Use of index overlay model in the production of groundwater potential map in Kota Kinabalu, Sabah through the Geographic Information System (GIS) method

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Abstract— **Kota Kinabalu is a very fast growing area in the state of Sabah, Malaysia. This enables the rapid development of existing water sources will be more susceptible to contamination and leading to lack of clean water for domestic consumption. This study was conducted with the aim of to generate groundwater potential map of the study area. Geographic Information System (GIS) method were used in this study. There are eleven parameters used in this study, namely rainfall, drainage, soil type, landuse, lithology, lineament density, topography, slope steepness, the ratio of sand and clay, major fault zones and syncline zone. All parameters are combined using index overlay model to produce the groundwater potential map of the study area. This study includes five stages, namely collection and preparation of basic data, data analysis, development of space database, spatial analysis and space integration. The final map of groundwater potential zones in the study area is divided into five classes, which are very low, low, moderate, high and very high.**

Index terms : **groundwater, GIS, index overlay model**

I. INTRODUCTION

GIS is a set of tools for collecting, storing, retrieving, converting and displaying spatial data from the real world to the particular forms for certain purposes (Burrough 1989).

Technically, GIS is a system that includes mapping software and applications of remote sensing, aerial photography, survey, mathematics, geography and equipment that can be used together with GIS software.

Groundwater is defined as water that fills the space, cavities, pores and cracks in the soil, rock or regolitos below the earth's surface (Ibrahim & Juhari, 1990). It has become an important and dependable source of water supplies in all climatic regions including both urban and rural areas of developed and developing countries (Todd & Mays, 2005. Groundwater already proven as the best alternative to replace the surface water as a main source of water supply for daily consumption.

The integration of GIS techniques followed by the observations in the field has known as a very effective method in groundwater mapping and exploration. Over the last decade, the international scientific community has shown great interest in this study, and many researchers have used this method in their study (Sabin, 1987 and Sikdar et al., 2004).

The method used in this study known as Index Overlay Model. This model is used by adding all the weightage of the thematic map layers. All the map layers that converted to grid format will be integrated by using the Boolean operation where alls of the thematic maps will be add with their weightage grid code value.

Among the advantages of this index overlay model, it has the flexibility and ability to show the priority (weightage) on unit factors that was studied (Bonham-Carter, 1994). Therefore, this model is useful to compare and evaluate the integration model in determining the potential of groundwater.

A. *Study area*

The study area, Kota Kinabalu is located on the west coast of Sabah, Malaysia. Geographically, the study area is situated between the latitude 5° 55' - 6° 12' North and longitude 116° 01' - 116° 17' East. The study area consists of Crocker Formation and Quaternary sediments. The age of the Crocker Formation is estimated from Oligocene to Lower Miocene. There are three main units of the Crocker Formation which is sandstone, interbedded of sandstone and shale, and shale.

Among the main reason this study were conducted is to generate the predictive groundwater potential maps of potential zones of groundwater in Kota Kinabalu through the integration of various thematic maps by using the Geographic Information System (GIS) method, and to define the areas in Kota Kinabalu that could be developed as a source of groundwater supply.

Another reason is why this study should be made because during the study were conducted there is no systematic method used to find the correlation between geological factors with the groundwater potential in the study area.

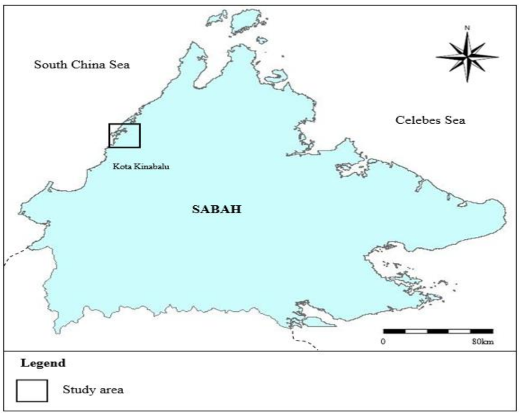

Fig. 1 Map showing the study area

II. MATERIALS AND METHOD

All the necessary data for this study, such as topographic map, landuse map, soil map series, annual rainfall data and satellite images will be collected. All data acquisition will involve departments like the Mineral and Geoscience Department (JMG) Malaysia, Malaysian Remote Sensing Agency (ARSM), the State Department of Survey and Mapping (JUPEM), the Malaysian Meteorological Service Department and so on. Random field inspections are also done at this stage to confirm the changes that occur in the study area.

