranging 0.7 µm to 0.4 µm, called red-green-blue (RGB) region, and going to infra-red wavelengths of 0.7 µm to 10 or more µm, classified as NIR-Near InfraRed, MIR-Middle InfraRed and FIR-Far InfraRed or Thermal. In the Landsat case there are 7 scenes comprising a 7 band multi spectral image (Harold, 1991). Active remote sensors are dependent upon neither EMR (electromagnetic radiation) from sun nor the thermal emission. They create and transmit EMR and record the return. On a remote sensing image, different surface will reflect differently since the surfaces reflect greater at a certain wavelength and the other way round.

According the Shneider (2009), there is only a small percentage of global land cover, urban areas significantly alter climate, biogeochemistry and hydrology at local, regional and global scales. Shneider (2009) decides that to understand the impact of urban areas on these processes, a high quality and regularly updated information on the urban environment that includes maps that monitor the location and extent of it is essentially in need.

In an urban area, developments are happening every day. New buildings are being built, empty spaces are being occupied by parks and lakes for recreation and other things are planned to be located near the area. In terms of development and infrastructure, building plays an important role. Building consists of many parts. Rooftop and wall are to name some. It is important to know the current state of a developing area so that better future planning can be made and the map can be used as reference for many purpose. According the Kim & Han (2012), building envelopes fulfill many functions such as structure, climate control, energy savings and generation, aesthetics, psychological well-being, and occupant comfort. The case study building was the New York Times (NYT) Building in New York. The building was located at mixed and humid climate area and was made of ceramic coated rod, which blocks unwanted solar hit while maximizing daylighting performance. The energy analysis that building envelopes of an integrated tower in an urban setting provide opportunities to enhance building energy savings and solar energy generation (Kim & Han, 2012). This proves that the materials chosen in building a building plays a big role in building climate. There are many other factors that contributes to the building climate. Other than materials used to build the building, orientation towards the sun, climate changes in the area, state and country, and design used for the building are also factors that contributes to the building climate. Building climate can be in terms of building temperature, pressure, humidity and wind speed. By analysing the climate of the building, this will help in the future building planning and development. Materials chosen to be used when constructing a building depends on the purpose of a building. Building materials are any materials that are used for construction purposes. Some of the materials that are occurring naturally, which have been used to construct building are clay, rocks, sand, wood, twigs and leaves. Man-made or synthetically made materials for building construction are also being used and the use of these materials are segmented into specific specialty trades, such as carpentry, insulation, plumbing and roofing work. These materials are actually making the building looks nicer or in another word, the make-up of habitats and structures including homes.

Building orientation is one of the things to be considered when designing a building, mainly with reference to solar radiation and wind speed (Al-Tamimi et. al., 2011). In hot and humid countries like Malaysia which receives sunlight all year round, buildings should be oriented to minimize solar gain and maximize natural ventilation (Al-Tamimi et. al., 2011). A climate change in the area is one of the most important factors that can contributes in building climate, especially temperature. Since Malaysia has a tropical weather that is warm and monsoon season through the year, it is important to construct a good building condition with well maintained temperature through the day and year. One of the most critical challenges facing society today is climate change (Oldewurtel et. al., 2010). Weather prediction method is also one way to increase energy efficiency while respecting constraints resulting from desired occupant comfort (Oldewurtel et. al., 2010) and by using Stochastic Model Predictive Control (SMPC) a strategy can be planned in order to maintain the climate of the building to make occupant and user comfortable. Design of a building also contributes in factors of building climate. Here in Malaysia, usually buildings being designed based on purpose of the building, budget, airways through the building as well as the look of the building. Civil engineers and architects cooperate together to design and built the most suitable building to match the purpose of the building. Wang et. al., (2010) developed a prototypical tool, for the design case, which offers an affective access to connect computational building modelling and
climatic parameters and in turn facilitated the new approach to sustainable buildings. This means building design does play an important role in building climate.

The objective of this study is to discuss the factors that contribute towards building climate, to determine the building climate of buildings in an urban area by using remote sensing image and to use these information to model them in GIS for mapping an urban area.

