Mapping facilities of the spatial agro-hydro-soil-salinity model SahysMod

R.J. Oosterbaan, 25-08-2019. On www.waterlog.info public domain

Abstract

The spatial (polygonal) Agricultural-Hydrological-Soil-Salinity model SahysMod (including a routine for the flow of groundwater from polygon to polygon) has been used frequently in irrigated lands in (semi)arid regions as can be seen in the list of references. Azar Inam, Jan Adamowsky et al. (2017) have applied the model in the Rechna Doab area of Pakistan. The purpose of this article is to use their data for demonstration of the large number of mapping options of SahysMod.

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1. Introduction

The SahysMod model [Ref. 1] uses polygons to simulate agricultural, hydrological and soil conditions in larger areas. It simulates the conditions over as many years as desired by the user.
The polygonal system makes it possible to present the results not only in tables or graphs, but also in maps.
The mapping options are summarized in figure 1.

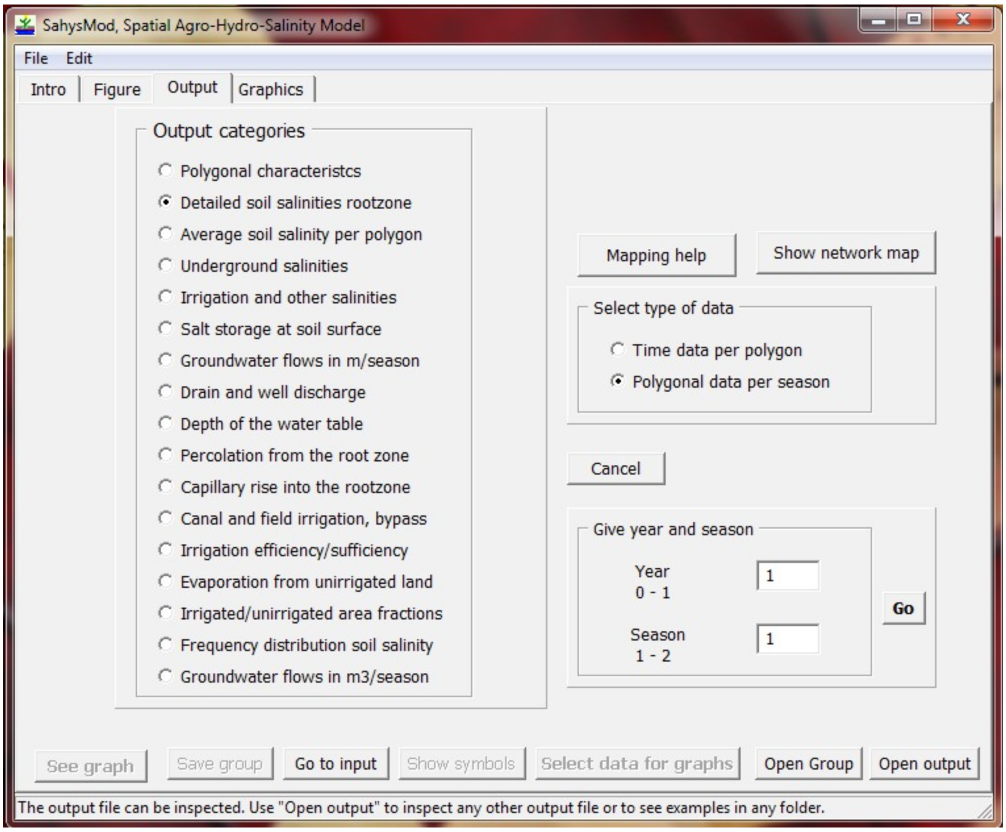


Figure 1. Output categories of Sahysmod and output selection procedure.

Azar Inam and Jan Adamowski et. Al [Ref. 2, Ref. 3, Ref. 4] have applied SahysMod to the Rechna Doab region in Pakistan. Their data will be used to illustrate the mapping options of SahysMod.

2. Mapping examples

As the study in Reachna Doab concerned amongst other the salinization of the irrigated land, the first mapping example is shown for this aspect.

The first example shows a map of the weighted average soil salinity per polygon (figure 2)

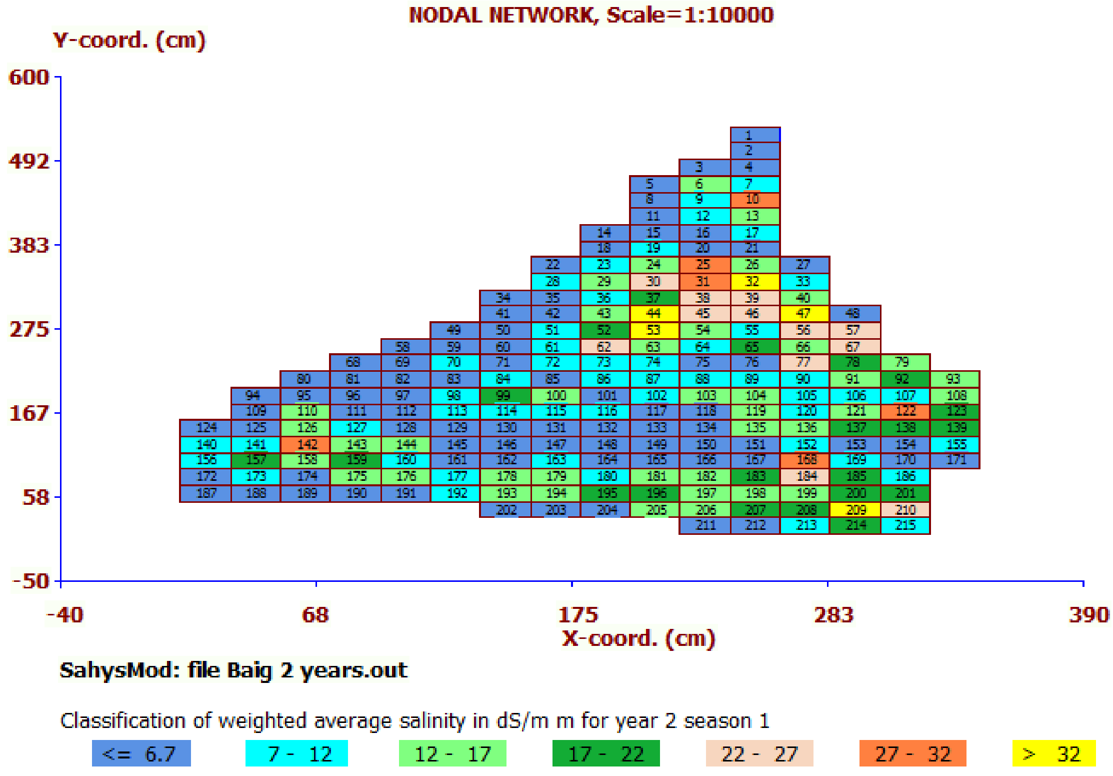


Figure 2. Average soil salinity per polygon in year 2, season 1. Especially in the North-Eastern part of the area the salinity is high, hampering crop production.

