Food and Agriculture Organization of the United Nations

AquaCrop
stand-alone (plug-in) program
Version 7.1

Reference manual

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AquaCrop stand-alone (plug-in) program Version 7.1

1. The AquaCrop stand-alone (plug-in) program

Although the stand-alone (plug-in) version of AquaCrop 7.1 is programmed in Fortran (the underlying open source code is publicly available), the calculation procedures in the stand-alone version are identical to the procedures in the AquaCrop standard window program with user interface and database (Version 7.1), which is still programmed in Pascal. Except for minor differences due to language-dependent rounding behaviour, the two implementations provide identical results given the same input.

As in earlier versions, the standalone has no user interface and no database, which make it easy to plug into other programs. Various executables built for specific operating systems are available:

- An executable built for Windows operating systems
- An executable built for Linux operating systems
- An executable built for Mac operating systems

By running the stand-alone (plug-in) program, a given list of pre-defined projects is carried out and results are stored in output files. The standalone program might be useful in applications where iterative or parallel runs are required.

More specifically, the stand-alone program “aquacrop.exe” can be simply executed by double clicking (Windows), or running ‘aquacrop’ on a command line in a terminal (Windows, Linux, Mac). Alternatively, the executable can be called with a system call from within a script, e.g. a Python script: “os.system('aquacrop')”, Matlab script: “system(aquacrop)”, or simply a bash script: “aquacrop”. Such scripts can be designed to produce, for example, simulations over different fields spatially in parallel.

The stand-alone program is tested on various systems with different (more recent) versions of Windows, Linux and Mac. The program output generated on the user-specific system can optionally be verified against reference output provided in an accompanying zip-file with a testcase.

2. Input

In the absence of a user interface only pre-defined simulation runs can be carried out in the AquaCrop stand-alone program. Therefore, the input need to consist of Project and Program Parameters files, which contain all the required information for a simulation run (Table1). Project and Program Parameters files are text files which can be composed[1] by the standard window AquaCrop program (i.e. the AquaCrop model with the user interface and database) when creating a project. Project (Tab. I.1) and Program Parameters (Table I.2) files can also be created by the user as long as the structure of the text file is respected as specified in Annex I.

Table 1. – The content of a Project file and the corresponding Program Parameter file

A Project file is a text file which contains all the required information for a simulation run. Distinction is made between projects containing the required information for a single simulation run (with 'PRO' as the filename extension) and projects consisting of a set of successive runs (for simulations in successive years), the so-called multiple run projects (with 'PRM' as the filename extension). A project file contains (Table I.1 in Annex 1):

- information about the project,
- the year number of cultivation,
- the start and end dates of the simulation and cropping period, and
- the file names (with their directory) containing the characteristics of the selected environment and crop (climate, calendar, crop, irrigation and field management, soil profile and ground water, initial and off-season conditions), and field data for evaluation of the simulation results.

A Program Parameter file is a text file which contains the settings for the program parameters (Table I.4 in Annex I). In ***absence of the program parameter file***, the project can still run perfectly, since the default settings of the program parameters will then be used (Tab. III.1 in Annex III). The program parameter file has the same file name as the project, but with the file extension 'PP1' (single projects) or 'PPn' (multiple projects).

To run projects in the stand-alone program, pre-defined **project files** need to be copied to the ***LIST subdirectory of the stand-alone version***. Project files are text files with the file extension 'PRO' (single projects) or 'PRM' (multiple projects):

- If the project files were created in a standard window AquaCrop program, copy the project files from the DATA subdirectory (of the AquaCrop window program where they were created) to the LIST subdirectory of the stand-alone version (Fig. 1);
- If the project files were created by the user, paste the project files in the LIST subdirectory of the stand-alone version.

In AquaCrop version 7.1, the settings for the program parameters are stored in another text file which has the same file name as the project, but with the file extension 'PP1' (single projects) or 'PPn' (multiple projects). The pre-defined **program parameters files** need to be copied to the

[1] Section 2.19 'Project characteristics' of Chapter 2 'Users guide' of the reference manual of AquaCrop, describes how projects are created and updated.

PARAM subdirectory of the stand-alone version. In absence of a program parameter file, the project will run with the default settings for the program parameters (Table III.1 in Annex III).

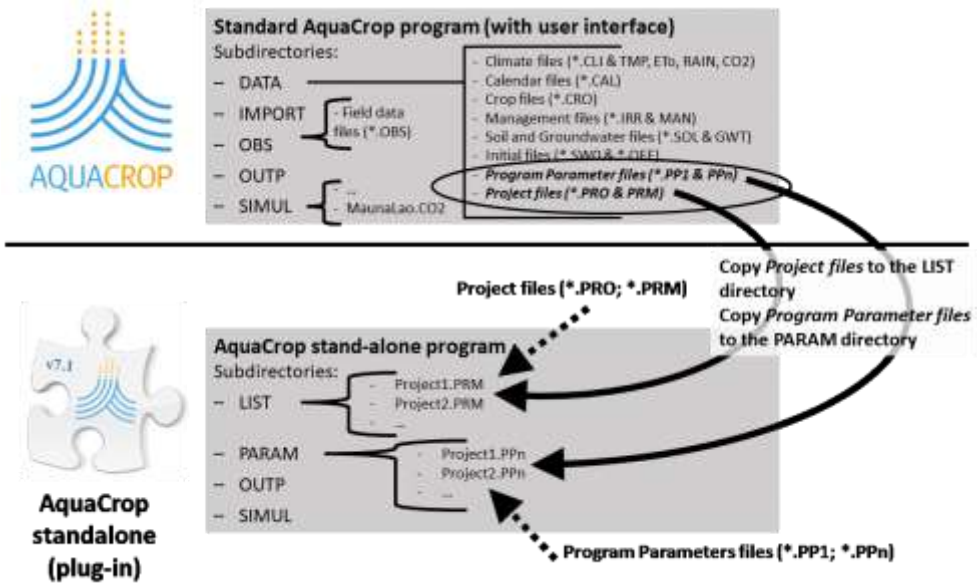

Figure 1. – Copying pre-defined Project files to the LIST directory and Program Parameters files to the PARAM directory as input for the AquaCrop stand-alone (plug-in) program

The project contains (i) all information to run the simulations and (ii) the paths where all required input data is stored on the computer (Table I.1 in Annex 1). Consequently, the data files containing the characteristics of the selected environment (climate, calendar, crop, soil profile, groundwater table, field and irrigation management), the corresponding initial and off-season conditions, and observed field data need **not** to be copied to the LIST directory. The only restriction is that these data files are stored on the same computer where the plug-in program is running. Information (path) in the project will guide the stand-alone program to the directories where the data files can be retrieved.

✓	Projects may contain data files created in previous versions of AquaCrop. These are files containing the characteristics of the selected environment (climate, calendar, crop, soil profile, groundwater table, field and irrigation management), files with the corresponding initial and off-season conditions, and files with field data.
✓	Project files (files with extension 'PRO' or 'PRM') and program parameters files (files with extension 'PP1' or 'PPn') of the AquaCrop version 7.0 can be loaded.
✗	However, due to an essential change of the structure of project files, the project files (files with extension 'PRO' or 'PRM') of AquaCrop versions 6 and lower cannot be loaded by Version 7.1 of the AquaCrop stand-alone (plug-in) program.

3. Running simulation(s)

When the AquaCrop stand-alone (plug-in) program is launched, the software runs, one by one, the projects listed in its LIST directory (Fig. 2). Information (the path) in the project files (Table I.1 in Annex 1) guides the standalone program to the directories where the required data files are stored. These data files contain the characteristics of the environment (climate, calendar, crop, soil profile, groundwater table, field and irrigation management), information regarding the initial and off-season conditions, and field data for the evaluation of simulation results. If the project files were created in the standard window AquaCrop program, the required data files are available in the DATA, OBS and SIMUL subdirectories of the AquaCrop window program (Fig. 2).

