Optimal use of groundwater for irrigation purposes in Al-Salhubia area , Al-Muthana Governorate, south Iraq, Case Study by using Optimization Model

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Introduction

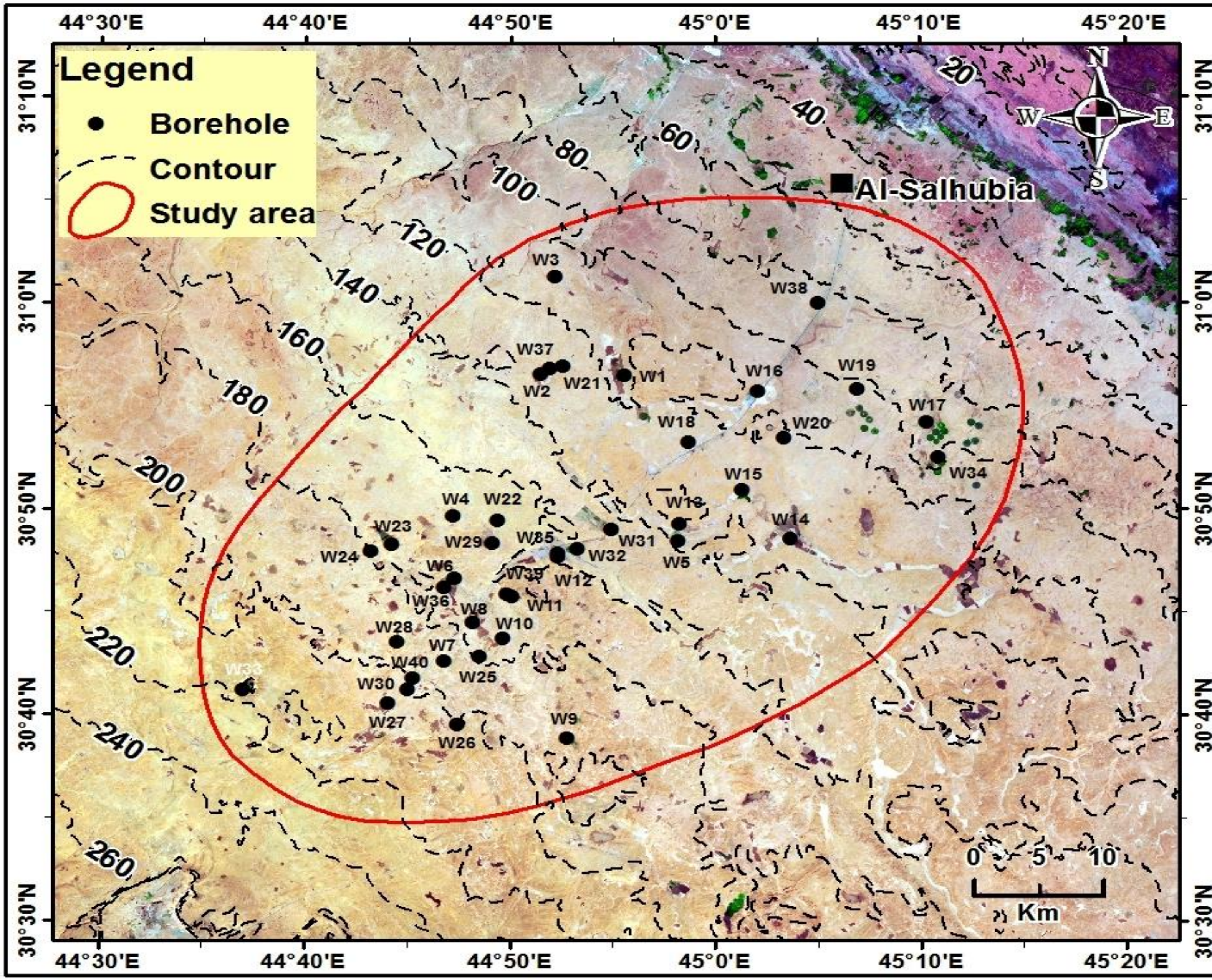
Iraq is facing shortages in surface water sources. This will lead to depend on groundwater mainly in now and future. Thus, groundwater extraction needs good management built on scientific plans and accurate foundation to conserve ground water sustained .Therefore, the groundwater management poses an especially challenge in the southern part of Iraq. One important area there, the Al-Salhubia area, depends on groundwater to meet the bulk of its water use demands.

In south Iraq, semiarid and arid regions with low precipitation and high potential of evapotranspiration are abundant. Rapid investment growth through last years, increased irrigation, and industrial development during the past decades have caused an increasing demand on water resources in semiarid and arid regions.

Continued climate variability and surface water shortages are raising the importance of groundwater as a strategic water source to manage carefully to meet growing water demands for all uses. Long term planning for the wise development and use of water is urgently needed to ensure the sustainability of strategic aquifers, especially in the world's arid regions.

