Groundwater Potential Zones in Relation to Catchment Condition in Orenburg, Russia

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Abstract. The objective of this study is to detect the groundwater availability for agriculture in the Orenburg. Remote sensing data (RS) and geographic information system (GIS) were used to locate potential zones for groundwater in the Orenburg. Diverse maps such as: base map, geomorphological, geological structural, Lithology, drainage, slope, land use/cover and groundwater potential zones were prepared using the remote sensing data, ground truth data and secondary data. ArcGIS software was utilized to manipulate these data sets. The groundwater availability of the study is classified into different classes such as very high, high, moderate, and low and very low based on its hydro-geomorphological conditions. The land use/cover map was prepared using a digital classification technique with the limited ground truth for mapping irrigated areas in the Orenburg.

1. Introduction

Groundwater is a form of water occupying all the voids within geological layers. The occurrence of groundwater in a geological formation and the scope for its absorption primarily depend on the formation porosity. The conventional methods used to prepare groundwater potential zones are mainly based on ground surveys. The groundwater conditions are significantly depending upon the slope, surface water body, depth of weathering, canals and irrigated fields etc. These factors can be interpreted in remote sensing data. Minor et al. [1] developed an integrated interpretation strategic to characterize groundwater resources for identification of well location in Orenburg using GIS. Gustafson [2] used GIS for the analysis of lineament data received from SPOT imagery for groundwater potential mapping. Krishnamurthy et al. [3] developed a GIS based model for describe groundwater potential zones. The field verification of this model established the efficacy of GIS in demarcating the potential groundwater reserves.

A GIS framework was developed and analysed by Das et al. [4] with rational conditions to groundwater zones using thematic layers like geomorphology, geology, drainage, slope and land use/cover generated using ArcGIS software. Based on the status of groundwater irrigated areas through remote sensing artificial recharge structures such as tanks, dams can be recommended upstream of groundwater irrigated areas to recharge wells in the downstream areas to increase groundwater resources [5].

Previous studies show wide range of using remote sensing (RS) and geographical information system (GIS) technology for GWPZ assessment. In that they use different thematic layers, give specific weight to all classes and each thematic layer based on their sensitivity or specific importance on ground water potentiality. In this paper we use RS and GIS technology, create different thematic layers, which are responsible for ground water possibility and then give specific weight. This research work confirms conservation of sustainable aquifer development judicious extraction of dynamic groundwater resource available in the Orenburg of Russia [6].

2. Study area

We choose east part of Orenburg Oblast, Russia (figure 1) as a study area. It's situated on the boundary of Europe and Asia on Ural rives with Kazakhstan border. The study area latitude is 51°77′ and longitude is 55°10′ with 107 meters above sea level elevation. Orenburg has a relatively dry humid continental climate with long and hot summers and long cold winters. The average January temperature is -15.6 °C (3.9 °F) and the average July temperature is 29.0 °C (84.2 °F). The most important river of the Oblast is the Ural River.