Figure 2 demonstrates that the salinity problems occur more strongly in the North-Eastern part of the Rechna Doab region, though elsewhere also instances of severe salinity happen, for example in polygon 142, 158 and 122.

Figure 3 maps the same salinity of figure 1, with the difference that the classification scales are increased and the color pattern is changed.

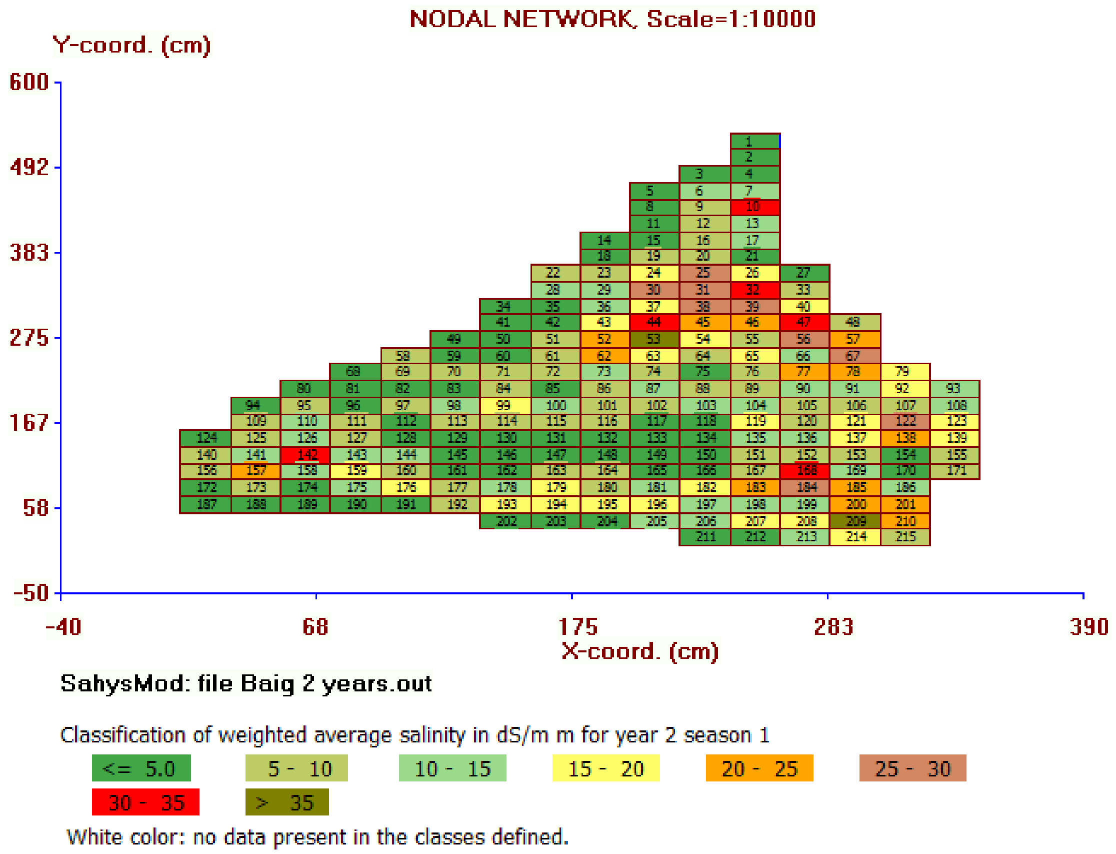


Figure 3. *Average soil salinity per polygon in year 2, season . As in figure 1, but using another classification scale and color pattern*

Figure 3 is like figure 2, but it has a different classification and another color pattern. These are optional characteristics.

SahysMod distinguishes three types of crops and up to 4 seasons per year. The crops of group A have the following areal distribution in season 1 (figure 4).