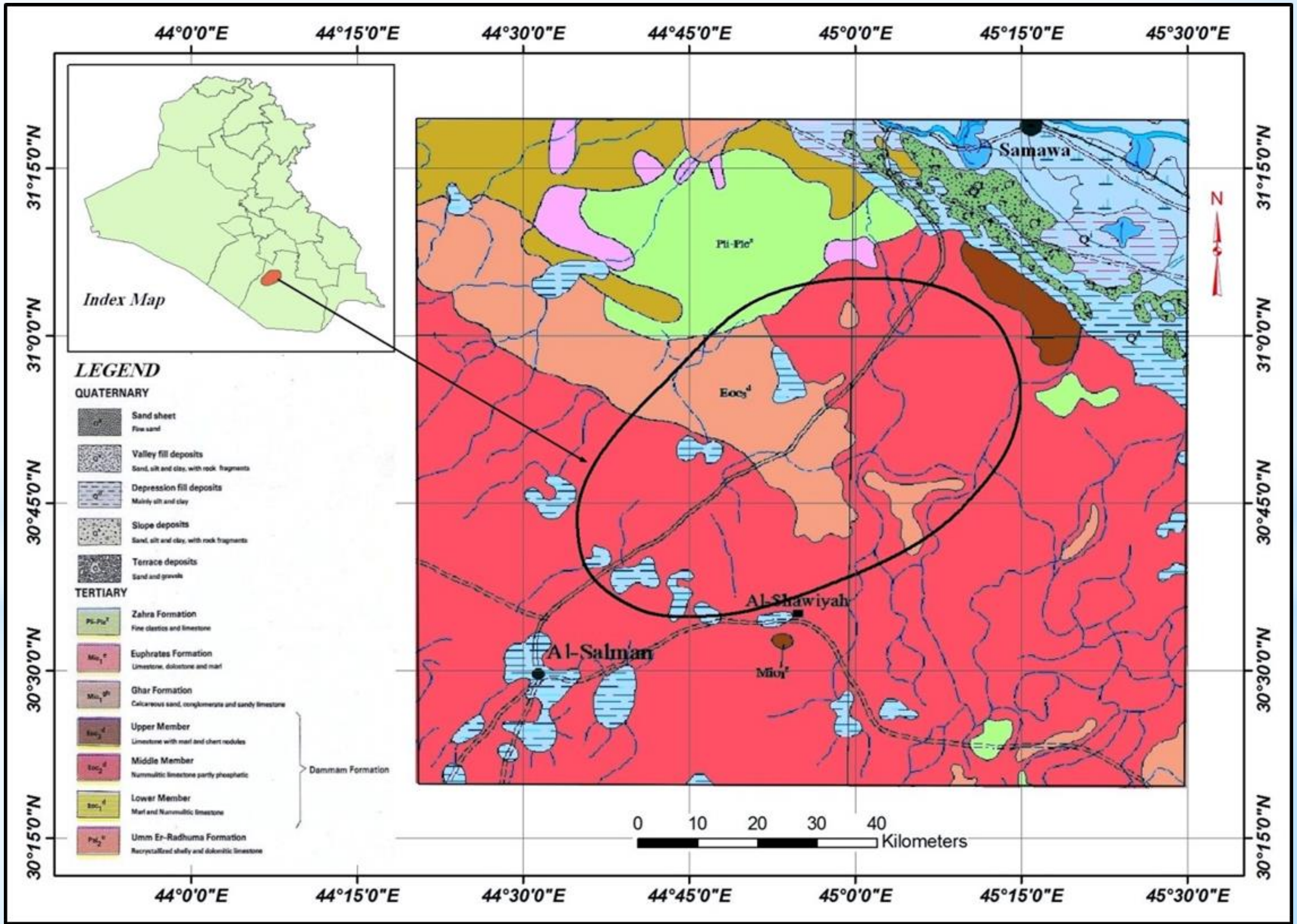
- ## **Study Area:**

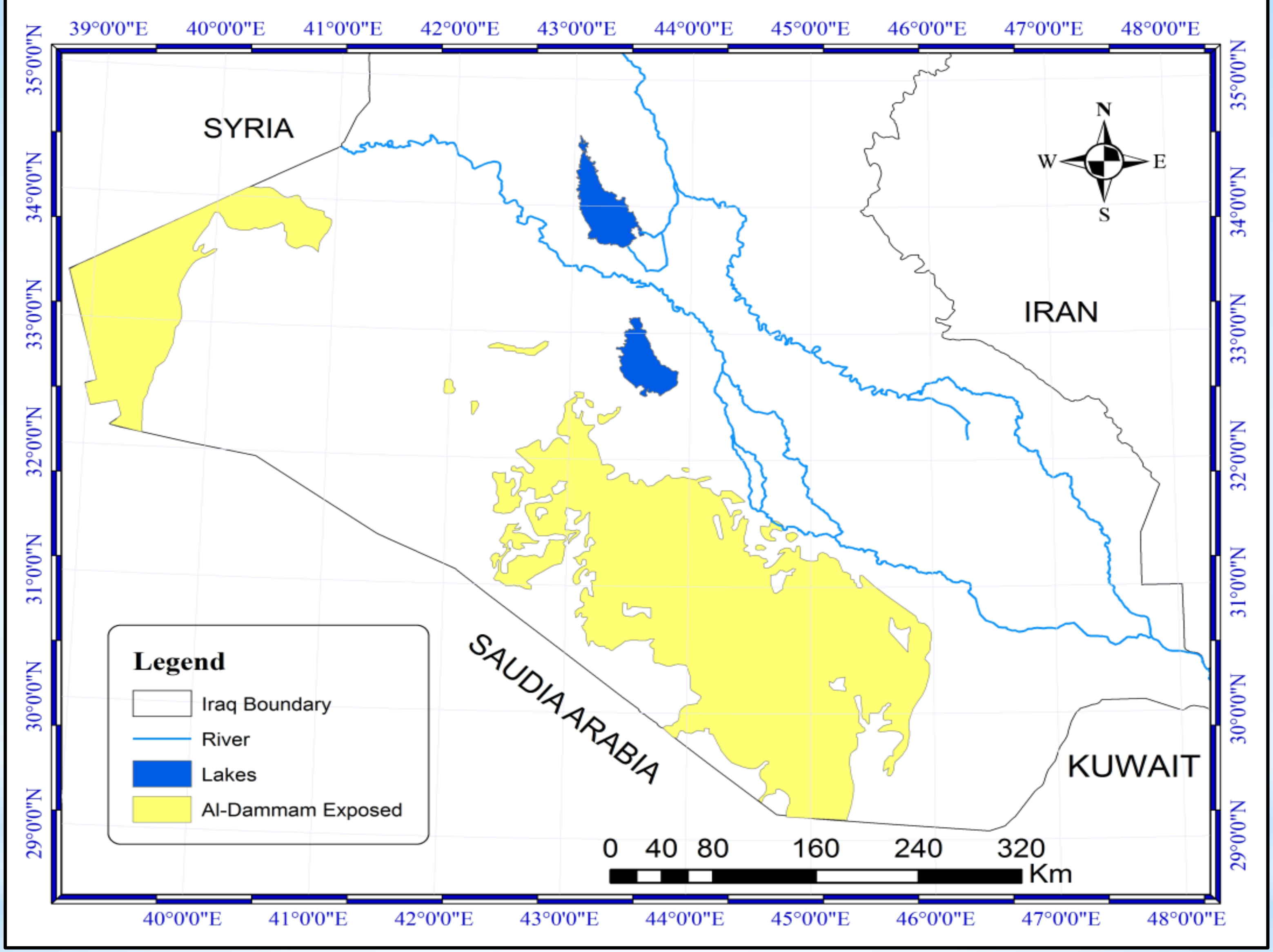
- Al-Salhubia area is considered one of the good areas in Al-Muthana Governorate, it is located about **70km** southwest Al-Samawa City. It is covering an area of approximately **3000 km^2** .



Location map of the studied area

►**Tertiary deposits** consist of important formations in the area is Upper - Middle Eocene. The carbonate aquifer is one of the most important underground reservoirs in western and southwestern Iraq (Fig. 2 and 3).It is composed of variable carbonate rocks mainly limestone, dolomitic limestone and dolomite





* The distribution of Upper and Miuddle Dammam outcrops on the surface in desert of Iraq

►The study aimed to:

Water users in that region have been dependent on groundwater pumping and use to meet their needs for water-related irrigation.

For that reason, groundwater at Al-Salhubia basin is the main water source to irrigation and other uses. Especially for the period 2007-2015, water-using investments were undertaken this region for many purposes. The most important purposes are which including development of cropping areas.

- Plan for the utilization and management of the unconfined aquifer (Upper- Middle Eocene) for agricultural investments.

Optimization Model (GAMS)

The General Algebraic Modeling System (GAMS) used in hydro-economic.

