Universidad Politécnica de Cartagena

Irriblend-DSW

USER GUIDE

Irriblend-DSW version v1.0 described in:

Gallego-Elvira et al., 2021

https://doi.org/10.1016/j.agwat.2021.107012

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1. What is Irriblend-DSW?

It is a Decision Support Tool (DST) designed to help users make more effective decisions to maximize profit in soilless crop fertigation with a mix of conventional waters (e.g. surface, underground, brackish) and Desalinated Sea Water (DSW). The user provides the DST with the following information (see details in Section 3): available water sources (quality and price), available commercial fertilizers (composition and price), nutritional needs of the crop and salinity thresholds and indicators of potential profit in optimal conditions. The DST gives the following output (see details in Section 4): the optimum (most profitable) water blend and amount of each commercial fertilizer for that water combination. Irriblend-DSW also provides the potential profitability for each possible water blend and the required amount of each commercial fertilizer to optimize costs.

2. Running Irriblend-DSW in Google Colaboratory

Do I need to install any software?

No, all that you need is a free google account to get access to *Google Colaboratory*.

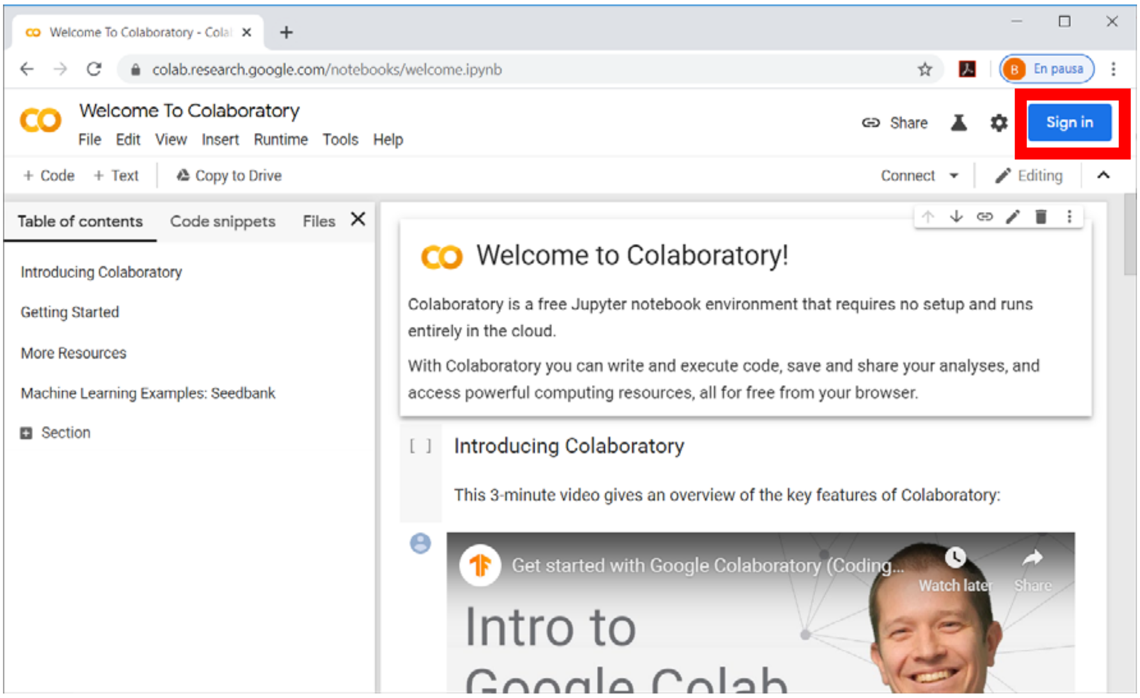
What is *Google Colaboratory* (GC)?

