✓ What is DMAP (Drought Monitoring And Prediction) software?

Among natural hazards, drought is known to cause extensive damage and affects a significant number of people (Wilhite 1993). To reduce the damage from drought, it is crucial to monitoring this event. Drought indices are quantitative measures that characterize drought levels by assimilating data from one or several variables such as precipitation and evapotranspiration into a single numerical value (Zargar et al. 2011). A reliable index must be able to quantify drought severity, detect drought beginning and end times for early warning systems, monitoring and prospective water resources planning.

Since calculating different indices are sometimes sophisticated and time consuming, so researchers need a comprehensive software. As we know, there are three main drought types, namely meteorological, agricultural, and hydrological droughts. The DMAP (Drought Monitoring And Prediction) software can calculate different drought indices in three different types of drought that are listed in following:

1- **Meteorological drought**

A: Rain Based-drought indices (Salehnia et al., 2017):

- SPI (Standardized Precipitation Index), McKee et al. 1993, 1995
- DI (Deciles Index), Gibbs and Maher, 1967
- PN (Percent of Normal Index), Willeke et al. (1994)
- CZI (China-Z Index), Wu et al. (2001)
- MCZI (Modified CZI), Wu et al. (2001)
- EDI (Effective drought Index), Byun and Wilhite (1999)
- RAI (Rainfall Anomaly Index), van Rooy (1965)
- ZSI (Z-score Index), Palmer (1965)

B: Other meteorological indices:

- PDSI (Palmer Drought Severity Index), Palmer (1965)
- PHDI (Palmer Hydrological Drought Index), Palmer (1965)
- SPEI (Standardized Precipitation Evapotranspiration Index), Vicente -Serrano et al., 2010
- RDI (Reconnaissance Drought Index), Tsakiris and Vangelis, 2005.

2- **Agricultural drought indices**
   - ARI (Agricultural Rainfall Index), Nieuwolt, 1981
   - SMDI (Soil Moisture Deficit Index), Narasimhan and Srinivasan, 2005
   - ETDI (Evapotranspiration Deficit Index), Narasimhan and Srinivasan, 2005

3- **Hydrological drought indices**
   - SWSI (Surface Water Supply Index), Garen, 1993
   - SDI (Streamflow Drought Index), Nalbantis and Tsakiris, 2009

In the monitoring phase in DMAP (Drought Monitoring And Prediction) software, through selecting every index, the user can calculating it and then by available graphs (line, columnar, and Boxplot), the user can monitoring the happened drought event in various time scale in the study area. In the prediction phase, the user by importing the downscaled outputs of GCMs models in DMAP tool, he/she can calculate every index the he wants for future period.

✓ Type of input file in DMAP (Drought Monitoring And Prediction) tool:

In DMAP the input file can be in different format files, namely csv, xls, xlsx, and also nc (NetCDF). This is a unique characteristic and due to this feature, users can easily import and browse his fie, without any concern. Another benefit of this software is the positioning of data in columns. In this software, the ordering of data in columns is not important, and the software recognizes the location of the data according to the input column header. This feature is not considered in other existing software that compute only a few indexes. So the user is having trouble, in such tools, therefore DMAP solve the problem and the user by selecting the header of each column can easily determine the order of them.

✓ Calculation of each index in DMAP (Drought Monitoring And Prediction) software:

In DMAP the equations of each index were extracted from the origin paper that it presented the intent index and all details of it. All the used equations were clarified in these papers. The main papers of each index are listed in the reference section in following. For an example we presented the calculations and the equations of PNI, according to Willeke et al. (1994).

$$PN = \frac{P_i}{P} \times 100$$

where P_i is the precipitation in time increment i (mm), and P is the normal precipitation for the study period (mm).

✓ *How can we run DMAP V.1.1 (Drought Monitoring And Prediction)?*

The DMAP (Drought Monitoring And Prediction) software is a comprehensive tool that can run 18 drought indices in three different drought types, namely meteorological drought (SPI, PN, DI, RAI, RDI, ZSI, CZI, MCZI, EDI, KBDI, PDSI, PHDI, SPEI), agricultural drought (ETDI, SMDI, ARI), and hydrological drought (SWSI and SDI). For running this software you can follow these steps one by one.

Step 1:

The DMAP tool has 4 tabs, that in this version the point option is active, the region ability and inner database will active in the next version (Fig. 1). For starting the software, first select the first tab, "Input Excel File" (Fig.2 No. 1). If you want to browse a text file, first you should assign your delimiter (such a space, comma, semicolon, etc.) (Fig.2 No. 2), if you want to browse an excel file or NetCDF file it doesn't need to assign a delimiter. Then you can press "Open File" (Fig.2 No. 3).

In Fig.2 No. 4, you can see the open window for selecting the desirable input file. In the open window, you select your file easily, and then click "Open" button. If you want use NetCDF files, you can select many nc files then will show the API for extracting data. This API is described in bellow.

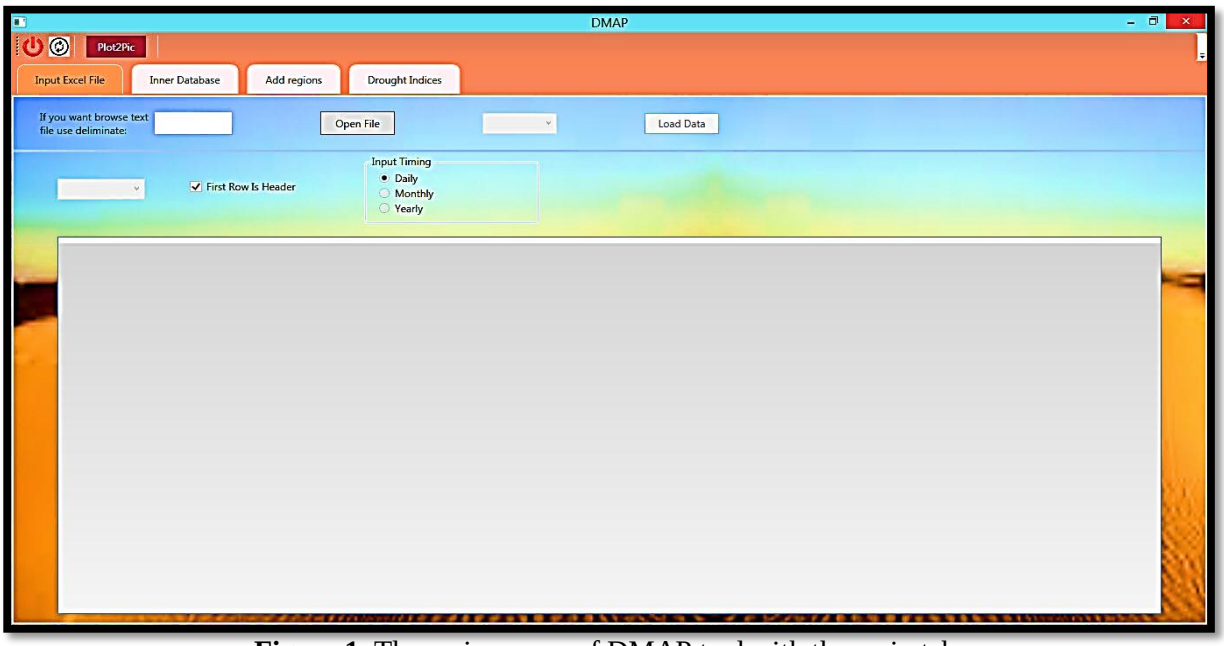

Figure 1. The main screen of DMAP tool with the main tabs.

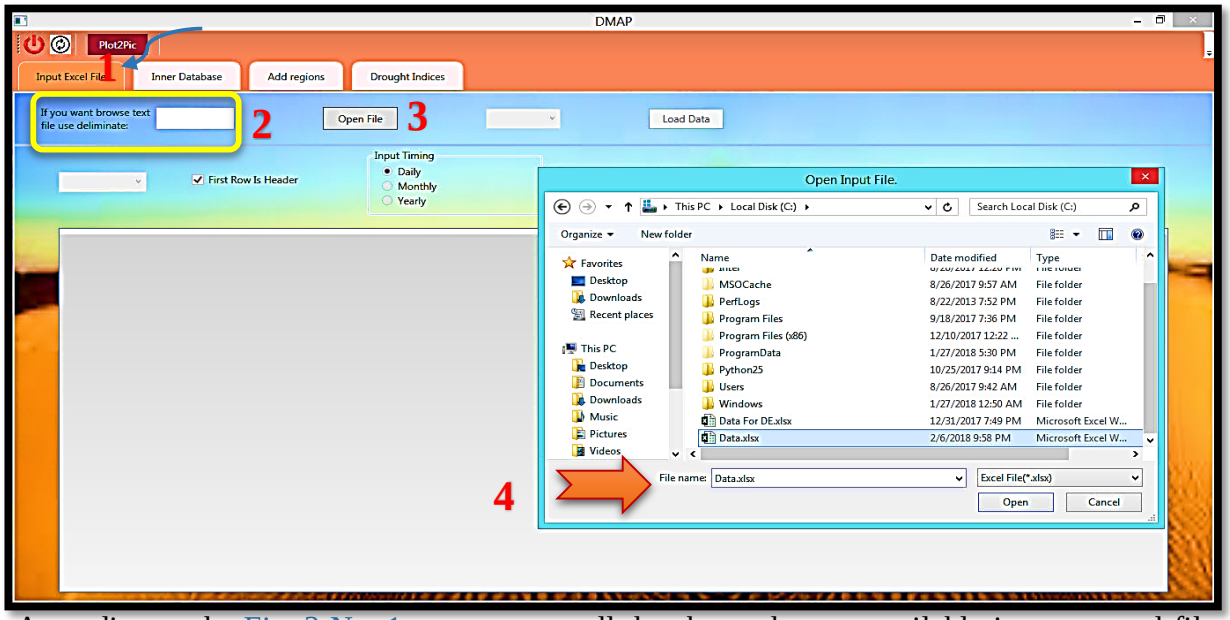

Figure 2. The input excel file tap and the details.

According to the Fig. 3 No. 1, you can see all the sheets that are available in your excel file, so select the proper sheet. In this example we select "Mashhad" sheet that it has several important weather data of Mashhad synoptic station. If your excel file sheet has header of columns so please select the "first Row is header" option (Fig. 3 No. 2), also in "Input Timing" you can select time scale of the input file. In the presented example here, the input data are in daily sale, so we check "Daily" (Fig. 3 No. 3).