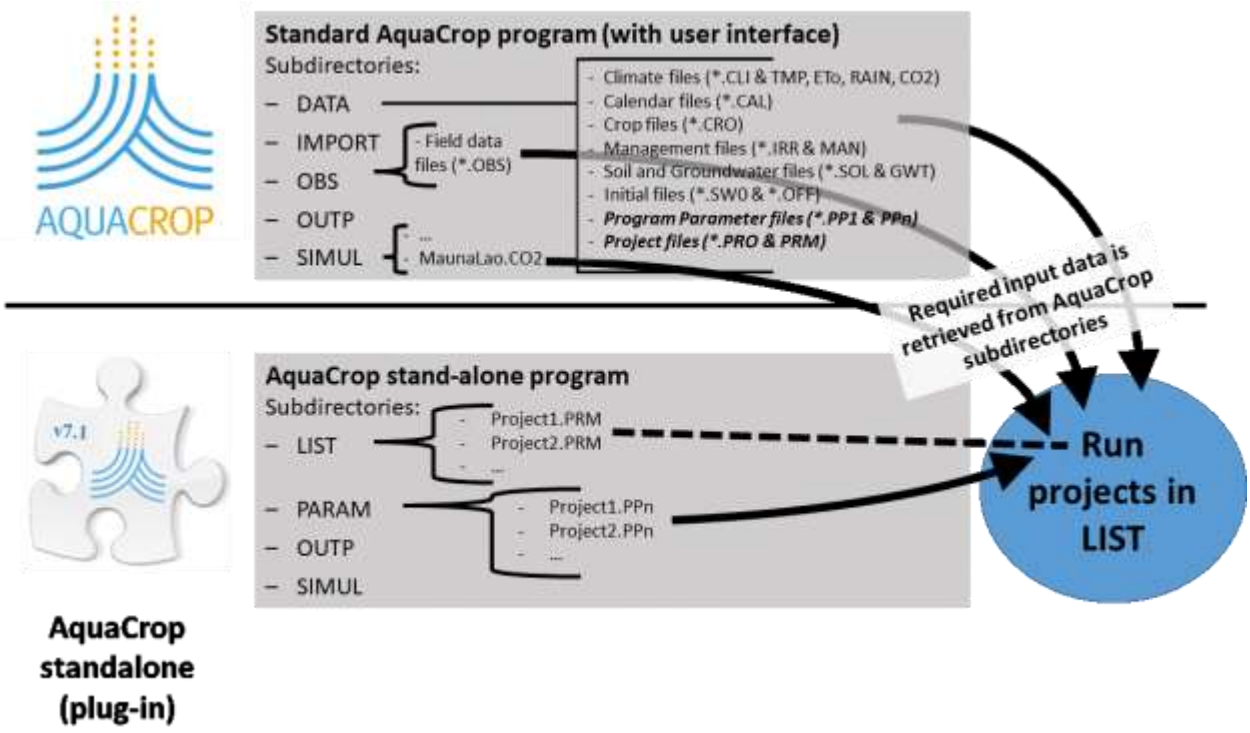

Figure 2. – Running projects by retrieving the required input from subdirectories where the data is stored.

When running the projects available in the LIST subdirectory of the AquaCrop stand-alone program:

☐ the software obtains from the project file (or for each run of a multiple project):
- the year number of cultivation;
- the starting and end date of the simulation period and growing cycle;
- the path of the filenames containing the characteristics of the selected environment (climate, calendar, crop, irrigation management, field management, soil profile and groundwater table file), the initial and off-season conditions, and the field data;

and from the PARAM directory, the setting for the Program parameters. In absence of the program parameter file, the project will run with the default settings for the program parameters (Table III.1 in Annex III).

- ☐ Before starting a simulation run, the program checks if:
  - the structure of the project file is correct (Table I.1 in Annex 1), and
  - all files describing the environment are available at the specified path.

  If not so, the project is skipped, and no output will be generated.

  The text file 'ListProjectsLoaded.OUT' in the OUTP directory of the AquaCrop stand-alone program, contains information on the projects which were loaded (Table 8 and 9).

- ☐ While running the successive projects, the seasonal and the requested daily and/or particular simulation results are saved in files in the OUTP directory (Fig. 3).

4. Output

When running a project, intermediate and final seasonal simulation results of a project are stored in the output file in the OUTP directory of the stand-alone (plug-in) program (Fig. 3). Additionally, daily results (as available in the standard window version of AquaCrop), and particular results can be requested as output.

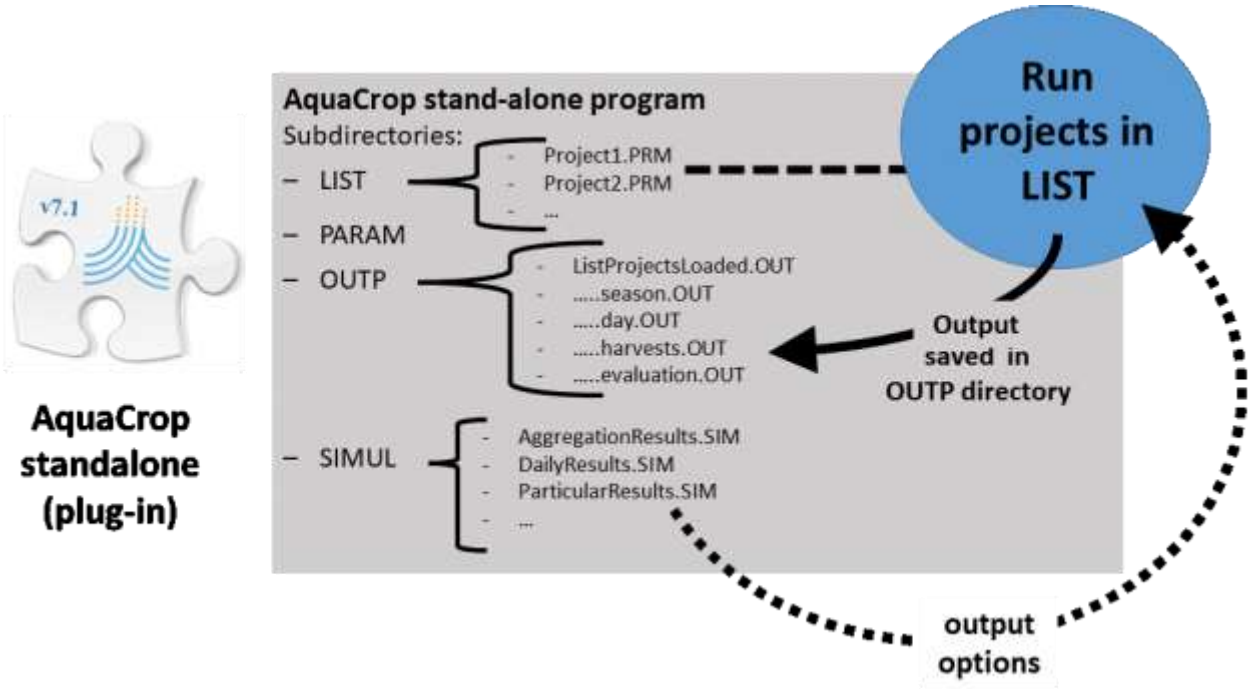

Figure 3. – Storage of simulation results in the OUTP directory

4.1 Seasonal Output

The seasonal output file contains length and dates of the simulation period, and the totals for climatic, soil water and soil salinity parameters, for average stresses during the growing period, for biomass production, crop yield and crop water productivity (Table II.1 in Annex II). Seasonal output files are stored in the OUTP directory of the programme.

