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REVIEW

Frequency ratio model for groundwater potential mapping and its sustainable management in cold desert, India

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Abstract Groundwater potential mapping and its sustainable development are an important aspect in Leh valley due to an increase of tourists and the local population. In the present study, the groundwater potential zones were delineated by adopting a frequency ratio (FR) model. Land use and land cover, hydro geomorphology, slope, geology, lineament density, drainage density, spring well locations and ground water level were the thematic factors considered for groundwater potential zone mapping. There are 86 spring wells located in the study area, of which 60 wells were considered for success rate and remaining 26 wells considered for prediction rate in the FR model. The final groundwater potential map was classified into five zones as very high, high, moderate, low, and very low. The success and prediction rates of FR model were measured as 81.25% and 77.23% respectively. Water budget of the valley was also calculated on the basis of consumption, demand and supply of water by taking account of the floating population. There is a huge demand of water supply requirement during the tourist season from May to September months and deficiency of water in the area was calculated as 4,224,557 (in l). Finally, suitable sites for artificial recharge for sustainable groundwater management were identified. The sites were selected on the basis of depth of groundwater level, source of spring well locations and gradient from natural spring to selected recharge wells.

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Contents

1. Introduction

Over the last few decades, areas with varying demographics and economic reliance have been forced into the 'water crisis', which has to be topmost among the many crises staring us in the face. In fulfilling the water needs of the majority of the population in India, groundwater resources have the highest priority. Groundwater is less vulnerable than surface water sources to climate fluctuations in an undisturbed aquifer system and therefore, acts as a key buffer against drought and normal variations in rainfall. Reliable supply of groundwater lead input for increasing yields, reducing agricultural risk, stabilizing farm incomes and thus leading to higher levels of social and economic security (Moench, 2003). Groundwater exploration entails delineation and mapping of different lithological, structural and geomorphologic units (Solomon and Quiel, 2006). In fluvio-glacial regions particularly outwash plains, valley fills and buried outwash are indicators for source of groundwater potential (Thornbury, 1969). Groundwater obtained from fluvio-glacial region is utilized for domestic and industrial purposes in many cities among the world such as Champaign, Urbana, Illinois, Canton, Ohio (White et al., 1946), Schenectady, New York (Simpson, 1949) etc. In hard rock terrain, the task of groundwater potential mapping becomes a relatively more complex task involving complex decisions owing to lack of reliable data and the highly variable nature of the geological environment (Kellgren, 2002; Anbazhagan et al., 2011). Groundwater in hard rock aquifers is essentially restricted to fractured horizons as the movement of water is mostly through these fractures. Therefore, extensive hydro geological investigations are required to thoroughly understand groundwater conditions in hard rock region (Krishnamurthy et al., 2000; Solomon and Quiel, 2006; Balamurugan et al., 2008; Pradhan, 2009; Anbazhagan et al., 2015) to delineate the groundwater potential zones (GWPZ) through remote sensing (RS) and Geographical information systems (GIS), which act as powerful tools and several studies have been carried out in different parts of the world (Evans and Myers, 1990; Saraf and Choudhury, 1998; Panagopoulus et al., 2005; Rai et al., 2005; Sener et al., 2005; Singh and Singh, 2009; Yan et al., 2010; Biswas et al., 2012; Hammouri et al., 2012; Kuria et al., 2012; Sharma and Kujur, 2012; Sudarsana, 2012; Anbazhagan and Jothibasu, 2014). The identification of GWPZ using remote sensing and GIS techniques involves interpretation of various themes such as vegetation, land use land cover, hydro geomorphology, drainage, lithology, subsurface lithology, structure, slope etc. which have been used in inferring the occurrence of groundwater (Hung et al., 2002; Xiuwan, 2002; Shaban et al., 2006). In hard rocks, which has low or absence of primary porosity, the intersections of secondary structural features are crucial for productive groundwater well (Kumanan and Ramasamy, 2003; Balamurugan et al., 2008). There are various statistical methods that were adopted for groundwater potential zone mapping such as frequency ratio (Davoodi et al., 2013; Manap et al., 2014; Pourtaghi and Pourghasemi, 2014; Naghibi et al., 2015), multi-criteria decision evaluation (Murthy and Mamo, 2009; Kumar et al., 2014; Rahmati et al., 2014; Machiwal and Singh, 2015; Razandi et al., 2015; Jothibasu and Anbazhagan, 2016), logistic regression model (Ozdemir, 2011; Pourtaghi and Pourghasemi, 2014), weights-of-evidence model (Ozdemir, 2011; Pourtaghi and Pourghasemi, 2014), random forest model (Rahmati et al., 2016; Naghibi et al., 2016; Zabihi et al., 2016; Naghibi and Pourghasemi, 2015), maximum entropy model (Rahmati et al., 2016), boosted regression tree (Naghibi et al., 2016; Naghibi and Pourghasemi, 2015), classification and regression tree (Naghibi et al., 2016), multivariate adaptive regression spline