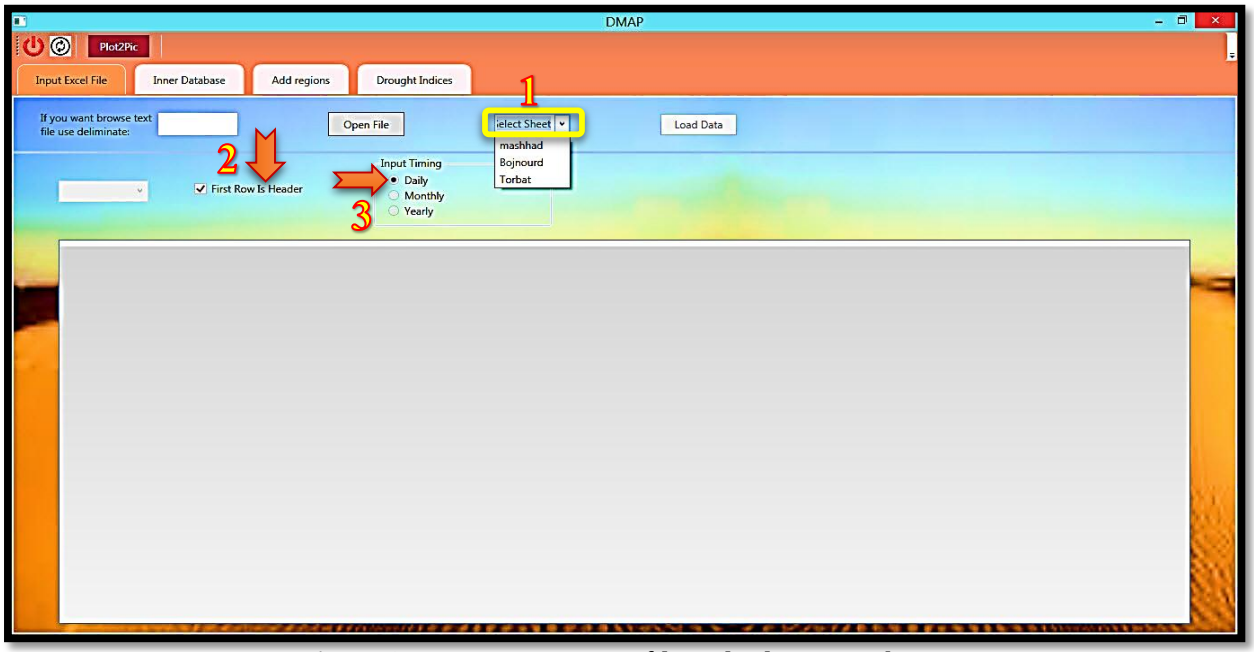

Figure 3. Browse your input file and select your sheet

After the desirable sheet was selected then it is the turn of assignments of weather variables. Therefore, as presented in Fig. 4 No.1, you can apply the format of your time scale. If your time data have a format like the 1986, then you should select "YYYY" in the combo box (Fig. 4). In this example for time, there are just the Julian years for each day of year.

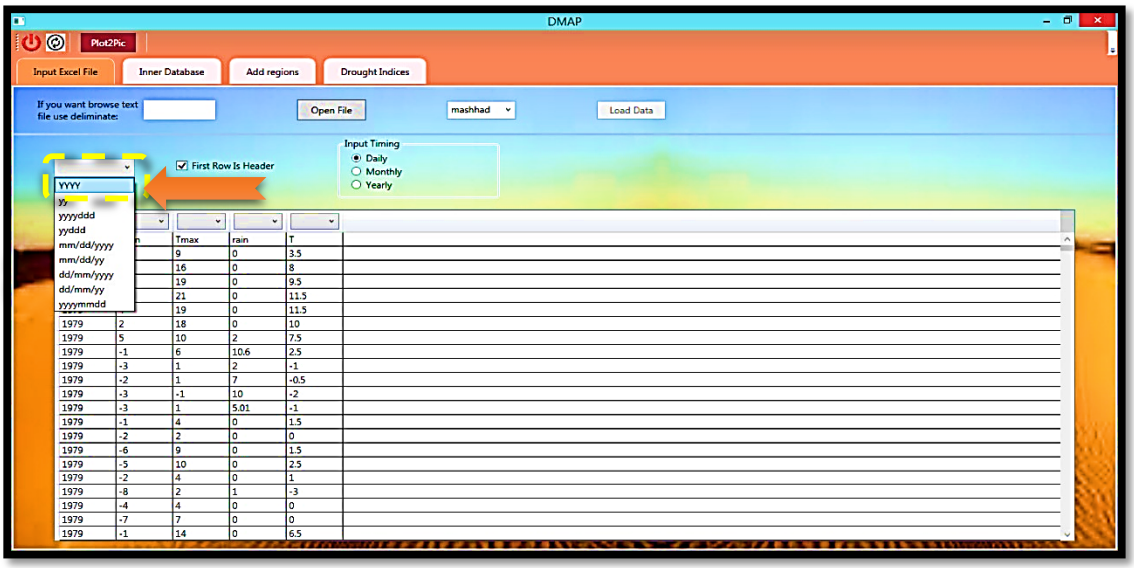

Figure 4. Select the format of time.

Then you should assign the header of each column. Attention please, as you see in Fig. 5, in this example the first column was assigned to the "Date", but there is not any special order for the columns, and this is actually one of the best advantage of the DMAP tool. Also, as presented in Fig.6 assign all the variables, if one or more columns are not necessary to assign, you should remain them with any header.

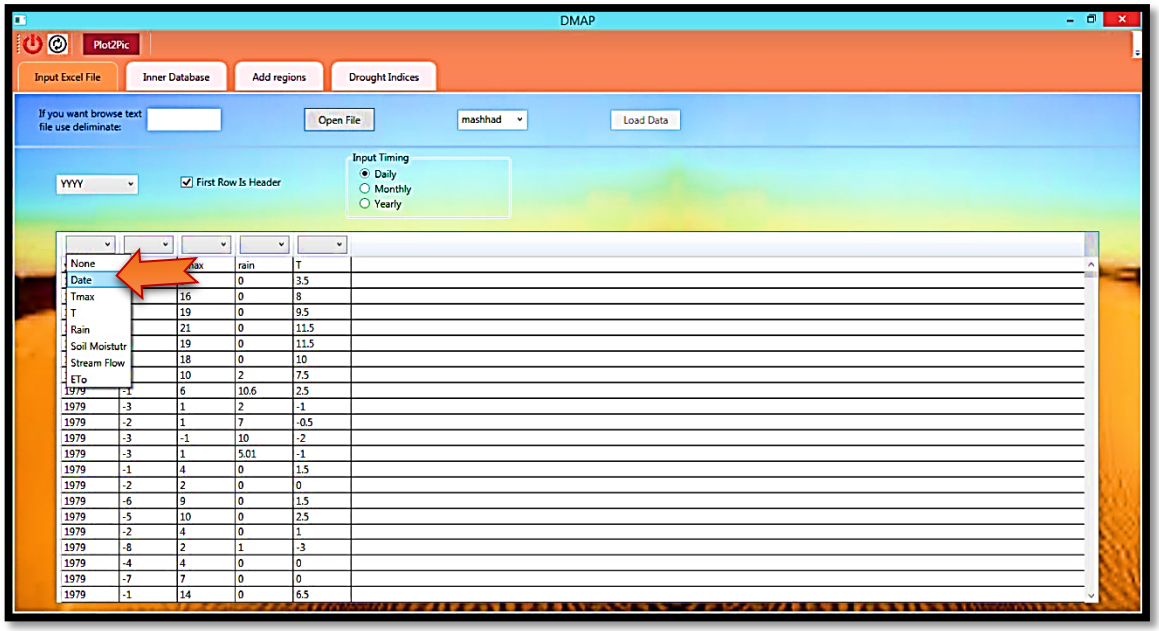

Figure 5. Assign the variables.

As you see in Fig. 6, in this sample input file the second column not necessary for assignment, so the header is “None“(Fig. 6 No. 1) and it doesn’t consider for calculation drought indices. In this sample the first column is “Date”, and others are respectively equal to “None”, “Tmax”, “Rain”, and “T”, that Tmax refers to maximum temperature, Rain for the amount of precipitation, and T refers to mean of temperature. Finally, press the “Load Data” button (Fig. 6 No. 2). Then you will face to a small window “Data loaded”, click it and go to the next step (Fig. 7).

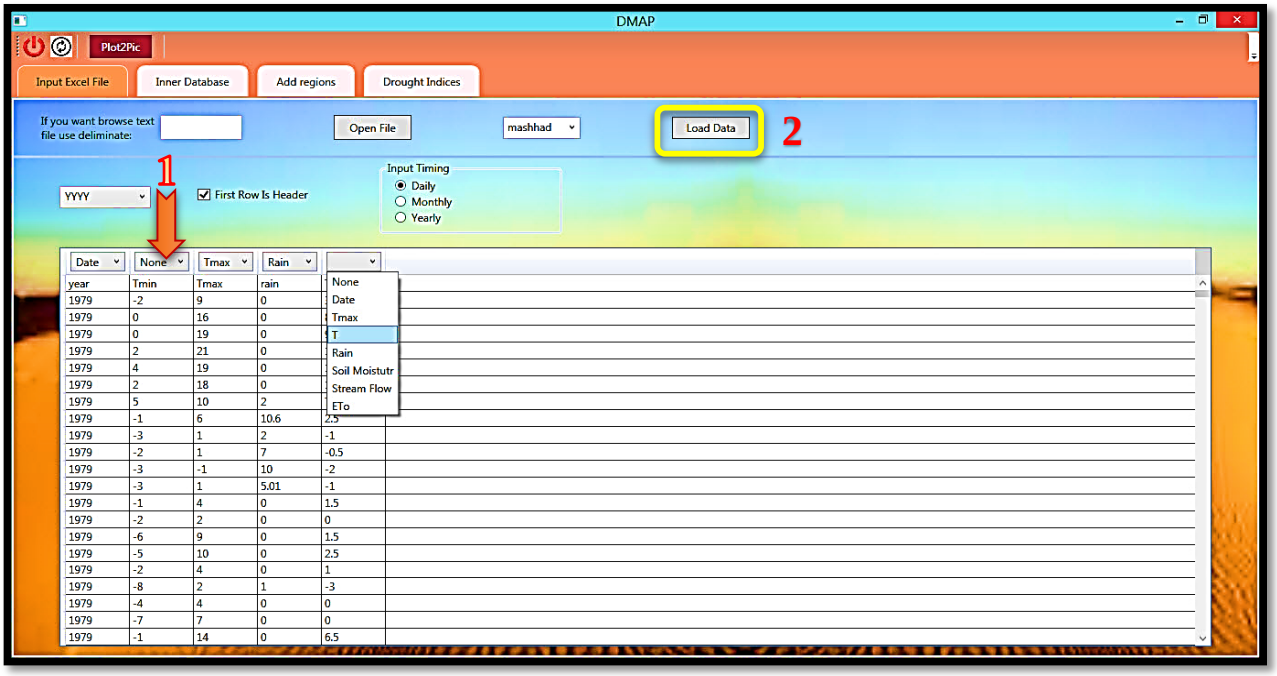

Figure 6. Assign all the variables, without any specific order.

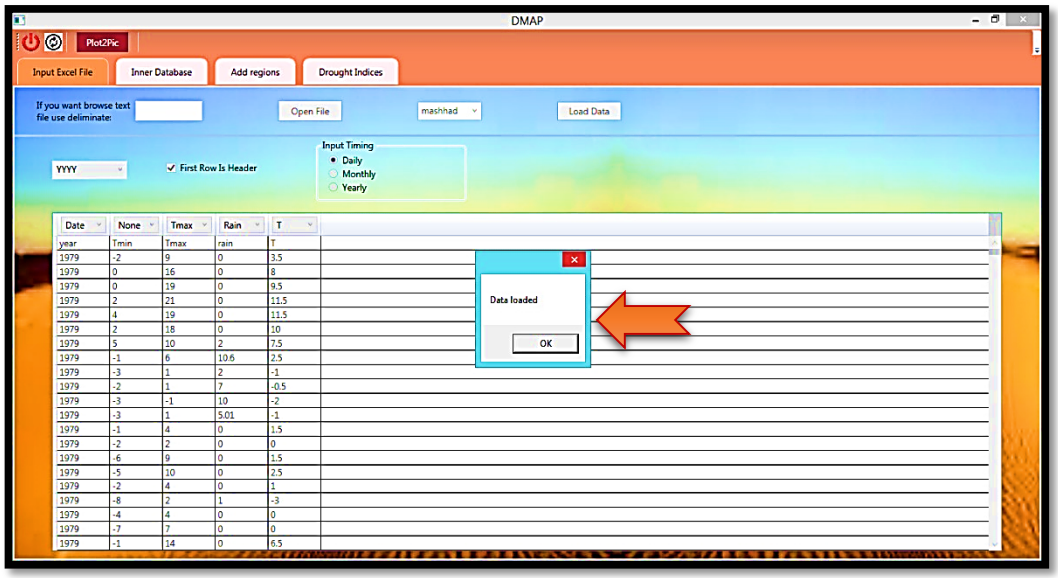

Figure 7. Click the “Data Loaded” button.