It is a free Jupyter notebook environment that requires no setup and runs entirely in the cloud, all for free from your browser. With GC you can execute Irriblend-DSW code and the output will be printed in your screen and saved to your Google Drive. For further info, please watch GC overview video: https://youtu.be/inN8seMm7UI

Let's start using GC

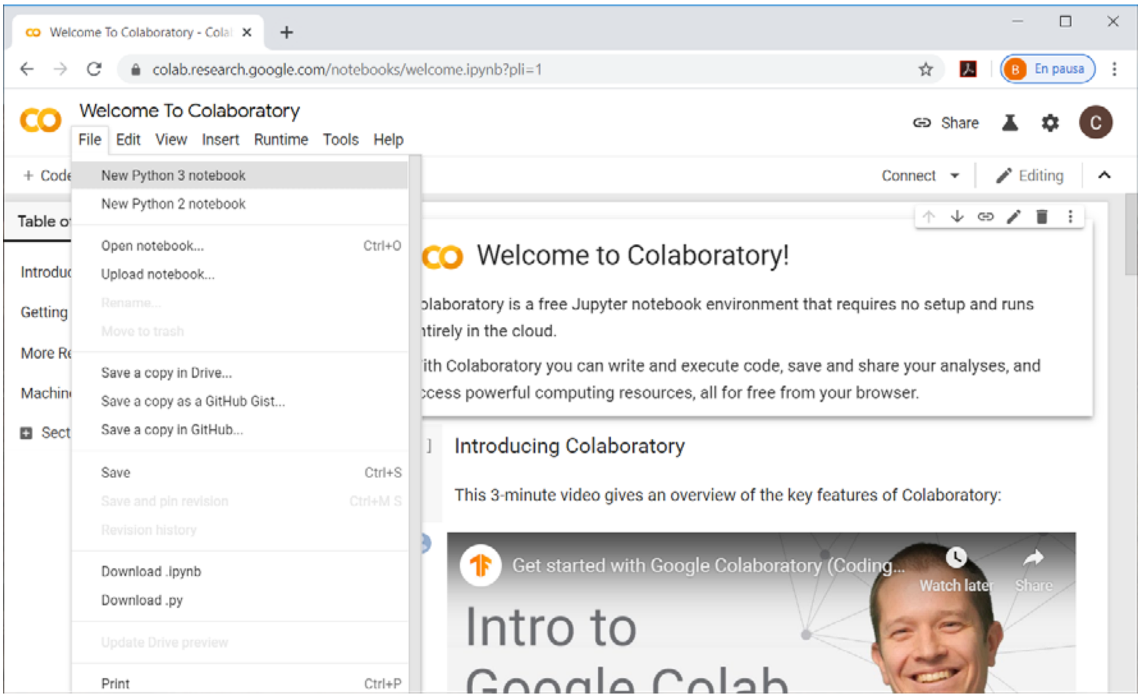
Step 1:

Create a *gmail* account, if you do not have one. Then, in your internet browser, go to https://colab.research.google.com/, and sign in your google account.



Step 2: Test that it is working:

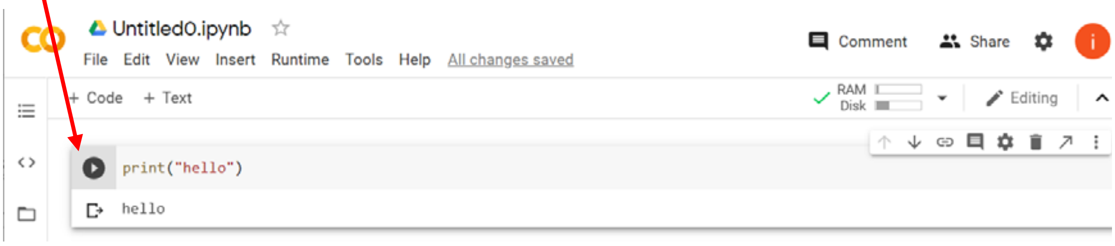
Open a new Python 3 notebook



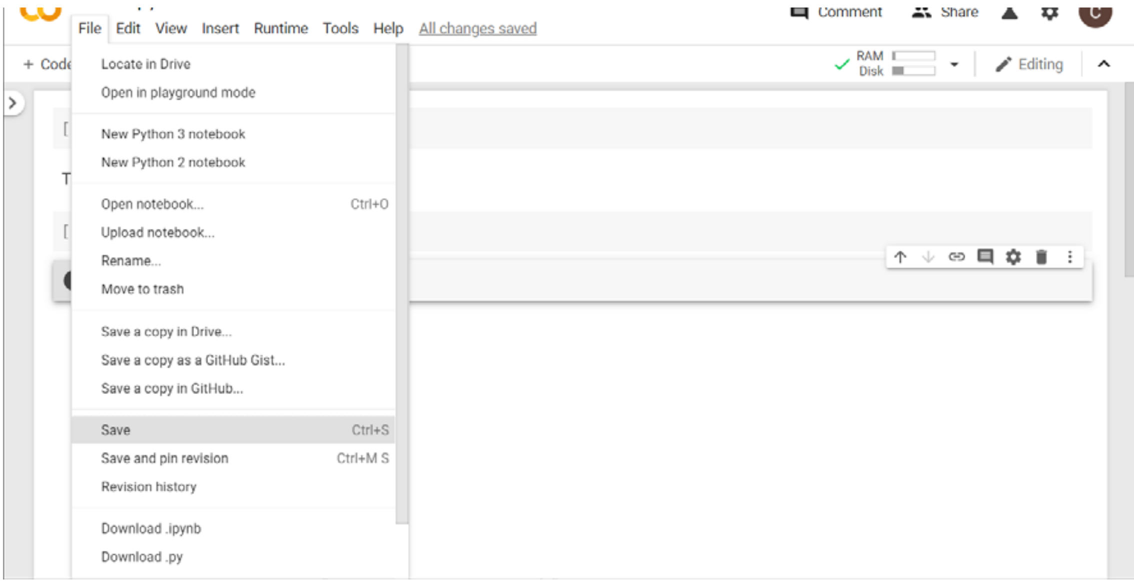
Step 3:

Test that you can type and run code, and save notebooks.

To run the code in the cell (press "play" bottom)



Then, save your notebook "Untitled0.ipynb".



All .ipynb files are saved by default in the folder Colab Notebooks in your Gdrive.

Saving the example "Untitled0.ipynb" will create this folder in which you can later copy the Irriblend-DSW code.

Runnig Irriblend-DSW in Google Colaboratory

Step 1:

Open your Gdrive (https://drive.google.com/drive/u/0/my-drive) and check that the folder “Colab Notebooks” is in your Gdrive.

Copy in the folder “**Colab Notebooks**” the two pieces of code provided with Irriblend-DSW:

- irriblend_dsw_funs.py
- irriblend_dsw_main-v1.0.ipynb

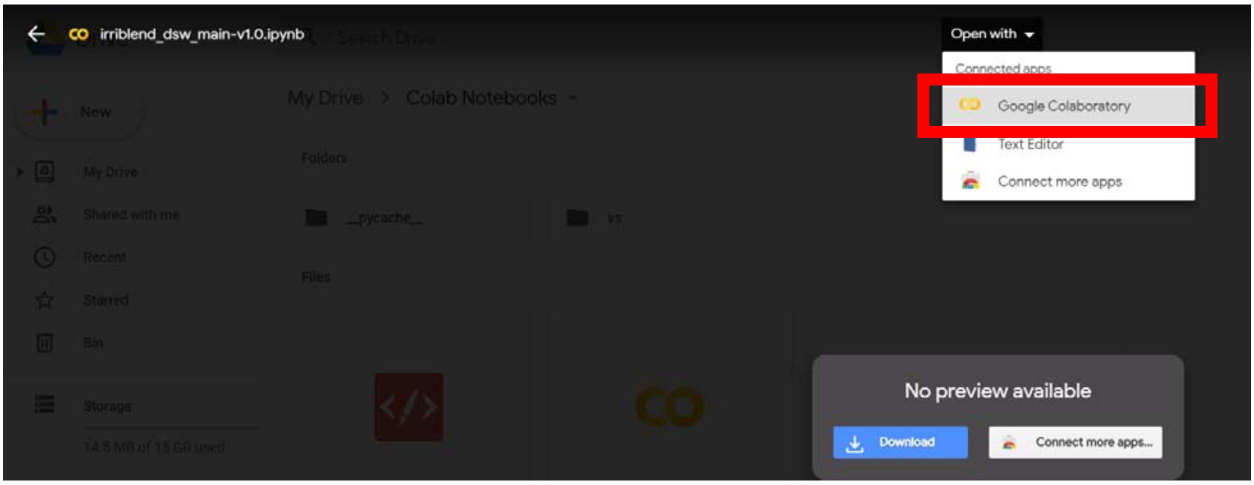
Step 2:

In your Gdrive, **create a new folder called “irriblend-dsw-data”** and copy in this folder:

- user_input.xlsx (See details of this file in Section 3 of this document)