- **File name:** The name of each seasonal output file corresponds with the filename of the corresponding project file but extended with 'PROseason' (for single projects) or 'PRMseason' (for multiple projects), and the extension OUT (Table 2).

Table 2. – Projects and the name of the corresponding seasonal output files

Project files (LIST directory)	Seasonal output files (OUTP directory)
Axum.PRO	AxumPROseason.OUT
Axum19Years.PRM	Axum19YearsPRMseason.OUT

- **Option for intermediate results:** The standard output consists of totals and averages of variables over the total simulation period (Table II.1 in Annex I). Additionally, daily, 10-daily

or monthly intermediate simulation results can be requested. Therefore, the user adjusts the number specified at the start of the first (and only) line of the 'AggregationResults.SIM' text file (file available in the SIM subdirectory). Depending on the number either none, daily, 10-daily or monthly intermediate simulation results will be provided next to the final simulation results (Tab. 3). The following code applies:

- 0 : for no intermediate results
- 1 : for daily results
- 2 : for 10-daily intermediate results
- 3 : for monthly intermediate results

In the absence of the 'AggregationResults.SIM' file, no intermediate results will be provided.

Table 3. – Example of the AggregationResults.SIM' text file (file available in the SIM subdirectory) generating 10-daily intermediate seasonal simulation results

2 : Time aggregation for intermediate results (0 = none ; 1 = daily; 2 = 10-daily; 3 = monthly)

- **Content and Structure:** The results are presented in 41 columns (Table II.1 in Annex II) and contain information of the length and dates of the simulation period, and the totals for climatic, soil water and soil salinity parameters, for average stresses during the growing period, for biomass production, crop yield and crop water productivity.
  In each seasonal output file there are for each simulation run as many lines as intermediate results plus one extra line for the totals of the simulation run. The individual runs of a multiple projects (PRM) are separated by an empty line and the Run number.
  There are as many seasonal output files as project files listed in the LIST directory.

4.2 Daily Output

In the standard AquaCrop window Version 7.0 with user-interface and database, daily simulation results are stored in a set of 8 output files (see section 2.25 'Output files' in Chapter 2 'Users guide' of AquaCrop Reference manual). The output files contain information on the:

- Crop development and production (file …Crop.OUT);
- Soil water content at various depths of the soil profile (file …CompWC.OUT);
- Soil salinity at various depths of the soil profile (file …CompEC.OUT);
- Soil water content in the soil profile and root zone (file …Prof.OUT);
- Soil salinity in the soil profile and root zone (file …Salt.OUT);
- Various parameters of the soil water balance (file …Wabal.OUT);
- Climate input parameters (file …Clim.OUT);
- Net irrigation water requirement (file …Inet.OUT).

These daily output files can also be requested as output of the AquaCrop stand-alone (plug-in) program. The daily output files are stored in the OUTP directory of the programme.

Note that recording all daily outputs might slow down significantly the speed of the AquaCrop stand-alone (plug-in) programme.

- **File name:** The name of the daily output files corresponds with the filename of the corresponding project file but extended with 'PROday' (for single projects) or 'PRMday' (for multiple projects), and the extension OUT (Tab. 4).

Table 4. – Projects and the name of the corresponding daily output files

Project files (LIST directory)	Output files (OUTP directory)
Axum.PRO	AxumPROday.OUT
Axum19Years.PRM	Axum19YearsPRMday.OUT

- **Content:** The user specifies the daily data that needs to be recorded with the help of codes (one code per line) in the 'DailyResults.SIM' text file (file available in the SIM subdirectory). The number of codes (specified in successive lines), and the value of the code (specified at the start of each of the successive lines) determine the content of the output (Table 5). The following codes apply:
  - 1 : for various parameters of the soil water balance. When net irrigation is calculated, column 9 (Irri) contains the daily net irrigation requirement;
  - 2 : for Crop development and production;
  - 3 : for Soil water content in the soil profile and root zone;
  - 4: for Soil salinity in the soil profile and root zone;
  - 5 : for Soil water content at various depths of the soil profile;
  - 6 : for Soil salinity at various depths of the soil profile;
  - 7 : for Climate input parameters

  In the absence of the 'DailyResults.SIM' file, no daily results will be provided.

Table 5. – Example of a 'DailyResults.SIM' file (file available in the SIMUL subdirectory) requesting a record of daily results of the (i) Crop development and production and of the (ii) Soil water content at various depths of the soil profile

2 : Crop development and production
5 : Soil water content at various depths of the soil profile

- **Structure:** If requested, there will be as many daily output files as project files listed in the LIST directory. In each daily output file there are for each simulation run as many lines as days in the simulation period. The individual runs of a multiple projects (PRM) are separated by an empty line and the Run number. The number of columns depend on the requested daily data and can be up to 98 columns if all daily results are requested (Table II.2 in Annex II).

4.3 Particular Output

In the standard window version 7.1 with user-interface and database of AquaCrop,

- the amount of biomass and crop yield harvested at each cut during the growing cycle in case of multiple cuttings, are stored in an 'harvests' output file.
- the evaluation of simulation results are recorded in statistics output files. The output files contain the statics of the evaluation of the simulation results for Canopy Cover, biomass and soil water content.

When appropriate, these particular output files can also be requested as output of the AquaCrop stand-alone (plug-in) program. As all other output, the particular output files are stored in the OUTP directory of the programme.

Note that recording particular output might slow down significantly the speed of the AquaCrop stand-alone programme.

- **File name:**
  - The name of the 'harvests' output files, corresponds with the filename of the corresponding project file but extended with 'PROharvests' (for single projects) or 'PRMharvests' (for multiple projects), and the extension OUT (Table 6).
  - The name of the evaluation statistics output files corresponds with the filename of the corresponding project file but extended with 'PROevaluation' (for single projects) or 'PRM(No)evaluation' (for multiple projects), and the extension OUT (Table 6). The number (No) refers to the simulation run for which a statistical evaluation was requested. The evaluation can only be done when Field data is available.

Table 6. – Projects and the name of the corresponding particular output files

Project files (LIST directory)	Output files (OUTP directory)
Axum.PRO Axum19Years.PRM	Information on the amount of biomass and crop yield harvested at each cut during the growing cycle: AxumPROharvests.OUT Axum19YearsPRMharvests.OUT
Axum.PRO Axum19Years.PRM	Evaluation data and statistical analysis of the simulation results in presence of observed field data: AxumPROevaluation.OUT Axum19YearsPRM1evaluation.OUT Axum19YearsPRM2evaluation.OUT Axum19YearsPRM3evaluation.OUT …

- **Content:** The user specifies the particular results that need to be recorded with the help of codes (one code per line) in the 'ParticularResults.SIM' text file (file available in the SIM subdirectory). The number of codes (specified in successive lines), and the value of the code (specified at the start of each of the successive lines) determine the content of the output (Tab. 7). The following codes apply:
  - 1 : Biomass and Yield at each cut during the growing cycle (in case of multiple cuttings)
  - 2 : Evaluation of simulation results - Statistics (when Field Data)

  In the absence of the 'ParticularResults.SIM' file, no particular output will be provided.

Table 7. – Example of a 'ParticularResults.SIM' file (file available in the SIMUL subdirectory) requesting a statistical evaluation of the simulation results

2 : Evaluation of simulation results - Statistics (when Field Data)

- **Structure:**
  - An example of an 'harvests' file is presented in Table II.3. The individual runs of a multiple projects (PRM) are separated by an empty line and the Run number. There are as many particular 'harvests' output files as project files listed in the LIST directory.
  - The content of a 'statistical evaluation of simulations' file is presented in Table II.4 and an example is presented in Table II.5 in Annex II.