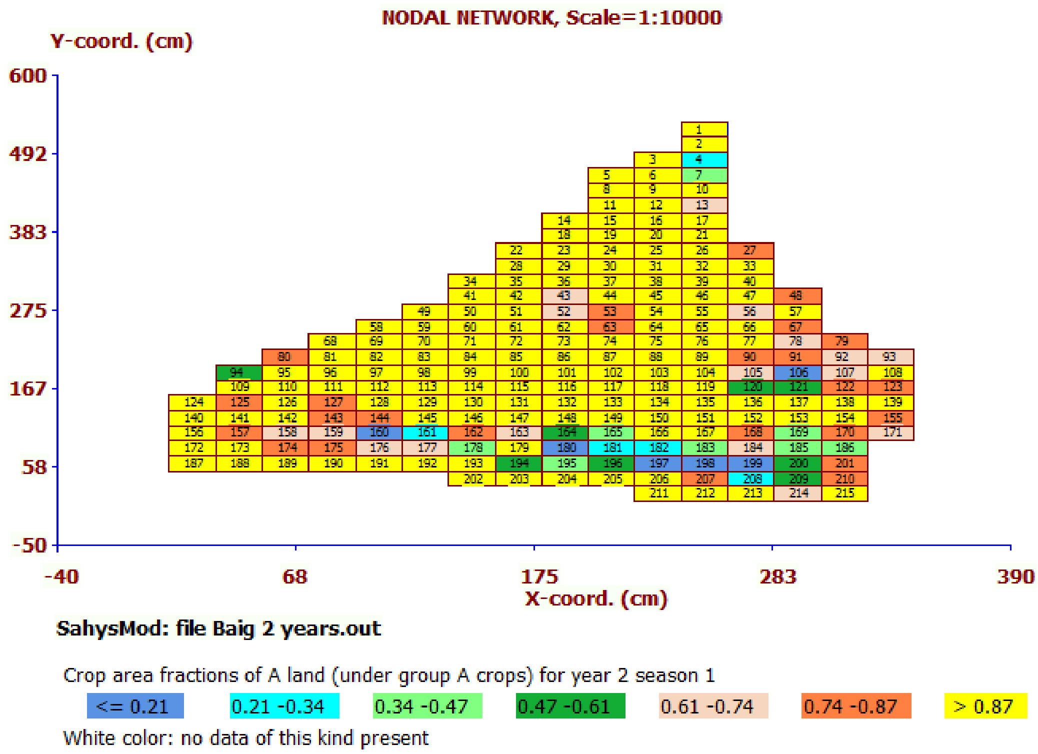


Figure 4. *Fraction of land under irrigated A type crops in season 1. The majority of the land is densely cultivated.*

The soil salinity in the areas under A type crops is depicted as follows (figure 5).

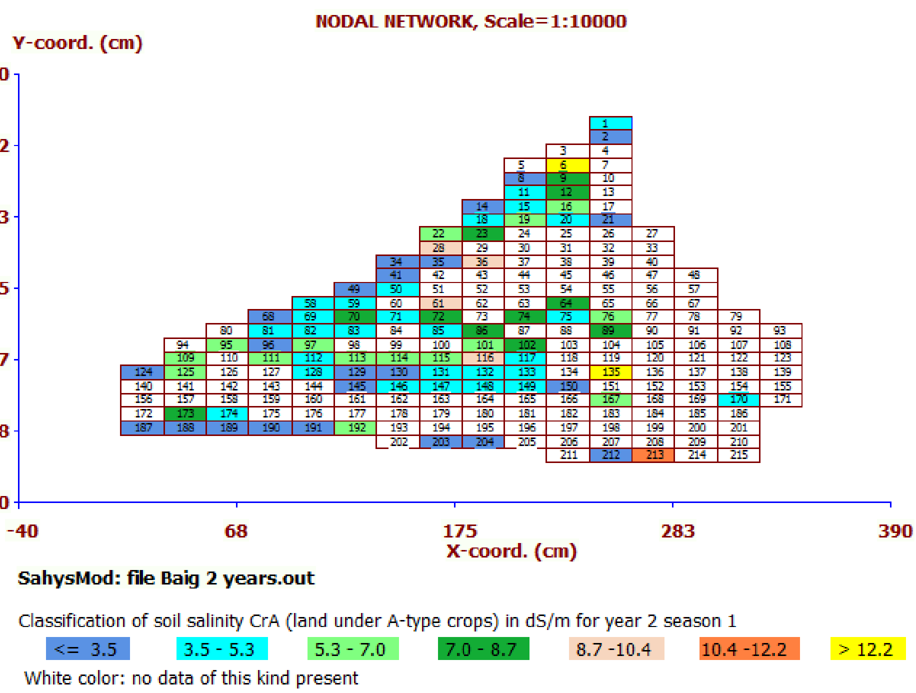


Figure 5. *Soil salinity of the land under A type crops in season 1.*

The crops can also be rotated over the seasons. The rotations may include fallow land. The salinity development in the areas of crop rotation outside the areas of the permanent A type crops can be seen in the next figure 6.

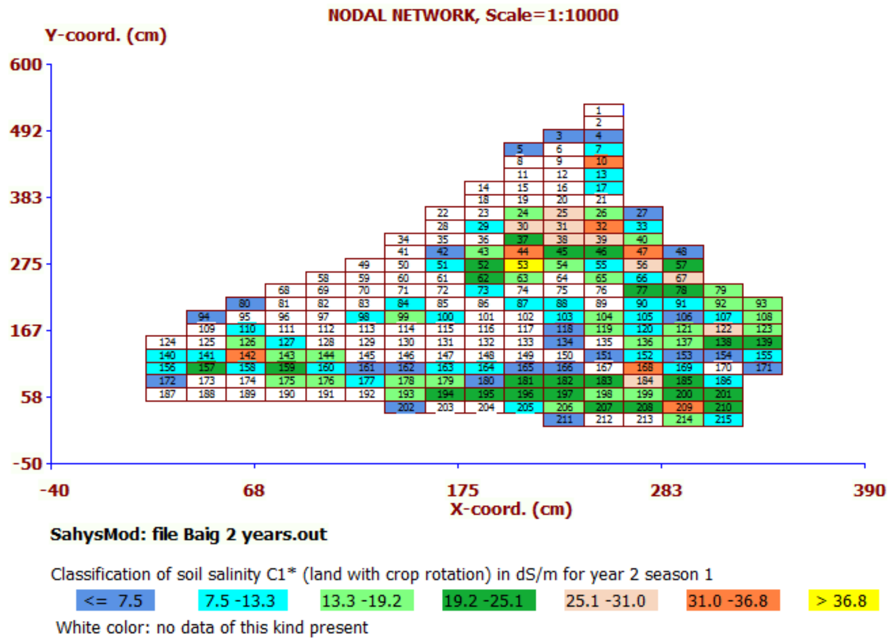


Figure 6. *Soil salinity in land with seasonal crop rotations.*

The salinity is not only calculated in the root zone, but also in the transition zone between root zone and aquifer (figure 7). This is of importance for the root zone when capillary rise occurs.