Step 2:

In this step please click on the "Drought Indices" tab in the Tab menu. The first panel in this screen is related to the "Calculator" setting. According to the Fig. 8, you can see a small panel that its name is "Timing". In this panel you can set the start (Fig. 8) and the end (Fig. 9) years.

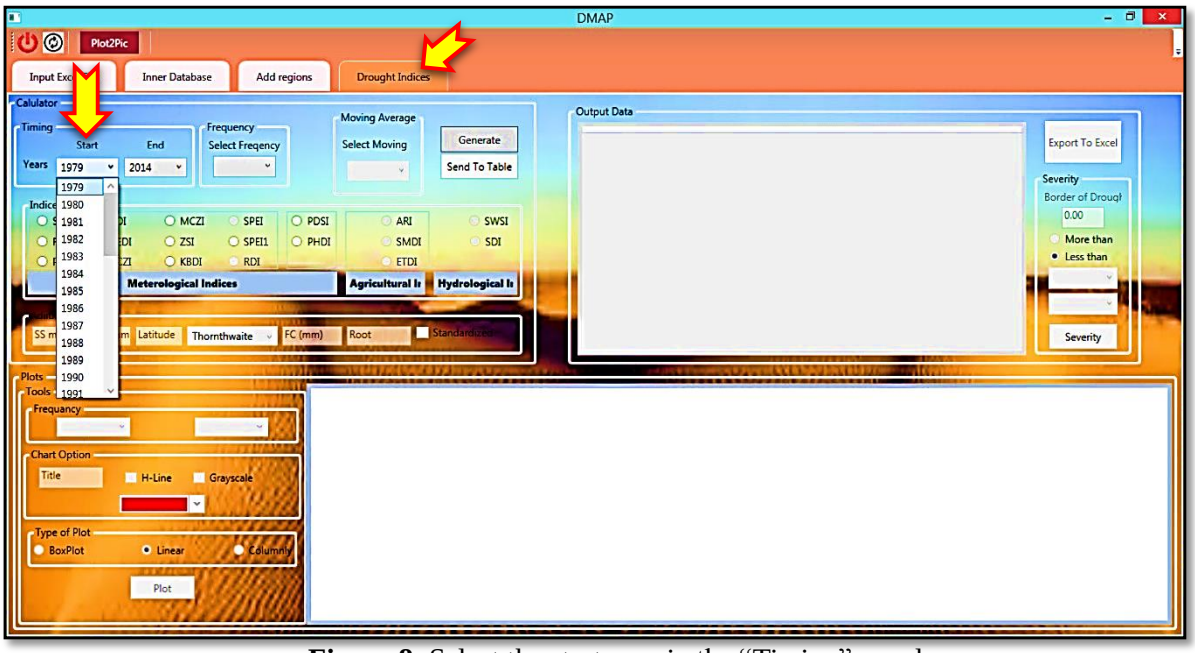

Figure 8. Select the start year in the "Timing" panel.

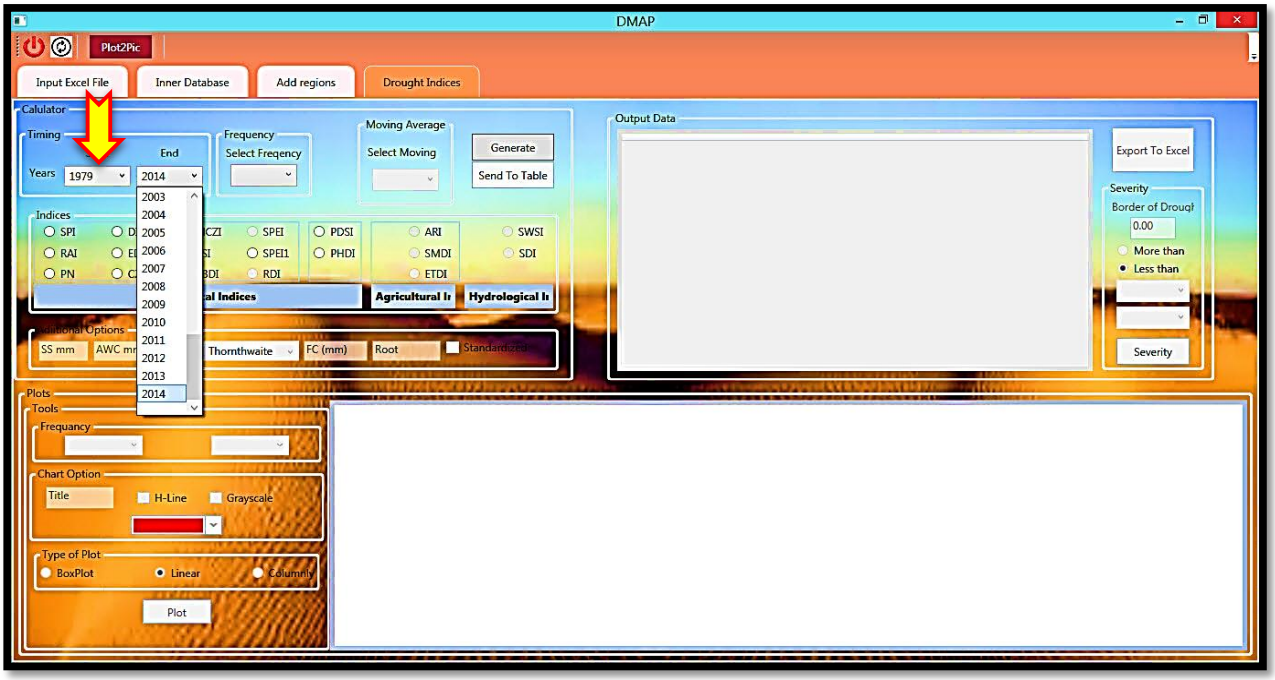

Figure 9. Select the end year in the "Timing" panel.

Then you can select your desirable index from the "Indices" panel, then the "Frequency" panel will highlighted for selecting. According to the selected index in "Indices" panel, the "Frequency" panel has different type. In this example, since the "SPI" index (Fig. 10 No. 1) was selected so the "Frequency" panel has three types, namely Yearly, Seasonally, and Monthly. As you see in Fig. 10, we selected "Yearly" type for calculation of SPI output (Fig. 10 No. 2).

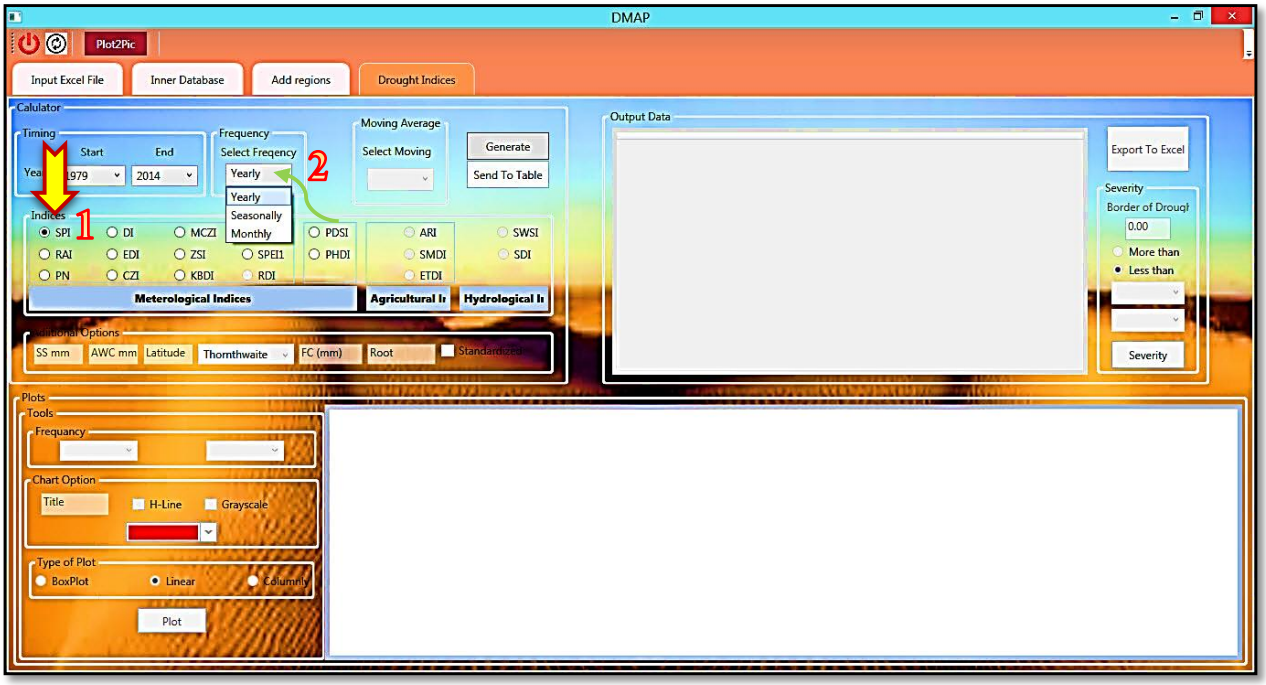

Figure 10. Select the end year in the "Timing" panel.

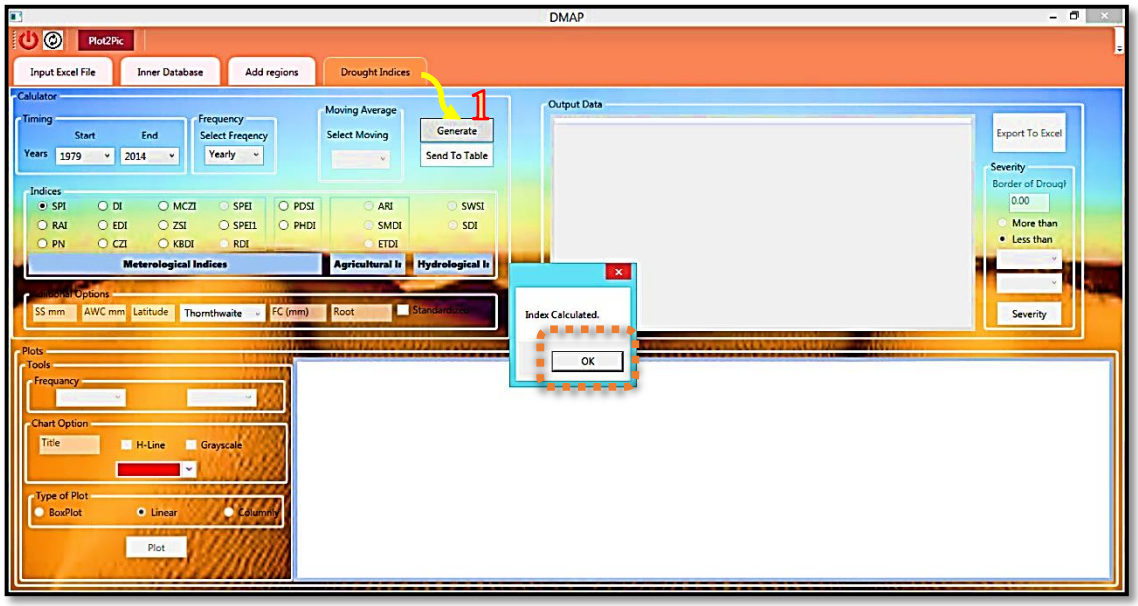

Figure 11. Generate value of the selected index.