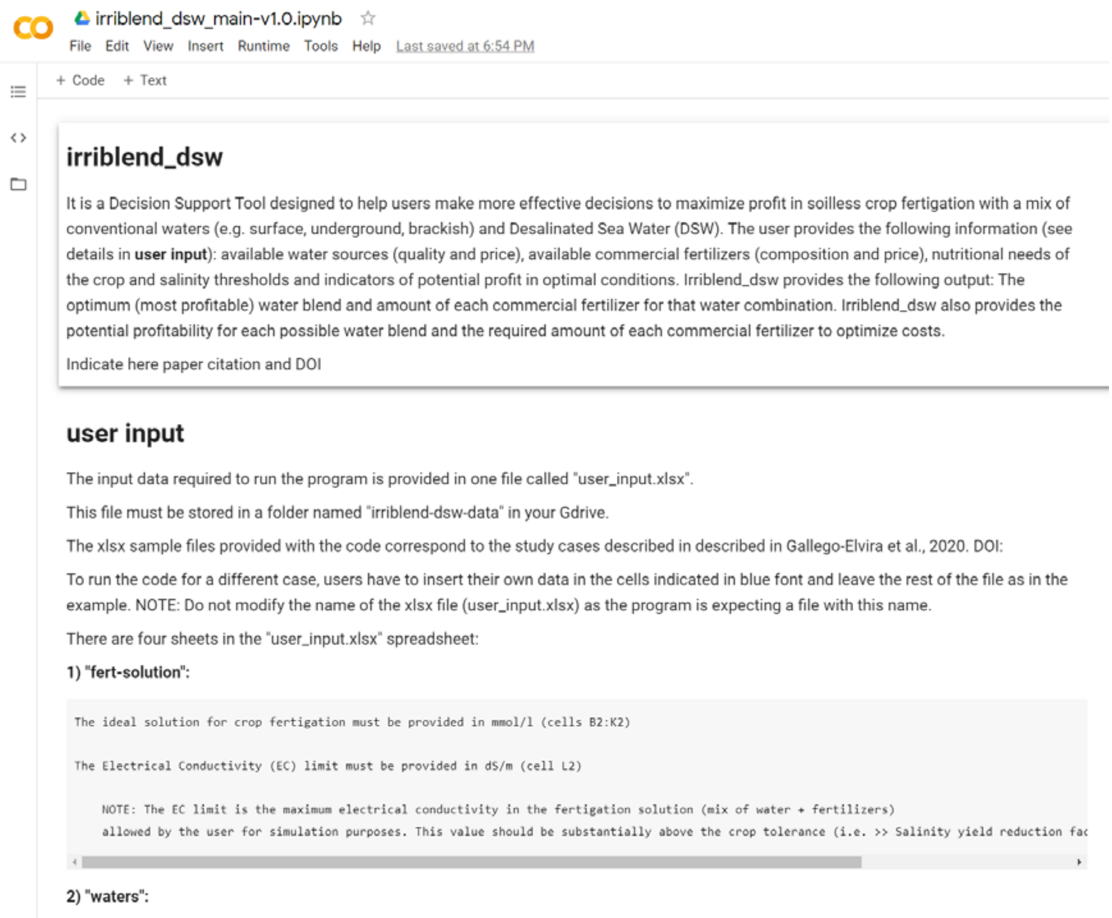
Step 3:

Go to the folder “Colab Notebooks” and double-click in irriblend_dsw_main-v1.0.ipynb, and the open it with GC.



Step 4:

Once in GC, you can read the user input requirements and run the code.



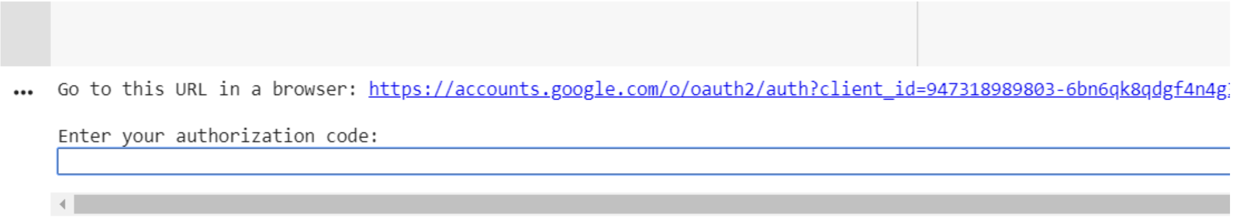
Below (scroll down) you can find the "Program:

To run the program:

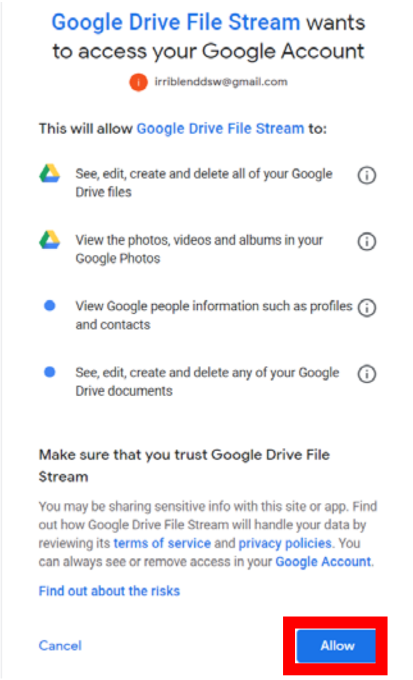
Step 5 (mount drive):

Click the play button (see red square) to mount Gdrive:

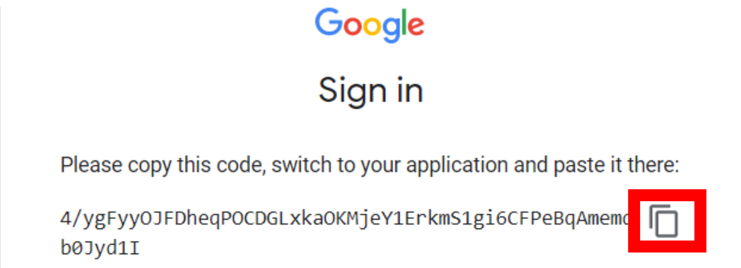
Once you click the button, it will ask you for permission to read and write in your Gdrive:

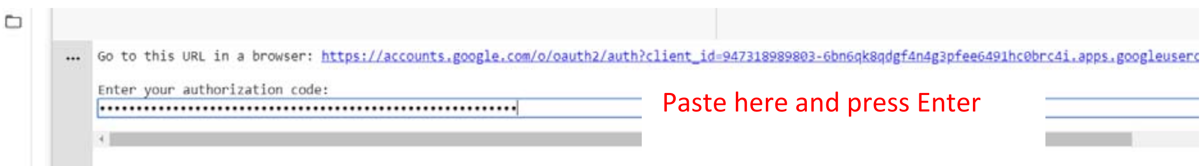


Click in the link provided and then click "Allow",



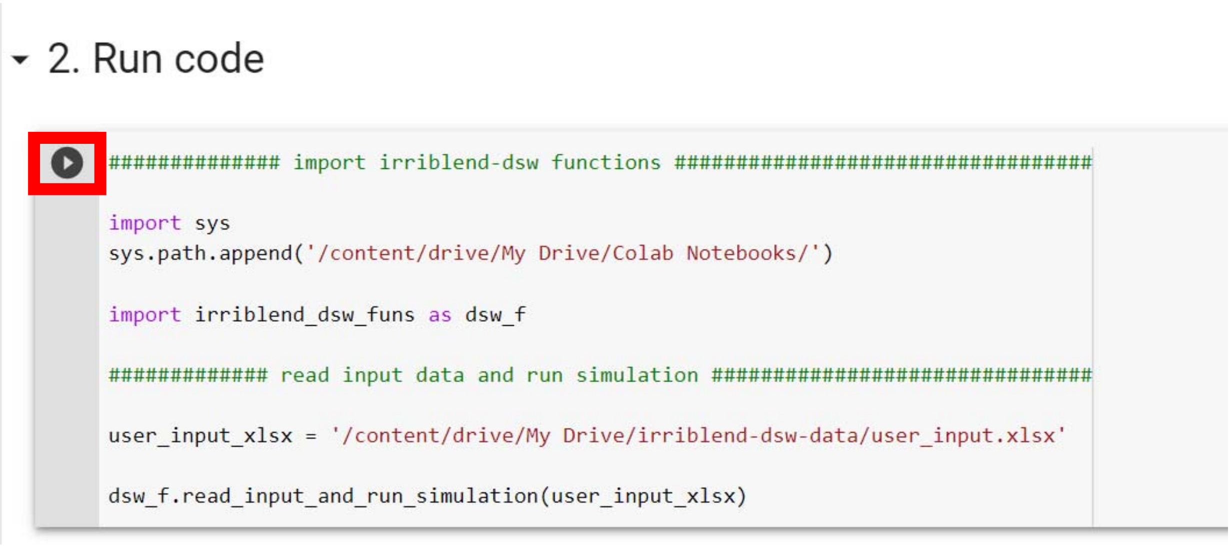
and finally copy/paste the authorization code and press Enter.