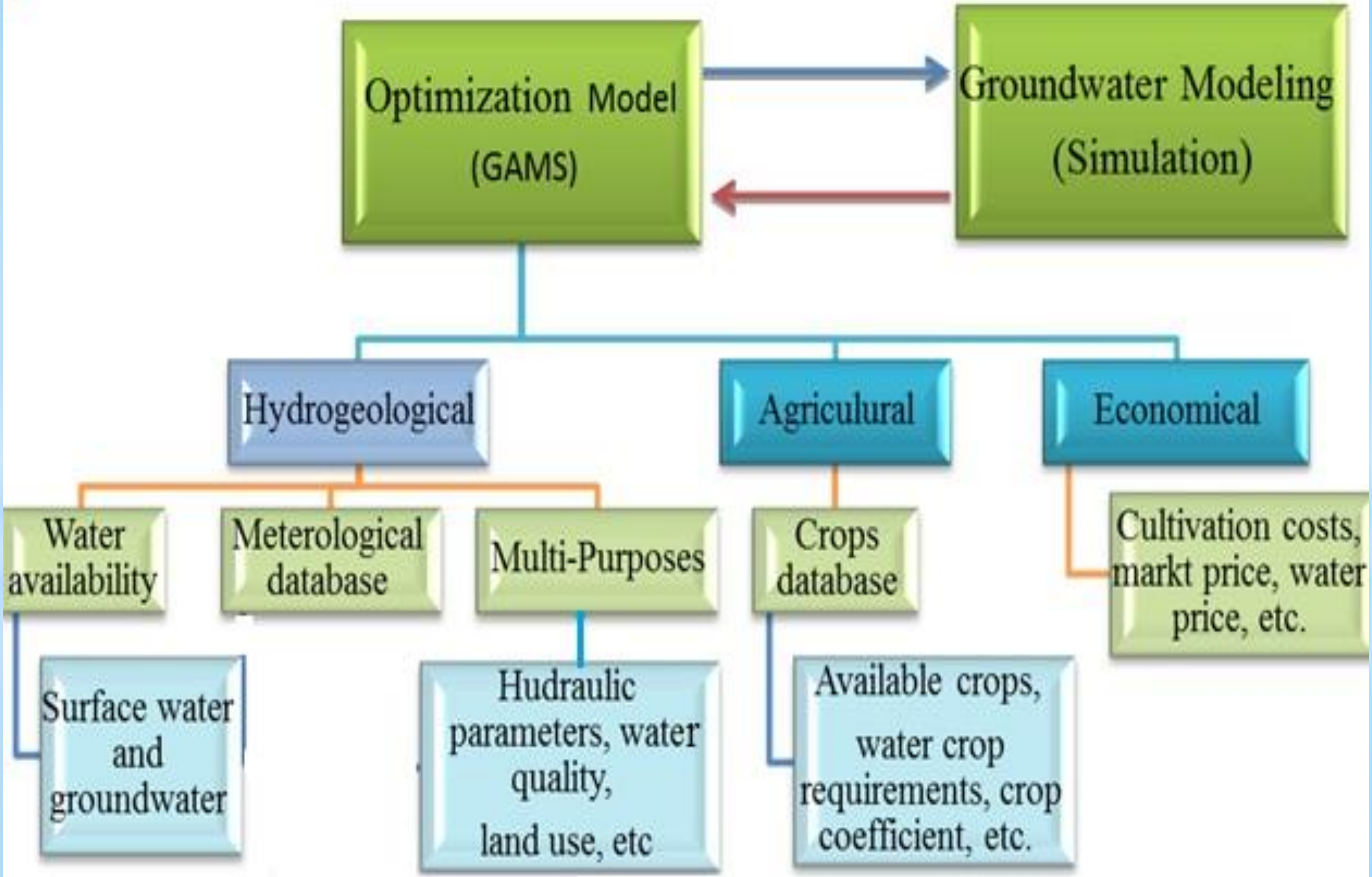
Optimization model have been used to help solve groundwater problems over the past decades. The principle of this optimization modeling is to construct a set of objective functions of decisive variables, which being subject to a series of constraints .

Optimal use of groundwater is an important for groundwater and the need to conserve it due to negative uses for groundwater. Optimization models can be used to solution with problems of minimizing or maximizing a function with several variables subjected to constraints.

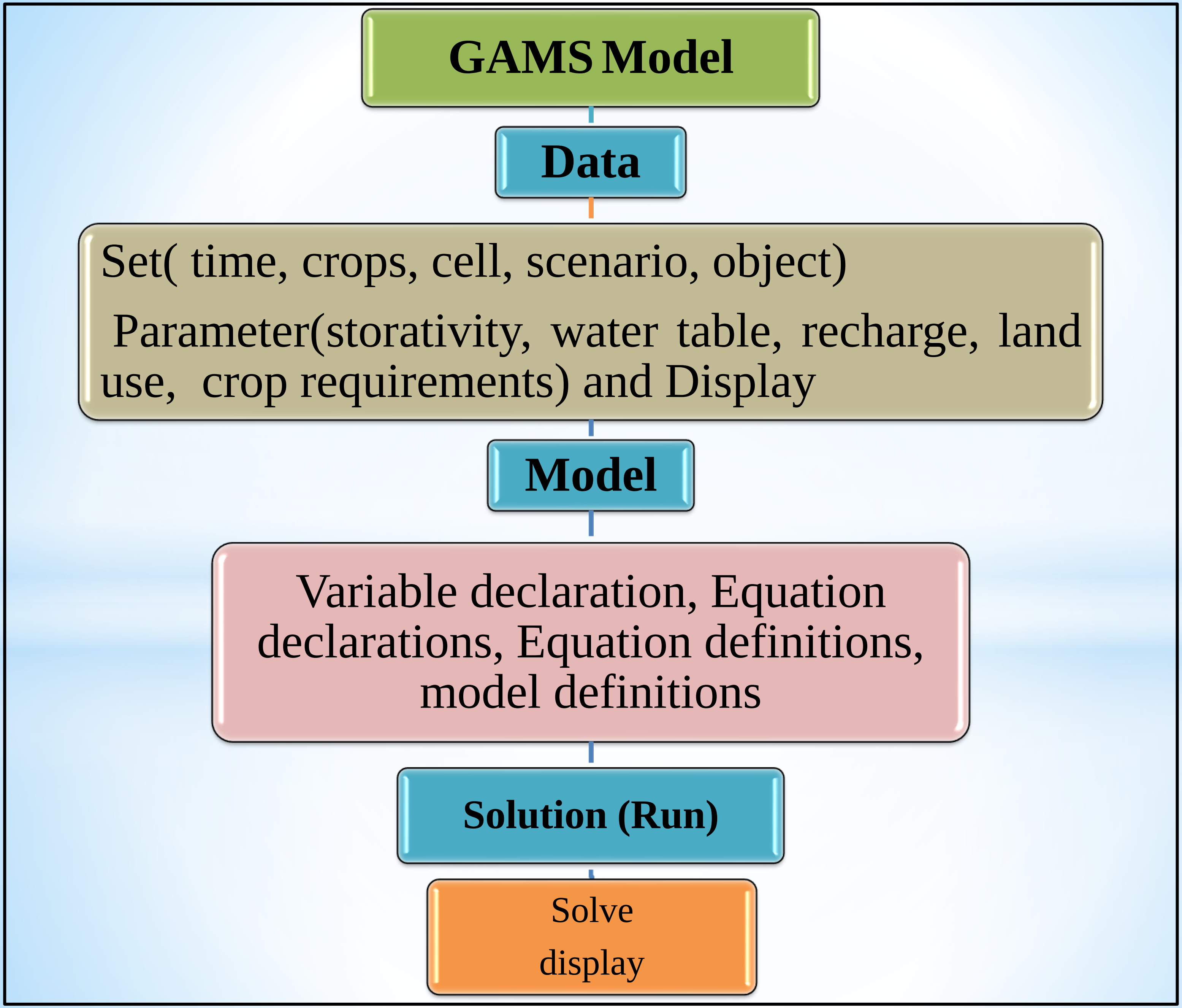
This study suggests an attempt to develop a groundwater management model in which the solution is performed through optimization model.