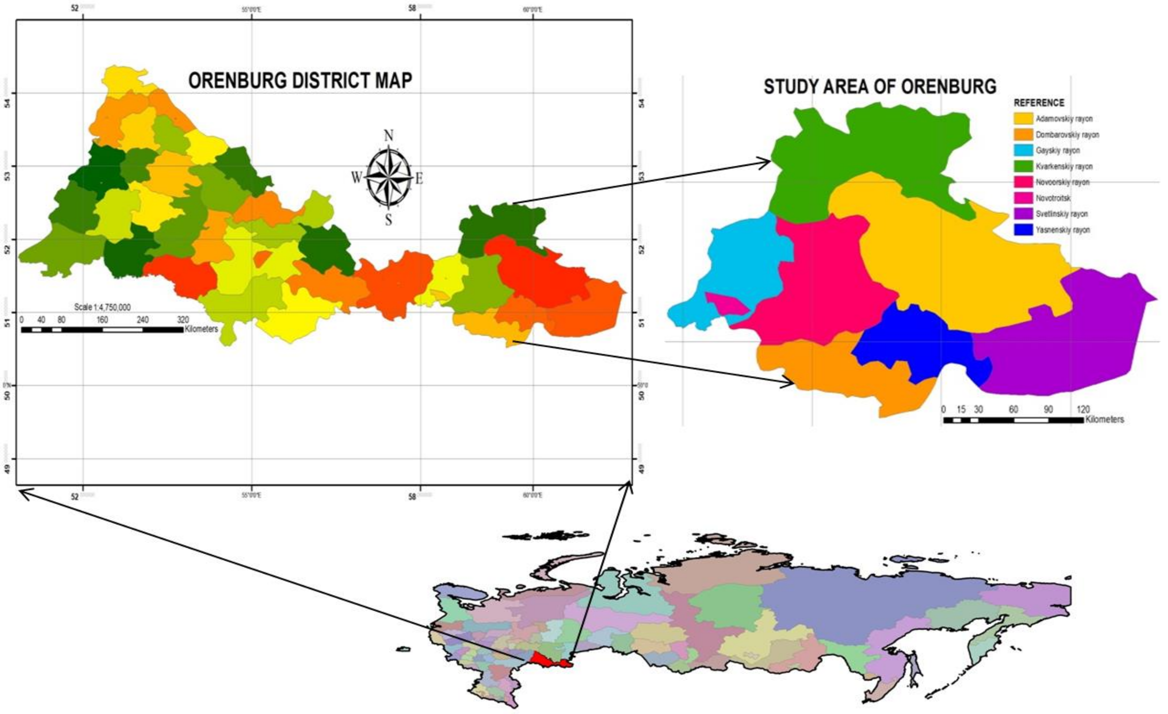

Figure 1. Location map of the Orenburg, Russia.

3. Materials and methods

In this research work we use Landsat-8/OLI (Operational land imager) images to make different thematic layers such as agriculture, forest, geomorphology, land use, lithology, soil, land use/cover, surface water, drainage density, flow accumulation, flow direction and base map. Also use Digital Elevation Model (DEM) from ASTER satellite (ASTER-GDEM) with 30m spatial resolution to create slope map for height information. We use ArcGIS and ERDAS software's for all types of image processing and GIS analysis. For accuracy assessment and verify our results we use ancillary data, topographic maps, field data and specific government departmental information.

In methodological steps after georeferenced the imagery in UTM/WGS84 projection, we remove radiometric and geometric errors [7]. Then identify best band combination for image interpretation and create following thematic layers (figure 2).

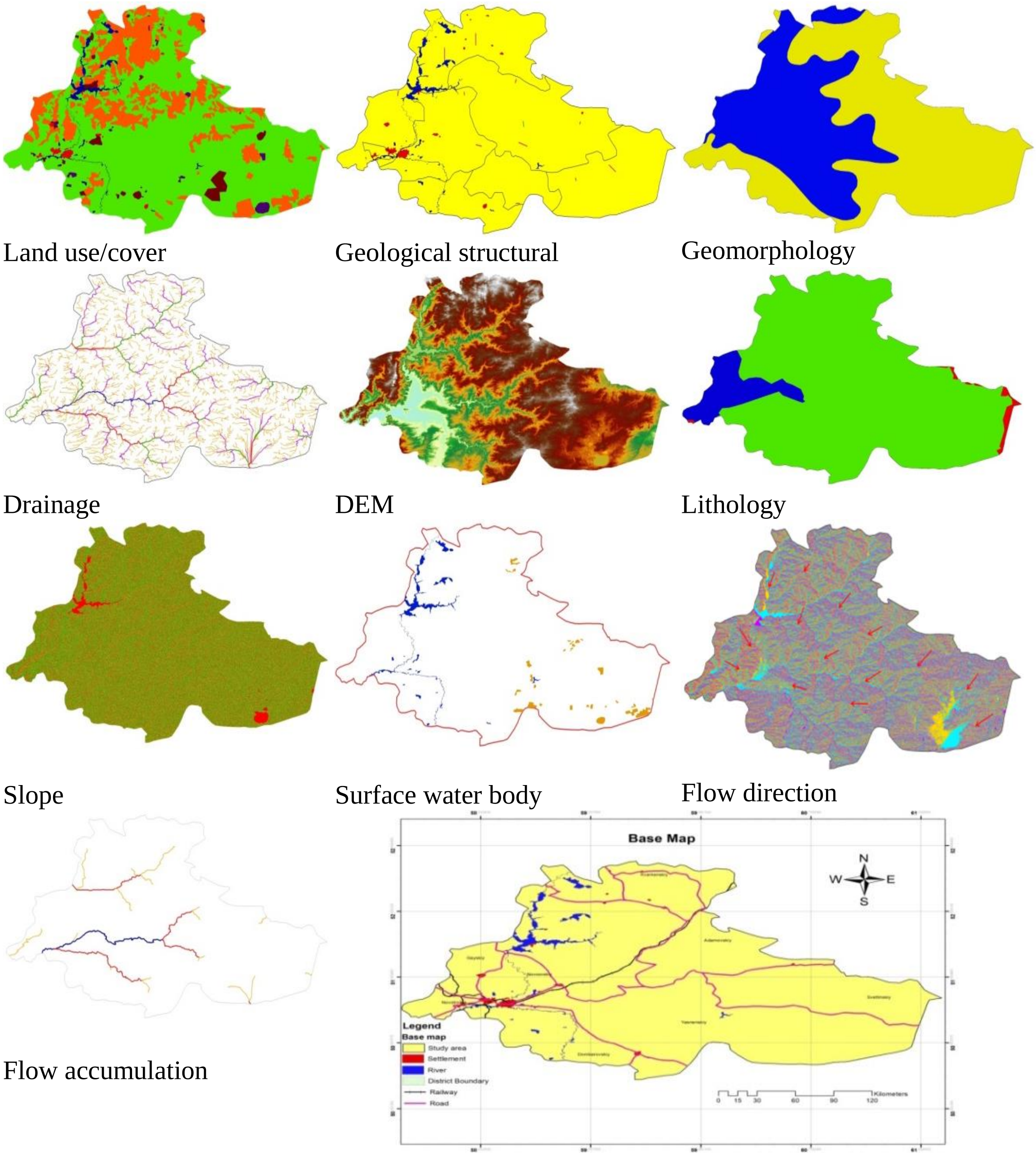

Figure 2. Thematic layers which used for ground water potential zone mapping.

