Environmental Earth Sciences (2019) 78:343
https://doi.org/10.1007/s12665-019-8340-y

ORIGINAL ARTICLE

Ten-year prediction of groundwater level in Karaj plain (Iran) using MODFLOW2005-NWT in MATLAB

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Received: 25 May 2018 / Accepted: 20 May 2019 / Published online: 4 June 2019

Abstract

The accelerated trend of urbanization as well as industrial development in Karaj can be mentioned as the major reasons for speeding up the exploitation of water resources in this study area, through the recent decades. The increase in industrial, domestic and agricultural water consumptions, as a result of the abovementioned development, has been accompanied by an irregular and wasteful extraction of groundwater resources considering drought in the recent years and reduced precipitation in the Middle East. The above direction has resulted in dire consequences such as unbelievable drop in groundwater level and reduced aquifer storage while several springs and qanats were deserted and dried up. Therefore, an accurate study of groundwater status, reasons for groundwater level drop and consequences besides presenting solutions for conservation and balancing groundwater should be known as the most critical issues for this area, since stepping out of the current situation requires reasonable policies for exploiting from the aquifer. Therefore, by utilizing MATLAB interface in this research, three scenarios entitled optimistic situation, pessimistic situation and continuing current situation were defined to predict groundwater level of Karaj study area until water year of 2023–2024. According to the results, 12.834, 19.089 and 4.906 m water level drops were computed for continuing current situation, pessimistic situation and optimistic situation, respectively.

Keywords Groundwater level · Groundwater management · Prediction scenario · MODFLOW · Semiarid region · MATLAB

Introduction

Groundwater is one of the major resources of supplying agricultural, industrial and domestic water requirements (Bai et al. 2011; Zahedi et al. 2017). This water resource, in some arid and semiarid districts, is the only source to provide water requirements (Emamgholizadeh et al. 2014, Zahedi 2017). In many regions, groundwater level has dropped at rates far in excess of recharge, having ended in environmental side effects, drying up of wells, reduction of water in streams and lakes, water-quality degradation, increased pumping costs, land subsidence and decreased well yields (Tizro et al. 2018). These are the dire consequences for the current wasteful exploitation of water in developing countries (Adamowski and Chan 2011; Aliyari et al. 2018). Groundwater level decline can be considered in terms of a period of minimum groundwater storage, in environmental terms as a period of minimum base flow, in water-supply terms as a period of minimum groundwater level at a supply resource and in water-demand terms as a period of maximum stress at a groundwater resource (Yousefi et al. 2018). To reduce the adverse effects of groundwater depletion, it is necessary to conduct strict groundwater management in over-exploited areas (Li et al. 2013). One of the adequate methods to study groundwater status is using numerical models (Daliakopoulos et al. 2005). Many of the recognized

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models are computer software used for groundwater simulation and forecast applications (Van-Camp et al. 2010). Groundwater modeling system (GMS) is one of the important interfaces presenting valuable functions such as interpolation tools. This application has the capacity to simulate quantity and quality of groundwater using finite-difference method. It should be noted that inaccessibility to the source code is the imperfection of this application (Khalaf and Abdalla 2014).

Along with allocating a remarkable amount of budget, various methods have been examined through the recent decade with the aim of obtaining any realistic estimation of groundwater level. For instance in the past studies, Kharmah (2007) utilized MODFLOW and GVM models for simulating and optimizing groundwater in Eocene aquifer in West Bank. The simulation was performed and calibrated for steady and transient states, and then, calculations were made using GVM in order to obtain optimal pumping rate of the farming wells in an aquifer. Wen et al. (2007) utilized FEFLOW model to predict groundwater level status in Zhangye Basin in east China. The quantitative model was calibrated for 4 years, and groundwater level status was predicted by two scenarios for 30 years from the year 2000 to the year 2030. El-Yaouti et al. (2008) utilized MODFLOW-96 code for simulating groundwater level in Bou-Arejpalin, Morocco, while the model was calibrated for both steady and transient conditions. The results illustrated that the groundwater level depended on precipitation and return flows from farming lands. Semiromi and Koch (2019) applied MODFLOW-NWT and SWAT models to analyze surface–groundwater interactions in the Gharehsoo River Basin, Iran, using a coupled SWAT–MODFLOW model. The analysis of the stream–aquifer exchange flows indicated that groundwater discharge toward the stream network (effluent conditions) would be orders of magnitude higher than the opposite process (influent conditions). In addition, findings revealed that many of the tributaries across the basin have shifted from a perennial regime to ephemeral/intermittent system over the past decades.

In other studies, Surinaidu et al. (2015) tried to estimate any quantitative measure for groundwater inflows into the coal mines of Andhra Pradesh, India, at different mine development stages, using MODFLOW. They argued that the applied method could be used to plan optimal groundwater pumping as well as probable locations of groundwater dewatering for safe mining at different mine development stages. Lilly and Ravikumar (2017) estimated the groundwater level using GIS for Chennai Metro Rail Corridor, Tamil Nadu, India. They illustrated annual map of groundwater level and calculated the mean values for 1995–2007 and 2008–2014. They also provided mapping to evaluate the existing water quantity scenarios in the metro rail corridor. Zare-Aghbolagh and Fataei (2017) studied variations related to groundwater level in Ardabil plain, Iran, using GIS. The results indicated that some parts of the plain had a 40-m decline. Hosseini et al. (2016) applied two intelligent optimization algorithms named back-propagation neural network (ANN-BP) and back-propagation ant colony optimization (ACO_R-BP) to simulate monthly groundwater levels in an unconfined coastal aquifer located in the Shabestar plain, Iran. The results indicated that a hybrid ACO_R-BP model would be a much more fitting tool for groundwater level prediction. Barzegar et al. (2017) utilized the ensemble hybrid multi-wavelet neural network-based models to evaluate the performance of different hybrid wavelet-group method of data handling (WA-GMDH) and wavelet extreme learning machine (WA-ELM) models. The other purpose is to combine different wavelet-based models of forecasting the groundwater level for 1, 2 and 3 months step ahead in the Maragheh–Bonab plain, Iran. To combine the advantages of different wavelets, they applied a least squares boosting (LS boost) algorithm. Use of the boosting multi-wavelet neural network models provided the best performances for groundwater level forecasts in comparison with single-wavelet neural network-based models. The results indicated that WA-ELM models outperformed WA-GMDH models. Makungo and Odiyo (2017) applied system identification models to estimate groundwater levels in Nzhelele and Luvuvhu areas, Limpopo Province, South Africa. The results of the study illustrated that the model would be able to estimate groundwater levels based on the graphical fits and model performance measures. In addition, the calibration period used in this study would be adequate to capture a reasonable description between input and output variables and could be used to estimate long-term groundwater levels. Wunsch et al. (2018) presented their research about forecasting groundwater levels using nonlinear autoregressive networks with exogenous input (NARX). The observations confirmed utterly reliable results generated by NARX for groundwater level predictions with a small set of inputs in all three aquifer types. Naderianfar et al. (2017) developed a MATLAB-based model to predict groundwater levels using the fuzzy standardized evapotranspiration and precipitation index (SEPI). The results generally illustrated that due to severe linearity between SEPI indicator and its timescales, the use of PCA would be essential for simulating fluctuations of the groundwater levels. Karimi et al. (2019) developed a MODFLOW-based model to forecast groundwater level fluctuations in Tehran aquifer. The results represented a good consistency between the predicted and observed hydraulic head values with the maximum absolute error of lower than 7 m and RMS error of 2%. They claimed that their model could simulate and predict the aquifer hydraulic head distribution and its changes with high accuracy.

