DELINEATION OF GROUNDWATER POTENTIAL ZONES USING REMOTE SENSING AND GIS APPROACH IN MALAYSIA

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PhD (GS20265)
4th Semester

1. Introduction

Groundwater is in demand in areas where surface water supply is inadequate and non-exist in Malaysia (Rakan Sarawak, 2003). Groundwater always being rises as an alternative source especially in water crisis during drought period (Bernama, 2005; JPS, 2007). Recently, Minister of NRE mentioned that groundwater in Malaysia is underutilized (only 2%) compare to other countries such as Thailand (80%) and China (70%) and need to be exploited. This is due to failure to recognize the vast potential of the invisible groundwater resource (Star, 2009). The demand for water in Malaysia (ie. surface water and groundwater) has been projected to increase by 63 per cent from 2000 to 2050 (Bernama, 2007). In order to meet future water demand for Selangor and Wilayah Persekutuan Kuala Lumpur, Government of Malaysia through the Ministry of Energy, Water and Communication (KTAK) has proposed an interstate water transfer project from Pahang to Selangor (KTAK, 2008). Mohammed Hatta (2006) has discussed several issues and challenges related to groundwater resources in Malaysia. The traditional way of groundwater assessment for alluvial and fractured rock aquifers in Malaysia is not so systematic and improper. The adhoc studies areas mostly are based on demands arise and where sources of groundwater are not developed. He suggested the new techniques with the help of remote sensing and geophysics need to be explored in order to improve the current practices of wild cat method for hard rock aquifers assessment.

2. Objectives

In this study, groundwater potential zones are delineated using remote sensing and GIS approach with the following objectives:

- To extract the groundwater storage controlling features from remote sensing data, DEM and ancillary data such as map, report and databases;
- To delineate groundwater potential zones through integration of various thematic maps and analyzed in GIS environment;
- To compare groundwater potential zones map derived from weighted index overlay, multi criteria analysis of Analytical Hierarchal Process (AHP) and statistical approach;
- To investigate whether the groundwater storage controlling parameter can be correlated with the groundwater occurrence in the area.

3. Research Methodology

Three types of satellite imagery are used in the study and being compared i.e. Landsat, SPOT, and Radarsat. The study area covers parts of the Upper Langat Basin and located in Hulu Langat district of Selangor state, Malaysia. It is within the latitude 2^o 53' north to 3^o 15' north and longitude 101^o 43' east to 101^o 58' east, with an area of around 500 km square. The area includes Kajang, Cheras, Pekan Batu 14 and Pekan Batu 18, which is almost 20 kilometer from the city centre of Kuala Lumpur. The scope of the study is limited only to hard rock aquifer. RS data were interpreted to produce lithological, lineaments, land use and geomorphology. DEM was used for lineaments, geomorphology and slope. Drainage, soil and rainfall were extracted from ancillary data. In the present study, eight themes were evaluated: (i) drainage, (ii) lineament, (iii) geomorphology, (iv) lithology, (v) slope, (vi) soil, (vii) landuse, and (viii) rainfall. All the thematic layers were integrated and analyzed in a GIS environment. Vector GIS layers, namely drainage density, lineament, lithology and soil, were converted to raster layers for integrating with raster thematic layers, namely geomorphology, landuse, rainfall and slope, in raster GIS modelling. All the thematic maps were resampled to match the same resolution. Field verification was conducted for interpreted features. Weighted index overlay, Multi criteria analysis of Analytical Hierarchal Process (AHP) and statistical approach were used and compared in predicting groundwater potential zones map. In order to reduce bias, the weight of groundwater storage controlling parameters and its classes were given by ten expert of groundwater from various agencies all over Malaysia. Actual bore well yield data were used for model validation. The correlation between the groundwater storage controlling parameters were investigated with the groundwater occurrence in the area.

The complete process of groundwater potential zoning is shown in figure 1.