By clicking “OK” button, the index’s value was calculated if the user wants to see the values, by clicking the “Send to table” button (Fig. 12 No. 1), the user can see the values of selected drought index in the “Output Data” table (Fig. 12 No. 2). If the user wants to export the outputs of the index, he/she can click on the “Export To Excel” button that it is located in the right corner of the screen (Fig. 12 No. 3). By clicking this button, a browse window will open to select a name for the excel output file in a wanted path (Fig. 13). When the file successfully saved, the user can see a small dialog box that will show a message with this content “The file was saved successfully” (Fig. 14).

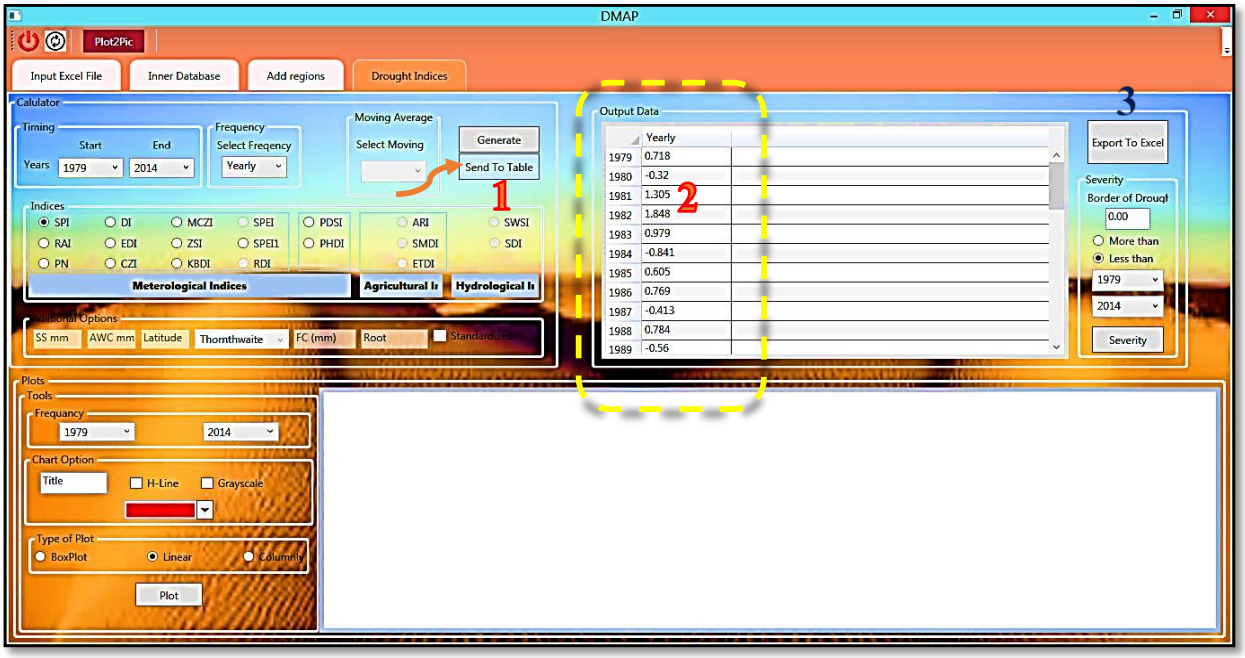

Figure 12. Send the output of selected index to the table.

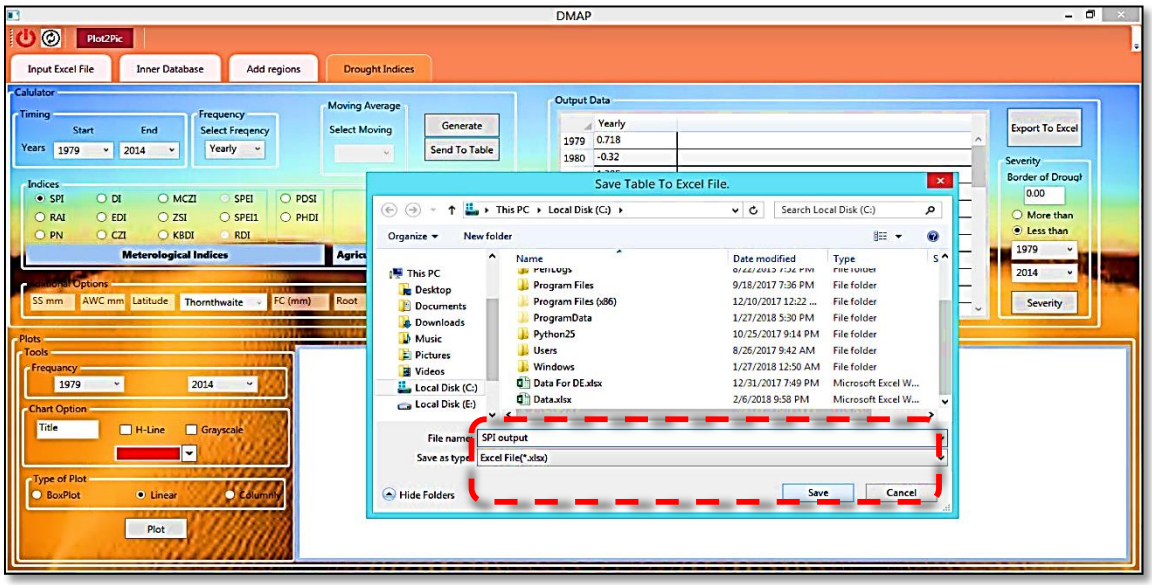

Figure 13. Select a name and path for the selected index’s outputs in an excel file.

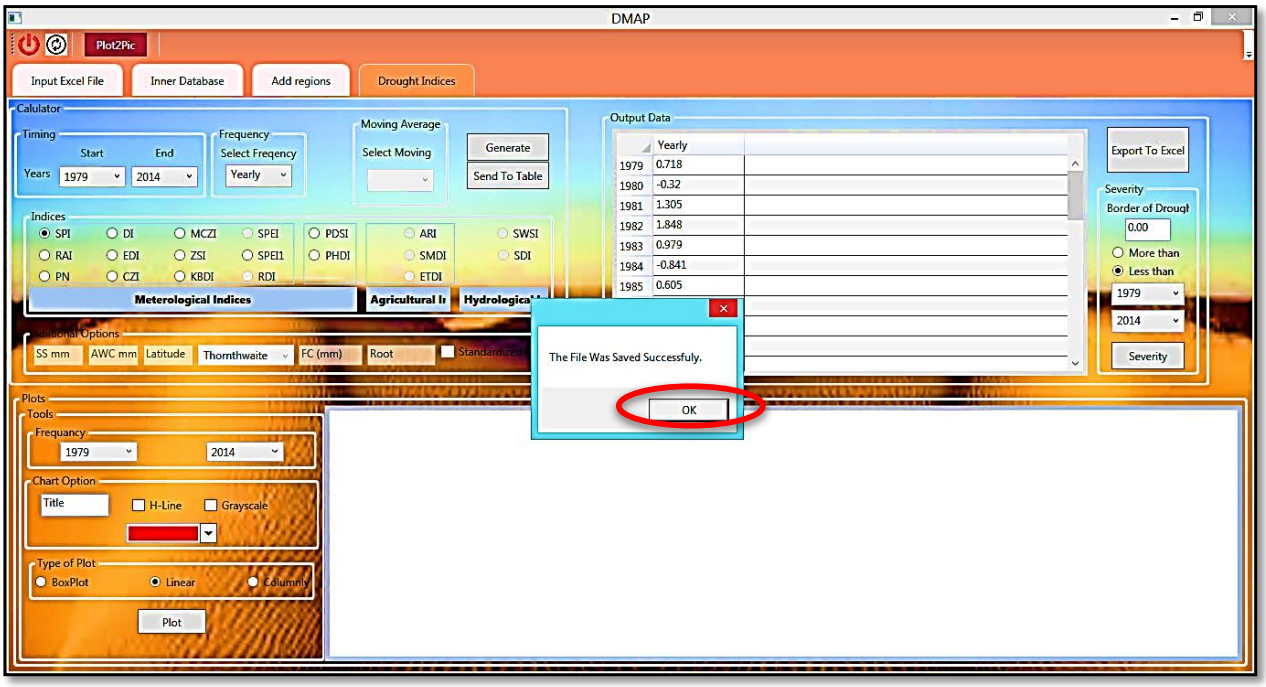

Figure 14. Select a name and path for the selected index's outputs in an excel file.

If you want to plot the values of calculated index, you can set some characteristics of the plot settings. You can do this settings in the "Plots" panel as shown in Fig. 15 No.1. In the "Tool" option, first the user can select desirable domain for start and end year. In "Chart Options", you can type a proper title (Fig. 15 No.2, in this sample we have typed "SPI Mashhad") for your graph and also if you want your graph has horizontal line in the background you can click the "H-Line" option (Fig. 15 No.3).

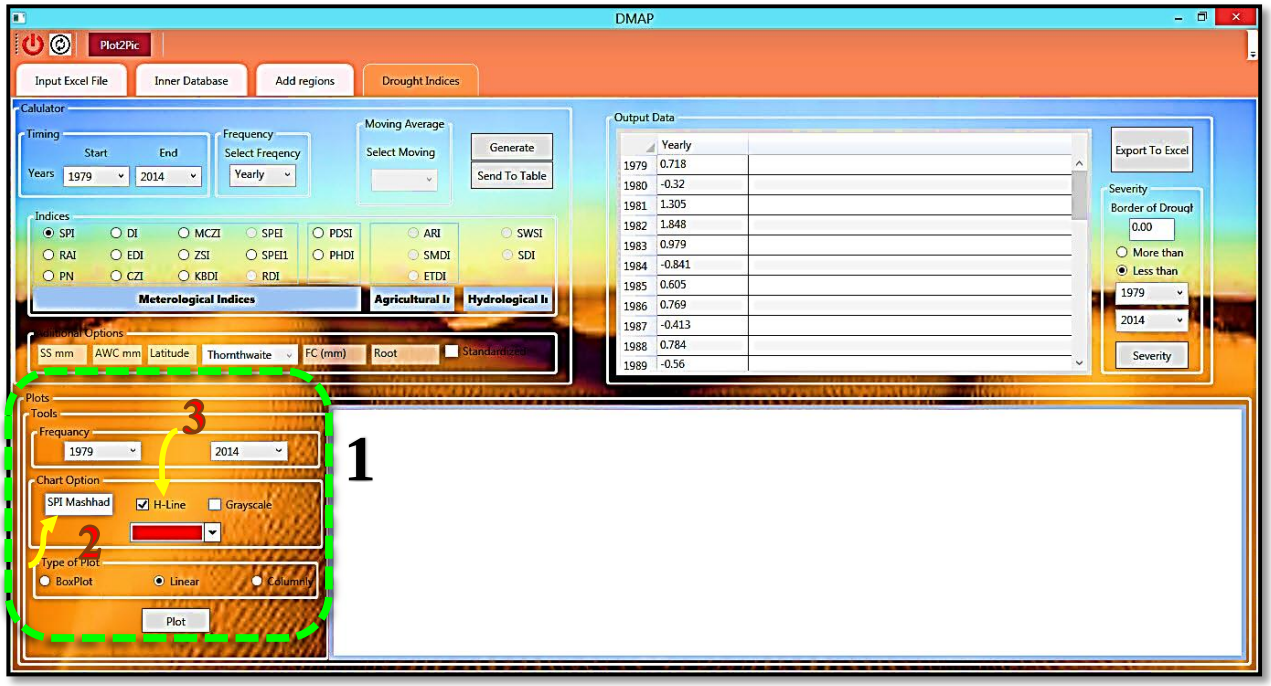

Figure 15. Assign some characteristics for Setting of the plot.