The purpose of this paper is to predict groundwater level in Karaj for 10 years using MODFLOW2005-NWT code in

MATLAB and apply three scenarios entitled continuing current status, optimistic status and pessimistic status to study all possible conditions in the region.

Study area

As can be observed in Fig. 1a, Karaj is a part of Alborz Province in the central part of Iran and located in the northwest of Tehran Province. Karaj plain lies between 50°45′ and 51°10′ east longitude and 35°39′–35°55′ north latitude in the center of Iran. The study area is about 507.94 km^2, and the mean altitude is nearly 1305 m above the sea level. All parts of the aquifer have been defined as an integrated alluvial unconfined aquifer with specific yield parameter (S_{y}) between 0.09 and 0.25 as well as transmissivity parameter (T) ranging from 1271 to 2680 m^2/s through the observational data in five points (Fig. 1b). Based on the Alborz Regional Water Authority's information (ARWA), the bedrock depth has been estimated between 200 m (in the south side) and 350 m (Fig. 1c). The subsurface stream flows from the northwest to the southeast, illustrating path of water within the aquifer.

It also has an arid and semiarid climate considering Dommartin and Ambreje category, respectively. The annual precipitation amount of the case study is approximately equal to 204 mm. Moreover, the mean annual temperature is near 15.1 °C (59.2 °F). According to the land-use map of the case study, agriculture is the main industry in Karaj plain. Figure 2a suggests that groundwater level has decreased down to 40 m from 1991 to 2016. Also the average annual groundwater level is revealed in Fig. 2b to indicate the groundwater status in each month for the water years 2014–2015.

Materials and methods

The conceptual model

The aim of the paper is to obtain a prediction model of the groundwater level status in Karaj plain through a 10-year period, from water year 2014–2015 until water year 2023–2024. One Hundred and twenty stress periods have also been used in order to compute a monthly groundwater level. The second step is to develop a conceptual model utilizing MATLAB, Excel and GMS (for validating the results made by MATLAB codes). This conceptual model is developed from six coverages including aquifer boundaries, piezometers, surface recharge, hydraulic conductivity and specific yield. The depth parameter also has been considered by applying the top layer (as the surface layer) and the bedrock layer into the model.

Values of surface recharge, horizontal hydraulic conductivity and specific yield were calibrated for each steady and transient state using parameter estimation (PEST) optimizer. Manual adjustment was also applied by identifying significant differences between the observation data and the computed ones. Moreover, in order to determine the surface recharge coverage, the recharge amount from returned water was considered in addition to the amount of recharge from precipitation in each month with permeability index ranging from 0.14 to 0.18. According to the reports of Alborz Regional Water Authority (ARWA), the amount of recharge from returned agricultural water was found to be 30–40% of the total amount of discharge and for domestic and industrial consumptions this value was estimated to be between 60 and 70%. It should be noted that data of October 2003 were utilized for steady state and the data of water year 2003–2004 to water year 2010–2011 were utilized for transient state. The data relating water year 2011–2012 to water year 2013–2014 were, on the other hand, used to validate the abovementioned conceptual model. In addition, a code entitled MODFLOW2005-NWT was utilized for simulating groundwater status. The network matrix of the study area has been formed by 297 rows and 338 columns consisting of 50826 active cells in 100×100 m^2 dimension (Fig. 3).

MODFLOW model

MODFLOW model was presented as the 3D modular finite-difference groundwater flow model in 1984 by US Geological Survey (USGS). In 1988, this model was presented with minor changes such as converting programming language from FORTRAN 66 to FORTRAN 77 as the MODFLOW-88. New versions of the MODFLOW model were, subsequently, developed by many researchers, and different simulation packages were produced to improve this model (Chiang, and Kinzelbach, 2001).

Techniques for solving flow equations in MODFLOW

Three-dimensional movement of groundwater flow in porous environment can be defined by the below deferential equation:

$$\frac{\partial}{\partial x}\left(k_{xx}\frac{\partial h}{\partial x}\right) + \frac{\partial}{\partial y}\left(k_{yy}\frac{\partial h}{\partial y}\right) + \frac{\partial}{\partial z}\left(k_{zz}\frac{\partial h}{\partial z}\right) - W = S_{\mathrm{y}}\frac{\partial h}{\partial t}, \quad (1)$$

where $k_{xx}, k_{yy}, k_{zz} = [L/T]$. $h = [L]$. S_{y} is the specific yield; W, discharge value; and $t = [T]$, time.

Equation (1) illustrates groundwater flow toward the main axis in an inhomogeneous environment under unstable conditions. It has to be mentioned that specifications of flow or conditions of an aquifer system boundaries and conditions of primary level of groundwater system would be considered as a mathematical form. The right side of the equation is considered to be in a homogenous environment.