4.4 Status report

While running the successive projects, the program keeps track of the requested output and the successive projects successfully loaded ('ListProjectsLoaded.OUT' file in the OUTP directory) (Table 8, 9 and 10).

Table 8. – Content of the Status Report ('ListProjectsLoaded.OUT' file) in the OUTP directory

– ***Requested intermediate results*** (none, daily, 10-daily or monthly); – ***Requested daily output results*** (Soil water balance, Crop development and production, Soil water content in the soil profile and root zone, Soil salinity in the soil profile and root zone, Soil water content at various depths of the soil profile, Soil salinity at various depths of the soil profile, and/or Climate input parameters); – ***Requested particular output results*** (Biomass and yield at multiple cuttings and/or statistical analysis of simulation results); – ***Status report*** (list of successfully and unsuccessfully loaded Projects, and information on the program parameters used)

Table 9. – Example of the Status Report ('ListProjectsLoaded.OUT' file) in the OUTP directory of successfully loaded projects

Intermediate results: None created Daily output results: 1. - soil water balance 2. - crop development and production 3. - soil water content in the soil profile and root zone 4. - soil salinity in the soil profile and root zone 5. - soil water content at various depths of the soil profile 6. - soil salinity at various depths of the soil profile 7. - climate input parameters Particular results: 1. - biomass and yield at multiple cuttings (for herbaceous forage crops) 2. - Evaluation of simulation results - Statistics (when Field Data) Projects loaded: 1. - AlBilXX4.PRM : Project loaded - with its program parameters 2. - AlBiXX4Irr00.PRM : Project loaded - with its program parameters 3. - AlBiXX4Irr50.PRM : Project loaded - with its program parameters

In case the project file failed to load due to (a) missing file(s), the status report provides information about the specific missing environmental or simulation file(s) in the particular Run. After finding errors in a Simulation Run, the program no longer checks subsequent runs (Table 10).

Table 9. – Example of the Status Report ('ListProjectsLoaded.OUT' file) in the OUTP directory of an unsuccessfully loaded project

Intermediate results: monthly results Daily output results: None created Particular results: 1. - biomass and yield at multiple cuttings (for herbaceous forage crops) 2. - evaluation of simulation results (when Field Data) Projects handled: 1. - Project123.PRM : Project NOT loaded - Missing Environment and/or Simulation file(s) in Run number 3 - Cannot find file(s) for: Crop (CRO), Field Management (MAN), Soil profile (SOL), Field data (OBS), - Check file Name(s), Path(s) or Structure of project file.

5. Installation

There are 3 standalone executables available for download: one for a Window, a Linux and a Mac operating system (Fig. 4). Select the appropriate ZIP file, copy it to your computer and Unzip it in a directory. When properly installed, the directory contains the standalone executable, and 4 subdirectories:

- LIST (copy in this directory the project files (files with extension PRO and/or PRM) that needs to be run)
- PARAM (copy in this directory the corresponding program parameters files (files with extension PP1 and/or PPn) of the projects that need to be run. If program parameters files are missing, AquaCrop will run the project with the standard program parameters)
- OUTP (in this directory the requested output will be stored)
- SIMUL, which contains the Manauloa.CO2 file and three text files with guidelines for composing the required output:
    - AggregationResults.SIM (select an option for intermediate results – see 3.1 'Seasonal output')
    - DailyResultsFullList.SIM (If Daily output is required, rename the file to 'DailyResults.SIM' and select one or more options – see 3.2 'Daily output')
    - ParticularResultsFullList (If Particular output is required, rename the file to 'ParticularResults.SIM' and select one or more options – see 3.3 'Particular output')

Figure 4. AquaCrop standalones (plug-ins) are available for Windows, Mac and Linux operating systems

Annex I. Structure of Project and Program parameter files

A **project file** is a text file which contains (a) information about the project, (b) the year number of cultivation and the start and end dates of the simulation and cropping period, and (c) the names of files (climate, calendar, crop, irrigation and field management, soil profile and ground water, initial and off-season conditions, and field data). The structure of the project file is presented in Table I.1, and an example is presented in Table I.5

The settings for the **program parameters** are saved in another text file which has the same file name as the project, but with the filename extension 'PP1' (for single projects) and 'PPn' (for multiple projects). Its structure is given in Table I.4, and an example is presented in Table I.6.

Table I.1 – Structure of a project file (file with extension PRO or PRM)

Line Number	Description
a. – Information	
1	Description of the project
2	AquaCrop version number
b. – Simulation and the growing cycle for the first run	
3	Year number of cultivation (always 1 for annual crops; and 1, 2, 3 … for perennials), with 1 being the Seeding/planting year
4	Day number(1) for the first day of the simulation period
5	Day number(1) for the last day of the simulation period
6	Day number(1) for the first day of the growing cycle
7	Day number(1) for the last day of the growing cycle
c. – The names(2) and directories(3) for the 14 files containing the characteristics of the crop, crop calendar, environmental (climate, management and soil), initial and off-season conditions, and field data	
8 up to 49	1. Climate (CLI) file and the enveloped: 1.1 air temperature (Tnx or TMP) file, 1.2 reference ET (ETo) file, 1.3 rain (PLU) file, and 1.4 atmospheric CO_2 concentration (CO2) file; 2. Calendar (CAL) file; 3. Crop (CRO) file; 4. Irrigation management (IRR) file; 5. Field management (MAN) file; 6. Soil profile (SOL) file; 7. Groundwater table (GWT) file; 8. Initial conditions (SW0) file;

	9. Off-season conditions (OFF) file; 10. Field Data (OBS) file.
In case of **multiple projects**, section 'b' (5 lines for the simulation and growing cycle) and section 'c' (42 lines for the 14 files) are specified for each of the successive runs, in successive blocks of (5 + 42 =) 47 lines.	
(1) Day number: The day number refers to the days elapsed since 0th January 1901 at 0 am (see Table I.2 and I.3 for the calculation procedure); (2) File name: in the absence of a file (None), the default conditions (see section 2.3 'Default settings at start' in Chapter 2 of the Reference manual of AquaCrop) are considered; (3) Directory (path): in the absence of a file, (None) is specified as directory.	

Table I.2 – Number of days elapsed since 0th January 1901, 0 am

Validity: The method is valid from 1901 to 2099 only (time range in AquaCrop)	
Rules 1. Subtract 1901 from the year 2. Multiply by 365.25 3. According to the month add: - January : 0 - February : 31 - March : 59.25 - April : 90.25 - May : 120.25 - June : 151.25 - July : 181.25 - August : 212.25 - September : 243.25 - October : 273.25 - November : 304.25 - December : 334.25 4. Add the number of the day within the month 5. Take the integer	
Example For 24 August 1982	
1. Subtract 1901 from the year	1982 – 1901 = 81
2. Multiply by 365.25	81 x 365.25 = 29585.25
3. Add 212.25 for August	29585.25 + 212.25 = 29797.5
4. Add the number of the day	29797.5 + 24 = 29821.5
5. Take the integer	29821

Table I.3 – Calculation code to derive a day-number from a given date (day/month/year)

```
CONST ElapsedDays :
ARRAY[1..12] of double = (0,31,59.25,90.25,120.25,151.25,181.25,
212.25,243.25,273.25,304.25,334.25);
INPUT: Dayi  : DD (Integer); Monthi : MM (Integer); Yeari   : YYYY (Integer);
OUTPUT:   DayNr (LongInt);
PROCEDURE DetermineDayNr (Dayi,Monthi,Yeari : INTEGER;
                                              VAR DayNr : Longint);
BEGIN
DayNr := TRUNC((Yeari - 1901)*365.25 + ElapsedDays[Monthi] + Dayi + 0.05);
END; (* DetermineDayNr *)
```