You have two options for selecting the color of the graph, namely “Grayscale” and “Color plot”. If you don’t select other colors you can just click “Grayscale” option, otherwise click on the combo box, then you can see lots of different colors and as well you can select one of them for the graph (Fig. 16). At last, you can choose your “type of plot” (Fig. 16 No. 1). There are three options, namely “BoxPlot”, “Linear”, and “Columnar” (Fig. 16 No. 1). Finally, after selecting the type of graph you can click on the “Plot” button, and observe the selected graph. The selected graph in this example is “Linear”, so in Fig.17 you can see it, according to this graph since the typed titled was “SPI Mashhad”, so in the presented graph you can see this title. If you want to change it you can easily do it by typing another one in the “Chart Option” panel.

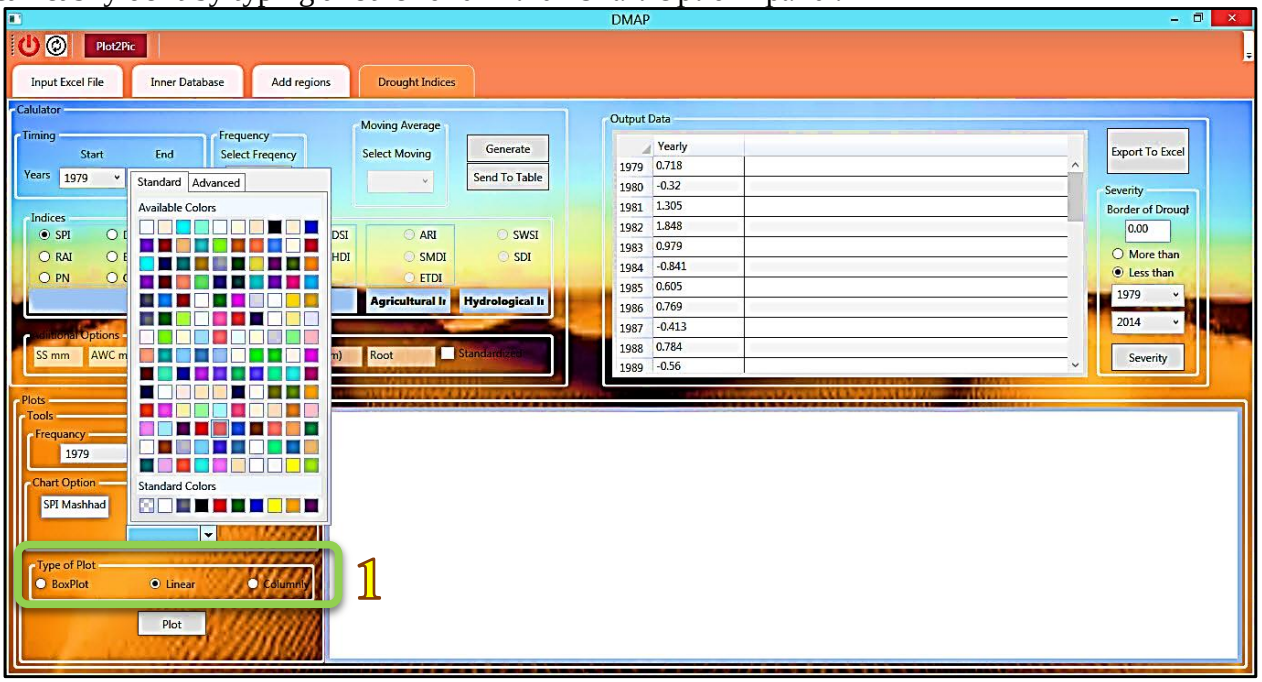

Figure 16. Select the proper color and title for the plot.

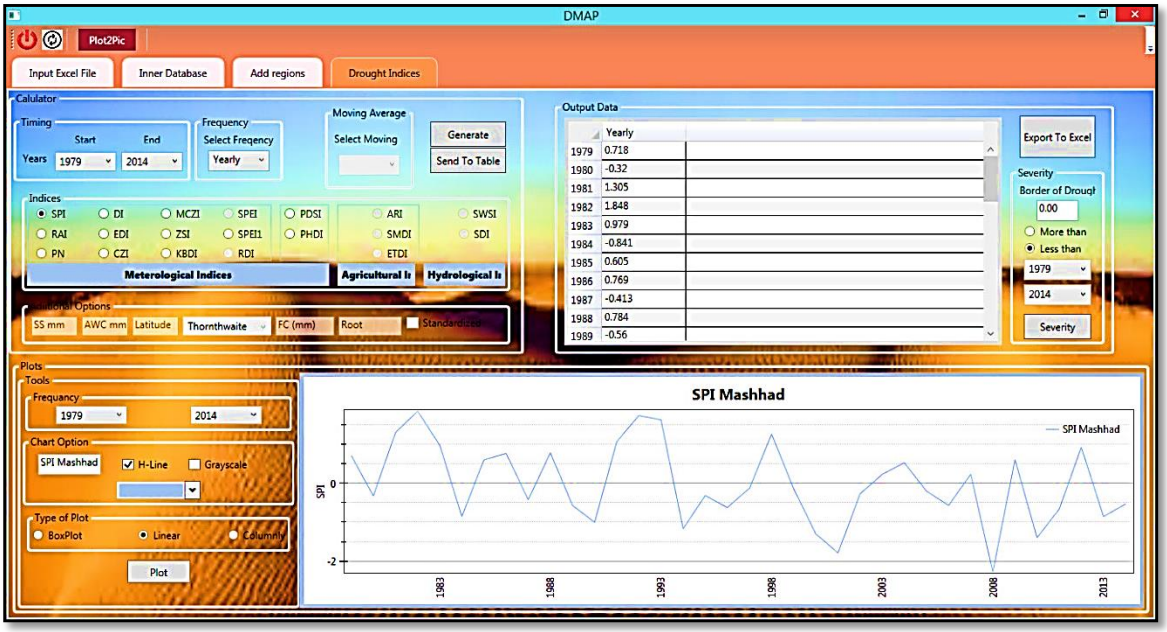

Figure 17. Plot the desirable graph for the output of index.

In Fig. 18 and Fig. 19, we plotted the yearly boxplot of SPI values, and the yearly columnar plot of SPI, respectively by clicking the "Boxplot" and "Columnar" options.

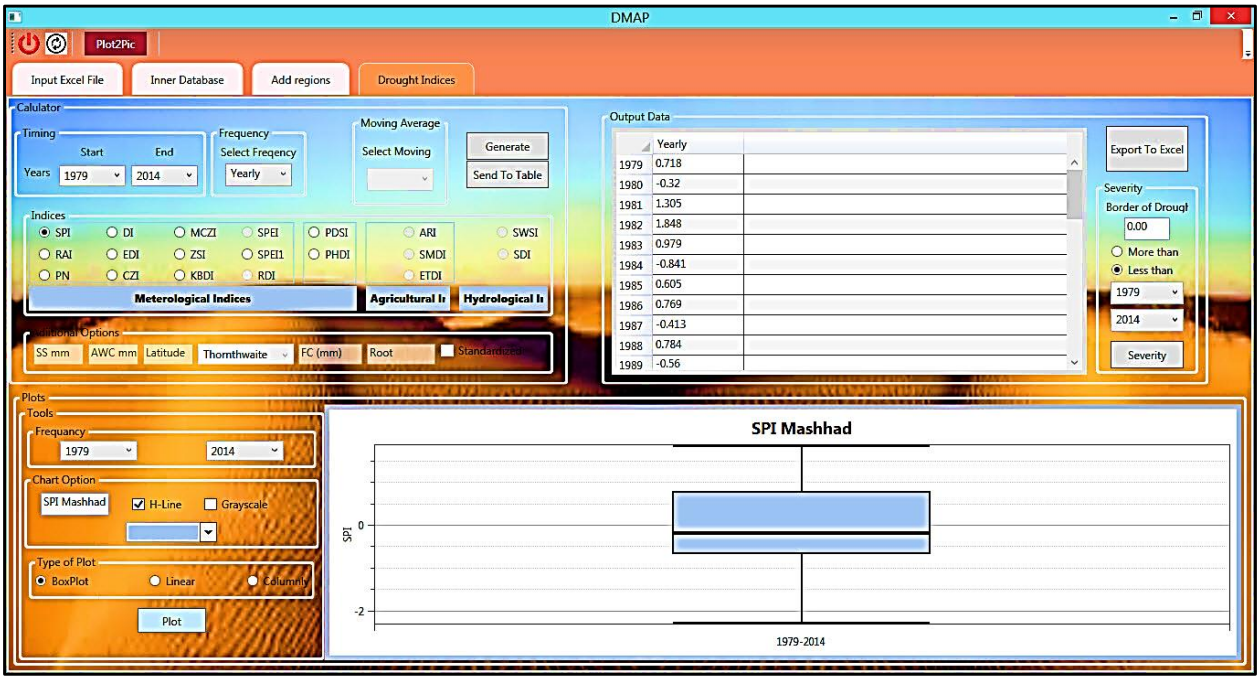

Figure 18. The yearly Boxplot for the output of SPI.

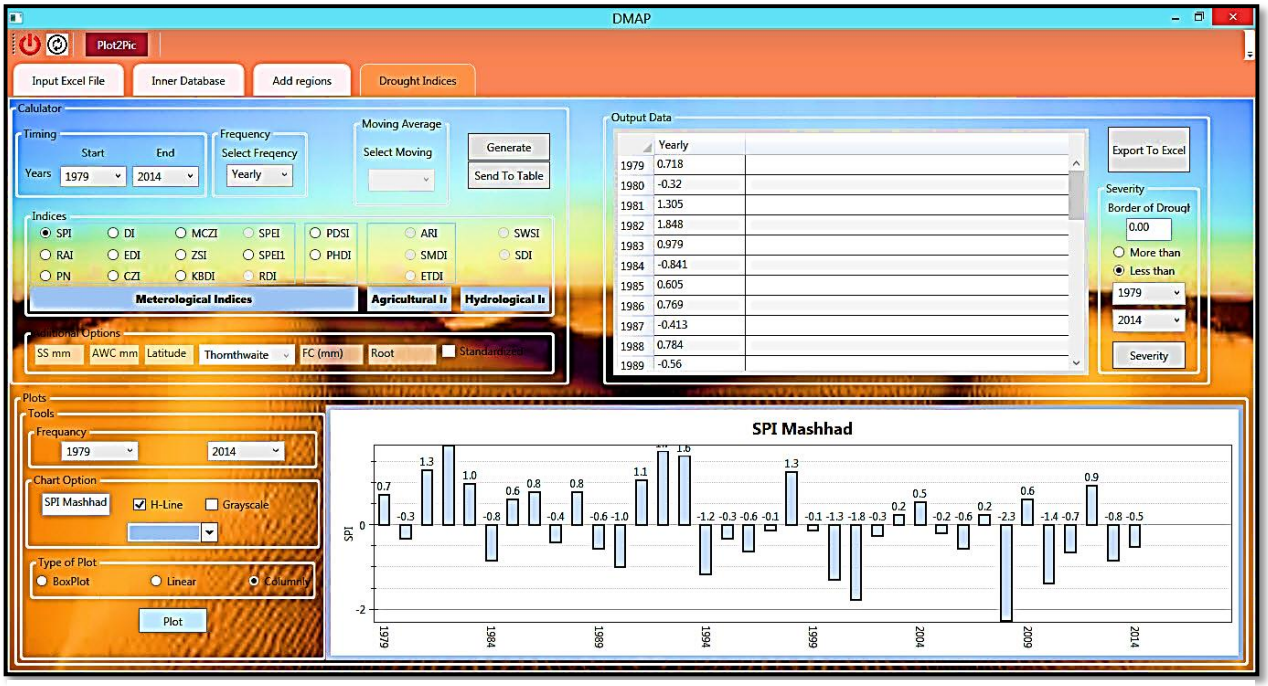

Figure 19. The columnar plot for the yearly output of SPI.