. The groundwater in the area is also important because of we needed for the groundwater management in this area is multi-objective to considering the current land use, water use, net benefit, management and future planning for investments purposes.

Frank Ward at the University of New Mexico State , **Jack Eggleston** at USGS (2014) and Ali Abdelrahim at Ministary of Water Resources/Iraq carried out preliminary Hydro-Economic studies by using GAMS model, so, they first developed and proposed the use of optimization model (GAMS) to connecting between Hydrogeological, Agricultural, and Economical aspects



Optimization Model (GAMS)
Groundwater Modeling (Simulation)
Hydrogeological
Agriculural
Economical
Water availability
Meterological database
Multi-Purposes
Crops database
Cultivation costs, markt price, water price, etc.
Surface water and groundwater
Hudraulic parameters, water quality, land use, etc
Available crops, water crop requirements, crop coefficient, etc.



General flowchart of GAMS model

►**Perennial yield (the term safe yield was used previously**), Perennial yield of aquifer can be calculated from hydraulic data such as storativity coefficient, recharge and water table elevation (Todd,2005).

●**We suggest** adding the amount of recharge to the equation that suggested from Fitter (2001), therefore, the final equation will be represented as:

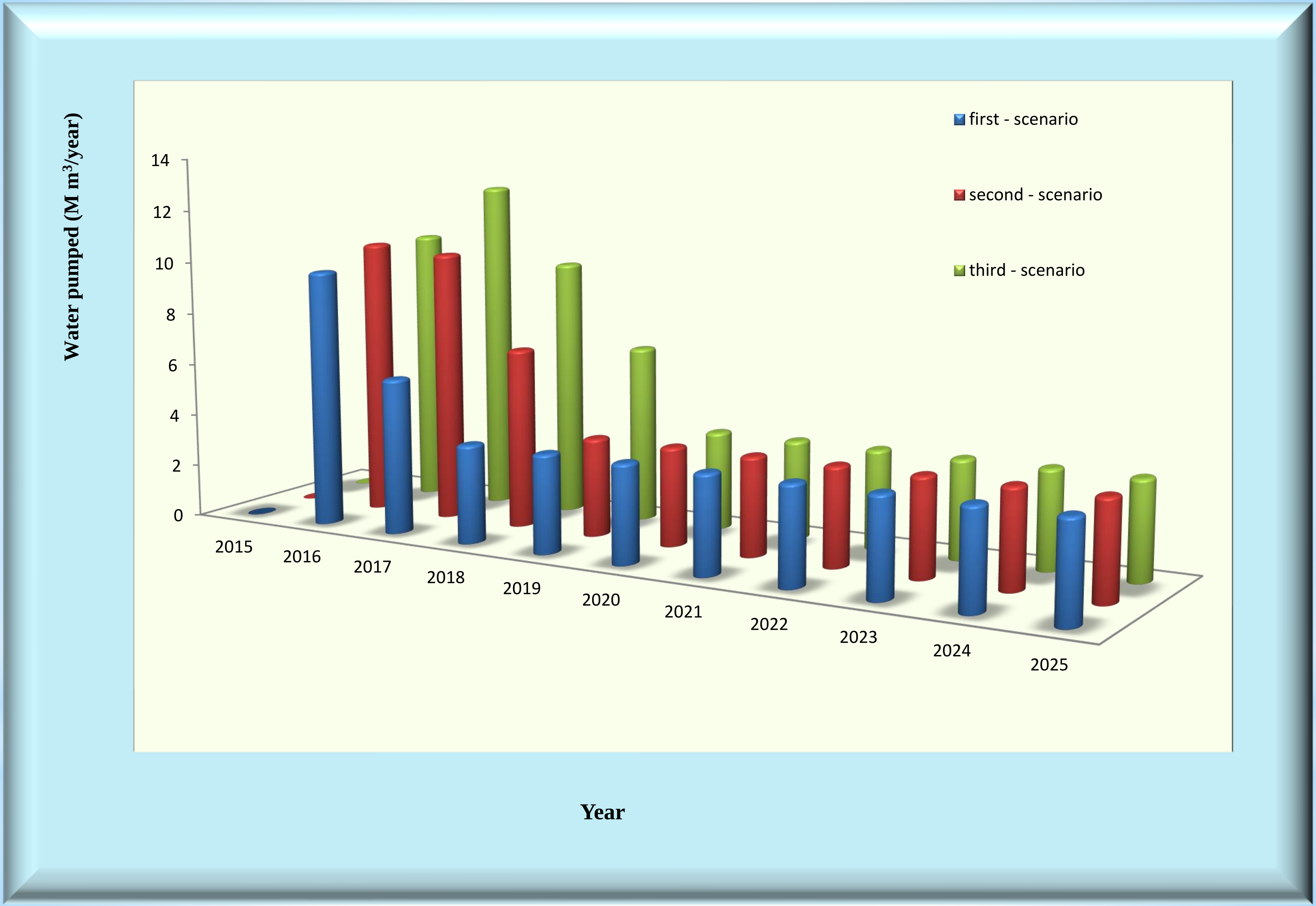
$V_w = S_y * A * \Delta h$ (Fetter, 2001)