The ILWIS 3.3 (Integrated Land and Water Information System) software is used to perform the all the processes in GIS. Attribute analysis, classification of polygons and weightaging value will be done to produce the thematic maps of rainfall, lithology, topographic elevation, slope steepness, drainage density, soil types and sand and clay ratio. In theory, spatial analysis used either to produce additional information using existing information, or increase the spatial structure or the relationship between the relevant geographic information (Murai, 1993).

For this study, the focus is on the technique or combination of overlapping raster data model in which all thematic maps that been given the weights are combined to predict the groundwater potential zones. Each polygon for thematic map layers that been given the weights is vary according to the characteristics of their remuneration like the annual rainfall (average annual rainfall in the study area) lithology (permeability properties and porosity of rocks) lineament density (remuneration class and features); drainage density (classes and attributes of permeability) land use (type and characteristics of remuneration) and the type of soils (properties of permeability and soils porosity). This stage is very important because the weight value assigned will determine or influence the accuracy of the final results that will integrated later. DRASTIC method (Aller et al., 1985) and the methods used by Krishnamurthy et al. (1996 and 1997) were used as a reference.

III. RESULTS AND DISCUSSION

Fig. 2 through 12 show all the thematic maps that have been produced. The final map after the integration process was shown as in the Fig. 13. The result divided into five classes or zones which are:

- very low
- low
- moderate
- high
- very high

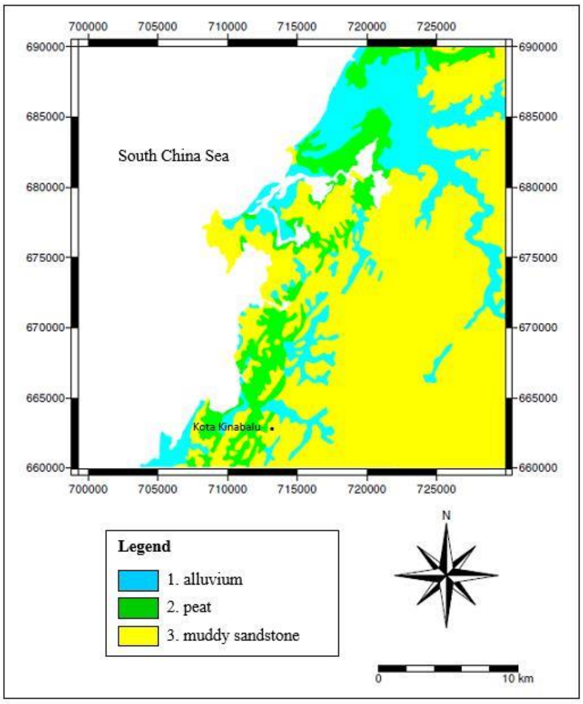

Fig. 2 Lithology map of the study area

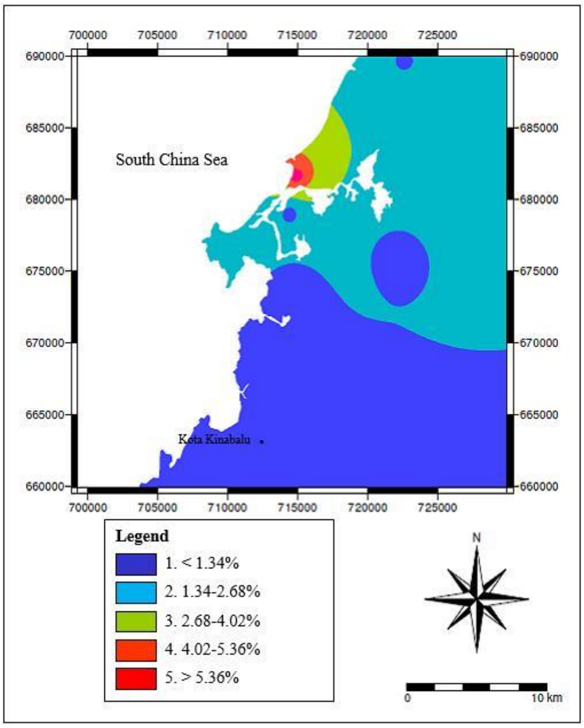

Fig. 3 Sand and clay ratio map of the study area

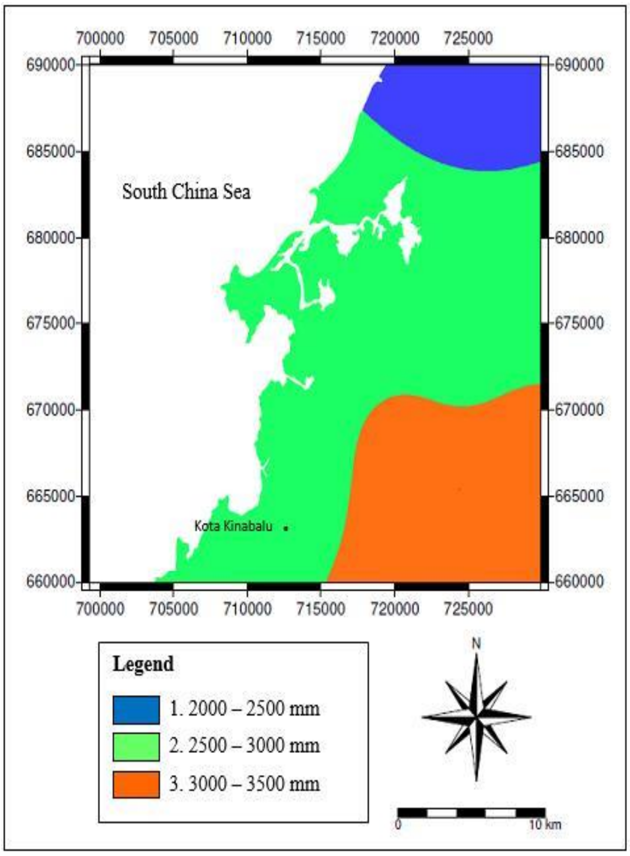

Fig. 4 Rainfall density map of the study area

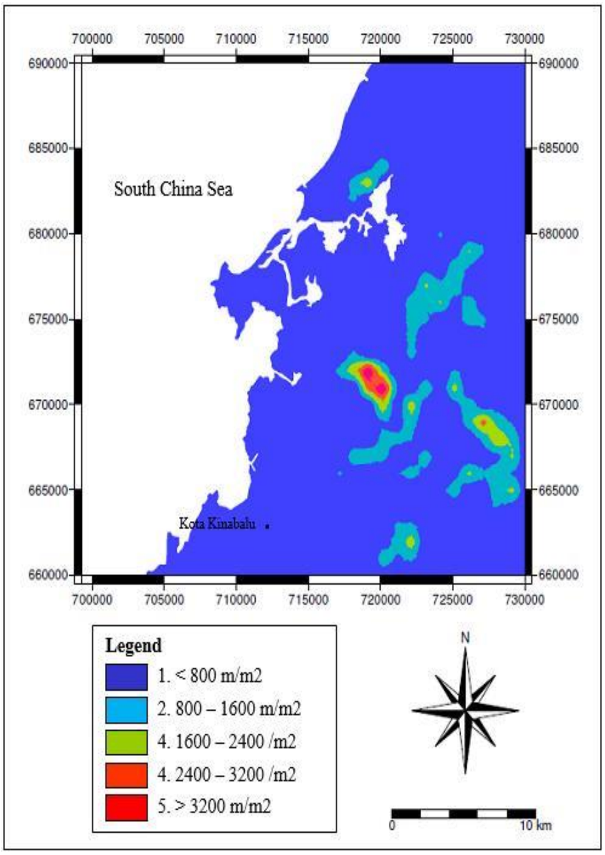

Fig. 6 Lineament density map of the study area

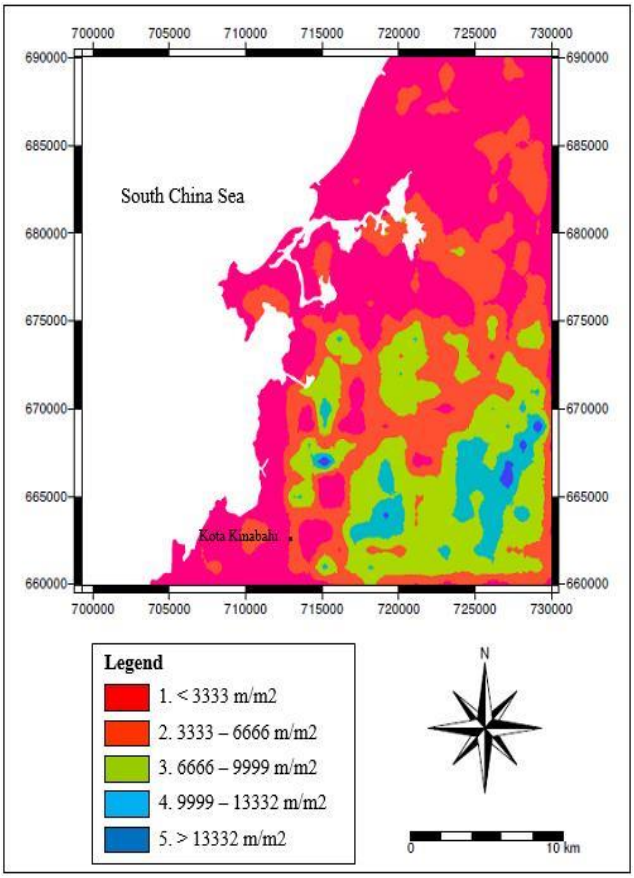

Fig. 5 Drainage density map of the study area

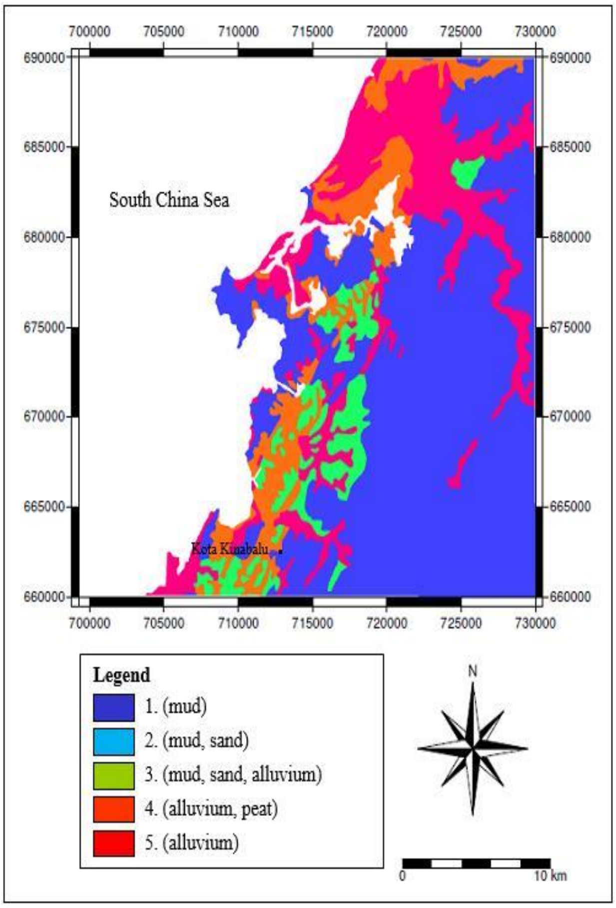