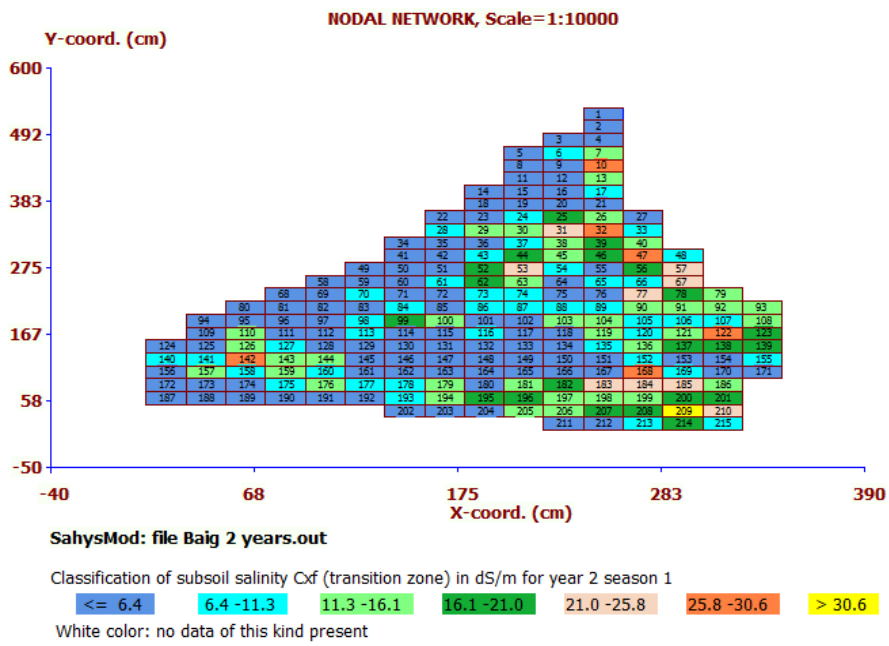


Figure 7. *Salinity of the transition zone between root zone and aquifer.*

The permanently fallow land runs a severe risk of salinization because there is no application of irrigation water that helps to leach the salts down away from the root zone. Figure 8 shows the actual evaporation from the fallow land, which is less than the potential evaporation, but which may be an indicator of the capillary rise.

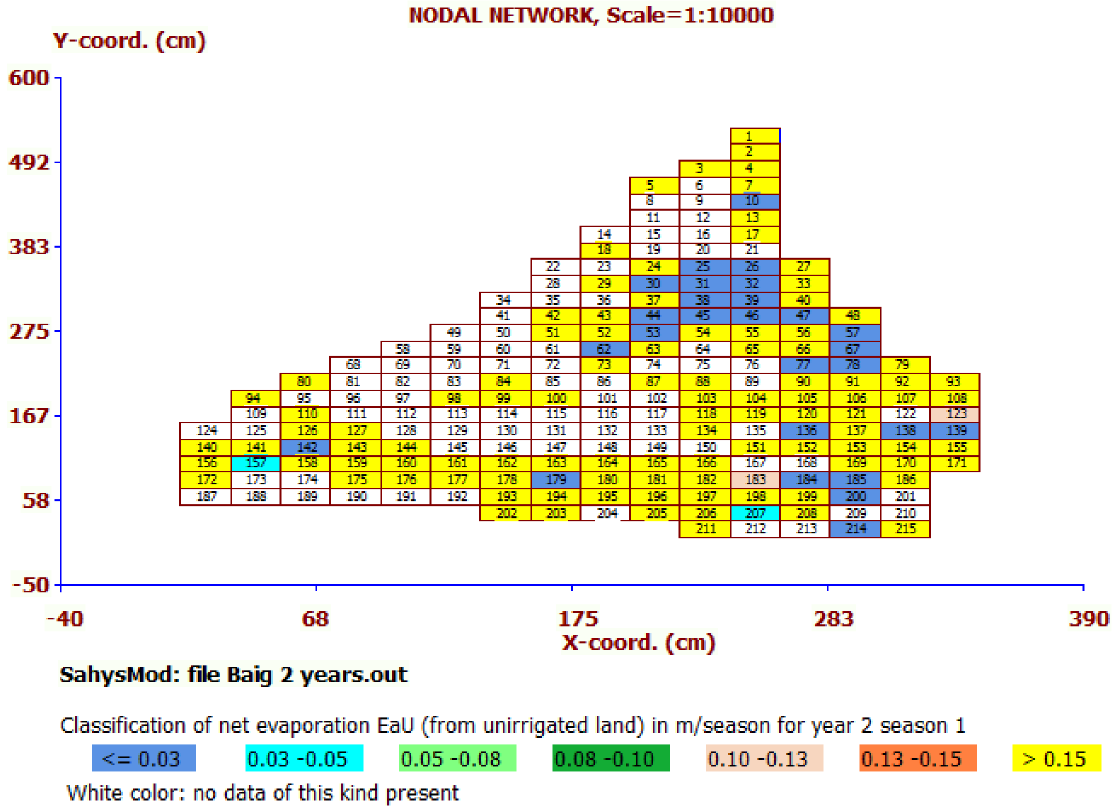


Figure 8. *Evaporation from dry land*

The fraction of non-irrigated land (see figure 9) is relatively large owing to a shortage of irrigation water as also discussed in figure 12.