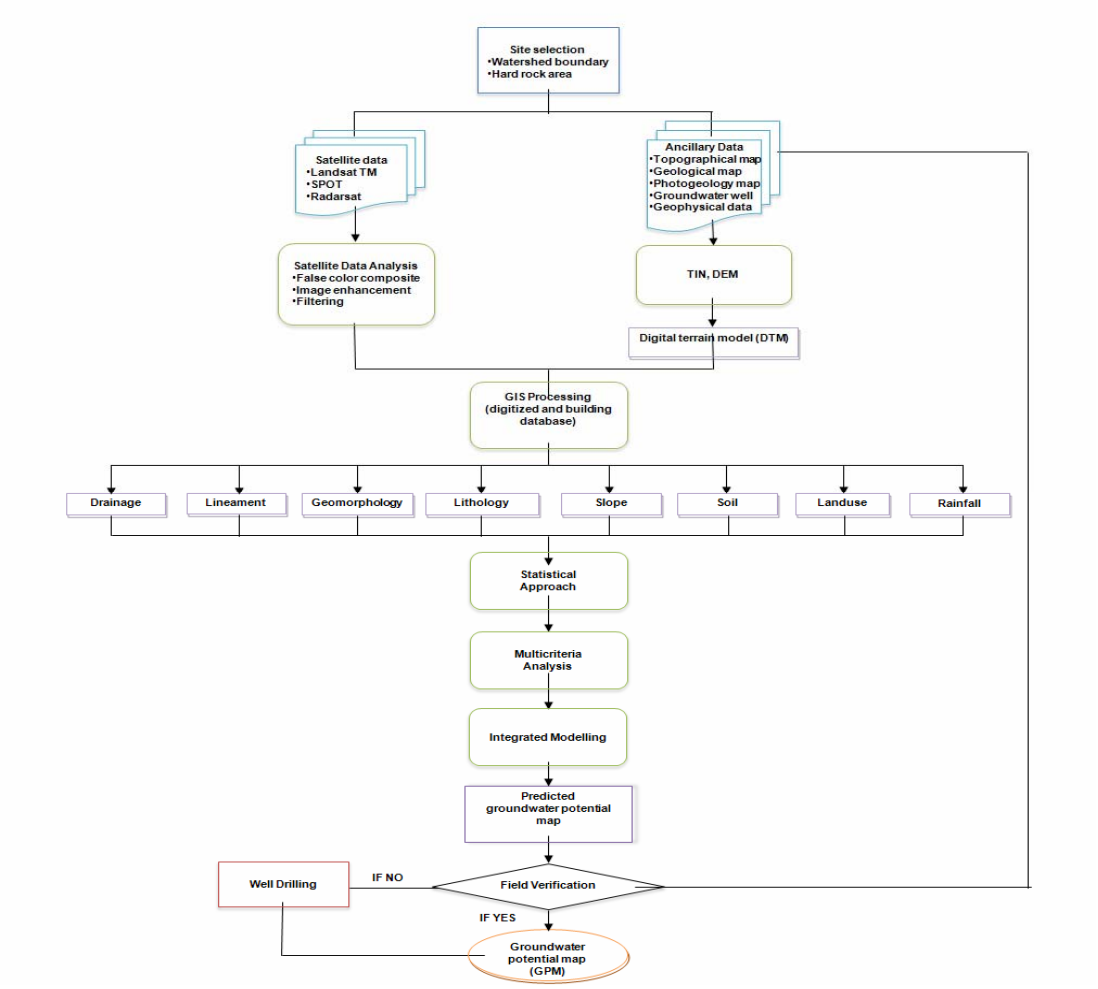

Figure 1. Flowchart for groundwater potential zoning using remote sensing and GIS approach

4. Results and Discussions

The discussions of the results are originated by research objectives.

4.1 To extract the groundwater storage controlling features from remote sensing data, DEM and ancillary data such as map, report and databases;

Results for this objective have been presented in previous colloquium.

4.2 To delineate groundwater potential zones through integration of various thematic maps and analyzed in GIS environment;

An index overlay method was adopted for combining the multiclass maps in the study area. In this model the map classes occurring in each input map are assigned different scores, in addition to the maps themselves receiving weights. The average score is then defined by:

$S = \Sigma S_{ij} W_i / \Sigma W_i$ (Borham Carter, 1994)

where *S* is the weight score of an area object (polygon, pixel), *Wi* is the weight for the *i*th input map and *Sij* is the rating score of the *j*th class of the *i*th map.

There is no standard scale for a simple weighted overlay method (Saraf and Choudhary 1997, 1998; Jasrotia et al., 2007). For the evaluation of weights to different thematic layers and each feature of the individual thematic layers, questionnaires were prepared and given to fifteen experts from various agencies in Malaysia. The information strength of groundwater expertise is shown in table 1.

Table 1: Groundwater expertise in Malaysia

Organisation	**Position**	**Number of expertise**
Mineral and Geoscience Department (JMG)	Hydrogeologist	7
Agency of Remote Sensing Malaysia (Remote Sensing Malaysia)	Geologist	1
National Hydraulic Research Malaysia (NAHRIM)	Hydrogeologist	1
Public Work Department (JKR)	Hydrogeologist	3
Universiti Putra Malaysia (UPM)	Lecturer	1
Universiti Kebangsaan Malaysia (UKM)	Lecturer	1
Agency of Nuclear Malaysia (Nuclear Malaysia)	Researcher	1
7 Agency		15

The weights assigned to different groundwater storage controlling parameters and scores to different classes of each theme (1-10) are given in table 2.

Table 2: Weights and score assigned to evidential themes

	Theme	**Weight**	**Classes**	**Score**
s1	Drainage Density	7	>0.0055 (Very High) 0.0040-0.0055 (High) 0.0025-0.0040(Moderate) 0.0010-0.0025(Low) <0.0010 (Very Low)	10 8 6 4 2
2	Lithology	9	Alluvium Limestone Quartz Volcanic Schist Phylite,schist and slate Granite Sandstone	10 6 5 8 4 5 6 8
3	Geomorphology	8	Denudational hill Dyke Floodplain Water bodies Structural hill	4 6 8 10 6
4.	Soil	8	Sand Coarse sandy clay Sandy clay Coarse sandy clay-clay Fine sandy clay loam-sandy clay-clay Fine sandy clay loam Fine sandy clay Clay	10 8 6 8 4 4 4 2
5	Slope	6	0-5 6-15 16-25 26-35 36-60 >60	10 8 6 4 2 1
6	Landuse	5	Rubber Forest Other crop Oil palm Man made dam Clear land Urban area	8 10 8 8 6 4 2
7	Lineament	9	>0.0075 (Vey High) 0.0055-0.0075 (High) 0.0035-0.0055 (Moderate) 0.0015-0.0035 (Low) <0.0015 (Very Low)	10 8 6 4 2
8	Rainfall	7	2500-2750 (Very High) 2250-2500 (High) 2000-2250 (Moderate) 1750-2000 (Low) 1500-1750 (Very Low)	10 8 6 4 2

5. Significance of Finding

The study significantly contributes a new knowledge in groundwater studies, in the context of tropical environments of Malaysia. This study comes out with new map of groundwater potential zones which can be used as a guide by government agencies as well as private sector for groundwater exploration in Malaysia. These new ideal methodologies provide a rapid, powerful tool and low cost technique in the search for groundwater compare to conventional method.

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