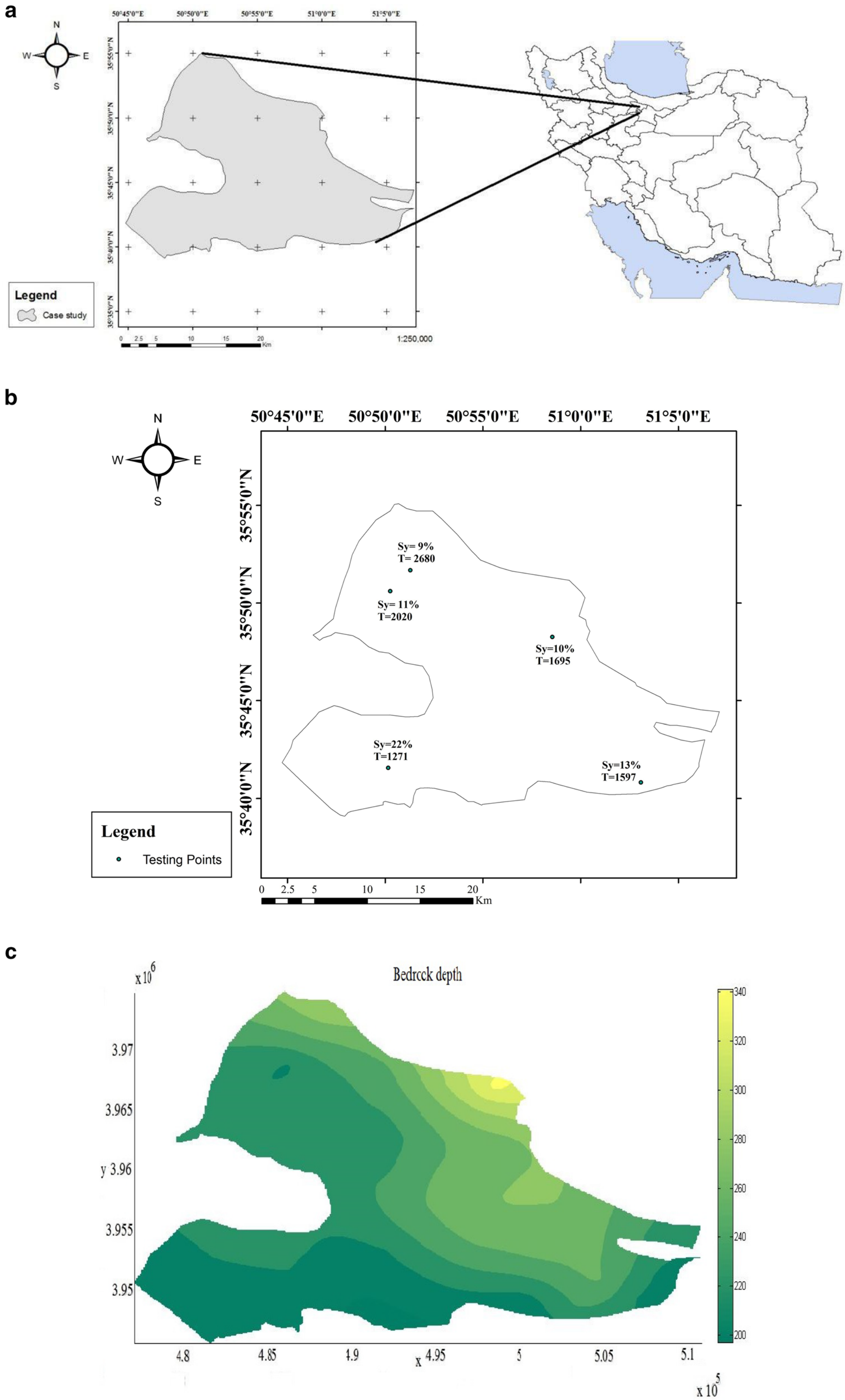


Fig. 1 **a** Location of the study area. **b** Hydrogeological situation of the study area. **c** Depth of the bedrock across the aquifer (in meters)

Fig. 2 **a** Average annual groundwater level of the study area during 1991–2016. **b** Average annual groundwater level of the study area during water year 2014–2015

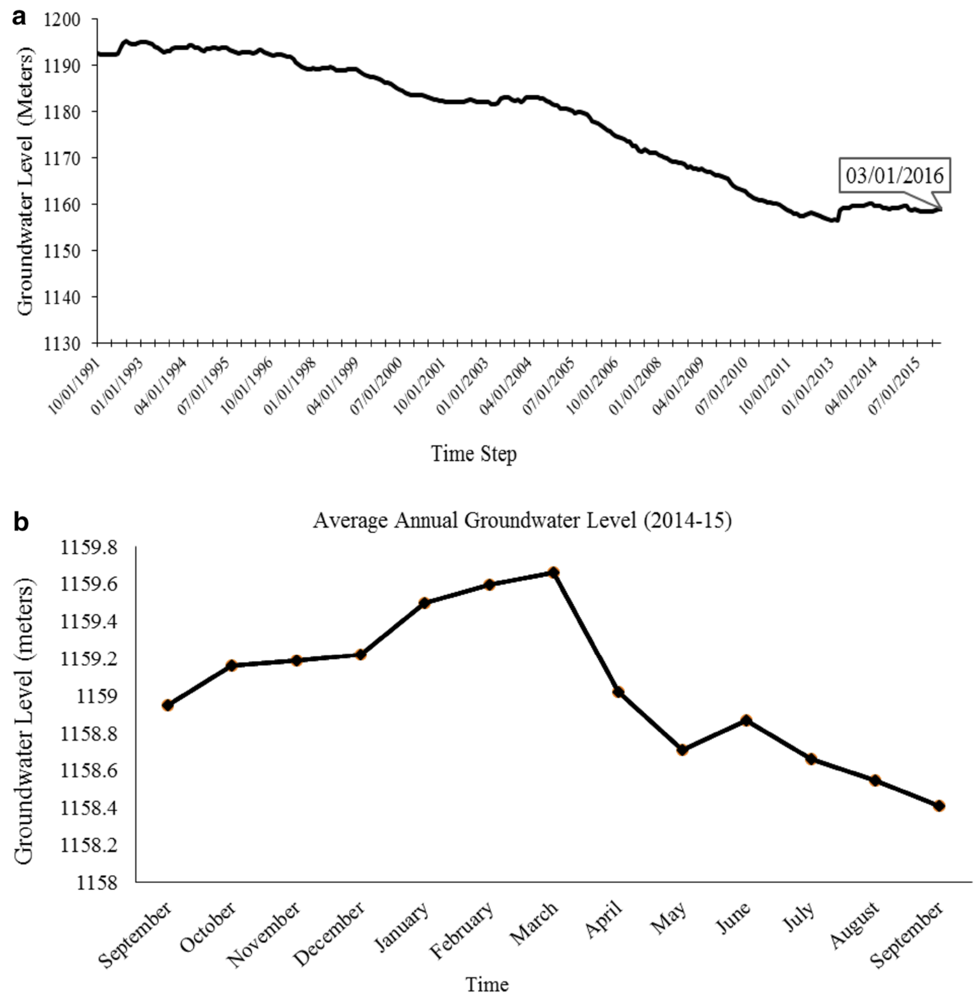
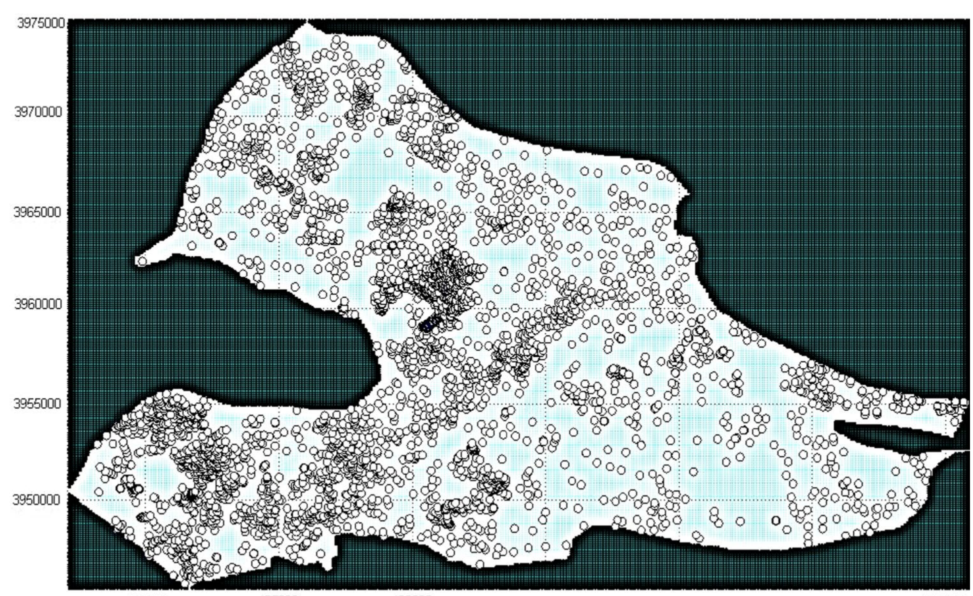


Fig. 3 Location of the study area in MATLAB



Equation (1) can only be solved in a simple system by analytical methods. In most cases, numerical methods would be suggested to obtain an approximate solution and finite-difference method can be recognized as one of them. In this method, continuous systems are classified into a collection of two coordinate points consisting period and position as coordinates. Moreover, water level differences in each point were calculated by partial derivative.