Perennial_yield=[(storativity **+ recharge) ×** **(**aqf_land × drawdown _v)]

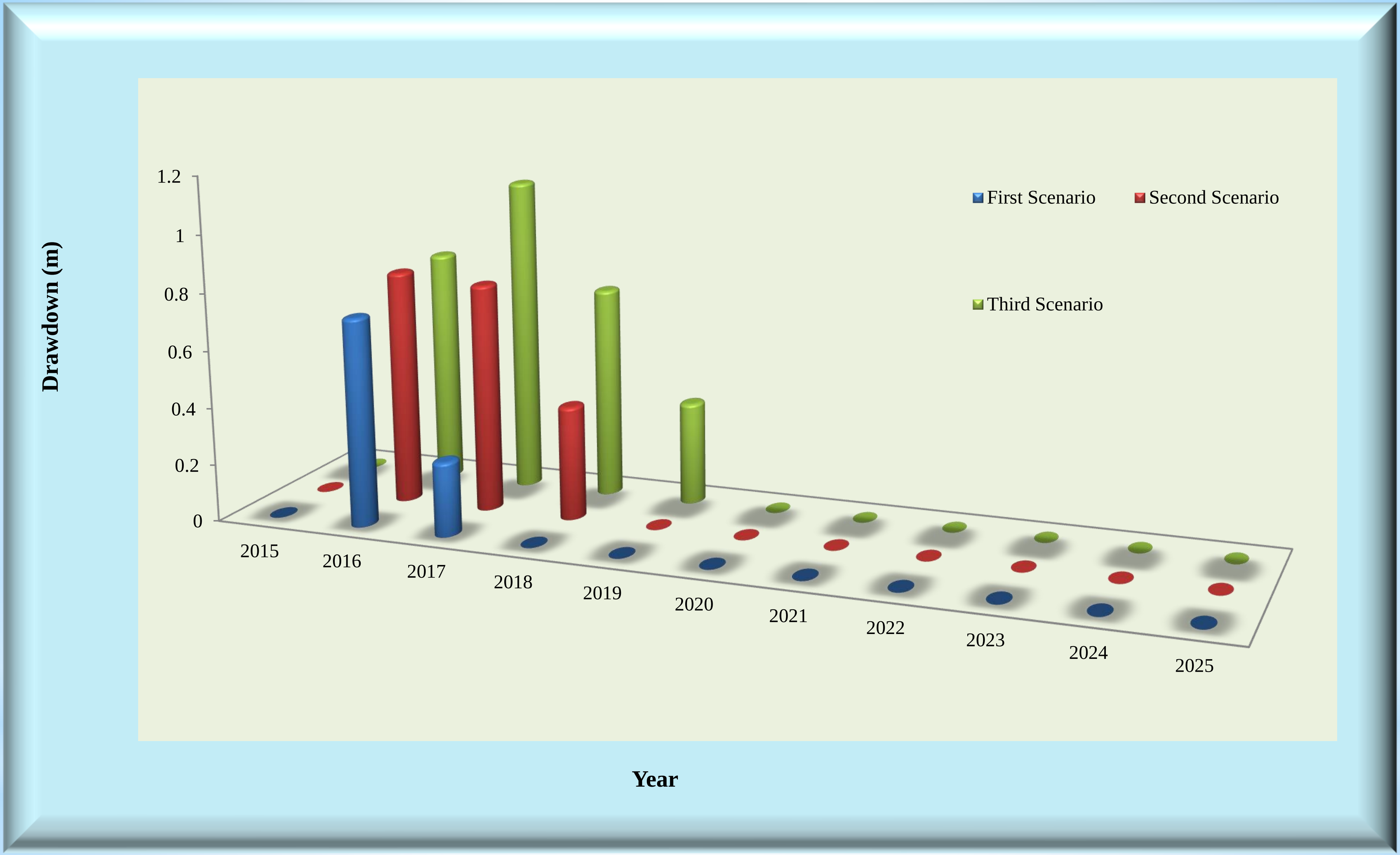
►Scenarios of optimization model

In all scenarios, the suggested constraints the water table depth of aquifer with drawdown are (58m and 1.0m), (59m and 2.0m), and (60m and 3.0m).