Table I.4 – Structure of program file parameters (file with extension PP1 or PPn)

Line No.	Description	Format	Example
Settings for crop program parameters (12 parameters)			
1	Evaporation decline factor for stage II	Integer	4
2	Ke(x) Soil evaporation coefficient for fully wet and non-shaded soil surface	XXX.XX	1.10
3	Threshold for green CC below which HI can no longer increase (% cover)	Integer	5
4	Starting depth of root zone expansion curve (% of Zmin)	Integer	70
5	Maximum allowable root zone expansion (fixed at 5 cm/day)	XXX.XX	5.00
6	Shape factor for effect water stress on root zone expansion	Integer	-6
7	Required soil water content in top soil for germination (% TAW)	Integer	20
8	Adjustment factor for FAO-adjustment soil water depletion (p) by ETo	XXX.X	1.0
9	Number of days after which deficient aeration is fully effective	Integer	3
10	Exponent of senescence factor adjusting drop in photosynthetic activity of dying crop	XXX.XX	1.00
11	Decrease of p(sen) once early canopy senescence is triggered (% of p(sen))	Integer	12
12	Thickness top soil (cm) in which soil water depletion has to be determined	Integer	10
Settings for field program parameters (1 parameter)			

13	Depth [cm] of soil profile affected by water extraction by soil evaporation	Integer	30
Settings for soil parameters (5 parameters)			
14	Considered depth (m) of soil profile for calculation of mean soil water content for CN adjustment	XXX.XX	0.30
15	Adjustment of CN to Antecedent Moisture Class (0 = Not adjusted; 1 = Adjusted)	0 or 1	1
16	Salt diffusion factor (capacity for salt diffusion in micro pores) [%]	Integer	20
17	Salt solubility [g/liter]	Integer	100
18	Shape factor for effect of soil water content gradient on capillary rise	Integer	16
Settings for temperature program parameters (3 parameters)			
19	Default minimum temperature (°C) if no temperature file is specified	XXX.X	12.0
20	Default maximum temperature (°C) if no temperature file is specified	XXX.X	28.0
21	Default method for the calculation of growing degree days	Integer	3
Settings for 10-day or monthly rain program parameters (4 parameters)			
22	Procedure to estimate daily rainfall (when input is 10-day/monthly rainfall) 0 : 100 % effective 1 : USDA-SCS procedure 2 : Fixed percentage	0, 1 or 2	1
23	Percentage of 10-day or monthly rainfall which is effective (when Procedure (option 2) is a fixed percentage)	Integer	70
24	Number of showers in a decade for run-off estimate (when input is 10-day/monthly rainfall)	Integer	2
25	Parameter for reduction of soil evaporation (when input is 10-day/monthly rainfall)	Integer	5

Table I.5 – Example of a (multiple) project file

```
5 years of alfalfa
      7.1       : AquaCrop Version (August 2023)
      1         : Year number of cultivation (Seeding/planting year)
```

```
  36281         : First day of simulation period - 1 May 2000
  36515         : Last day of simulation period - 21 December 2000
  36281         : First day of cropping period - 1 May 2000
  36515         : Last day of cropping period - 21 December 2000
-- 1. Climate (CLI) file
   Bru76-05.CLI
   C:\FAO\AquaCrop7\DATA\
   1.1 Temperature (Tnx or TMP) file
   Bru76-05.TMP
   C:\FAO\AquaCrop7\DATA\
   1.2 Reference ET (ETo) file
   Bru76-05.ETo
   C:\FAO\AquaCrop7\DATA\
   1.3 Rain (PLU) file
   Bru76-05.PLU
   C:\FAO\AquaCrop7\DATA\
   1.4 Atmospheric CO2 concentration (CO2) file
   MaunaLoa.CO2
   C:\FAO\AquaCrop7\SIMUL\
-- 2. Calendar (CAL) file
   1May.CAL
   C:\FAO\AquaCrop7\DATA\
-- 3. Crop (CRO) file
   alfalfa.CRO
   C:\FAO\AquaCrop7\DATA\
-- 4. Irrigation management (IRR) file
   (None)
   (None)
-- 5. Field management (MAN) file
   (None)
   (None)
-- 6. Soil profile (SOL) file
   Loam.SOL
   C:\FAO\AquaCrop7\DATA\
-- 7. Groundwater table (GWT) file
   (None)
   (None)
-- 8. Initial conditions (SW0) file
   (None)
   (None)
-- 9. Off-season conditions (OFF) file
   (None)
   (None)
-- 10. Field data (OBS) file
   (None)
   (None)
     2         : Year number of cultivation (Non-seeding/planting year)
  36516         : First day of simulation period - 22 December 2000
  36845         : Last day of simulation period - 16 November 2001
  36565         : First day of cropping period - 9 February 2001
  36845         : Last day of cropping period - 16 November 2001
-- 1. Climate (CLI) file
   Bru76-05.CLI
   C:\FAO\AquaCrop7\DATA\
   1.1 Temperature (Tnx or TMP) file
   Bru76-05.TMP
   C:\FAO\AquaCrop7\DATA\
   1.2 Reference ET (ETo) file
   Bru76-05.ETo
   C:\FAO\AquaCrop7\DATA\
   1.3 Rain (PLU) file
   Bru76-05.PLU
   C:\FAO\AquaCrop7\DATA\
```

```
   1.4 Atmospheric CO2 concentration (CO2) file
   MaunaLoa.CO2
   C:\FAO\AquaCrop7\SIMUL\
-- 2. Calendar (CAL) file
   1May.CAL
   C:\FAO\AquaCrop7\DATA\
-- 3. Crop (CRO) file
   alfalfa.CRO
   C:\FAO\AquaCrop7\DATA\
-- 4. Irrigation management (IRR) file
   (None)
   (None)
-- 5. Field management (MAN) file
   (None)
   (None)
-- 6. Soil profile (SOL) file
   Loam.SOL
   C:\FAO\AquaCrop7\DATA\
-- 7. Groundwater table (GWT) file
   (None)
   (None)
-- 8. Initial conditions (SW0) file
   KeepSWC
   Keep soil water profile of previous run
-- 9. Off-season conditions (OFF) file
   (None)
   (None)
-- 10. Field data (OBS) file
   (None)
   (None)
Etc.
```

Table I.6 – Example of a Program Parameter file

```
  4     : Evaporation decline factor for stage II
  1.10  : Ke(x) Soil evaporation coefficient for fully wet and non-shaded soil surface
  5     : Threshold for green CC below which HI can no longer increase (% cover)
 70     : Starting depth of root zone expansion curve (% of Zmin)
  5.00  : Maximum allowable root zone expansion (fixed at 5 cm/day)
 -6     : Shape factor for effect water stress on root zone expansion
 20     : Required soil water content in top soil for germination (% TAW)
  1.0   : Adjustment factor for FAO-adjustment soil water depletion (p) by ETo
  3     : Number of days after which deficient aeration is fully effective
  1.00  : Exponent of senescence factor adjusting drop in photosynthetic activity of dying crop
 12     : Decrease of p(sen) once early canopy senescence is triggered (% of p(sen))
 10     : Thickness top soil (cm) in which soil water depletion has to be determined
 30     : Depth [cm] of soil profile affected by water extraction by soil evaporation
  0.30  : Considered depth (m) of soil profile for calculation of mean soil water content for CN adjustment
  1     : CN is adjusted to Antecedent Moisture Class
 20     : Salt diffusion factor (capacity for salt diffusion in micro pores) [%]
100     : Salt solubility [g/liter]
 16     : Shape factor for effect of soil water content gradient on capillary rise
 12.0   : Default minimum temperature (°C) if no temperature file is specified
 28.0   : Default maximum temperature (°C) if no temperature file is specified
  3     : Default method for the calculation of growing degree days
  1     : Daily rainfall is estimated by USDA-SCS procedure (when input is 10-day/monthly rainfall)
 70     : Percentage of effective rainfall (when input is 10-day/monthly rainfall)
  2     : Number of showers in a decade for run-off estimate (when input is 10-day/monthly rainfall)
  5     : Parameter for reduction of soil evaporation (when input is 10-day/monthly rainfall)
```