Using a continuous model is required to utilize finite-difference method in the development of groundwater flow equation. Accordingly, the difference between input and output flows of a cell is considered equal to the rate of groundwater storage changes of that cell. Continuous model is defined for each cell in Eq. (2), while groundwater density is assumed constant.

$$\sum Q_i = S_{\mathrm{y}} \Delta h \Delta V, \tag{2}$$

Q_i is the flow rate into i(th) cell; $\Delta V = \left[L^3\right]$, cell volume; Δh, water level changes in (Δt) period; and S_{y}, specific yield.

$\sum Q_i$ is considered equivalent to water input (storage volume of a cell) in the time period of Δt, rendering changes in water level of a cell to the amount of Δh. Input flows, storage and recharge amounts are considered as positive values while output and discharge values are negative for each cell. These equations can be produced for all cells, and the problem would be, then, converted to N equations for N unknowns (Harbaugh 2005).

Nonlinear stress packages can be used along with MODFLOW-NWT without modification. However, adding the stress derivative to the Jacobian in MODFLOW-NWT can enhance convergence. The following example presents the steps required for adding stress package derivatives to MODFLOW-NWT. Consider the simple quadratic function that relates flow to a cell as a function of head:

$$Q = f(h) = ah^2 + bh, \tag{3}$$

where Q is the volumetric flow rate into a cell, h is the groundwater head and a and b are coefficients. The Newton method is applied as:

$$\frac{\partial}{\partial h} f(h) \Delta h = -f(h). \tag{4}$$

In this case, the nonlinear boundary condition has a known functional relationship to h and the analytical derivative can be determined. However, if this function is not known, then a numerical derivative can be used. Equation (5) can be rewritten as:

$$(2ah + b)\Delta h = -\left(ah^2 + bh\right), \tag{5}$$

where $\Delta h = h_k - h_{k-1}$, the subscripts k and $k-1$ designate values of h for nonlinear iterations k and $k-1$, and all other occurrences of h in equation b4 are assumed equal to h_{k-1}. After rearranging the terms, the equation can be presented in the form of the equations that are solved by MODFLOW-NWT.

$$\left(2ah_{k-1} + b\right)h_k = ah_{k-1}^2, \tag{6}$$

where h_k is the unknown head, and h_{k-1} is the known head from the previous nonlinear iteration. Now that Eq. (6) is in the same form as the equations solved by MODFLOW-NWT, these terms can be added to the appropriate arrays within the MODFLOW-NWT source code (Niswonger et al. 2011). Detailed discussions of numerical modeling of groundwater flow can be found in Fig. 4 by Betancur et al. (2012).

Model evaluation

The criteria such as mean error (ME), mean absolute error (MAE) and root-mean-square error (RMSE) were used to assess and evaluate the model as follows (Hassan 2004):

$$\mathrm{ME} = \frac{\sum_{i=1}^{n} \left(h_o - h_i\right)_i}{n}, \tag{7}$$

$$\mathrm{MAE} = \frac{\sum_{i=1}^{n} \left|\left(h_o - h_i\right)_i\right|}{n}, \tag{8}$$

$$\mathrm{RMSE} = \sqrt{\frac{\sum_{i=1}^{n} \left(h_o - h_i\right)_i^2}{n}}. \tag{9}$$

Determining exploitation scenarios for a 10-year prediction

Three scenarios entitled optimistic status, pessimistic status and continuing the current exploitation status are considered to predict the trend of water exploitation in the next 10 years. For the optimistic status scenario, the amount of domestic water consumptions is assumed constant and exploitation from other wells is supposed to be constantly 10% lower than the current status (in which the groundwater exploitation has been calculated in September 2014). For the continuing current status scenario, all amounts of exploitation from aquifer are considered constant, equal to the estimated value of the groundwater exploitation in September 2014. For the pessimistic status scenario, on the other hand, amount of all exploitation is increased 1.5% per year, such that the amount of exploitation at the end of the tenth year is increased 15% compared to the current status in September 2014.

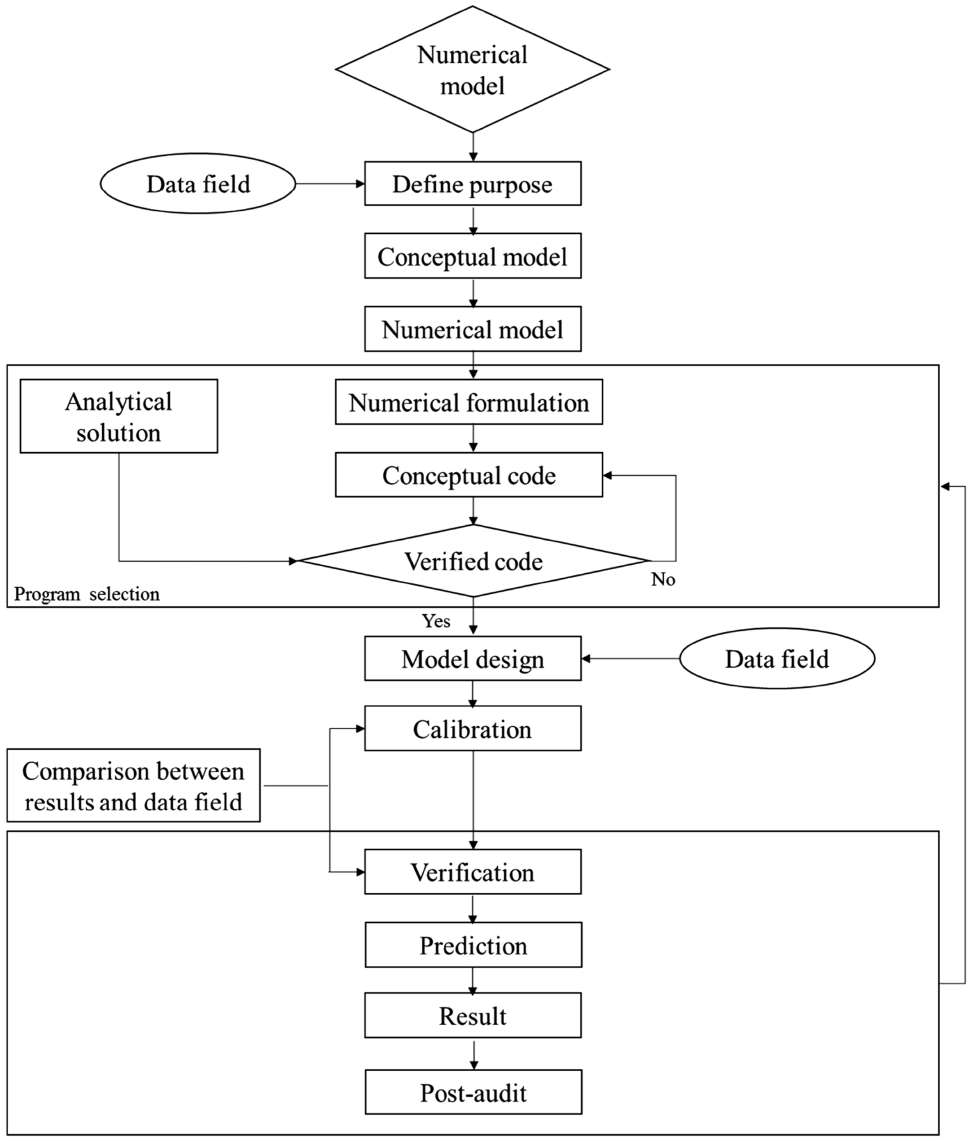


Fig. 4 Schematic of conceptual model used for verification of numerical model by Betancur et al. (2012)