Fig. 7 Soil types map of the study area

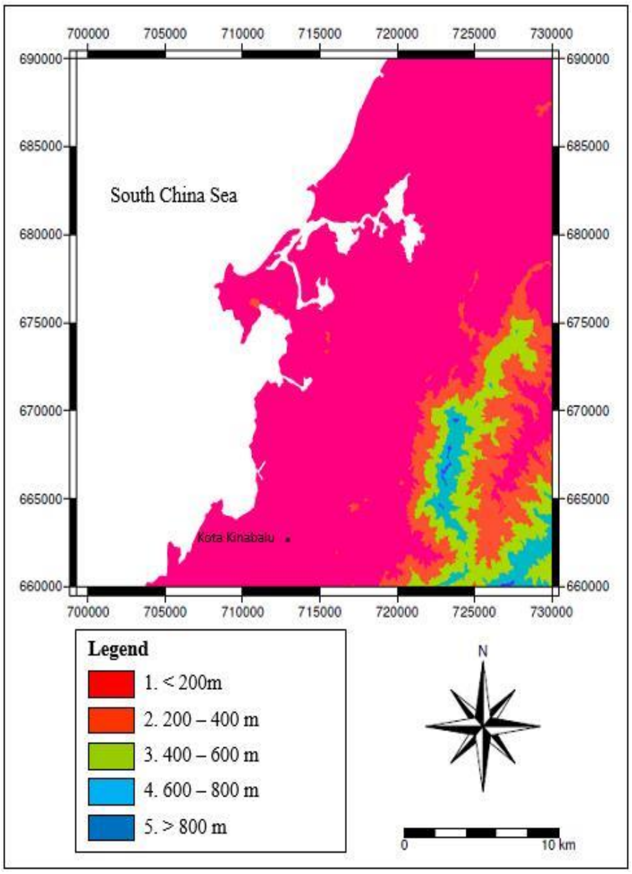

Fig. 8 Topographic elevation map of the study area

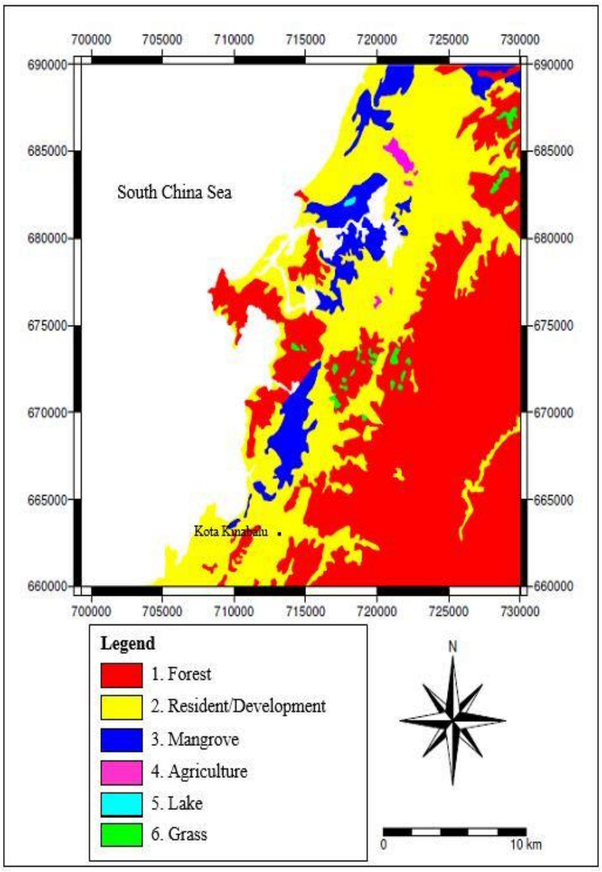

Fig. 10 Landuse map of the study area

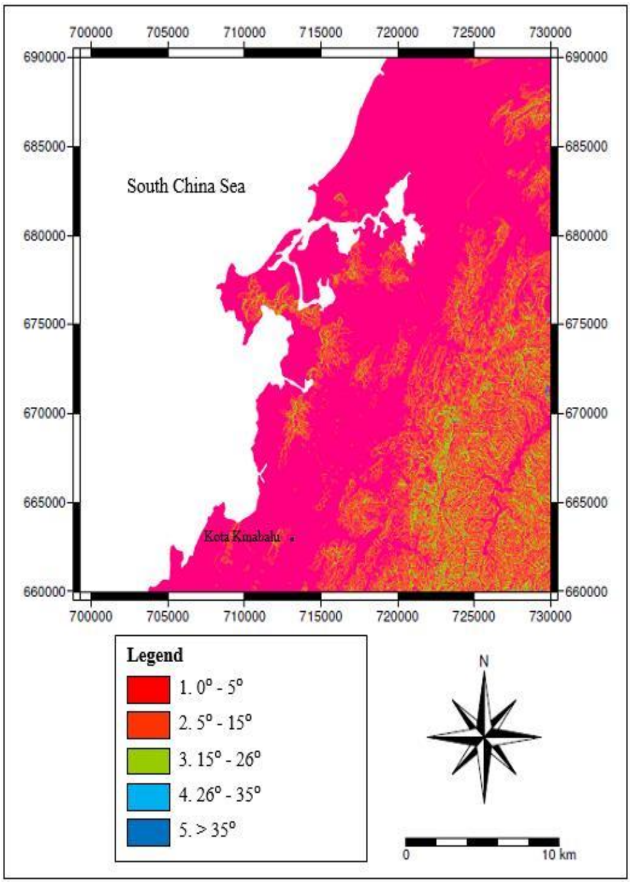

Fig. 9 Slope steepness map of the study area

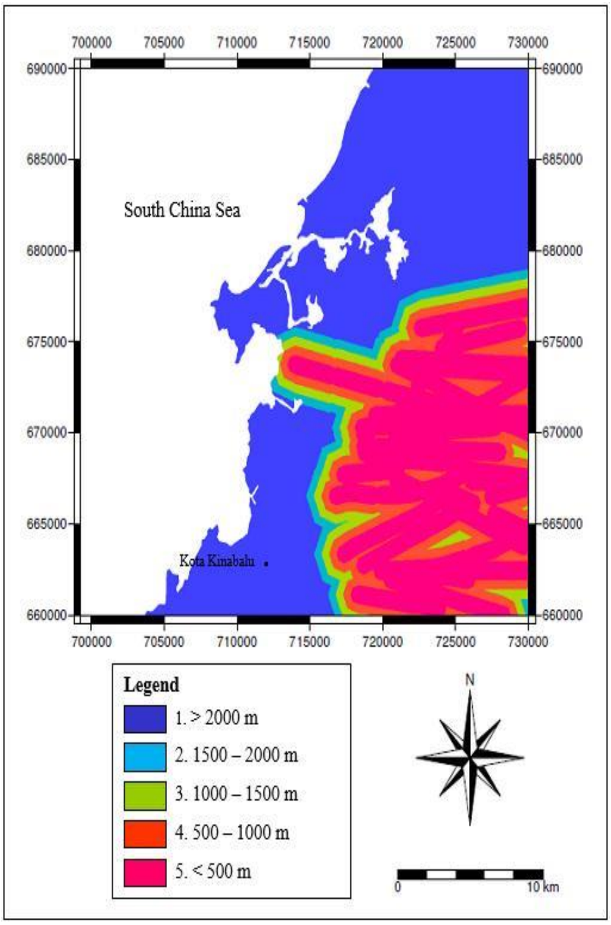

Fig. 11 Major fault zones map of the study area

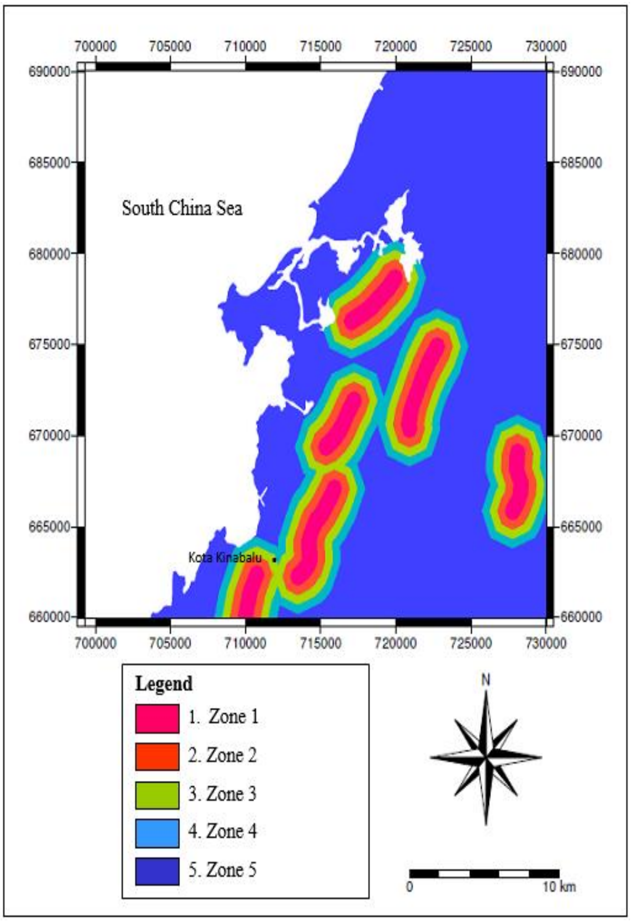

Fig. 12 Syncline zones map of the study area

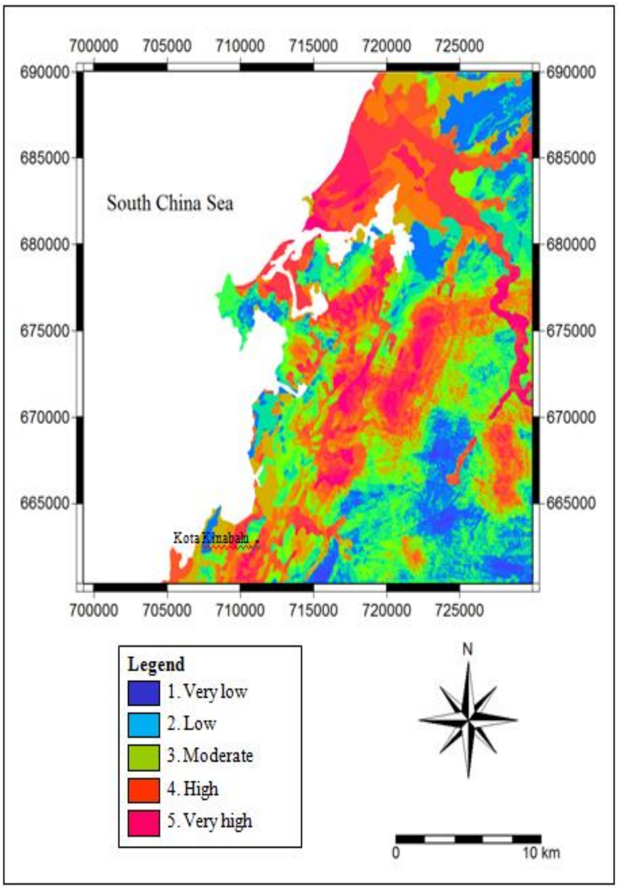