Step 3:'Calculate Severity and Duration'

One of the most important characteristic that Agrimetsoft was considered in the DMAP (Drought Monitoring and Prediction) software, is calculating severity and duration of drought event. In Fig. 20 and in the right side of screen, you can see a panel with the name of "Severity". In this panel for calculating the severity and duration of drought in a specific region, first of all you should determine the range of the desirable drought, for example in SPI the specific border of drought classification is less than -0.99. This border can easily find for every index according to the origin paper that was published for each index. You can select one of the two options, namely "More than" or "Less than". Fig. 21 presented the severity and durations of drought index. In this sample, we have calculated SPI, so the label of "Y" axe is "SPI". Also, as you can see in Fig. 21at the top the graph, there is a table that

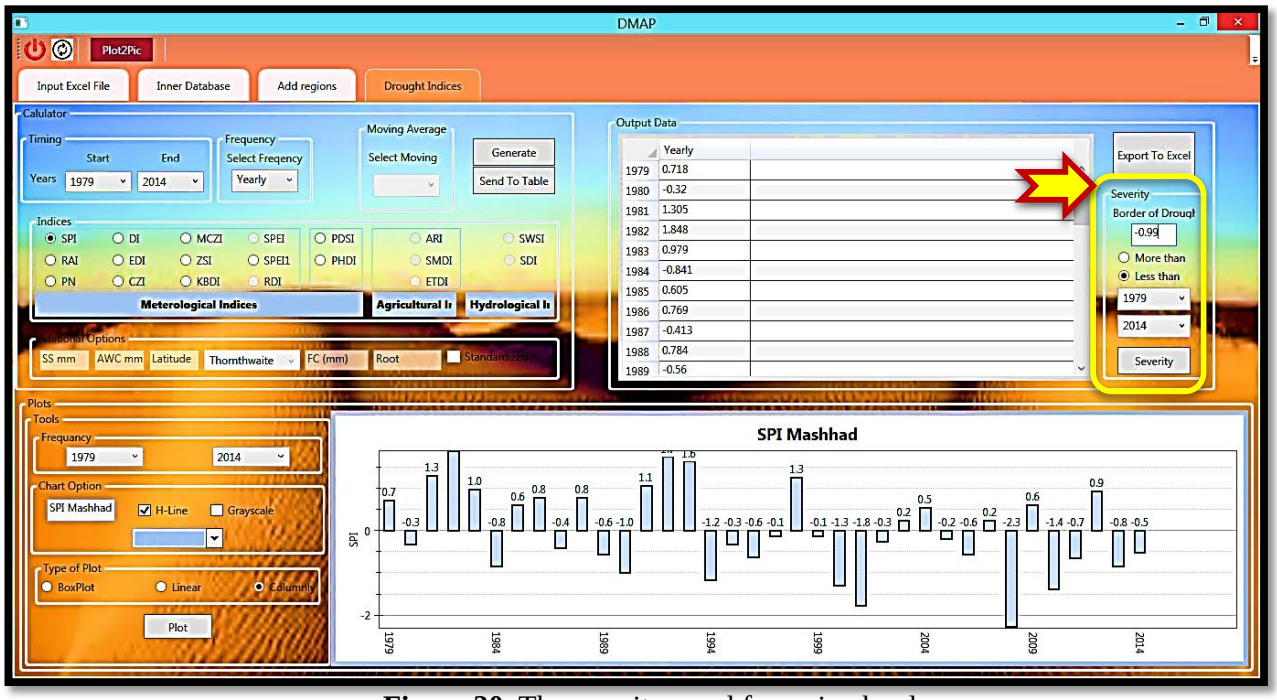

Figure 20. The severity panel for assign border.

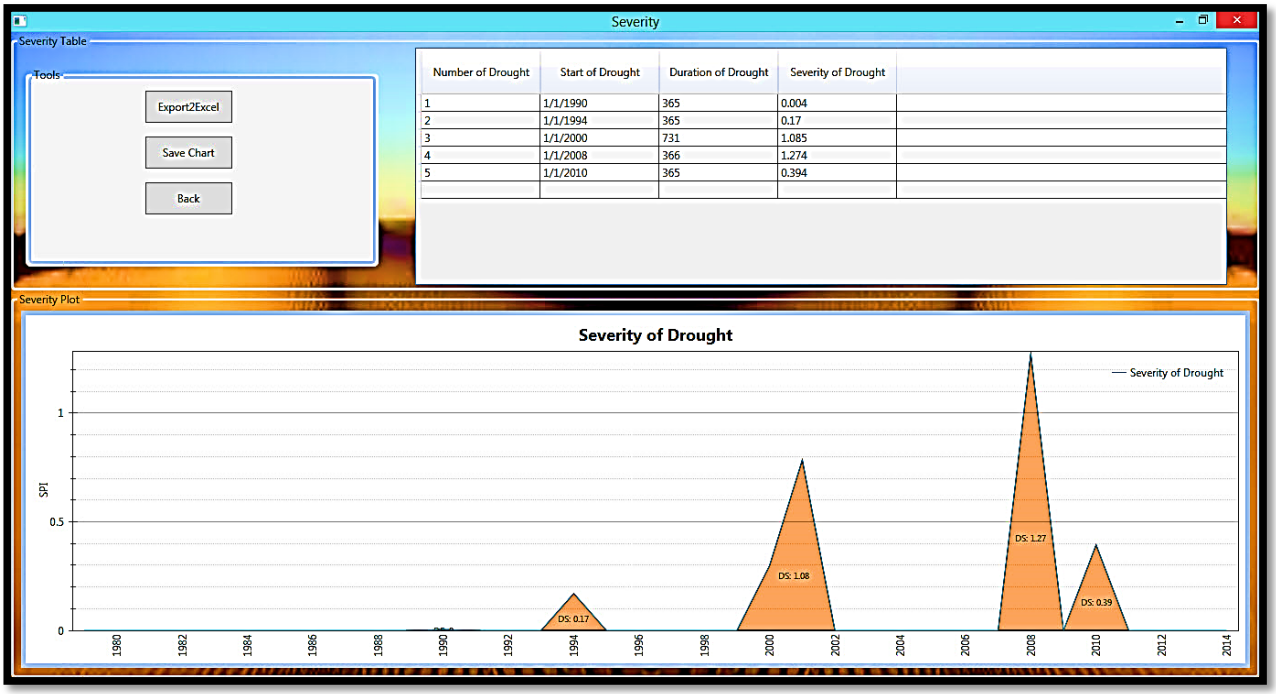

Figure 21. The values of severity and duration.

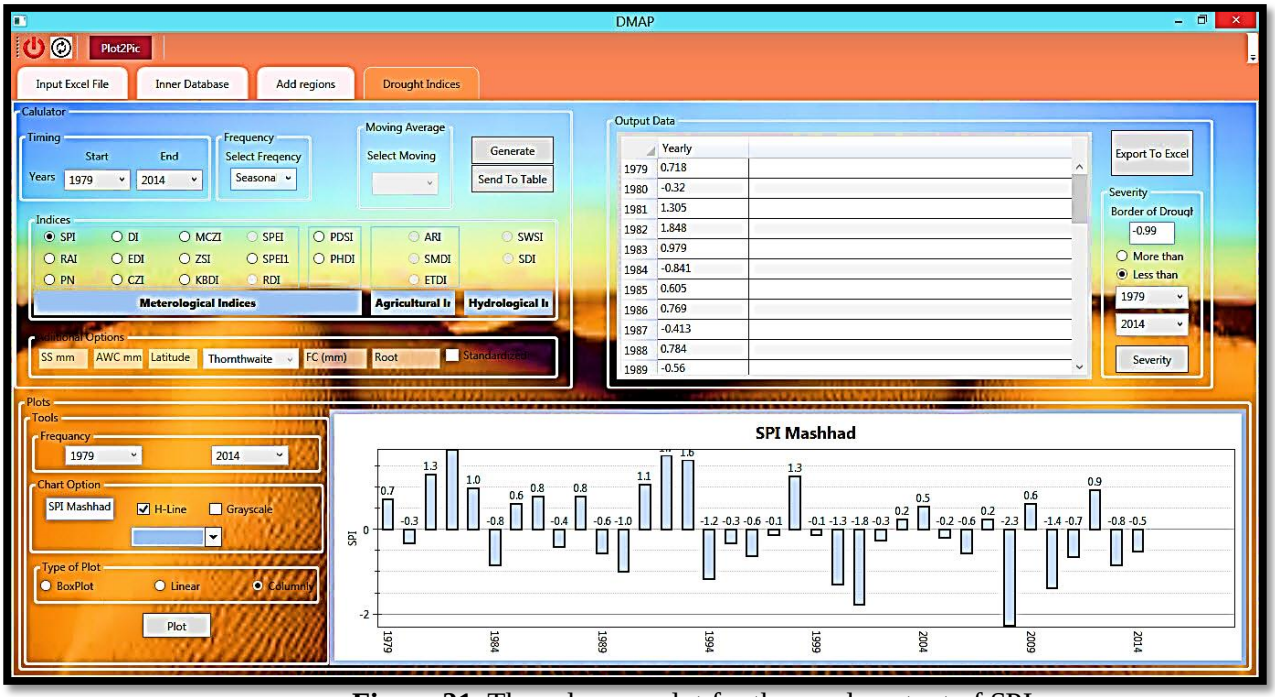

Figure 21. The columnar plot for the yearly output of SPI.