Results

The main objective behind this research is the continuing industrial development as well as the growing portion of undercultivation lands in the plain which have resulted in a continuous population growth. According to the governmental statistics, city of Karaj (a part of Karaj plain) is the second welcoming city in Iran and its population is expected to increase from 1.5 million in 2014 to 2.2 million people until the year 2024. To analyze future situation, a 10-year prediction for the groundwater level of Karaj plain was developed using three probable scenarios, formerly explained. A conceptual model was, also, obtained from MATLAB software using MODFLOW2005-NWT and LPF package. Validation of the conceptual model was executed using three criteria entitled mean error (ME), mean absolute error (MAE) and root-mean-square error (RMSE). Table 1 illustrates the results of simulation errors. In addition, Fig. 5 confirms that there is a good linearity between the groundwater levels of the observed wells with the calculated values obtained from MODFLOW.

Table 1 Evaluation of error values for simulation

ME	MAE	RMSE
0.08	0.64	0.8

According to the results obtained from the conceptual model, groundwater flow follows topography status and moves from the north to the south. The results of hydraulic conductivity and specific yields—obtained from the PEST optimizer—demonstrated varied simulated values in all parts of the aquifer. According to Fig. 6a, no harmony could be observed in the values of S_y, denoting that the parameter was dependent on the type of the soil in all parts. Moreover, as

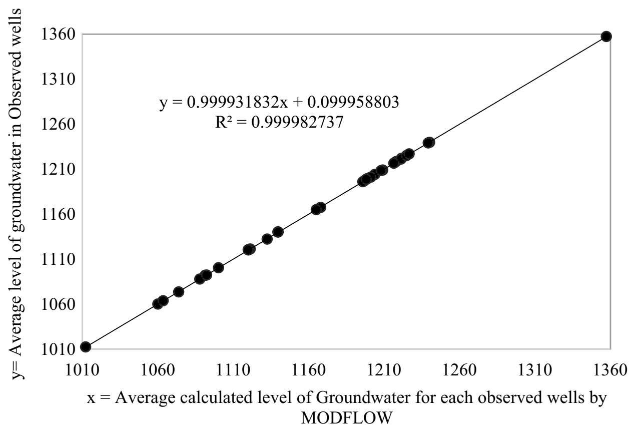


Fig. 5 Comparison of groundwater level of observed wells and calculated value for groundwater level by MODFLOW

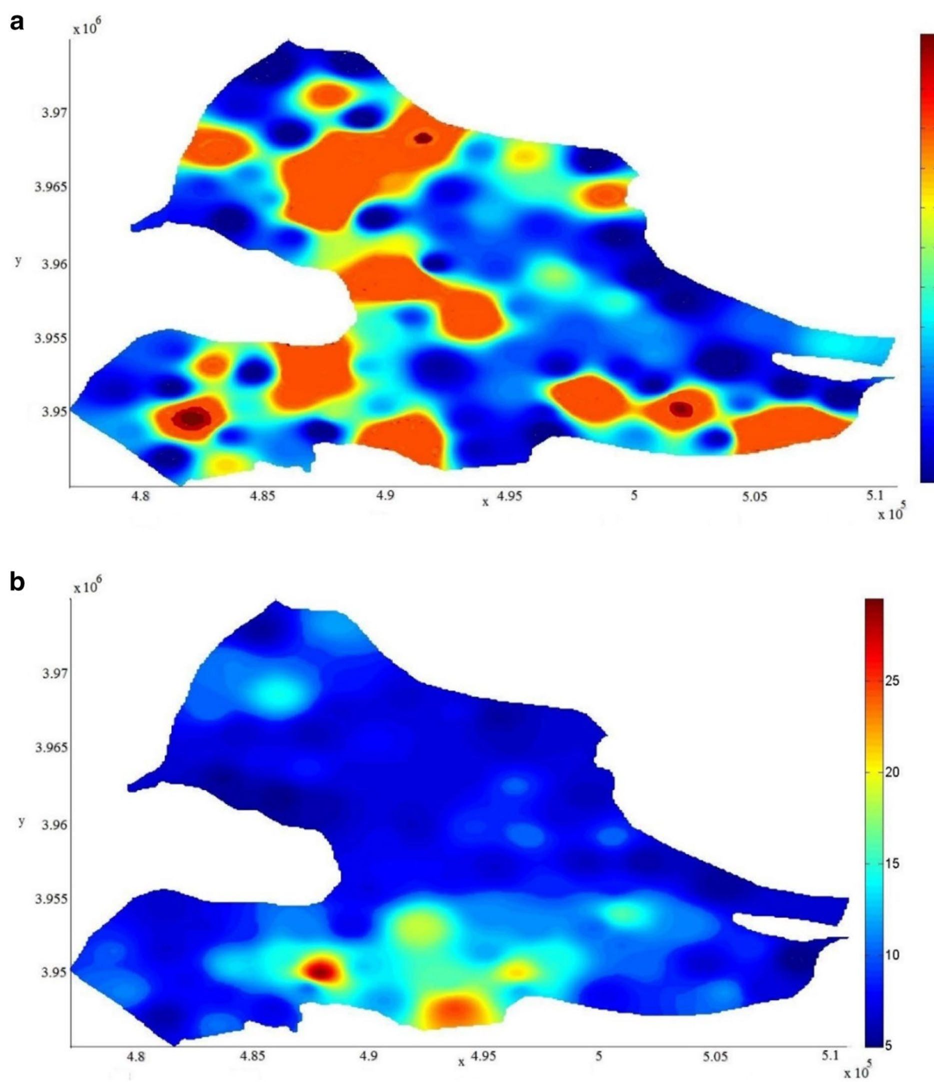
can be observed in Fig. 6b, hydraulic conductivity (K) has increased from the north side to the south part of the aquifer, due to the significant decrease in the depth.

In addition, it is specified that the groundwater level is decreased, according to the 10-year prediction of groundwater level for all the three scenarios. Figure 7 depicts groundwater level of the study area at step number 0 in September 2014. Groundwater level status at the zero time step is so important, as it would be compared to the groundwater status (at the final time steps) predicted based on the predefined scenarios after 10 years. Results of the three scenarios, namely continuing the current status, optimistic status and pessimistic status, can be summarized as follows.

