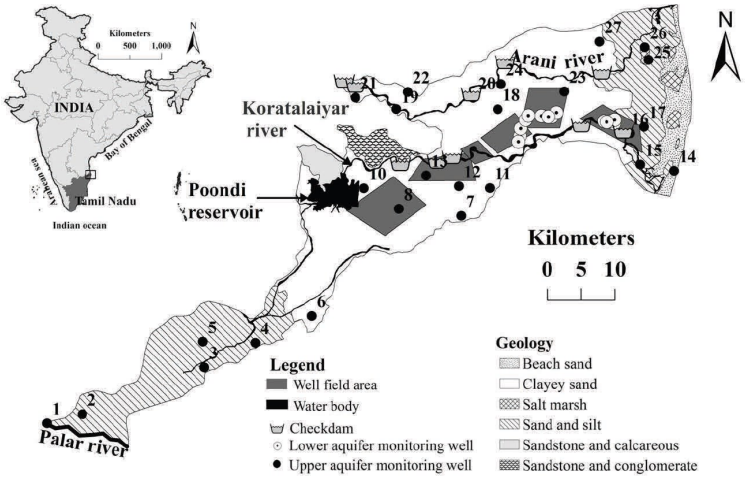
MITIGATION OF SEAWATER INTRUSION THROUGH MANAGED AQUIFER RECHARGE IN SOUTHEAST INDIA

Application of coupled surface and groundwater modelling in a coastal aquifer

The water supply system of the metropolitan area of Chennai is facing problems due to high groundwater abstraction and progressing salt water intrusion. To increase groundwater recharge, several check dams have been constructed in this area. A supporting analysis and planning tool has been developed for long-term analysis of managed aquifer recharge (MAR) measures. An increase in groundwater levels was verified, but a reduction of the current abstraction rate is necessary for a sustainable management of the water resources.

CHENNAI'S WATER SHORTAGE PROBLEM

The Chennai metropolitan area relies on groundwater abstraction and surface water reservoirs to account for the city's water supply and the demands from agriculture and industry. The majority of the groundwater is originating from the well fields located in the Arani and Koratalaiyar (A-K) river basin, about 40 km north of Chennai. As a result of increasing water requirements, excessive abstraction from the groundwater supplies has occurred, leading to progressive salt water intrusion.



Geology of study area. © ANNA University/Rajaveni

With precipitation occurring mostly during the monsoon periods, heavy peak rainfalls lead to rapid runoffs to the sea, preventing natural groundwater recharge through river bank infiltration. To counteract this, several check dams have been built in the A-K basin and more are planned in future. The need of a supporting

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CHALLENGE

- Progressing salt water intrusion due to excessive groundwater abstraction
- Low groundwater infiltration, since most annual rainfall occurs during monsoon periods only
- Investigation of required managed aquifer recharge (MAR) techniques

SOLUTION

Development of an integrated surface and density-dependent groundwater model to analyse MAR options.

VALUE

- Integrated modelling tool which can be used to analyse MAR scenarios as well as general water resources investigations
- Positive effect on groundwater levels through implementation of check dams verified

LOCATION / COUNTRY

Chennai, Tamil Nadu, India

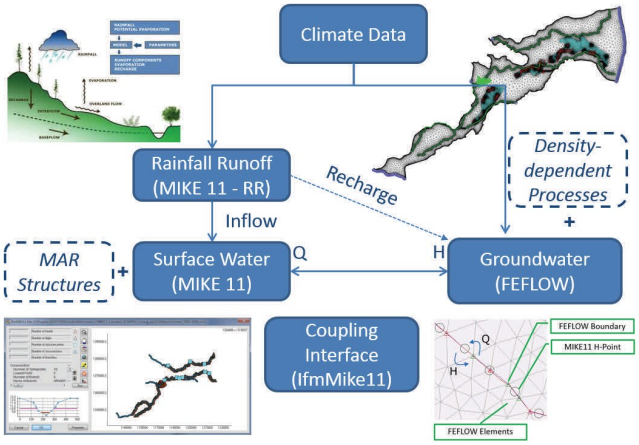
SOFTWARE USED

FEFLOW / MIKE 11

analysis and planning tool for the implementation of such MAR structures was identified and developed as part of the European Union-funded project Saph Pani.

