

Evaluation of groundwater overexploitation and identification of overexploitation factors

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Objectives

Research is conducted to identify the factors contributing to groundwater overexploitation in the Sanjiang Plain by studying the dynamic changes of groundwater levels under the influence of hydrological conditions and human activities. Key data such as the distribution and amount of groundwater overexploitation in the Sanjiang Plain are evaluated. By analyzing existing hydrological observation data, experimental parameters, and statistical data, the study aims to understand the mechanisms of groundwater circulation and transformation in the Sanjiang Plain under the “precipitation-soil water-surface water-groundwater” four-water conversion system. The research also explores the impact of transboundary water utilization, water-saving measures in agriculture, industry, and daily life, as well as changes in the ratio of surface water to groundwater for irrigation on water replenishment, drainage, consumption, and overall water balance in the Sanjiang Plain. The study assesses the effects on food production, the role in groundwater overexploitation remediation, and changes in regional groundwater flow field and burial depth.

Methods

Based on the construction of the hydrogeological conceptual model and research on hydrogeological parameters, the current situation of groundwater resources and their development and utilization in the Sanjiang Plain was investigated and evaluated. According to 1148 borehole data, 89 pumping tests and 50 seepage tests were conducted. Using recurrent neural networks (RNN) and generative adversarial networks (GAN), the thickness distribution of the upper cover of the aquifer was finely characterized, and the spatial distribution rules of groundwater types and aquifers were analyzed. The distribution patterns of permeability coefficient and steady seepage rate were also obtained. On the basis of analyzing the environmental hydrogeological issues associated with groundwater exploitation, the identification and study of groundwater overexploitation, overexploitation volume, and overexploitation factors were carried out. The simulation verification of groundwater overexploitation status, overexploitation factors using the MODCYCLE model was also conducted.

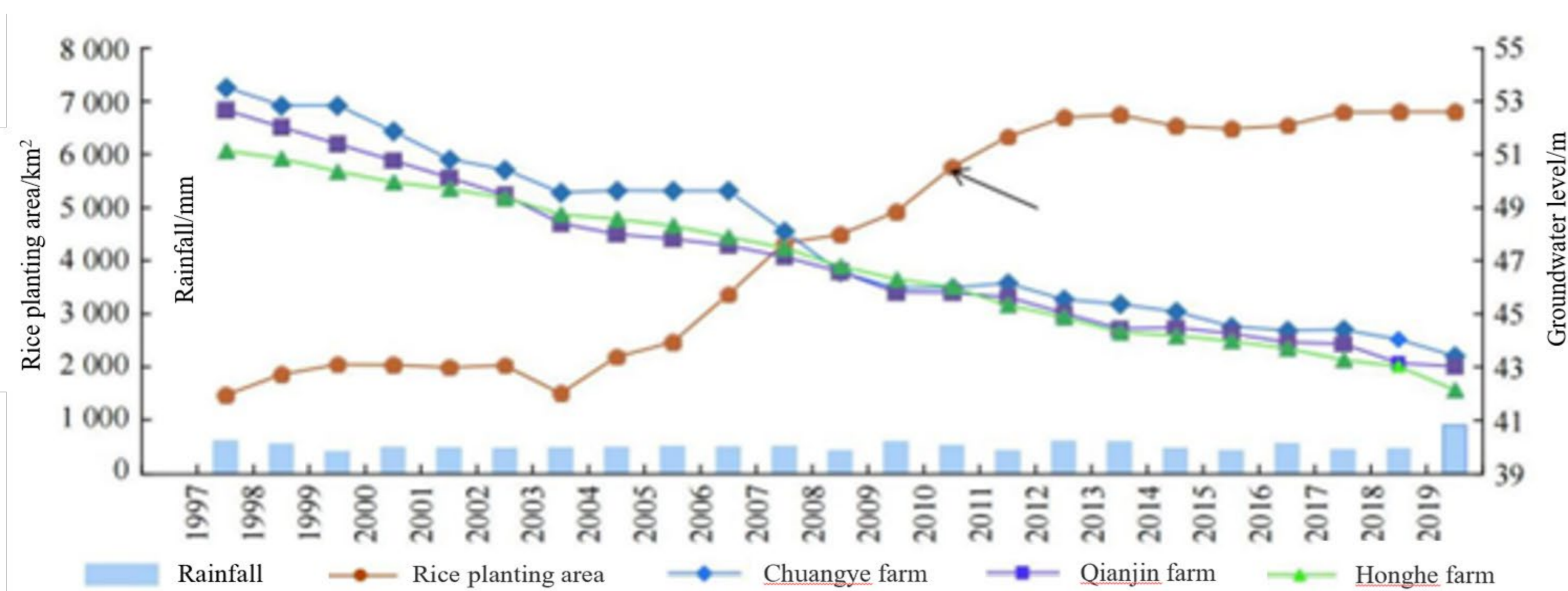


Figure 2 The relationship between the water level of groundwater funnel and the area under rice cultivation in Sanjiang plain.