Continuing the current status

Figure 8a illustrates groundwater level for all time steps. According to this figure, it is specified that groundwater mean level of Karaj plain decreased from 1158.96 m in

Fig. 6 **a** Results of interpolated data for specific yield (S_y) made by PEST and manual modification. **b** Results of interpolated data for hydraulic conductivity (K ($^{m}/_{day}$)) made by PEST and manual modification



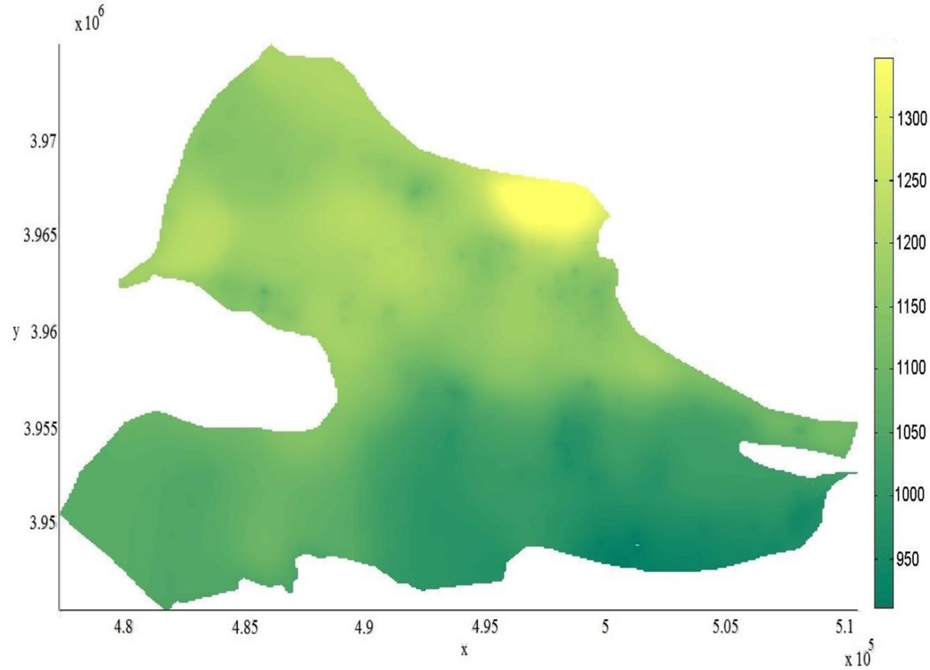


Fig. 7 Groundwater level (m) of Karaj plain in September 2014

September 2014 to 1146.12 m in September 2024. This computation gives 12.84 m decline for 120 stress periods. Moreover, Fig. 8b presents a topographic study of the groundwater level at the end of a 10-year period. Accordingly, one can observe an apparent decrease (near 18 m) of the groundwater level in some parts of the plain. The above findings highlighted a severe drop of the ground water level through a 10-year period of time ending in serious socioeconomic harms and prolonged stresses against a commercial, industrial and agricultural populous district.

Pessimistic status

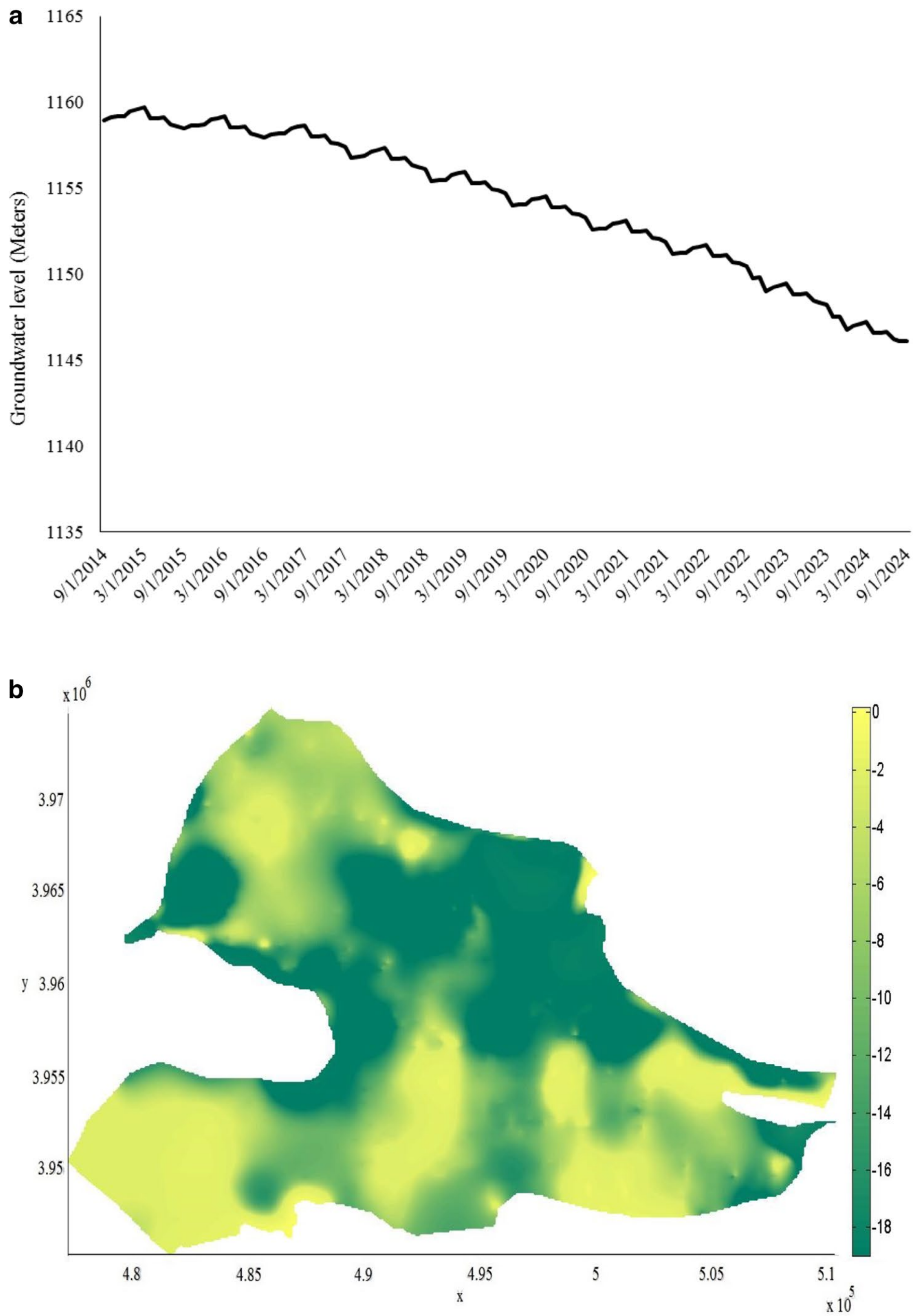
Figure 9a illustrates groundwater level for all time steps. According to this figure, it is specified that groundwater mean level of Karaj plain decreased from 1158.96 m in September 2014 to 1141.94 m in September 2024. This computation showed 17.02 m decline for 120 stress periods. Figure 9b presents a topographic study of the groundwater level at the end of a 10-year period. According to this figure, groundwater level of the plain decreased to nearly 33 m in some parts. Such a decline in groundwater level in 10 years can be known as a serious threat endangering all of socioeconomic structures. What can be inferred is that moving toward development and excessive groundwater consumption without considering limitations and volume of available groundwater resources can be ended in serious damage to the aquifer.