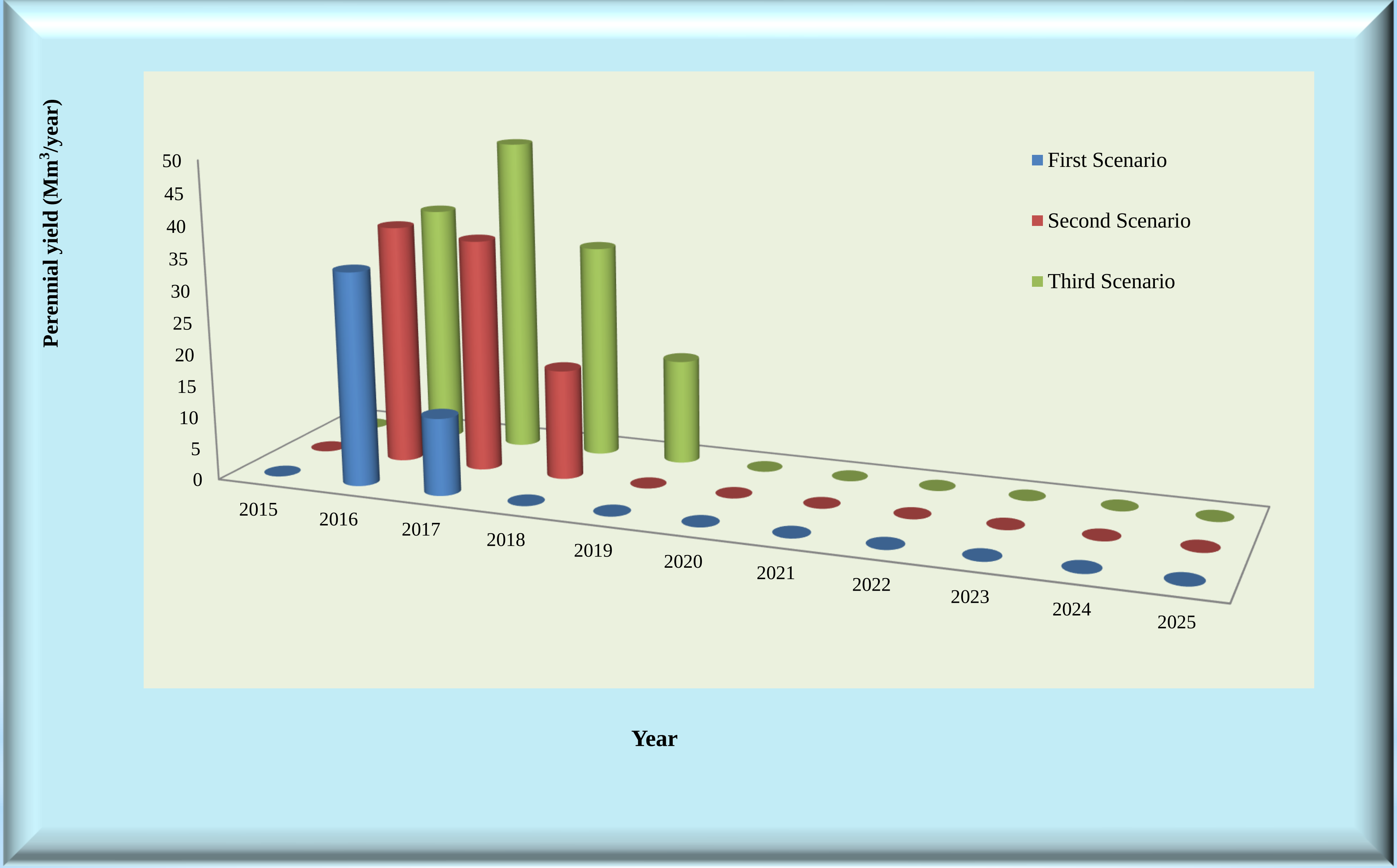
Year	Optimization model Scenarios								
	Water pumped ($M\ m^3$)			Perennial (safe)Yield ($M\ m^3$)			Drawdown (m)		
	First	Second	Third	First	Second	Third	First	Second	Third
2016	9.81	10.55	10.55	33.60	37.70	37.70	0.73	0.82	0.82
2017	5.94	10.34	12.66	12.15	36.53	49.40	0.26	0.80	1.1
2018	3.75	6.86	9.81	0.00	17.27	33.62	0.00	0.40	0.74
2019	3.75	3.75	6.73	0.00	0.00	16.53	0.00	0.00	0.36
2020	3.75	3.75	3.75	0.00	0.00	0.00	0.00	0.00	0.00
2021	3.75	3.75	3.75	0.00	0.00	0.00	0.00	0.00	0.00
2022	3.75	3.75	3.75	0.00	0.00	0.00	0.00	0.00	0.00
2023	3.75	3.75	3.75	0.00	0.00	0.00	0.00	0.00	0.00
2024	3.75	3.75	3.75	0.00	0.00	0.00	0.00	0.00	0.00
2025	3.75	3.75	3.75	0.00	0.00	0.00	0.00	0.00	0.00