Fig. 13 Groundwater potential zones map of the study area

CONCLUSION

A summary of the relationship between the parameters studied with groundwater potential zones is presented in Table I.

Table I A summary of the results from the final groundwater potential map of the study area

Maps	High potential zones	Very high potential zones
Lithology	Alluvium, peat, muddy sandstone	Alluvium, muddy sandstone
Sand and Clay Ratio	Very low – very high (< 1.34 - > 5.36%)	Very low – very high (< 1.34 - > 5.36%)
Rainfall Density	Low - moderate (< 2400 – 3200 mm)	Low - moderate (< 2400 – 3200 mm)
Drainage Density	Very low - moderate (< 3333 - 9999 m/m2)	Very low - moderate (< 3333 - 9999 m/m2)
Lineament Density	Very low – very high (< 1000 – > 4000 m/m2)	Very low – very high (< 1000 – > 4000 m/m2)
Topographic Elevetion	Very low - low (< 200 - 400 m)	Very low - low (< 200 – 400 m)
Slope Steepness	Very low - low (0° - 15°)	Very low - low (0° - 15°)
Soil Types	Weston, Tuaran, Brantian, Lokan, Crocker	Tanjung Aru, Tuaran, Brantian, Lokan
Landuse	Forest, Resident / Development, Mangrove	Forest, Resident / Development, Mangrove, Agriculture
Major Fault Zones	500 – 1000 m	< 500 m
Syncline Zones	500 – 1000 m	< 500 m

From the results obtained, there are three main factors that influence the availability of groundwater potential in the study area which is the lithology, topographic elevation and the syncline zones. The higher groundwater potential zones are located at the northern part of study area. The area is low-lying area consisting of alluvium lithology.

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