Annex II. Output files

Table II.1. – Information available in the 41 columns of the seasonal output file

Nr	Symbol	Description	Unit	Format(1)
Time aggregation				
1	Period	Length of period: - Tot (Number simulation run) : for total simulation run - Day : for intermediate daily results - 10Day : for intermediate 10-daily results - Month : for intermediate monthly results	-	9 characters
First day of considered period				
2	Day1	Start Day of period	-	9 (INT)
3	Month1	Start Month of period	-	9 (INT)
4	Year1	Start Year of period	-	9 (INT)
Climatic parameters for considered period				
5	Rain	Rainfall	mm	9:1 (REAL)
6	ETo	Reference evapotranspiration	mm	9:1 (REAL)
7	GD	Growing degrees	°C day	9:1 (REAL)
8	CO2	Atmospheric CO_2 concentration	ppm	9:2 (REAL)
Soil water parameters for considered period				
9	Irri	- Amount of water applied by irrigation, or - Net irrigation requirement (if requested)	mm	9:1 (REAL)
10	Infilt	Infiltrated water in the soil profile	mm	9:1 (REAL)
11	Runoff	Water lost by surface runoff	mm	9:1 (REAL)
12	Drain	Water drained out of the soil profile	mm	9:1 (REAL)
13	Upflow	Water moved upward by capillary rise	mm	9:1 (REAL)
14	E	Soil evaporation	mm	9:1 (REAL)
15	E/Ex	Relative mean soil evaporation (100 E/Ex)	%	9 (INT)
16	Tr	Total transpiration of crop and weeds	mm	9:1 (REAL)
17	TrW	Crop transpiration in weed infested field	mm	9:1 (REAL)
18	Tr/Trx	Relative mean crop transpiration (100 Tr/Trx)	%	9 (INT)

Soil salinity parameters for considered period				
19	SaltIn	Salt infiltrated in the soil profile	ton/ha	10:3 (REAL)
20	SaltOut	Salt drained out of the soil profile	ton/ha	10:3 (REAL)
21	SaltUp	Salt moved upward by capillary rise from groundwater table	ton/ha	10:3 (REAL)
22	SaltProf	Salt stored in the soil profile	ton/ha	10:3 (REAL)
Average stresses during growing cycle (from germination onwards)				
23	Cycle	Length of crop cycle: from germination to maturity (or early senescence)	days	9 (INT)
24	SaltStr	Average soil salinity stress	%	9 (INT)
25	FertStr	Average soil fertility stress	%	9 (INT)
26	WeedStr	Average relative cover of weeds	%	9 (INT)
27	TempStr	Average temperature stress (affecting transpiration)	%	9 (INT)
28	ExpStr	Average leaf expansion stress	%	9 (INT)
29	StoStr	Average stomatal stress	%	9 (INT)
Biomass production in considered period				
30	Biomass	Total above-ground dry biomass	ton/ha	10:3 (REAL)
31	Brelative	Relative biomass (Reference: no water, no soil fertility, no soil salinity stress, no weed infestation)	%	9 (INT)
Crop yield (only specified at end of simulation run)				
32	HI	Harvest Index adjusted for failure of pollination, inadequate photosynthesis and water stress	%	9:1 (REAL)
33	Y(dry)	Dry crop Yield (HI x Biomass)	ton/ha	9:3 (REAL)
34	Y(fresh)	Fresh crop Yield	ton/ha	9:3 (REAL)
35	WPet	ET Water Productivity for yield part (kg yield produced per m^3 water evapotranspired)	kg/m^3	9:2 (REAL)
Transfer of assimilates between above ground parts and root system				
36	Bin	Total mass of assimilates mobilized from root system at start of season	ton/ha	9:3 (REAL)
37	Bout	Total mass of assimilates stored in root systeme at end of season	ton/ha	9:3 (REAL)
Last day of considered period				
38	DayN	Day at end of period	-	9 (INT)
39	MonthN	Month at end of period	-	9 (INT)
40	YearN	Year at end of period	-	9 (INT)

Name of project				
41	File	Project file name	-	n characters

(1) Text: total number of characters
Integer: Total number of digits
Real: Total number of digits (including the decimal point) : decimal places

Table II.2 – Structure of the daily output file

Nr	Symbol	Description	Unit	Format(1)
General information				
1	Day		-	6 (INT)
2	Month		-	6 (INT)
3	Year		-	6 (INT)
4	DAP	Days after planting/sowing	-	6 (INT)
5	Stage	Crop growth stage: 0: before or after cropping; 1: between sowing and germination or transplant recovering; 2: vegetative development; 3: flowering; 4: yield formation and ripening -9: no crop as a result of early canopy senescence	-	6 (INT)
IF Code 1: Various parameters of the soil water balance				
6	WC(x.xx)	Water content in total soil profile with (x.xx): the soil depth in meter	mm	10:1 (REAL)
7	Rain	Rainfall	mm	8:1 (REAL)
8	Irri	Water applied by irrigation Or net irrigation requirement if the determination of Net Irrigation requirement is requested in the IRR file	mm	9:1 (REAL)
9	Surf	Stored water on soil surface between bunds	mm	7:1 (REAL)
10	Infilt	Infiltrated water in soil profile	mm	7:1 (REAL)
11	RO	Surface runoff	mm	7:1 (REAL)
12	Drain	Water drained out of the soil profile	mm	9:1 (REAL)
13	CR	Water moved upward by capillary rise	mm	9:1 (REAL)
14	Zgwt	Depth of the groundwater table (-9.90 if absent)	m	8:2 (REAL)
15	Ex	Maximum soil evaporation	mm	9:1 (REAL)
16	E	Actual soil evaporation	mm	9:1 (REAL)
17	E/Ex	Relative evaporation (100 E/EX)	%	7 (INT)

18	Trx	Maximum crop transpiration	mm	9:1 (REAL)
19	Tr	Total transpiration of crop and weeds	mm	9:1 (REAL)
20	Tr/Trx	Relative transpiration (100 Tr/Trx)	%	6 (REAL)
21	ETx	Maximum evapotranspiration	mm	9:1 (REAL)
22	ET	Actual evapotranspiration	mm	8:1 (REAL)
23	ET/ETx	Relative evapotranspiration (100 ET/ETx)	%	8 (INT)

If Code 2: Crop development and production				
24	GD	Growing degrees	°C-day	9:1 (REAL)
25	Z	Effective rooting depth	m	8:2 (REAL)
26	StExp	Percent water stress reducing leaf expansion	%	7 (INT)
27	StSto	Percent water stress inducing stomatal closure	%	7 (INT)
28	StSen	Percent water stress triggering early canopy senescence	%	7 (INT)
29	StSalt	Percent salinity stress	%	7 (INT)
30	StWeed	Relative cover of weeds	%	7 (INT)
31	CC	Total green canopy cover of crop and weeds	%	8:1 (REAL)
32	CCw	Crop green Canopy Cover in weed infested field	%	8:1 (REAL)
33	StTr	Percent temperature stress affecting crop transpiration	%	7 (INT)
34	Kc(Tr)	Crop coefficient for transpiration	-	9:2 (REAL)
35	Trx	Maximum crop transpiration of crop and weeds	mm	9:1 (REAL)
36	Tr	Total transpiration of crop and weeds	mm	9:1 (REAL)
37	TrW	Crop transpiration in weed infested field		9:1 (REAL)
38	Tr/Trx	Relative total transpiration of crop and weeds (100 Tr/Trx)	%	6 (INT)
39	WP	Crop water productivity adjusted for CO2, soil fertility and products synthesized	g/m^2	8:1 (REAL)
40	Biomass	Total above-ground dry biomass	ton/ha	10:3 (REAL)
41	HI	Harvest Index adjusted for failure of pollination, inadequate photosynthesis and water stress	%	8:1 (REAL)
42	Y(dry)	Dry crop yield (HI x Biomass)	ton/ha	9:3 (REAL)
43	Y(fresh)	Fresh crop yield	ton/ha	9:3 (REAL)
45	Brelative	Relative biomass (Reference: no water, no soil fertility, no soil salinity stress, no weed infestation)	%	8 (INT)

