Chapter 19
The Effect Degree Analysis of Human Activities on Regional Groundwater Level Based on Variable Fuzzy Optimization Model

Dong Liu
Northeast Agricultural University, China

Wenting Liu
Northeast Agricultural University, China

Tianqi Luo
Northeast Agricultural University, China

ABSTRACT

Along with the population increasing and social economic developing rapidly, the groundwater resource is affected by human activities seriously. In order to achieve optimal local allocation of water resources and promotion of local economic development, a suitable method for measuring the effect degree of human activities on groundwater resource system is very important. In this paper, regarding Hongxinglong Administration of Heilongjiang Agricultural Reclamation in China as the study area, the comprehensive assessment system to analysis the influence of human activities on groundwater level change with eight evaluated indicators closely related to the amount of groundwater exploitation is established by applying variable fuzzy optimization model. According to relative superiority, the function of effect degree index to evaluate the impact situation is constructed. The results in 2012 show that the human activities on Farm Youyi have the strongest impact on groundwater level variation, while Farm Beixing weakest. Comparing the results from 2003 to 2012, the trend of most effect degree indices reveals decrease by some effective measures. However, there are four farms whose human activities have a stronger influence on groundwater table.

DOI: 10.4018/978-1-4666-9619-8.ch019

1. INTRODUCTION

Water as an important natural resource, is the foundation of human survival and social development. Groundwater is the main source of water supply, and due to the exploitation of groundwater resources continuing increasing in recent years, the issue of groundwater level declining has attracted much attention. There are many reasons for the influence of groundwater level dynamic change, mainly divided into two aspects that natural factors and human factors. Jan et al (2007) analyzed the effect of rainfall intensity and distribution on groundwater level fluctuations and they proposed a mathematical equation describing the relationship between the groundwater level increment and the effective accumulated rainfall amount in the study. Gunawardhana and Kazama (2012) used the Predefined Impulse Response Function in Continuous Time (PIRFICT) method and VS2DH model to discuss that climate change effects will expand into deeper aquifer depths, but the impacts will vary according to the transient change of ground surface temperature and changes in ground water recharge rates. Kløve et al (2013) expressed that aquifers and groundwater-dependent ecosystems (GDEs) were facing increasing pressure from water consumption, irrigation and climate change. These pressures modified groundwater level and their temporal patterns and threatened vital ecosystem services such as arable land irrigation and ecosystem water requirements, especially during droughts. Long et al (2012) had shown that the general water quality in the Vratza region of northern Bulgaria is poor and that agricultural activities had not only added chemicals to the groundwater system, but that these chemicals had likely disrupted geochemical processes. While along with the population increasing and social economic developing rapidly, the water resource demand has been more and more. Due to the lack of controlling system and water conservancy facilities, the exploitation of groundwater resource is acuter and the impact of human activities on groundwater is becoming serious. Researchers at the University of Colorado expressed that human activities led to the land subsidence of most global deltas, and the main reason was excessive extraction of groundwater resource resulting in plain sediment rising, etc.

Human activity is a comprehensive concept, involving many aspects, and there is large spatial variation among the factors. Most of the previous studies are qualitative research, such as pointing out that the influence mechanism of a certain factor on the groundwater level fluctuation (Zhang et al 2009), or using principal component analysis to select the main role in changing groundwater table (Jiang et al 2014), which did not make a comprehensive assessment or introducing the effect situation. There are many comprehensive evaluation methods, such as fuzzy comprehensive evaluation (Wang et al 2012), set pair analysis (Liu 2012), matter element model (Gong et al 2012) and so on. These methods have one common defect that it is not objective when grading of assessed indicators. There is much subjective thought of the authors in degree classification which has no unified scale. Based on these, in this study, the goal is to use variable fuzzy optimization model and construct the function of effect degree index according to relative superiority to measure the effect degree of human activities on groundwater resource system. Thus, the assessment system can contain multiple indices related with human activities and the construction of the function can avoid grade classing of indicators.

The paper is organized as follows: after introduction, the Materials and methods are introduced. A specific case study is provided in section 3. The general condition of study area, the data of eight evaluated indices we collected and the effect degree of twelve farms are presented. Conclusions and future research directions are summarized in the last section.