DMAP
Plot2Pic
Input Excel File
Inner Database
Add regions
Drought Indices
Calculator
Timing
Start
End
Years
1979
2014
Frequency
Select Freqency
Seasonal
Moving Average
Select Moving
Generate
Send To Table
Indices
SPI
DI
MCZI
SPEI
PDSI
ARI
SWSI
RAI
EDI
ZSI
SPEI1
PHDI
SMDI
SDI
PN
CZI
KBDI
RDI
ETDI
Meterological Indices
Agricultural Ir
Hydrological Ir
Additional Options
SS mm
AWC mm
Latitude
Thornthwaite
FC (mm)
Root
Standardized
Output Data
Yearly
1979 0.718
1980 -0.32
1981 1.305
1982 1.848
1983 0.979
1984 -0.841
1985 0.605
Export To Excel
Severity
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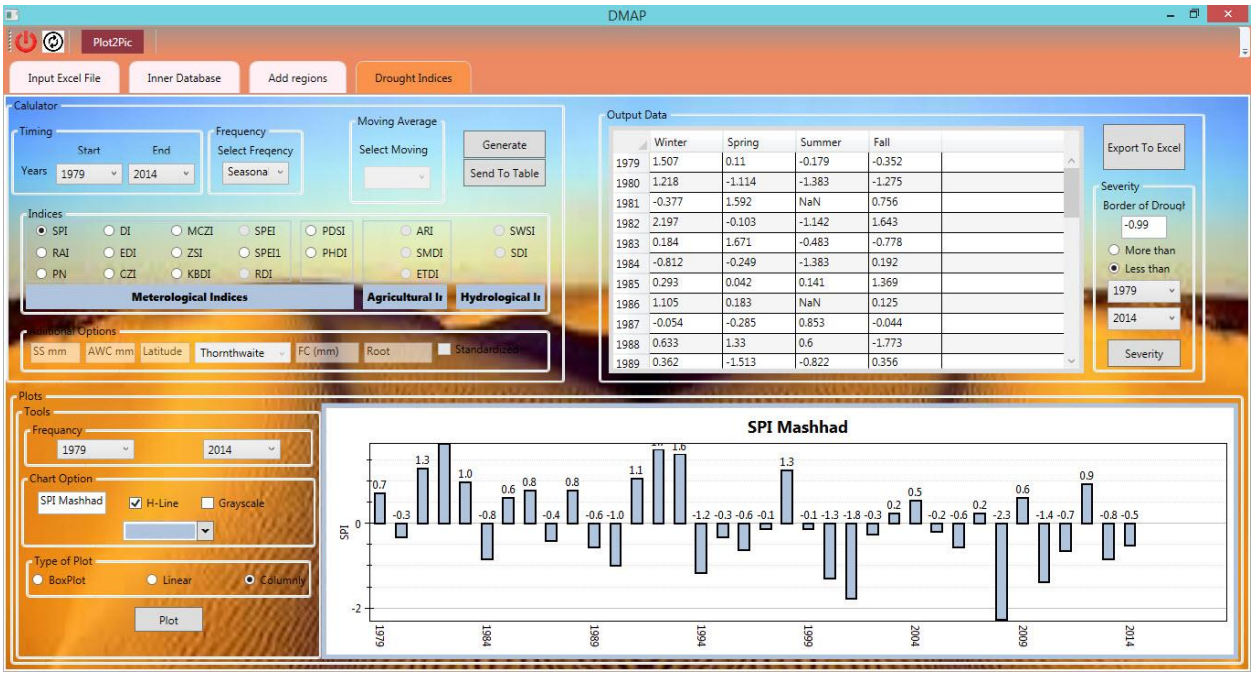
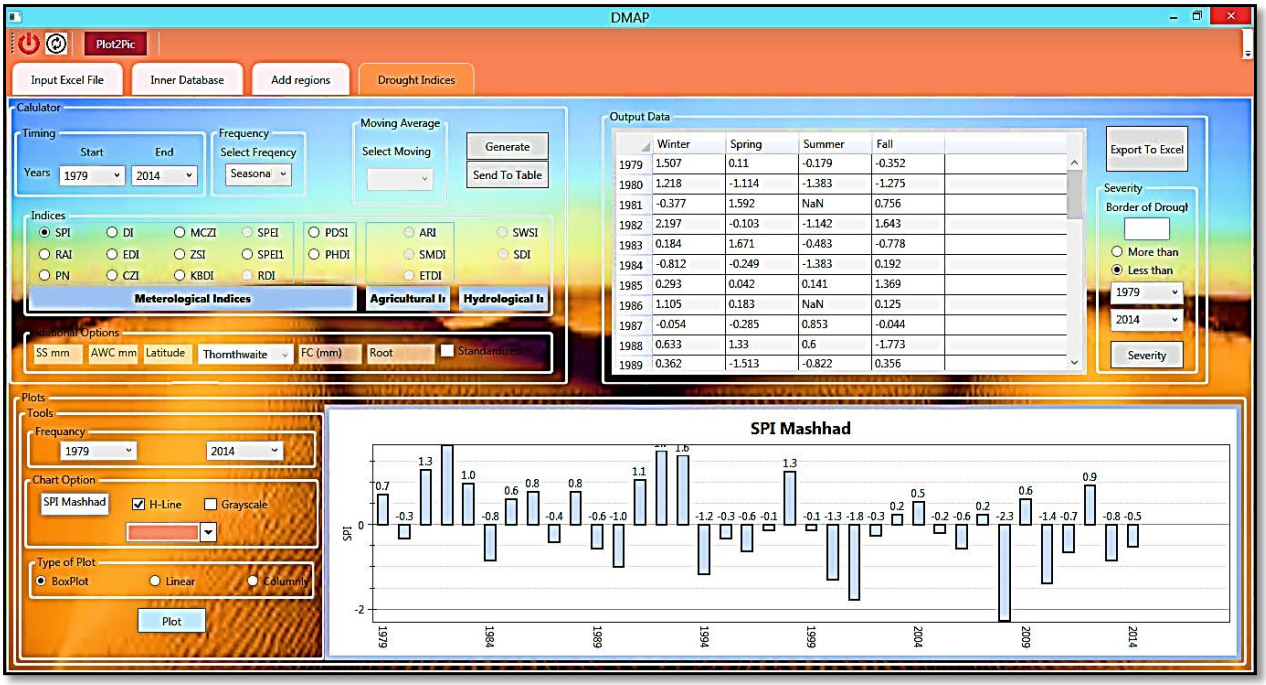
-0.99
More than
Less than
1979
2014
Severity
Index Calculated.
OK
Plots
Tools
Frequancy
1979
2014
Chart Option
SPI Mashhad
H-Line
Grayscale
Type of Plot
BoxPlot
Linear
Columnly
Plot
SPI Mashhad
SPI
1979
1984
1989
1994
1999
2004
2009
2014

Figure 21


DMAP
Plot2Pic
Input Excel File
Inner Database
Add regions
Drought Indices
Calculator
Timing
Start
End
Years
1979
2014
Frequency
Select Freqency
Seasonal
Moving Average
Select Moving
Generate
Send To Table
Indices
SPI
DI
MCZI
SPEI
PDSI
ARI
SWSI
RAI
EDI
ZSI
SPEI1
PHDI
SMDI
SDI
PN
CZI
KBDI
RDI
ETDI
Meterological Indices
Agricultural Ir
Hydrological Ir
Additional Options
SS mm
AWC mm
Latitude
Thornthwaite
FC (mm)
Root
Standardized
Output Data
Winter Spring Summer Fall
1979 1.507 0.11 -0.179 -0.352
1980 1.218 -1.114 -1.383 -1.275
1981 -0.377 1.592 NaN 0.756
1982 2.197 -0.103 -1.142 1.643
1983 0.184 1.671 -0.483 -0.778
1984 -0.812 -0.249 -1.383 0.192
1985 0.293 0.042 0.141 1.369
1986 1.105 0.183 NaN 0.125
1987 -0.054 -0.285 0.853 -0.044
1988 0.633 1.33 0.6 -1.773
1989 0.362 -1.513 -0.822 0.356
Export To Excel
Severity
Border of Drougl
-0.99
More than
Less than
1979
2014
Severity
Plots
Tools
Frequancy
1979
2014
Chart Option
SPI Mashhad
H-Line
Grayscale
Type of Plot
BoxPlot
Linear
Columnly
Plot
SPI Mashhad
SPI
1979
1984
1989
1994
1999
2004
2009
2014


DMAP
Plot2Pic
Input Excel File
Inner Database
Add regions
Drought Indices
Calculator
Timing
Start
End
Years
1979
2014
Frequency
Select Freqency
Seasonal
Moving Average
Select Moving
Generate
Send To Table
Indices
SPI
DI
MCZI
SPEI
PDSI
ARI
SWSI
RAI
EDI
ZSI
SPEI1
PHDI
SMDI
SDI
PN
CZI
KBDI
RDI
ETDI
Meterological Indices
Agricultural Is
Hydrological Is
Additional Options
SS mm
AWC mm
Latitude
Thornthwaite
FC (mm)
Root
Standardized
Output Data
Winter
Spring
Summer
Fall
1979 1.507 0.11 -0.179 -0.352
1980 1.218 -1.114 -1.383 -1.275
1981 -0.377 1.592 NaN 0.756
1982 2.197 -0.103 -1.142 1.643
1983 0.184 1.671 -0.483 -0.778
1984 -0.812 -0.249 -1.383 0.192
1985 0.293 0.042 0.141 1.369
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1987 -0.054 -0.285 0.853 -0.044
1988 0.633 1.33 0.6 -1.773
1989 0.362 -1.513 -0.822 0.356
Export To Excel
Severity
Border of Drougl
More than
Less than
1979
2014
Severity
Plots
Tools
Frequancy
1979
2014
Chart Option
SPI Mashhad
H-Line
Grayscale
Type of Plot
BoxPlot
Linear
Columnly
Plot
SPI Mashhad
SPI
1979
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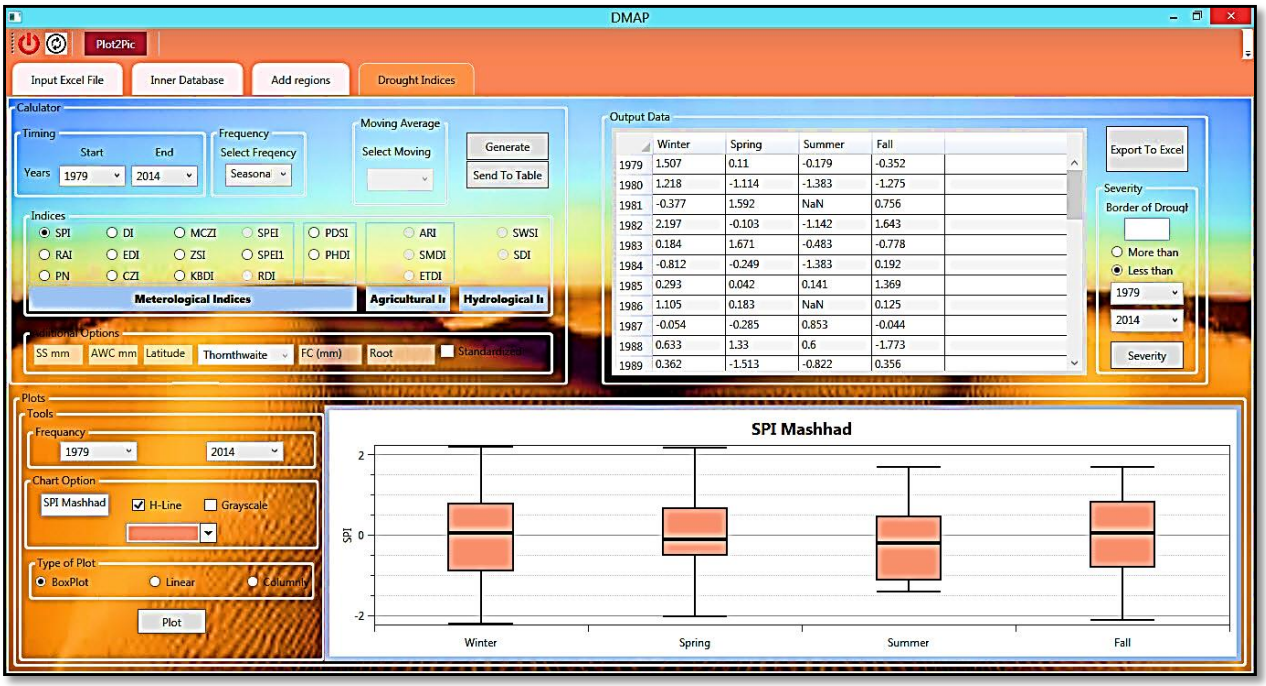
2004
2009
2014


DMAP
Plot2Pic
Input Excel File
Inner Database
Add regions
Drought Indices
Calculator
Timing
Start
End
Years
1979
2014
Frequency
Select Freqency
Seasonal
Moving Average
Select Moving
Generate
Send To Table
Indices
SPI
DI
MCZI
SPEI
PDSI
ARI
SWSI
RAI
EDI
ZSI
SPEI1
PHDI
SMDI
SDI
PN
CZI
KBDI
RDI
ETDI
Meterological Indices
Agricultural Is
Hydrological Is
Additional Options
SS mm
AWC mm
Latitude
Thornthwaite
FC (mm)
Root
Standardized
Output Data
Winter
Spring
Summer
Fall
1979 1.507 0.11 -0.179 -0.352
1980 1.218 -1.114 -1.383 -1.275
1981 -0.377 1.592 NaN 0.756
1982 2.197 -0.103 -1.142 1.643
1983 0.184 1.671 -0.483 -0.778
1984 -0.812 -0.249 -1.383 0.192
1985 0.293 0.042 0.141 1.369
1986 1.105 0.183 NaN 0.125
1987 -0.054 -0.285 0.853 -0.044
1988 0.633 1.33 0.6 -1.773
1989 0.362 -1.513 -0.822 0.356
Export To Excel
Severity
Border of Drougl
More than
Less than
1979
2014
Severity
Plots
Tools
Frequancy
1979
2014
Chart Option
SPI Mashhad
H-Line
Grayscale
Type of Plot
BoxPlot
Linear
Columnly
Plot
SPI Mashhad
SPI
Winter
Spring
Summer
Fall

✓ *How Can We Use NetCDF API?*

In this version of DMAP, when user open nc or nc4 files, will show the NetCDF API. The user can open one file to extract desirable region. Many users need to run several files simultaneously. Therefore, Agrimetsoft has developed the API that it can merge and extract many files at the same time.