Optimum water pumped for ten years period (2015-2025) to all scenarios



Optimum drawdown for ten years period (2015-2025) to all scenarios



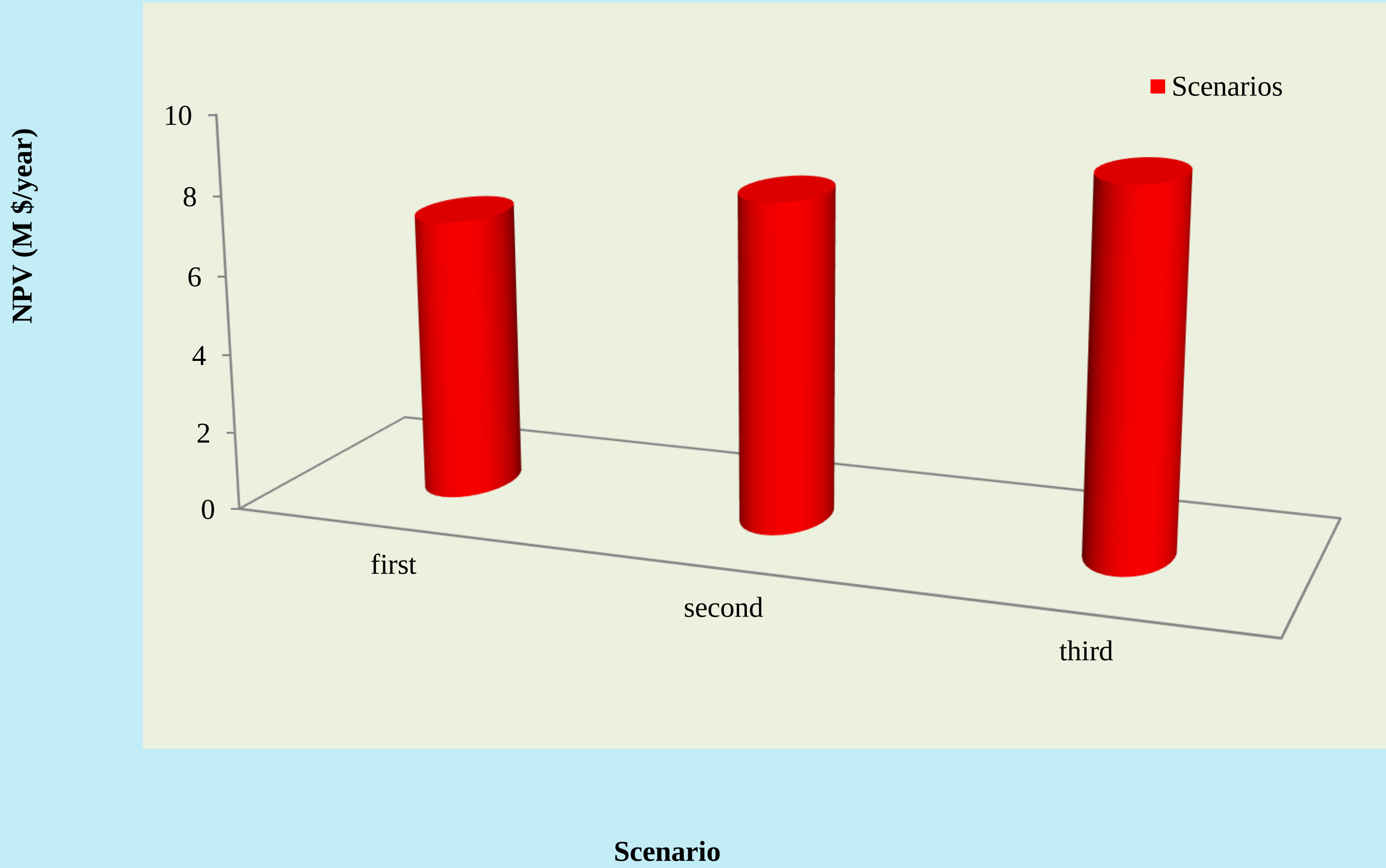
Optimum perennial yield(safe yield) for ten years period (2015-2025) to all scenarios.

►Optimum model scenarios for Net Benefits Value over crops land for ten years period (2016-2025).

Optimization model Scenarios	Net Benefits Value(NBV) M US $/year
First Scenario	7.14
Second Scenario	8.26
Third Scenario	9.29

►Sensitivity Analysis for optimization model

Results indicated that the optimum solution for different scenarios, the model is highly sensitive to changes in **recharge values and land use**, and slightly sensitive to other parameters.



Optimum Net Present (Benefit) Value for ten years period (2015-2025) to all scenarios

►**Optimization GAMS** model used for the prediction by using the different scenarios within the next **ten-years** through joining between **groundwater, agriculture, and economy**. The results show that the **maximum water extractions are a little higher than the perennial yield.**

►**The results from the optimization model**, that indicate good relationship between Hydrogeological, Agricultural, and Economical aspects , which lead to encourage increasing water extractions from the unconfined aquifer, as well as increasing the investments without effecting groundwater storage.

THANK YOU