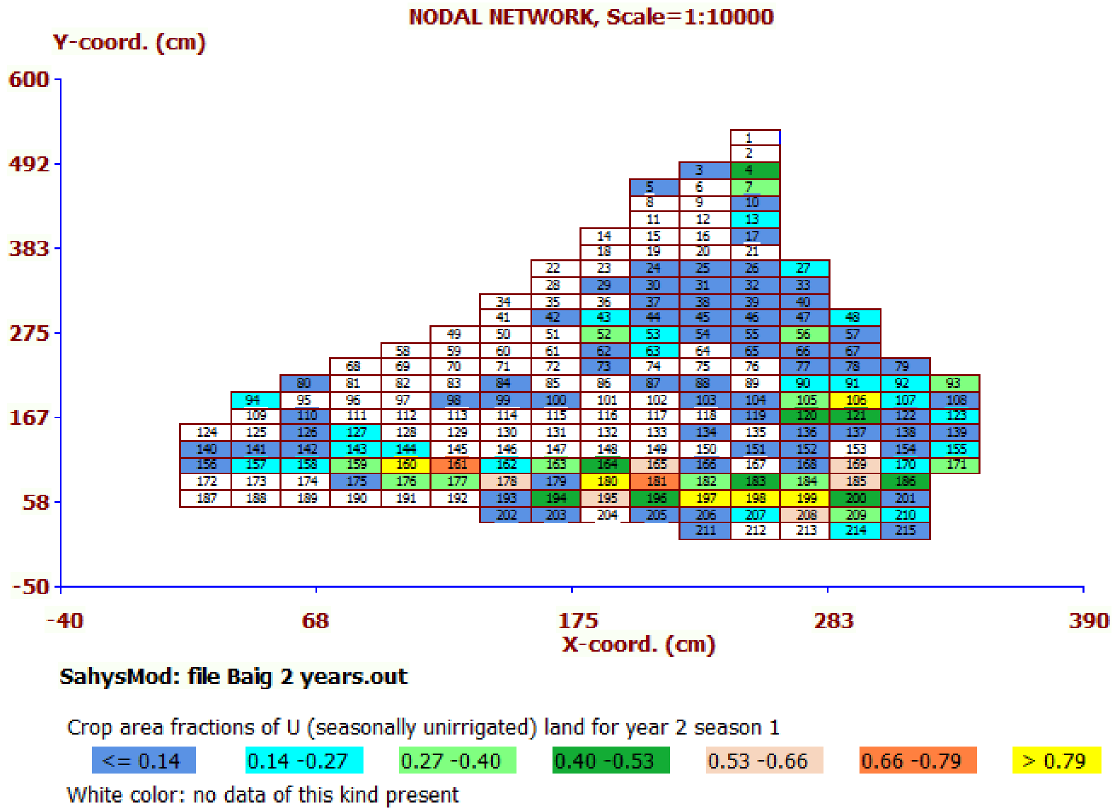


Figure 9. *Fractions of fallow land*

The groundwater balance in the aquifer is determined by the inflow from neighboring polygons (figure 10), the outflow to other neighboring polygons (figure 11), the downward percolation of irrigation water that is not evaporated and/or the capillary rise.

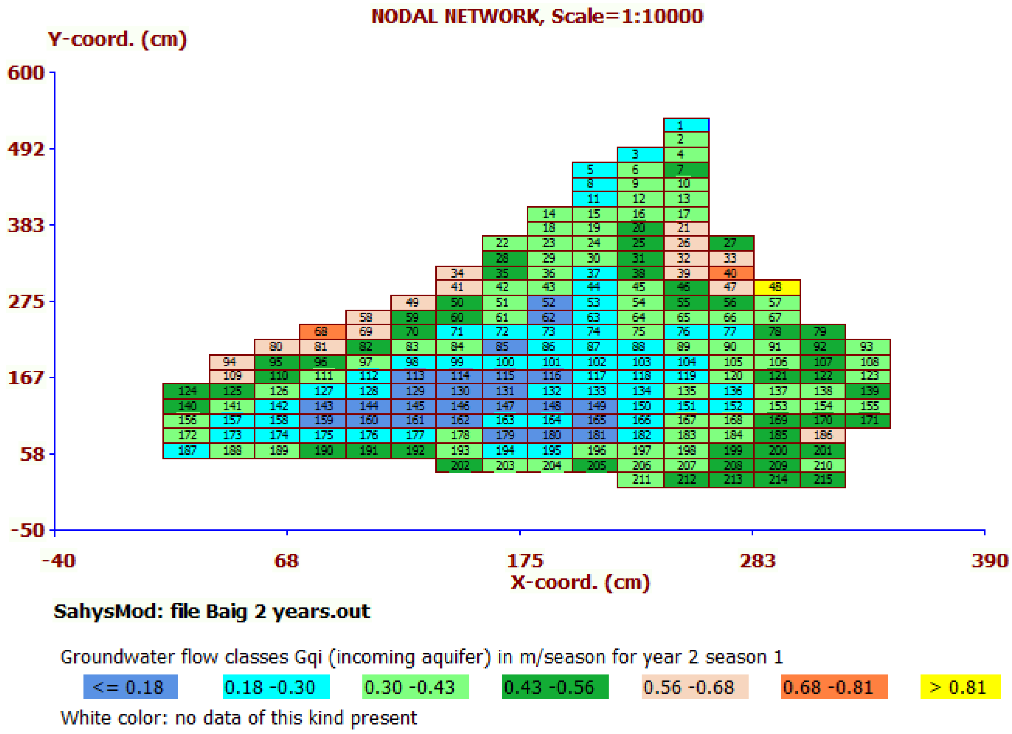


Figure 10. *Groundwater inflow through the aquifer per polygon.*

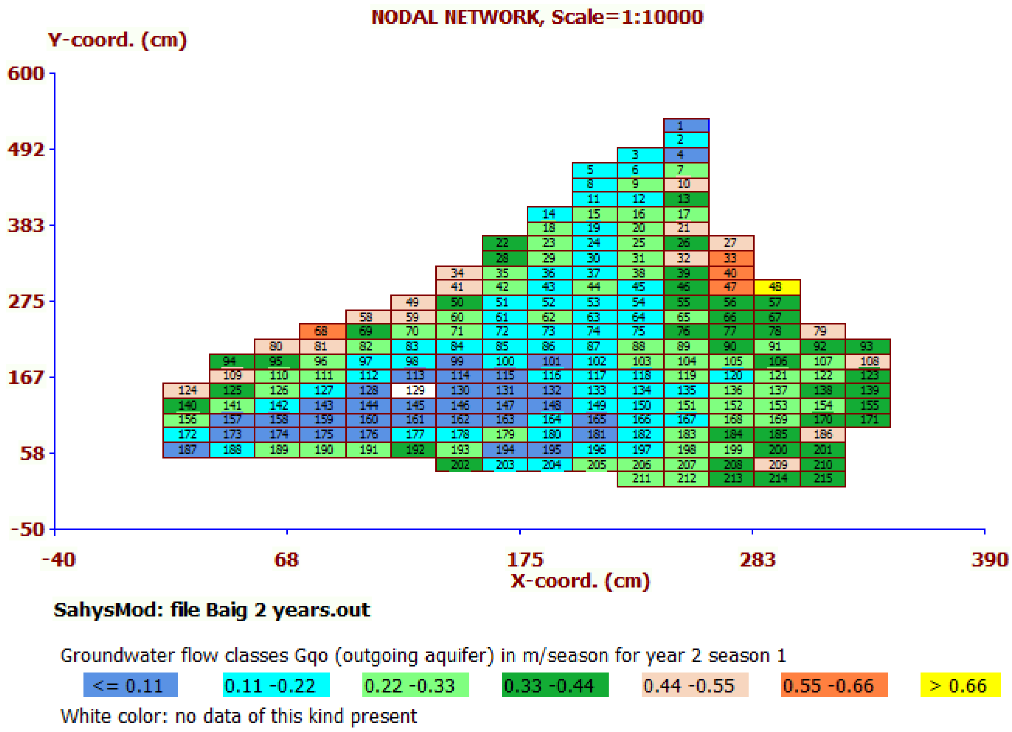


Figure 11. *Groundwater outflow through the aquifer per polygon. The inflow (figure 10) reduced by the outflow (this picture) determines the depth of the water table, together with other water balance factors like downward percolation and upward capillary rise.*

The following picture gives an overview of the irrigation sufficiency (figure 12) indicating the fraction of the potential evapo-transpiration of the crops that is covered by the amount of net irrigation and rain water, i.e. after subtraction of the losses to the under ground.owing to a less than 100% irrigation efficiency.