45	WPet	ET Water productivity for yield part (kg yield produced per m3 water evapotranspired)	kg/m^3	12:2 (REAL)
46	Bin	Daily mass of assimilates mobilized from root system at start of season	ton/ha	9:3 (REAL)
47	Bout	Daily mass of assimilates stored in root system at end of season	ton/ha	9:3 (REAL)

IF Code 3: Soil water content in the soil profile and root zone				
48	WC(x.xx)	Water content total soil profile with (x.xx): the soil depth in meter	mm	10:1 (REAL)
49	Wr(x.xx)	Water content in maximum effective root zone with (x.xx): the maximum effective root zone	mm	9:1 (REAL)
50	Z	Effective rooting depth	m	8:2 (REAL)
51	Wr	Water content in effective root zone	mm	8:1 (REAL)
52	Wr(SAT)	Water content in effective root zone if saturated	mm	10:1 (REAL)
53	Wr(FC)	Water content in effective root zone at field capacity	mm	10:1 (REAL)
54	Wr(exp)	Water content in effective root zone at upper threshold for leaf expansion	mm	10:1 (REAL)
55	Wr(sto)	Water content in effective root zone at upper threshold for stomatal closure	mm	10:1 (REAL)
56	Wr(sen)	Water content in effective root zone at upper threshold for early canopy senescence	mm	10:1 (REAL)
57	Wr(PWP)	Water content in effective root zone at permanent wilting point	mm	10:1 (REAL)

IF Code 4: Soil salinity in the soil profile and root zone				
58	SaltIn	Salt infiltrated in the soil profile	ton/ha	9:3 (REAL)
59	SaltOut	Salt drained out of the soil profile	ton/ha	10:3 (REAL)
60	SaltUp	Salt moved upward by capillary rise from groundwater table	ton/ha	10:3 (REAL)
61	Salt(x.xx)	Salt content in the total soil profile with (x.xx): the soil depth in meter	ton/ha	10:3 (REAL)
62	SaltZ	Salt content in the effective root zone	ton/ha	10:3 (REAL)
63	Z	Effective rooting depth	m	8:2 (REAL)
64	ECe	Electrical conductivity of the saturated soil-paste extract from the root zone	dS/m	9:2 (REAL)
65	ECsw	Electrical conductivity of the soil water in the root zone	dS/m	8:2 (REAL)

66	StSalt	Salinity stress	%	7 (INT)
67	Zgwt	Depth of the groundwater table	m	8:2 (REAL)
68	ECgw	Electrical conductivity of the groundwater	dS/m	8:2 (REAL)

IF Code 5: Soil water content at various depths of the soil profile				
69	WC 1	soil water content compartment 1 *	vol%	11:1 (REAL)
70	WC 2	soil water content compartment 2	vol%	11:1 (REAL)
71	WC 3	soil water content compartment 3	vol%	11:1 (REAL)
72	WC 4	soil water content compartment 4	vol%	11:1 (REAL)
73	WC 5	soil water content compartment 5	vol%	11:1 (REAL)
74	WC 6	soil water content compartment 6	vol%	11:1 (REAL)
75	WC 7	soil water content compartment 7	vol%	11:1 (REAL)
76	WC 8	soil water content compartment 8	vol%	11:1 (REAL)
77	WC 9	soil water content compartment 9	vol%	11:1 (REAL)
78	WC10	soil water content compartment 10	vol%	11:1 (REAL)
79	WC11	soil water content compartment 11	vol%	11:1 (REAL)
80	WC12	soil water content compartment 12	vol%	11:1 (REAL)
* The corresponding soil depth (at the centre of the compartment) is specified in meter below the symbol				

IF Code 6: Soil salinity at various depths of the soil profile				
81	ECe 1	Electrical conductivity of the saturated soil-paste extract (ECe) - compartment 1 *	dS/m	11:1 (REAL)
82	ECe 2	Electrical conductivity of the saturated soil-paste extract (ECe) - compartment 2	dS/m	11:1 (REAL)
83	ECe 3	Electrical conductivity of the saturated soil-paste extract (ECe) - compartment 3	dS/m	11:1 (REAL)
84	ECe 4	Electrical conductivity of the saturated soil-paste extract (ECe) - compartment 4	dS/m	11:1 (REAL)
85	ECe 5	Electrical conductivity of the saturated soil-paste extract (ECe) - compartment 5	dS/m	11:1 (REAL)
86	ECe 6	Electrical conductivity of the saturated soil-paste extract (ECe) - compartment 6	dS/m	11:1 (REAL)
87	ECe 7	Electrical conductivity of the saturated soil-paste extract (ECe) - compartment 7	dS/m	11:1 (REAL)
88	ECe 8	Electrical conductivity of the saturated soil-paste extract (ECe) - compartment 8	dS/m	11:1 (REAL)
89	ECe 9	Electrical conductivity of the saturated soil-paste extract (ECe) - compartment 9	dS/m	11:1 (REAL)
90	ECe10	Electrical conductivity of the saturated soil-paste extract (ECe) - compartment 10	dS/m	11:1 (REAL)

91	ECe11	Electrical conductivity of the saturated soil-paste extract (ECe) - compartment 11	dS/m	11:1 (REAL)
92	ECe12	Electrical conductivity of the saturated soil-paste extract (ECe) - compartment 12	dS/m	11:1 (REAL)
* The corresponding soil depth (at the centre of the compartment) is specified in meter below the symbol				

IF Code 7: Climate input parameters				
93	Rain	Rainfall	mm	9:1 (REAL)
94	ETo	Reference evapotranspiration	mm	10:1 (REAL)
95	Tmin	Minimum air temperature	°C	10:1 (REAL)
96	Tavg	Average air temperature	°C	10:1 (REAL)
97	Tmax	Maximum air temperature	°C	10:1 (REAL)
98	CO2	Atmospheric CO_2 concentration for that year	ppm	10:2 (REAL)

(1) Text: total number of characters
Integer: Total number of digits
Real: Total number of digits (including the decimal point) : decimal places

Table II.3 – Example of a multiple harvest file (ProjectPRMharvests.OUT)

AquaCrop 7.1 (August 2023) - Output created on (date) : …… at (time) : ……
Biomass and Yield at Multiple cuttings

Run: 1

Nr	Day	Month	Year	DAP	Interval days	Biomass ton/ha	Sum(B) ton/ha	Dry-Yield ton/ha	Sum(Y) ton/ha	Fresh-Yield ton/ha	Sum(Y) ton/ha
0	1	4	2017				0.000		0.000		0.000
1	29	6	2017	90	90	13.432	13.432	13.339	13.339	66.693	66.693
2	29	7	2017	120	30	5.770	19.202	5.770	19.108	28.848	95.541
3	28	8	2017	150	30	5.815	25.017	5.815	24.923	29.074	124.615
4	27	9	2017	180	30	5.489	30.506	5.489	30.412	27.444	152.059
5	27	10	2017	210	30	3.727	34.233	3.727	34.139	18.637	170.696
9999	13	12	2017				35.027		34.933		174.664