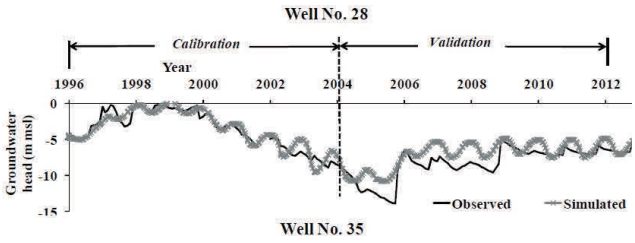
AN INTEGRATED MAR MODELLING CONCEPT

An integrated modelling approach was developed, coupling surface and groundwater processes. This consists of a rainfall-runoff model (NAM) producing surface flow for a 1D river model (MIKE11), in which the already existing check dam structures are included. The MIKE11 model is linked to a 3D groundwater model (FEFLOW) through the coupling interface (ifmMIKE11). After the successful calibration of the single and integrated models, density-dependent flow processes were included in the 3D groundwater model.



Integrated MAR modelling concept. © DHI

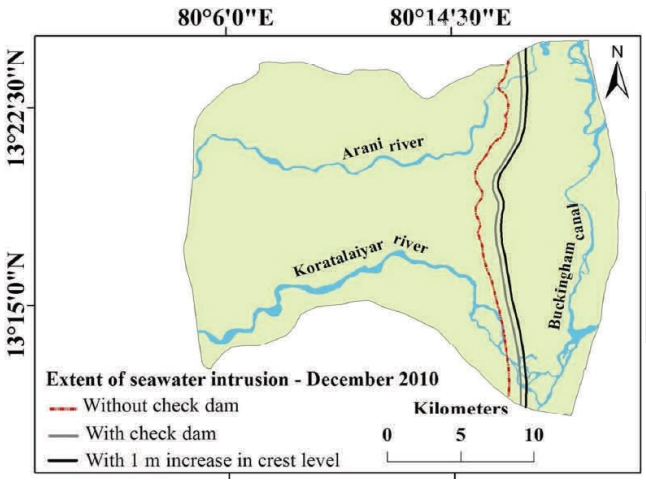
The interaction with the river model increases the simulated groundwater heads by passing the effect of the peak flows in combination with the check dams into the groundwater model. This process would have been underestimated by a decoupled groundwater model, showing the advantage of using such an integrated model.



Integrated MAR modelling concept. © DHI, © ANNA University/Rajaveni

MAR SOLUTIONS

With this tool, several scenarios were analysed, including the construction of additional check dams, increasing the crest level of the check dams, rejuvenation of non-operational water bodies and reducing the abstraction by limiting the pumping in some of the well fields. The simulation results indicate that the most effective aquifer recharge is reached by including additional check dams, but even with combined increased dam crest levels and rejuvenation of non-operational water bodies, this is not sufficient to restore the aquifer with respect to seawater intrusion.



Extent of seawater intrusion without check dams, with existing check dams and with 1 m increase in crest level of existing check dams. © ANNA University/Rajaveni

OUTLOOK

A calibrated modelling tool which displays the current salt water intrusion process has been successfully developed. A positive local effect of the MAR structures was identified both on the groundwater levels and in pushing back the saltwater front. It shows that a reduction of the current abstraction rate is necessary for sustainable management of the existing water resources. This tool can be used for the long-term analysis of MAR structures by using current seasonal cycles of climatological and groundwater recharge conditions. It can also be used for predicted seasonal variations through climate change conditions as well as for general water resources quantifications.

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