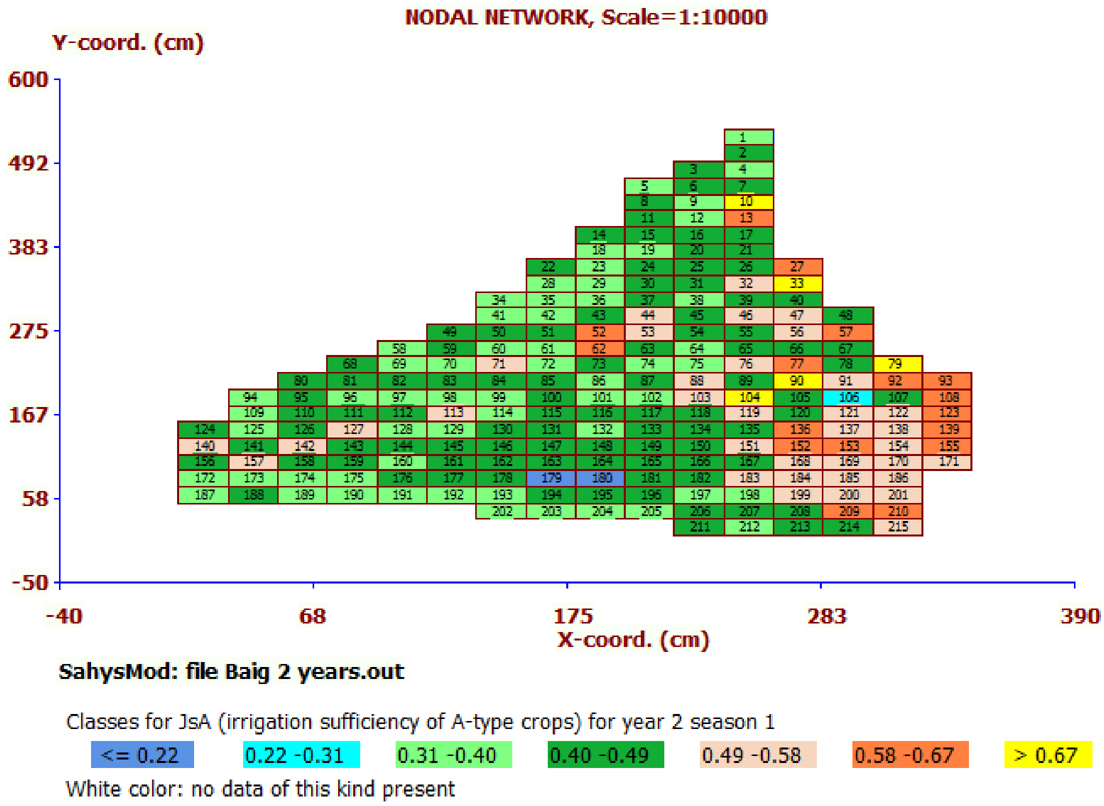


Figure 12. This makes it clear that the irrigation sufficiency is low and that scarcity of irrigation water plays an important role in the region

Although there are many more mapping options, this series of examples is terminated with a map of depths of the water table (figure 13).

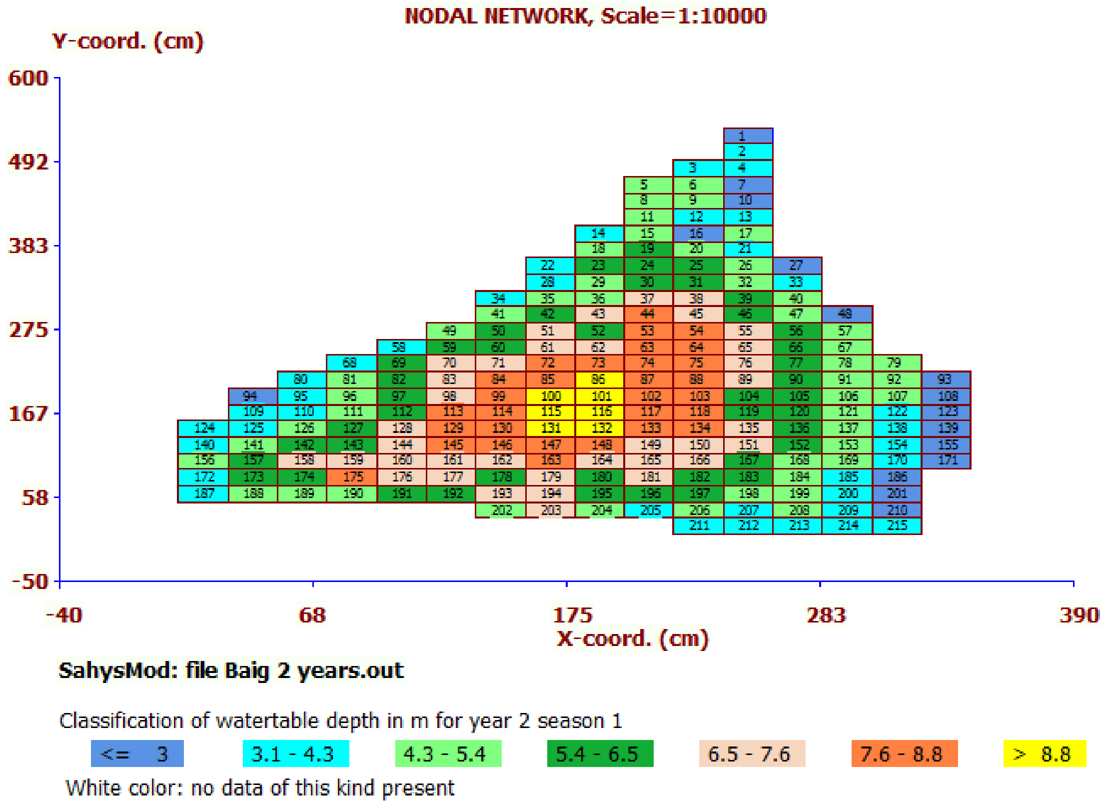


Figure 13*. The water table is fairly deep except in the dark blue polygons bordering the river. Especially the central part of the region has deep water tables. This may be partly due to the scarcity of irrigation water as discussed before so that the recharge to the water table is limited.*

3. Conclusions

The SahysMod model integrates many soil and water management aspects of irrigated lands and offers the possibility to study a large number of phenomena over a large project area.