Results

According to the analysis of the dynamic data of groundwater level from 2001 to 2020, the average groundwater level of Sanjiang low plain decreased by 0.43m, and the area of the decline area was 17,400km², and the areas with the decline rate of more than 3m were mainly concentrated in the eastern part of Jiansanjiang Reclamation Area and Zuoli River Basin, with the decline rate of 0.15-0.44m/a, and the area of the decline area was 0.82km²; the calculation and analysis of the groundwater level of the Sanjiang Plain The cumulative over-exploitation in the decline area is 12.194 billion m³, with an average annual over-exploitation of 646 million m³, of which the cumulative over-exploitation in the decline area of Sanjiang low plain is 11.962 billion m³, with an average annual over-exploitation of 630 million m³; the cumulative over-exploitation in the decline area of Muleng Xingkai low plain is 232 million m³, with an average annual over-exploitation of 0.17 billion m³.

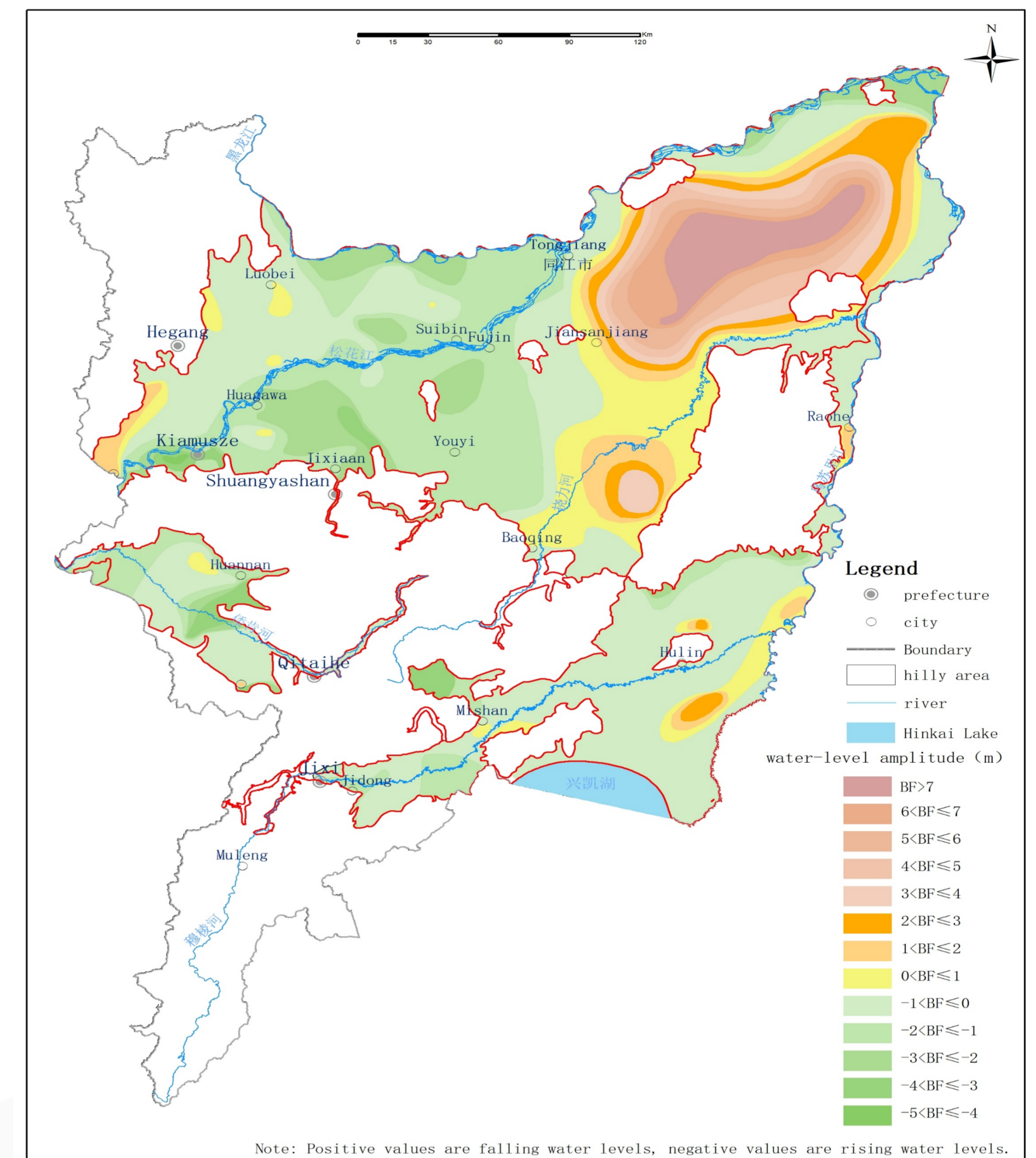


Figure 1 Map of groundwater level variability in the Sanjiang Plain

Conclusions