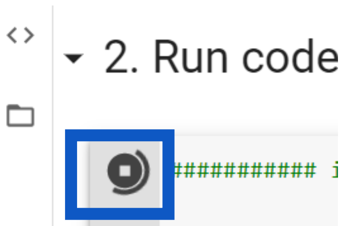


Step 6 (run Irriblend-DSW code):

Click the play button to run the code:

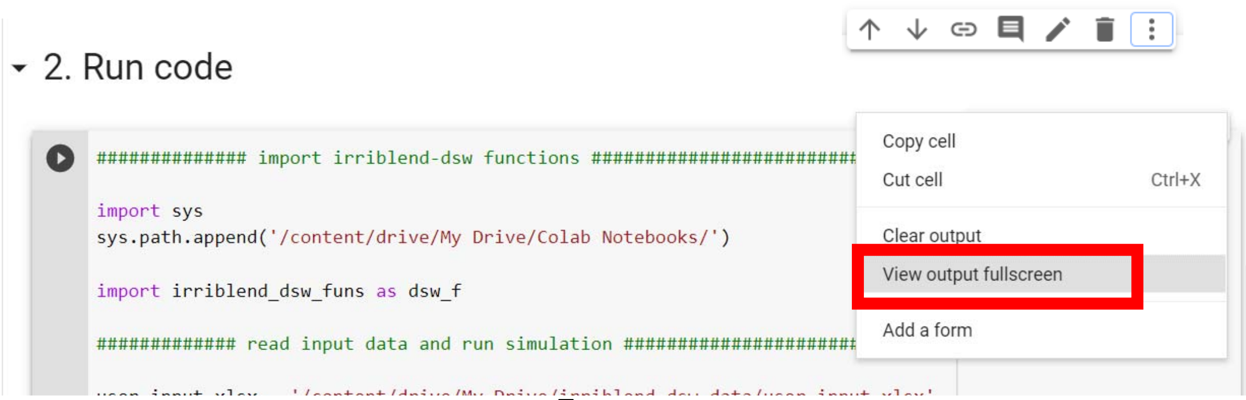


Then, you will see that the code is running:



Wait until you see the “play button” again, that means that the run has been executed. If you are running the program with the sample user_input files provided, it will take less that one minute to get the output. If you are running a more complex case, it may take a bit longer. Once the program is executed, the output file “output.xlsx” (see details in Section 4 of this document) can be found in your Gdrive in the folder “irriblend-dsw-data” and you can see the output in your screen:

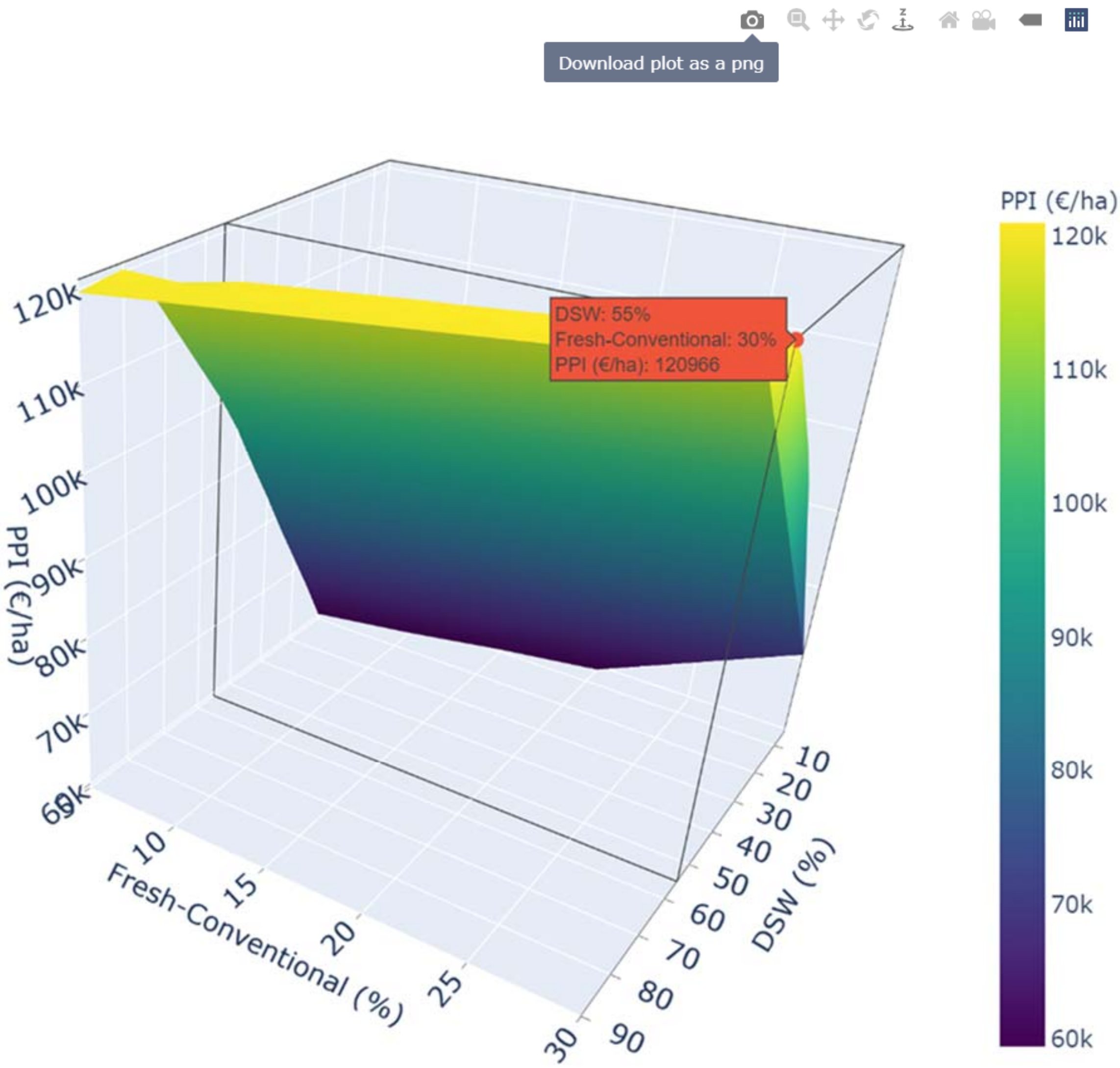
To see the output in full screen:



The output in your screen consist of text with a short summary (highlights) of the simulation output and interactive graphs which show the PPI vs the percentual amounts of two different water sources.

```
************************* Simulation-output highlights *************************

------------------------- SIMULATED WATER COMBINATIONS -------------------------

The total number of water combinations (5% steps) is:  93
The total number of water combinations with solution (subjected to user constraints*) is:  87

*User input constraints:

The percent availability of each water source is:
DSW : 100 %
Fresh-Conventional : 30 %
Brackish-underground : 100 %

The EC (dS/m) in the simulated fertigation solution cannot exceed: 6.0


------------------------- OPTIMAL WATER COMBINATION ----------------------------

The optimal water combination (subjected to user constraints*) is:
DSW : 55 %
Fresh-Conventional : 30 %
Brackish-underground : 15 %

The water_blend CE (dS/m) is:  1.411

The water_blend price (€/m3) is:  0.387


------------- FERTILIZERS FOR THE OPTIMAL WATER COMBINATION ---------------------

The fertilizer combination with the lowest cost is the following (name : amount (g/l))
Phosphoric acid 85%  : 0.1152
Nitric acid 59%  : 0.1359
Calcium nitrate 15,5% N, 27% CaO  : 0.4265
Potassium nitrate (13-0-46)  : 0.4688
Ammonium nitrate 33.5% N  : 0.047
Potassium sulphate  : 0.2285
```

In the interactive graphs, you can explore the values of each water combination, change the size and rotation of the figure and download plots as .png files.