4. References

1 – SahysMod, free software for polygonal agro-hydro-soil-salinity modeling including aquifer conditions and groundwater flow. Download from https://www.waterlog.info/sahysmod.htm

2 - Azhar Inam et al. , 2017. '' Coupling of a distributed stakeholder-built system dynamics socio-economic model with SAHYSMOD for sustainable soil salinity management – Part 1: Model development''. In Journal of Hydrology, http://dx.doi.org/10.1016/j.jhydrol.2017.03.039

3 - Azhar Inam et al. , 2017. '' Coupling of a distributed stakeholder-built system dynamics socio-economic model with SAHYSMOD for sustainable soil salinity management – Part 2: Model coupling and application''. In Journal of Hydrology, https://www.sciencedirect.com/science/article/pii/S0022169417301865?via%3Dihub

4 - Jan Adamowski et al., 2017. ''Parameter estimation and uncertainty analysis of the Spatial Agro Hydro Salinity Model (SAHYSMOD) in the semi-arid climate of Rechna Doab, Pakistan''. Journal of Environmmental Modelling & Software 94 (2017) 186-211.
http://dx.doi.org/10.1016/j.envsoft.2017.04.002

List of other publications in which SahysMod is used, chronologically

1 - Sina Akram, Heydar Kashkouli, Ebrahim Pazira, 2008. ''Sensitive variables controlling salinity and water table in a bio-drainage system using SahysMod''. Irrigation and Drainage Systems Volume 22, Numbers 3-4, December, 2008 pp. 271-285. Online:
http://www.springerlink.com/content/r102ju4952710421/

2 - Hosein Liaghat, M Mashal, 2008. ''Sustainability of Biodrainage Systems Considering Declining of Evapotranspiration Rate of Trees Due to Soil Salinization.'' Published by the American Society of Agricultural and Biological Engineers (http://www.asabe.org), St. Joseph, Michigan . Citation: 9th International Drainage Symposium held jointly with CIGR and CSBE/SCGAB Proceedings, 13–16 June 2010 IDS-CSBE-100129. Online: http://elibrary.asabe.org/abstract.asp?aid=32127

3 - Tsegay F. Desta, 2009. ''Spatial modeling and timely prediction of salinization processes using SahysMod in GIS environment''. Thesis International Institute for Geo-information Science and Earth Observation (ITC), Enschede, The Netherlands. On line :
http://www.itc.nl/library/papers_2009/msc/aes/desta.pdf

4 - Sina Akram and Hossein Liaghat. (2010) ''Performance of biodrainage systems in arid and semiarid areas with salt accumulation in soils''. 9th International Drainage Symposium held jointly with CIGR and CSBE/SCGAB Proceedings, 13–16 June 2010.
http://www.csbe-scgab.ca/docs/meetings/2010/CSBE100116.pdf

5 - Ajay Singh, Sudhindra Nath Panda. (2012) ''Integrated Salt and Water Balance Modeling for the Management of Waterlogging and Salinization. I: Validation of SAHYSMOD''. Journal of Irrigation and Drainage Engineering 138:11, 955-963
http://ascelibrary.org/doi/abs/10.1061/%28ASCE%29IR.1943-4774.0000510

6 - Singh, A. and Panda, S. (2012).''Integrated Salt and Water Balance Modeling for the Management of Waterlogging and Salinization. II: Application of SAHYSMOD'' J. Irrig. Drain Eng., 138(11), 964–971. http://ascelibrary.org/doi/abs/10.1061/%28ASCE%29IR.1943-4774.0000510

7 - Yao, R.J, Yang, J.S., Wu, D., Xie, W. 2017. Calibration and Sensitivity Analysis of Sahysmod for Modeling Field Soil and Groundwater Salinity Dynamics in Coastal Rainfed Farmland. Irrig Drain. 66(3):411-427. https://doi.org/10.1002/ird.2106.

