Geophysical Research Abstracts
Vol. 20, EGU2018-8448, 2018
EGU General Assembly 2018

Quantifying groundwater resilience in Noord-Brabant, the Netherlands

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This case study explores groundwater resilience in the Province of Noord-Brabant (5108 km2) in the south of the Netherlands. Groundwater resilience is defined as the relative impact of abstractions, climate change and other anthropogenic influences on phreatic groundwater levels, environmental base flow and other ecohydrological boundary conditions. The area is characterized by alternation of intensive agriculture, urban areas, level controlled and freely drained areas. Changes in land use and spatial planning changed groundwater levels and base flow. There is a need to regulate groundwater abstractions of agriculture, industry and water companies to minimize negative impacts on wetlands and ecological valuable natural streams. However, there was a lack in understanding in aquifer response to future climate and economical changes.

The aim of this study is to quantify the groundwater resilience of the Province of Noord-Brabant, taking into account future changes in groundwater demand and supply. Groundwater demand is expected to change in response to changes in population density and industrial and agricultural activity. Groundwater supply (groundwater recharge) is expected to change in response to climate change. The expected changes are scenario input for a regional groundwater model simulating both saturated and unsaturated flow in a time frame of 10 years. Effects were assessed using scale-independent resilience indicators, such as change in base flow relative to change in abstraction rate, the relative change in groundwater seepage and infiltration, and changes to the horizontal and vertical flux per aquifer. These indicators are also used in the European Water Framework Directive approach.

The water balance per climate scenario shows a wide range in effects. The average annual recharge is expected to increase due to an increase in precipitation. In the dry climate scenario this entails a recharge increase in winter and a decrease in summer. Less recharge results in prolonged low groundwater levels and lower base flows during the summer months, which are exacerbated by additional drawdown due to a sharp increase in irrigation. In the wet climate scenario average summer recharge and irrigation demand do not change much.

Changes in groundwater abstraction have markedly different effects in several subareas of the province. Phreatic groundwater levels and base flows are mostly impacted in the upper catchments. Effects are relatively small in low-lying level controlled areas with predominantly upward seepage. In a graben in the central part of the Province additional drawdown is distributed to neighbouring and upstream areas outside of the province.

The results provide useful insight in the range of expected changes to the groundwater system in the Province of Noord-Brabant. This can be used to manage the strategic groundwater reserves and to set limits on irrigation and deep groundwater abstraction. Quantified groundwater resilience indicators allow for the identification of critical sub areas with significant effects on groundwater levels and other ecohydrological boundary conditions. Taking into account a bandwidth of uncertainties in climate change and water demand by different users the present and future groundwater can be analysed in mutual perspective.