Methodology:

A Geographical Information System (GIS) of an urban area is going to be produced by using remote sensing image as the base map. A good base map is really important in producing a good GIS. In this paper, a remote sensing image is used as a base map. In the map, a building classification and categorization is being made, according to its name and purpose. Every building in the area has information such as building temperature, humidity, wind speed and pressure. These informations will be related and linked to the building's building climate factors. The building climate factors are building materials, building orientation towards the sun, building surrounding climate and building design. Remote sensing images are chosen as the base map because it gives different display on different surfaces and different times. These make the user to easily differentiate between different types of building of different names and purposes. It makes the classification and categorization process easier.

RESULTS AND DISCUSSION

Building orientation towards the sun:

Mainly, building temperature is being affected by building orientation. Since Malaysia is a tropical country that is located at the equator line, it is going to get 100% sunshine through the year. This making all building in Malaysia receives sunlight at least 12 hours a day. The building inclination angle to the sun is about the same for all buildings. Hence most building in Malaysia will be having the same temperature at the same time of the day, which will start off with normal about 25 degree Celsius at the beginning of the day, getting warmer towards the afternoon and can reach up to 40 degree Celsius at time and going down by the end of the day. Almost all building in the urban area especially are using air conditioning system in their building to make the user comfortable. On a remote sensing image, building surfaces will appear differently at a different time the image is being captured. This is due to the amount of light absorbed by the remote sensing sensor that was reflected from the surface of the earth. Since in an urban area there is a lot of building around, it is good to use remote sensing data when categorizing different types and purpose of buildings for mapping purpose.

Building materials:

Materials being used to build a building also relates indirectly to the building temperature. Building being made by brick wall will be much cooler during a warm day, compared to wooden wall building. Same goes to the rooftop materials, which will contribute mainly to the temperature of the building especially during midday time, since it will have direct contact with the sun. Different material will appear differently on a remote sensing image, hence different materials can be distinguished from a remote sensing image. This will make it easier to produce map. This map can later be used as a base map when creating a Geographical Information System for the area and other information can be added into the GIS such as building type (single storey or multi-storey), building purpose, building temperature and others. As mentioned by Kim (2012) that in the case study of NYT building, it proves that building materials is one of the major things to consider when building a controllable climate building to give comfort to the user.

Building design:

Design of a building also affects the climate of a building. A good building design will take into consideration the airflow within the building, aesthetical value, building usage and purpose and also lifespan of the building. The design too relates to the temperature of the building, pressure of the building and wind speed of internal and external of the building. Design of a building can easily be used to differentiate different buildings when mapping an urban area. An article by Marni (2013) stated that one of the way to design a climate responsive building is to design for natural ventilation building. By following the rule of warm air rises, a building can be cooled by designing for stack ventilation by drawing cooler air from openings low in the building, while carrying heat away through openings in the top of the space.

Surrounding climate:

In an urban area, the surrounding climate is slightly higher compared to rural area. The main cause of this is that the characteristics of an urban area is full of existing building and developing building to accommodate population density between 1000 to 19,999 at an urban centre. Building in Malaysia majority has air conditioning system and this release heat and raise the surrounding climate around the building. Imagining if all buildings are implementing this, the whole urban area will definitely has higher climate but the climate will
reduce as the area is farther away from the urban central. Generally, an area which has lots of buildings and people in it will have less vegetation features around it. Rural area on the other hand has less buildings and less population density and it has more space for vegetation features. Development of an area will start from the central and slowly moving away to the out circuit area. Here in Malaysia developers are doing development according to the suitability of the area together with the project development that they are proposing to do. Surrounding climate is definitely one of the factors that contribute to the building climate.

Building orientation towards the sun, building materials, building design and surrounding climate of the building are factors that contributes to towards building climate. These factors are to be considered when planning to build a building in an urban area. These factors will contribute in adding more information into the GIS system of an urban area and are important in having these information for future urban planning. The results is this study is parallel with Evans (2013), Wan et. al. (2010), Olmeduertel et. al. (2010) and Kim et. al. (2012) all of the said factors are to be considered when planning and mapping urban or high climate area.

**Conclusion:**

Building climate factors such as materials used to build the building, orientation towards the sun, climate changes in the area, state and country, and design used for the building are the contributing factors to the building climate. Remote sensing image shows different display for different type of materials, taken at different time of the day and at different building climate. Hence remote sensing is the best way to be used for mapping urban area since the urban area is a developing area and consist of a lot of people, buildings and new planning for construction work. These information can later be used by the civil engineers, town planners, architects and all built environment personnel to do further development in the urban area, or new development in rural area.

**REFERENCES**