Optimistic status

Figure 10a illustrates groundwater level for all time steps. According to this figure, it is specified that groundwater mean level of Karaj plain decreased from 1158.96 meters in September 2014 to 1154.05 m in September 2024. This computation showed 4.91 m decline for 120 stress periods. Figure 10b depicts a topographic status of the groundwater level after 10 years. According to this figure, groundwater level decreased about 12 m in some parts of the plain. Although this process, is again presumed to end in declines in the groundwater level, the negative trend can be controlled by setting restrictions on the current wasteful exploitation and preventing severe drop in the study area.

As a result of achieving a new package of data from Alborz Regional Water Authority (ARWA), Fig. 11 is illustrated to present a realistic comparison between the measured groundwater level reflected in the observation data results (Obsv.) and the computed data obtained from the abovementioned scenarios. The Obsv. curve was found to intersect diagrams related to the formerly defined continuing current scenario (CCS) as well as pessimistic scenario (PS) in correlated time steps. It is ironic that the Obsv. data demonstrated even a lower groundwater level in some time steps compared to the PS results. However, in 17th and 18th time steps, groundwater level calculated based on the pessimistic scenario showed a slight difference from the observed water levels (Obsv. curve). The above findings shed light on this fact that critical parameters are likely to play essential roles in the water crisis of Karaj plain. One could argue that serious management crisis

Fig. 8 **a** Groundwater mean level in 120 stress periods with date based on the scenario of the continuing current status. **b** Difference of groundwater level (m) between time step number 0 and time step number 120 based on the scenario of the continuing current status



and lack of attention to water consumption are among significant underlying reasons behind generating the current water crisis and degradation of groundwater resources. It should be noted that precipitation drop during the years 2015–2016 has a little impact on the final data analysis of this research, as the occurrence of precipitation decline in the anticipated time period has been considered by the paper. In addition, Fig. 11 is illustrated assuming that groundwater level is a function of time step values, starting from 0 for September 2014 to 18 for April 2016. It is ironic to mention that proximity between the Obsv. curve reflecting the measured groundwater level and the PS curve specifically throughout the initial time steps confirms that the current aquifer state has the highest conformation to the pessimistic scenario.