By following these steps, all users can easily extract their data from NetCDF files. And send the data to DMAP.

Stage 1: Open nc files and show up the API

The best advantage of NetCDF API is open many files and extract them, simultaneously for saving time of users. If the user needs to load several files and extracts them as well, he/she can browse and select every file that he/she wants. This can do with 3 steps that has been shown in (Fig. 22). As you see in the Fig. 22, the user can select many files from the files. In this example four files of MIROC5 was selected. This API can merge "Unlimited Dimension" of all files that usually it is time dimension.

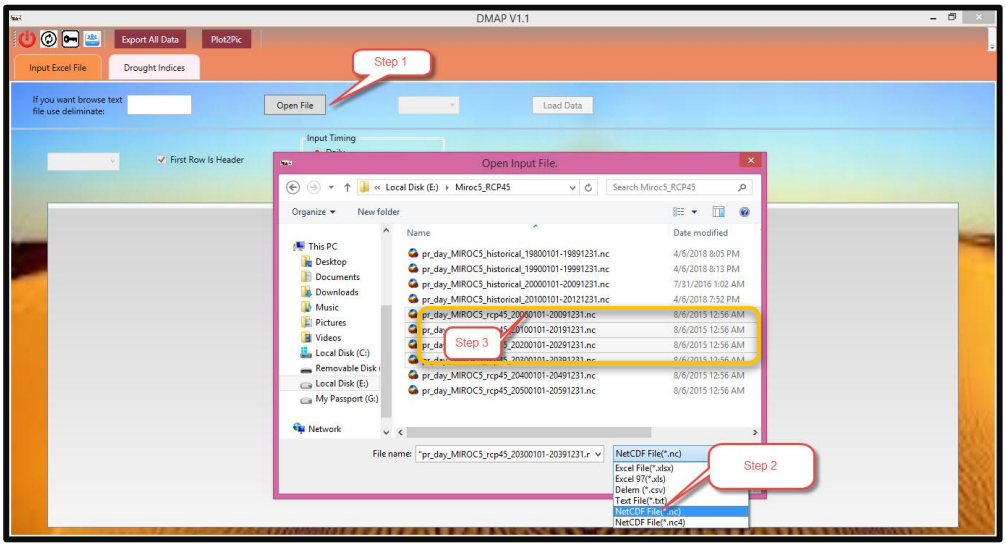


Fig. 22 load NetCDF API

Stage 1: Using the API

In (Fig. 23, No.1), you can see all files that you selected and you can expand to get information about dimension of files. In (Fig. 23, No.2), you can see the unlimited dimension in all files and the result of merged. This is the limitation of numbers that you can enter for grid numbers in unlimited dimension. In (Fig. 23, No.3), you should enter the name of variable that you want to extract then click on "Load".

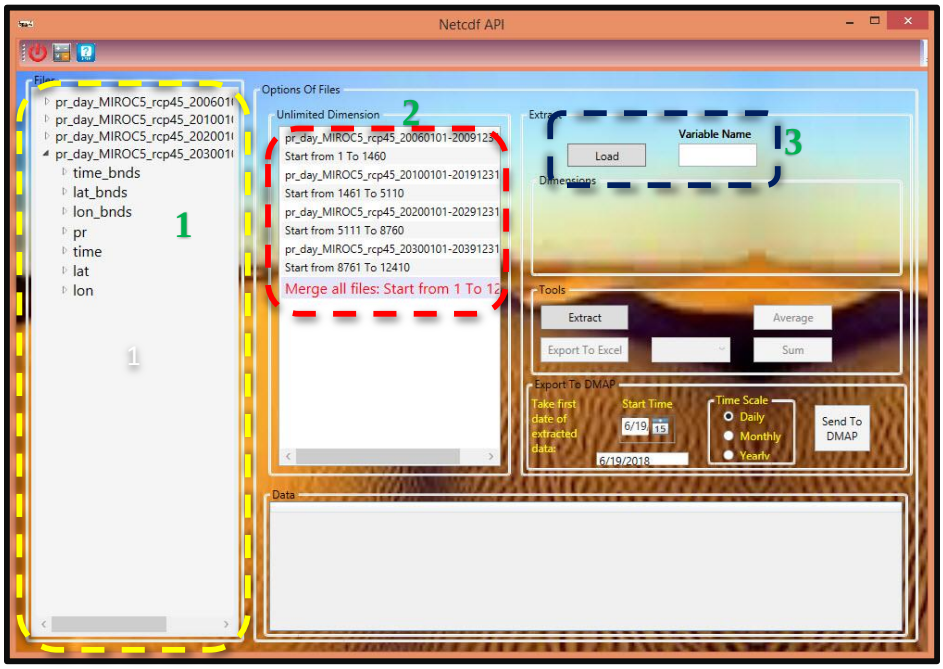


Fig. 23 See the API

In the "NetCDF API", you can see an important tip for merge NetCDF files, namely: "Merge all files": Start from 1 To 12410" (Fig. 24, No.1). Due to the selected files in this example are related to the "Precipitation" of MIROC5 from 2006 up to 2039 (12410 days) so, all these files merge in this panel. In (Fig. 24, No.2), you should enter the grid numbers. In unlimited dimension (usually time dimension), you should enter the start grid number that you want and number of grid that you want. If you want select all data you should enter 1 and 12410(from and numbers). If you want extract first year, you should enter 1 and 365. If you want extract second year, you should enter 366 and 365. For calculation of other grid numbers (Latitude and Longitude), you can use Grid Number Calculator or watch

the videos in our channel in YouTube or you can contact to kolsoomi57@gmail.com for creating an excel file for you to simplifying. Then click on “Extract”.

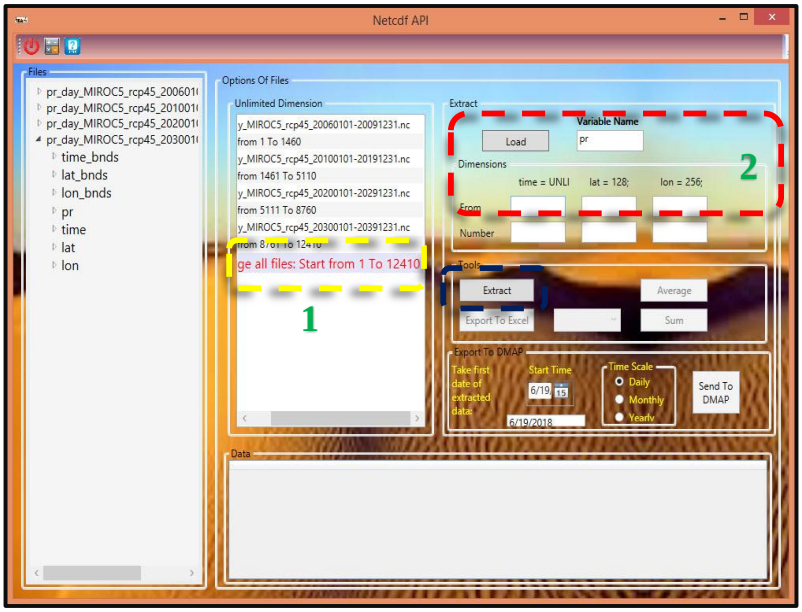


Fig. 13 The “Merge all files” sentence in the “Option of Files”.

In the Fig. 25, No.1 you can see two options: “Sum” and “Average”. It is an important option for the user to calculate the sum or average of a variable for the selected region. In this sample, the “Average” button was selected and the average of values was presented in the Fig. 25, No.2.

Finally, In (Fig. 25, No.3), you should enter the first date depend on your first time grid and select time scale and click on “Send to DMAP”. By clicking the “Send to DMAP” button will show the “Unit Conversion” and the data will export to DMAP. Now you can use the data and start from Fig 4

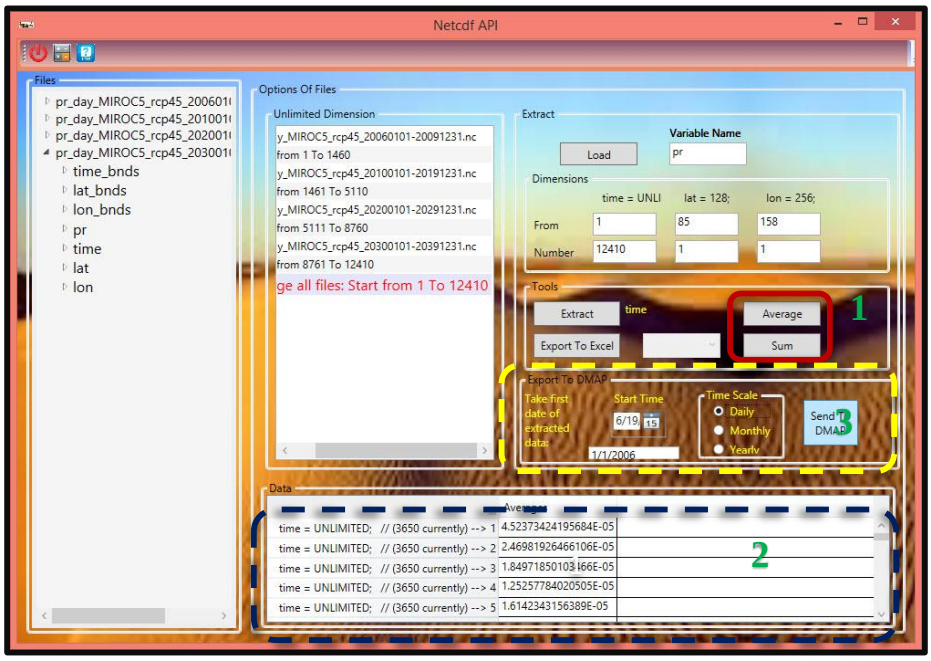
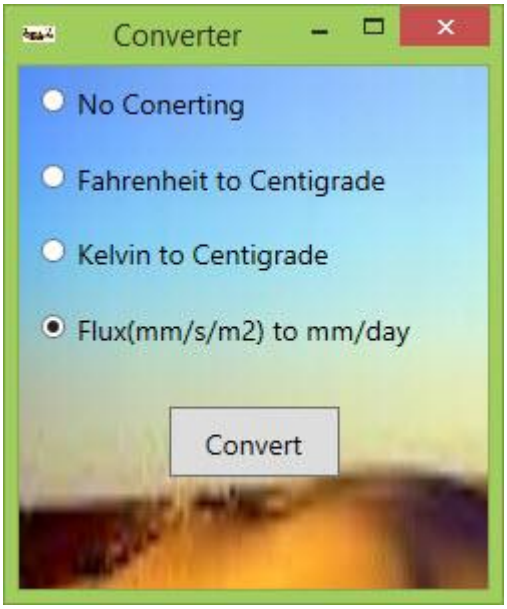


Fig. 25 The "Data" panel with Average of data



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