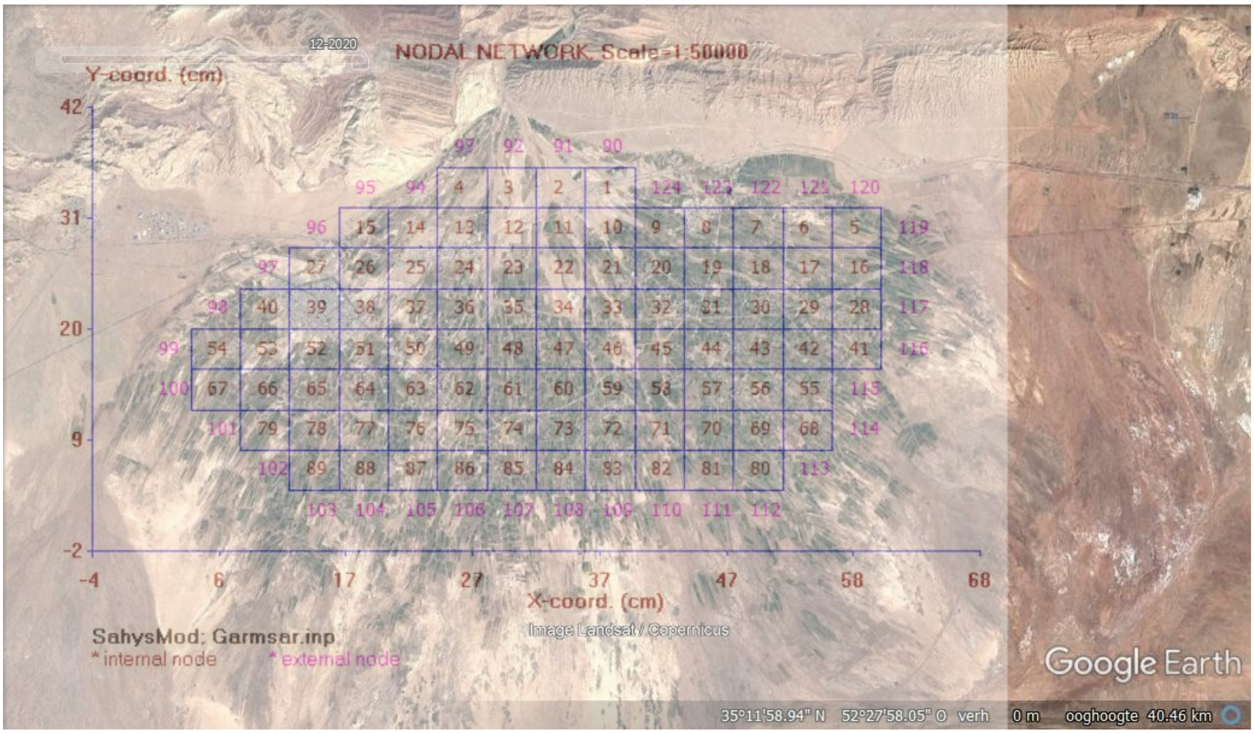
8- Yao, R.J., Yang, J.S., Wu, D., Xie, W., Wang, X,P. 2017. Scenario Simulation of Field Soil Water and Salt Balances Using SahysMod for Salinity Management in a Coastal Rainfed Farmland. Irrig Drain. 66. https://doi.org/10.1002/ird.2159.

9 - Agro-hydro-soil-salinity characteristics of the irrigated Garmsar alluvial fan, Iran, described with the SahysMod model. On line:
https://www.researchgate.net/publication/336680433_Agro-hydro-soil-salinity_characteristics_of_the_irrigated_Garmsar_alluvial_fan_Iran_described_with_the_SahysMod_model
or:
https://www.waterlog.info/pdf/Garmsar.pdf

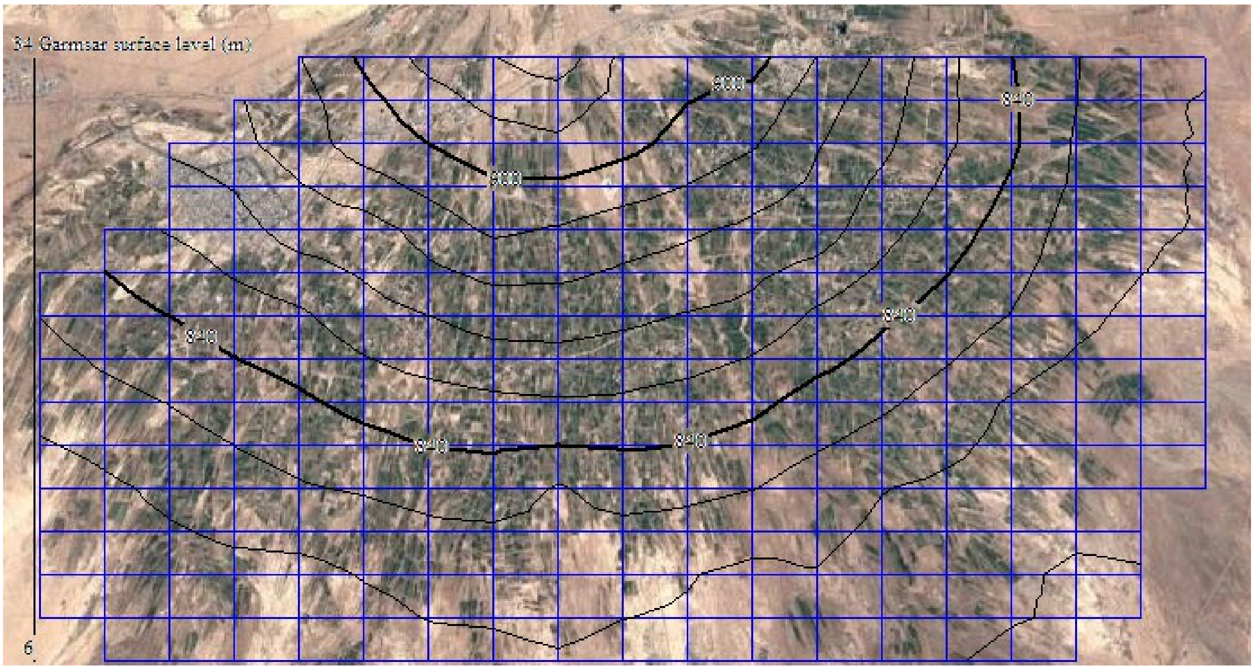
10 - Irrigation, groundwater, wells, drainage and soil salinity control in the alluvial fan of Garmsar, Iran – assessments with the Sahysmod model. On line:
https://www.researchgate.net/publication/341607069_Irrigation_groundwater_wells_drainage_and_soil_salinity_control_in_the_alluvial_fan_of_Garmsar_Iran_-assessments_with_the_Sahysmod_model
or:
https://www.waterlog.info/pdf/Garmsar irrigation.pdf

11 - The groundwater hydraulics of the Garmsar alluvial fan, Iran, assessed with the SahysMod model. On line:
https://www.researchgate.net/publication/336232156_The_groundwater_hydraulics_of_the_Garmsar_alluvial_fan_Iran_assessed_with_the_SahysMod_model
or:
https://www.waterlog.info/pdf/Garmsar groundwater.pdf

5. *Appendix. SahysMod nodal networks overlaid on Google Earth*



The Garmsar alluvial fan (Google Earth) overlain by the SahysMod nodal network (blue lines) with internal/external polygon numbers using https://overlay.imageonline.co/



The Garmsar alluvial fan (Google Earth) overlain by the SahysMod nodal network (blue lines) and the surface level contour lines (black) made with the QuikGrid program, see *https://www.waterlog.info/pdf/QuikgridHelp.pdf* .