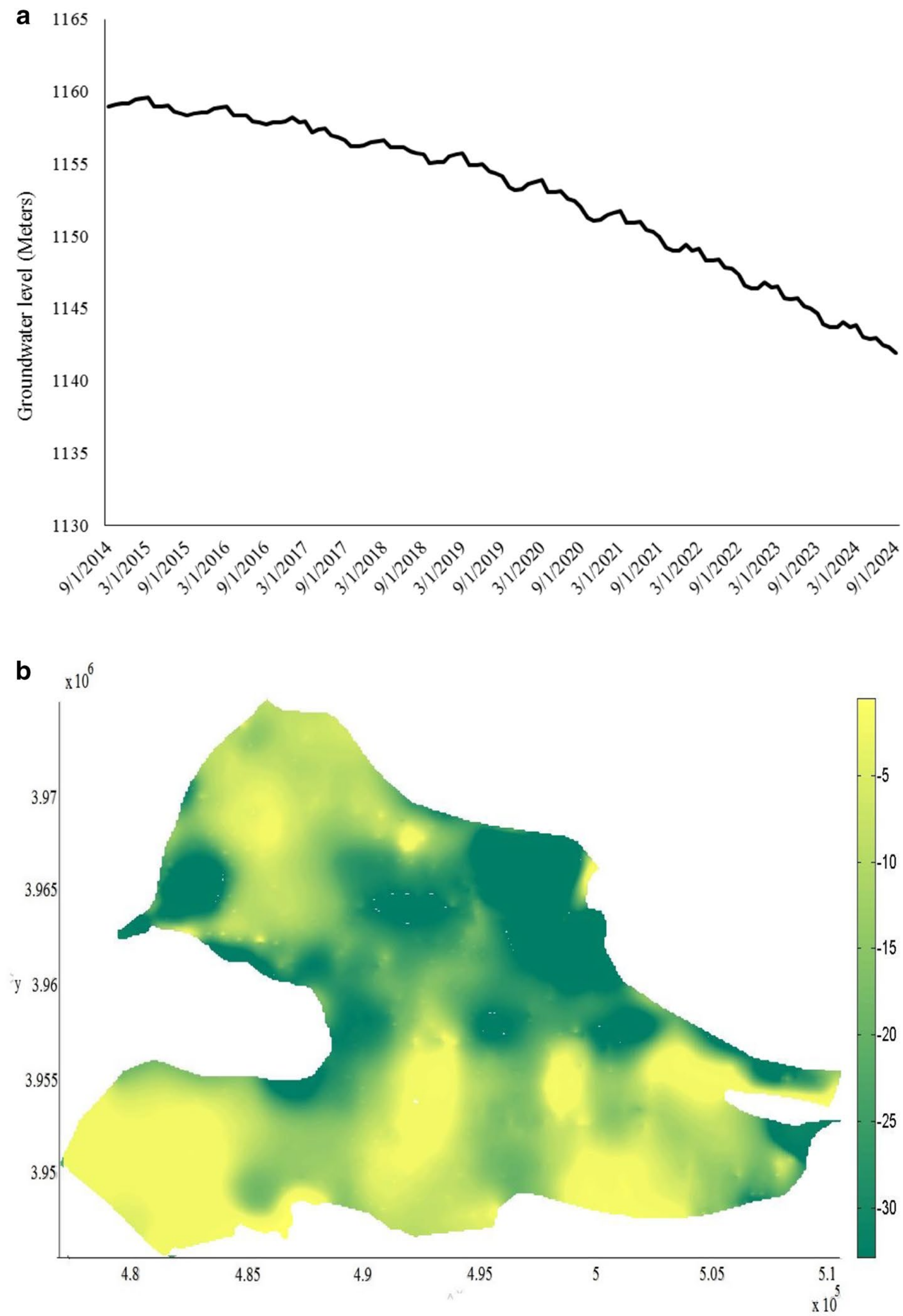


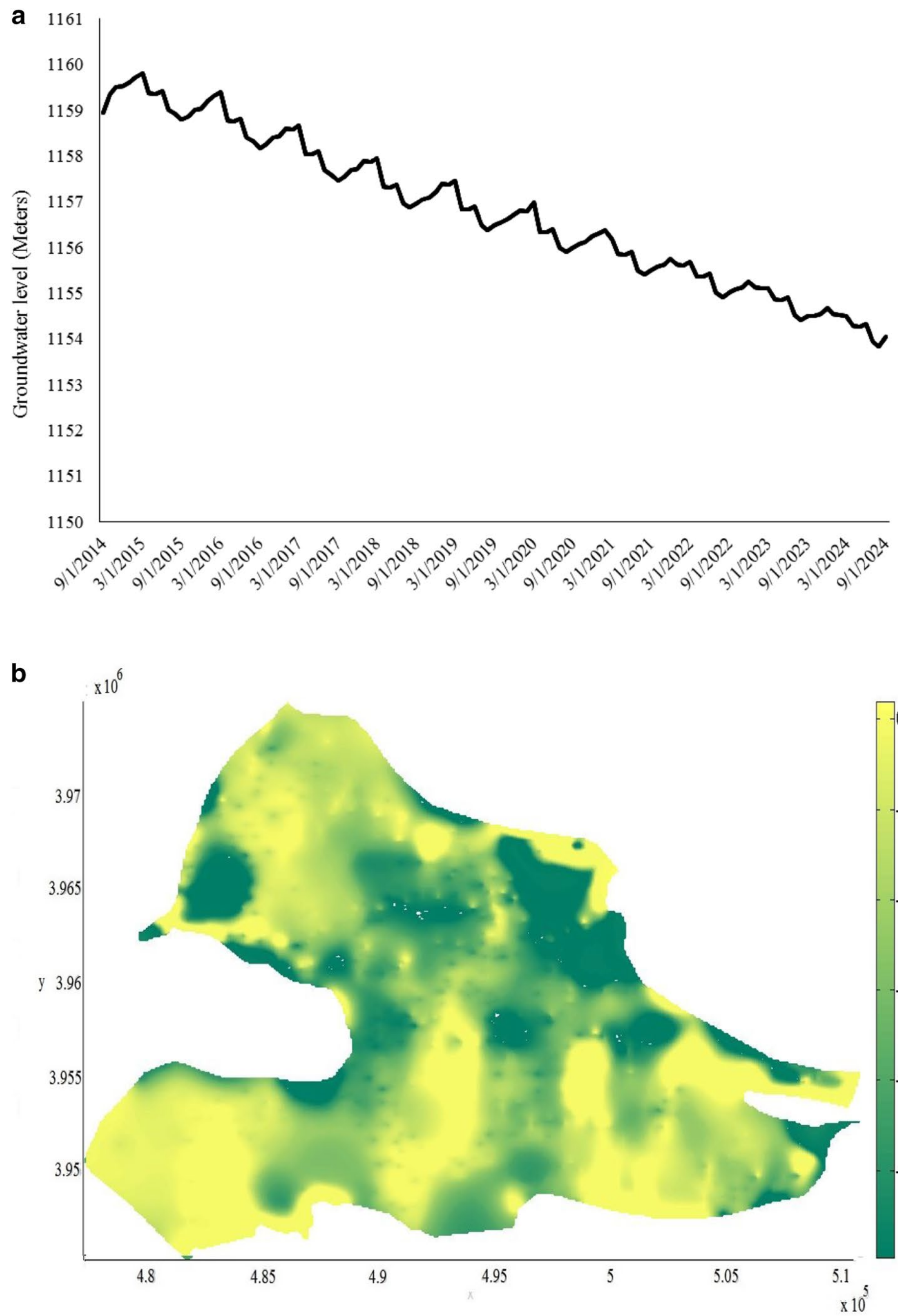
Fig. 9 **a** Groundwater mean level in 120 stress periods with date based on the scenario of pessimistic status. **b** Difference of groundwater level (m) between time step number 0 and time step number 120 based on the scenario of the pessimistic status

Conclusion

The aim of the current paper was to develop a model for groundwater simulation, obtained as an open source code in MATLAB. Utilizing an open source code reduces requirements to the close source software such as GMS and causes groundwater simulation to be more flexible. This is also expected to promote local models. A conceptual model was utilized to simulate and predict groundwater level of Karaj plain through a 10-year period, based on determining three scenarios with different approaches. These scenarios were defined as continuing the current status, optimistic status and pessimistic status. The transient model was obtained after 120 time steps (121 months) from September 21, 2014 to September 22, 2024.

The conceptual model took the advantage of MATLAB and Excel for simulating changes in groundwater level, and GMS was applied to validate results obtained from the MATLAB codes. To develop this model, six coverages including aquifer boundaries, piezometers, surface recharge, hydraulic conductivity and specific yield were considered while the depth parameter was connected to the model by

Fig. 10 **a** Groundwater mean level in 120 stress periods with date based on the scenario of optimistic status. **b** Difference of groundwater level (m) between time step number 0 and time step number 120 based on the scenario of optimistic status



applying the top layer as the surface layer as well as the bedrock layer. Values of the above coverages were calibrated for each steady and transient state using parameter estimation (PEST) optimizer followed by manual adjustments in case of significant differences between the observation data and the computed ones.

In this research, it was specified that direction of groundwater flow was from north to south being in a good accordance with topography status. The groundwater mean level of the plain was obtained to be 1158.95 for September 21, 2014. Regarding the scenario of continuing the current status, the groundwater mean level of the plain was calculated to be 1146.12 m for September 22, 2024, showing 12.83 m decline compared to the present time, September 21, 2014. In the pessimistic status, on the other hand, the groundwater mean level of the plain was calculated to be 1141.94 m for September 22, 2024, demonstrating a higher divergence from the present, nearly 17.01 m decline compared to that value of September 21, 2014. Even, based on the data developed by the optimistic scenario, the groundwater status of the plain is again expected to undergo a negative trend as the above systematic computations calculated

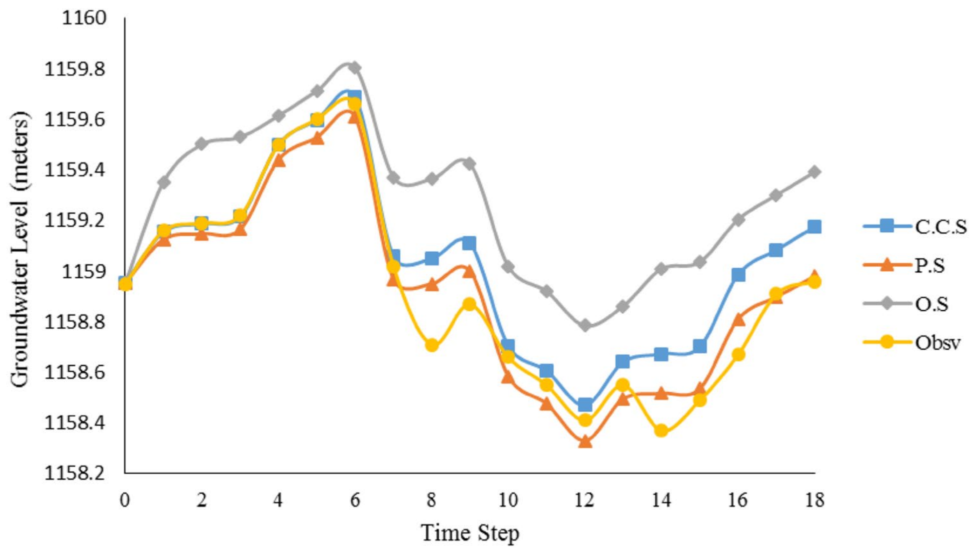


Fig. 11 Comparison of the observation data (Obsv.) to the results obtained through estimations of continuing current status (CCS), pessimistic status (PS) and optimistic status (OS) scenarios during the first 18 time steps

groundwater mean level to be 1154.05 m for September 22, 2024. This analysis affirms that even the optimistic scenario, in spite of showing a moderate decline in the groundwater level (4.9 m), can never be adopted as an ideal procedure. Moreover, after obtaining new package of data from Alborz Regional Water Authority (ARWA), it is easy to remark that the aquifer state mostly complies with the pessimistic situation of the scenarios due to an obvious decline in the groundwater level.

It is worth to mention that the possibility of connecting to other applications as well as the capability of deriving computational algorithms (such as optimization algorithms) can be appreciated as the major advantages of using open source code, which is highly recommended to be tried by other researchers.

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