3. Irriblend-DSW input file

The input data required to run the program are provided in one file called "user_input.xlsx". This file must be stored in a folder named "irriblend-dsw-data" in your Gdrive.

Two sample input files are provided with the program. They correspond to the case studies described in Gallego-Elvira et al., 2020 [REF]. To run the code for a different case, users have to insert their own data in the cells indicated in blue font and leave the rest of the file as in the example. Please, do not modify the name of the xlsx file (user_input.xlsx) as the program is expecting a file with this name.

There are four sheets in the "user_input.xlsx" spreadsheet:

- "fert-solution":
  - The ideal solution for crop fertigation must be provided in mmol/l (cells B2:K2)
  - The Electrical Conductivity (EC) limit must be provided in dS/m (cell L2)

  NOTE: The EC limit is the maximum electrical conductivity in the fertigation solution (mix of water + fertilizers) allowed by the user for simulation purposes. This value should be substantially above the crop tolerance (i.e. >>salinity yield reduction factor given in input section "crop-profit").
- "waters":
  - The composition of each water source must be provided in mg/l (cols B:K, rows 2-4)
  - The EC of each water source must be provided in dS/m (col L, rows 2-4)
  - The price of each water must be provided in €/m^3 (col M, rows 2-4)

  - o The maximum percent available of each water source in % (col N, rows 2-4). NOTE: 100% means no restrictions in availability of the water source. The program can run simulations with two or three water sources.
- "ferts":
  - o The composition of each available fertilizer must be provided in mmol/g (cols B:K)
  - o The price of each fertilizer must be provided in €/kg (col L)
  - o The density of each fertilizer must be provided in g/cm^3 (col M)

  NOTE: The program reads the data of up to 30 fertilizers (rows 2-31). The program does the simulation accounting for all (up to 30) the fertilizers provided.
- "crop-profit":

  The following profitability indicators are to be provided, assuming a crop without stress/limitations of water, salinity, nutrients, climate or pests:
  - o Water productivity (kg yield/m^3 water used for fertigation) (cell B3)
  - o Land productivity (kg yield/m^2 of crop surface) (cell B4)
  - o Crop market price (€/kg) (cell B5)
  - o Crop salinity threshold (dS/m) above which there is yield loss (cell B6)
  - o Salinity yield reduction factor (cell B7)

    NOTE: This factor corresponds to “b” in FAO 61, Annex 1. Crop salt tolerance data. Yield is reduced linearly over Crop salinity threshold:

    Relative yield: Yr = 100 - b(ECr - a)

    b = the slope expressed in percent per dS/m (= yield decrease factor)

    a = the salinity threshold expressed in dS/m (= CE threshold)

    ECr = EC in the root zone in the soilless culture in dS/m

4. Irriblend-DSW output file

The simulation output is saved in the file "output.xlsx" which is stored in the folder "irriblend-dsw-data" in your Gdrive.

There are five sheets in the " output.xlsx " spreadsheet:

- " water_combs":

It shows all the water combinations that have a solution (i.e. those that provide the target fertigation solution with the given set of commercial fertilizers under the user restrictions). The EC (dS/m) and price (€/m^3) of each water combination is provided.

- "opt_fert_comb":

It shows the optimum (cheapest) combination of commercial fertilizer for each water combination in " water_combs". The amount of each fertilizer is given is g/l.

- "fertig_sol":

It gives the fertigation solution (ions in mmol/l) for each water combination in " water_combs". The final EC (dS/m) in the solution and the price (€/m^3) are also provided. This solution is the closest to the (user-input) ideal solution for a given water combination with the imposed constrains (which are: CE < EC limit; Exact amounts of user input of NO_3, NH_4, H_2PO_4, K, HCO_3; Amounts of Ca, Mg, SO_4, Cl, Na, equal or above needs given by user).

- "profitability":

For each water combination in "water_combs", the profit potential indicator (PPI, €/ha), water productivity (kg yield/m^3) and production cost (€/kg yield) are given. The PPI is the yield benefit (production (kg) x market price (€/kg)) minus the fertigation cost (cost of water plus fertilizer).

- "optimun_water_blend":

Indicates the water blend that provides the maximum PPI.