The Quaternary pore aquifer in the Sanjiang Plain is characterized by its wide distribution, single structure, and large thickness. It mainly consists of sand and gravel with no regional water separators, making it a unified Quaternary aquifer system. However, the rapid increase in groundwater extraction has led to a decline in groundwater levels and localized landing funnels formation. Despite taking pressure-mining measures in recent years, some areas are still experiencing overexploitation of groundwater due to massive exploitation. The continuous decline in groundwater levels has weakened the conservation of lakes and wetlands in some areas. Over-exploitation and utilization of groundwater for irrigation of paddy fields are the dominant factors causing overexploitation of groundwater. Additionally, the construction of surface water projects in the Sanjiang Plain is lagging behind, joint surface water-groundwater control is low, and the water-saving capacity of water transmission and distribution processes in fields is limited, making it difficult to meet the water demand caused by the rapid expansion of well irrigation and rice cultivation areas.

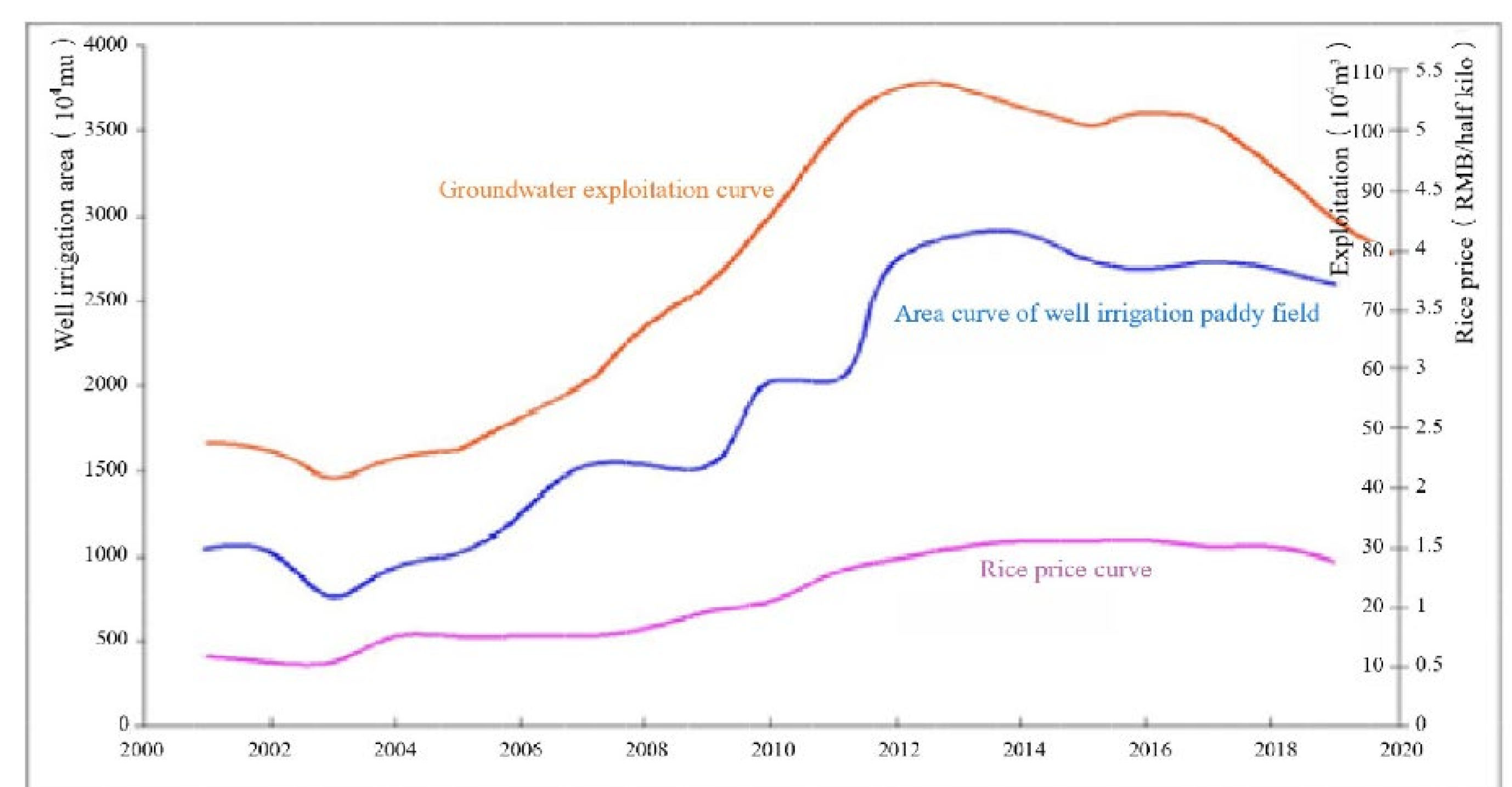


Figure 2 Plot of the area of well irrigated paddy fields in the Sanjiang Plain in relation to the amount of groundwater extraction.