After creating above thematic layers, we combined all layers in ArcGIS software by using raster calculator module to generate final groundwater potential zone map of Orenburg. In this work all factor in each thematic layer were given a weight (arithmetic value in between 1 to 9) based on its sensitivity or strength of influence to the groundwater possibility [8]. In last we further classify final groundwater potentiality map into five classes from very high to very low classes.

After giving specific weight to all factors, than calculate normalized weight (Wn) by geometric mean (GM) and in finally get ground water potential zone map ($GWPZ$) using following equations:

$$Wn = \left(GMn / \sum_{n=1}^{nf} GMn \right)$$

Where the geometric mean of the ith row of the judgment matrices is calculated as:

$$GMn = \mathrm{n}\sqrt{\mathrm{p1np2n \ldots \ldots pnNf}}$$

The groundwater potential zone map was mathematically calculated using ArcGIS raster analysis as follows:

$$GWPZ = \sum Wi * Ri,$$

$$Ef = Wi * Ri$$

$$\text{GWPZ} = \sum(Ef\ of\ all\ thematic\ layers)$$

Where the meaning of equations words as follows:

- E_f = effectiveness of a factor for groundwater potentiality in the study area.
- W_i = map weight for factor i,
- R_i = rating value for i factor.

4. Results

Finally after combined all thematic layers, we get groundwater potential zone map of Orenburg (figure 3) with five classes from very high to very low possibility of groundwater. Approximately 16% of study area in northwest part comes under high and a very high class, means they have maximum possibility of groundwater. Generally low elevations, less slop, low drainage density, high soil porosity increase high infiltration rate of water so its increase the groundwater possibility. Around 33% study area show moderate possibility of groundwater. The north part of the study area comes under low water possibility due to its higher slop, unfavourable geological and geomorphological conditions and covers 42.50% area of the study site (figure 3).

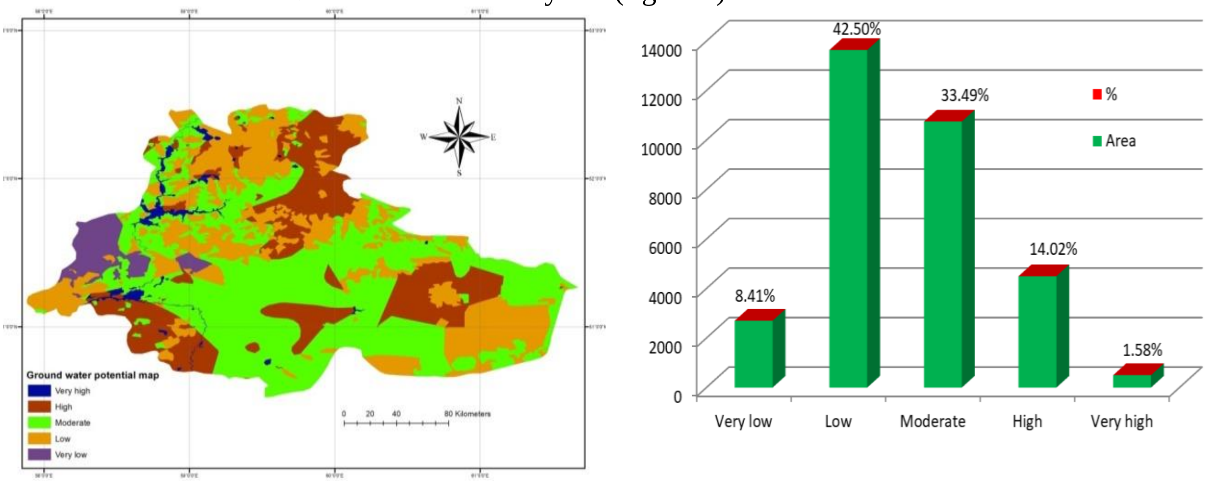

Figure 3. Groundwater potential map of Orenburg, Russia.

5. Conclusion

In this research work we generate groundwater potential zone map of Orenburg, Russia by combined different thematic layers, which relevant to groundwater possibility and by give them specific weight in RS and GIS technology. Recent year's groundwater resources mapping have been increasing due to increased demand for water.

6. References

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