Run: 2

Nr	Day	Month	Year	DAP	Interval days	Biomass ton/ha	Sum(B) ton/ha	Dry-Yield ton/ha	Sum(Y) ton/ha	Fresh-Yield ton/ha	Sum(Y) ton/ha
0	17	3	2018				0.000		0.000		0.000
1	10	5	2018	55	149	8.034	8.034	8.034	8.034	40.169	40.169
2	11	6	2018	87	32	5.959	13.993	5.959	13.993	29.794	69.963
3	21	7	2018	127	40	7.794	21.786	7.794	21.786	38.970	108.932
4	15	8	2018	152	25	4.819	26.606	4.819	26.606	24.097	133.029
5	19	9	2018	187	35	6.697	33.303	6.697	33.303	33.486	166.515
6	29	10	2018	227	40	5.379	38.682	5.379	38.682	26.896	193.410
9999	13	12	2018				39.391		39.391		196.954

Run: 3

Nr	Day	Month	Year	DAP	Interval days	Biomass ton/ha	Sum(B) ton/ha	Dry-Yield ton/ha	Sum(Y) ton/ha	Fresh-Yield ton/ha	Sum(Y) ton/ha
0	19	3	2019				0.000		0.000		0.000
1	17	5	2019	60	156	6.041	6.041	6.041	6.041	30.203	30.203
2	24	6	2019	98	38	7.332	13.372	7.332	13.372	36.659	66.862
3	29	7	2019	133	35	6.849	20.222	6.849	20.222	34.247	101.109
4	3	9	2019	169	36	7.060	27.281	7.060	27.281	35.298	136.407
5	7	10	2019	203	34	6.080	33.361	6.080	33.361	30.400	166.807
6	11	11	2019	238	35	3.472	36.834	3.472	36.834	17.362	184.169
9999	17	12	2019				37.203		37.203		186.016

Legend:

DAP: days after planting
Interval : Number of days between events
Nr = 0: at atart of season
Nr= 1 to n: Harvest event
Nr = 9999: At end of season

Table II.4 – Content of the statistical evaluation of simulation results output file

Text file with:

- at the dates of observations: the observed (with standard deviation) and simulated Canopy Cover, Biomass production and Soil water content;
- the number of valid observations/simulations sets and the average of observed and simulated Canopy Cover, Biomass production and Soil water content;
- statistical indicators for Canopy Cover, Biomass production and Soil water content: Pearson Correlation Coefficient (r); Root mean square error (RMSE); Normalized root mean square error CV(RMSE); Nash-Sutcliffe model efficiency coefficient (EF); and Willmott's index of agreement (d).

An example is presented in Table II.5.

Table II.5 – Example of ProjectPRM(No)Evaluation.OUT

AquaCrop 7.1 (August 2023) - Output created on (date) : …… at (time) : ……
Evaluation of simulation results - Statistics
** Run number: 1

ASSESSMENT OF CANOPY COVER

Nr	Observed	+/- St Dev	Simulated	Date
	--------- Canopy Cover (%) ---------			
1	96.9	-9.0	96.8	10 May 2018
2	99.6	-9.0	96.8	11 June 2018
3	99.7	-9.0	96.8	21 July 2018
4	99.7	-9.0	96.8	15 August 2018
5	99.6	-9.0	96.8	19 September 2018
6	95.2	-9.0	93.5	29 October 2018

Valid observations/simulations sets (n) ..... : 6
Average of observed Canopy Cover ..... : 98.5 %
Average of simulated Canopy Cover ..... : 96.3 %

Pearson Correlation Coefficient (r) ..... : 0.82
Root mean square error (RMSE) ..... : 2.4 % CC
Normalized root mean square error CV(RMSE).... : 2.5 %
Nash-Sutcliffe model efficiency coefficient (EF): -0.89
Willmotts index of agreement (d) ..... : 0.68

ASSESSMENT OF BIOMASS PRODUCTION

Nr	Observed	+/- St Dev	Simulated	Date
	--------- Biomass (ton/ha) ---------			
1	6.430	-9.000	7.104	10 May 2018
2	13.920	-9.000	12.308	11 June 2018
3	18.880	-9.000	17.961	21 July 2018
4	22.500	-9.000	20.566	15 August 2018
5	25.680	-9.000	23.942	19 September 2018
6	28.210	-9.000	27.054	29 October 2018

Valid observations/simulations sets (n) ..... : 6
Average of observed Biomass production ..... : 19.270 ton/ha
Average of simulated Biomass production ..... : 18.156 ton/ha

Pearson Correlation Coefficient (r) ..... : 1.00
Root mean square error (RMSE) ..... : 1.414 ton/ha
Normalized root mean square error CV(RMSE).... : 7.3 %
Nash-Sutcliffe model efficiency coefficient (EF): 0.96
Willmotts index of agreement (d) ..... : 0.99

ASSESSMENT OF SOIL WATER CONTENT

Nr	Observed	+/- St Dev	Simulated	Date
	------ Soil water content (mm) -----			
1	448.2	-9.0	436.7	23 April 2018
2	439.6	-9.0	422.0	20 May 2018
3	494.3	-9.0	471.8	21 May 2018
4	437.7	-9.0	395.4	26 June 2018
5	436.4	-9.0	375.6	9 July 2018
6	433.1	-9.0	361.7	21 July 2018
7	445.6	-9.0	371.5	5 August 2018
8	440.0	-9.0	374.6	15 August 2018
9	444.7	-9.0	388.5	26 August 2018
10	448.6	-9.0	396.0	4 September 2018
11	448.8	-9.0	401.1	14 September 2018
12	445.6	-9.0	410.7	27 September 2018
13	451.5	-9.0	423.8	15 October 2018
14	477.4	-9.0	462.3	29 October 2018

```
Valid observations/simulations sets (n) ....... :    14
Average of observed Soil water content ........ :   449.4   mm
Average of simulated Soil water content ....... :   406.6   mm

Pearson Correlation Coefficient (r) ........... :     0.84
Root mean square error (RMSE) ................. :    47.6   mm
Normalized root mean square error  CV(RMSE).... :    10.6   %
Nash-Sutcliffe model efficiency coefficient (EF):    -7.78
Willmotts index of agreement (d) .............. :     0.44
-----------------------------------------------------------------
```

Annex III. Default setting for program parameters

Table III.1 – Default setting for program parameters

Settings for crop program parameters (12 parameters)	
4	Evaporation decline factor for stage II
1.10	Ke(x) Soil evaporation coefficient for fully wet and non-shaded soil surface
5	Threshold for green CC below which HI can no longer increase (% cover)
70	Starting depth of root zone expansion curve (% of Zmin)
5.00	Maximum allowable root zone expansion (fixed at 5 cm/day)
-6	Shape factor for effect water stress on root zone expansion
20	Required soil water content in top soil for germination (% TAW)
1.0	Adjustment factor for FAO-adjustment soil water depletion (p) by ETo
3	Number of days after which deficient aeration is fully effective
1.00	Exponent of senescence factor adjusting drop in photosynthetic activity of dying crop
12	Decrease of p(sen) once early canopy senescence is triggered (% of p(sen))
10	Thickness top soil (cm) in which soil water depletion has to be determined
Settings for field program parameters (1 parameter)	
30	Depth [cm] of soil profile affected by water extraction by soil evaporation
Settings for soil parameters (5 parameters)	
0.30	Considered depth (m) of soil profile for calculation of mean soil water content for CN adjustment
1	Adjustment of CN to Antecedent Moisture Class (1 = Adjusted)
20	Salt diffusion factor (capacity for salt diffusion in micro pores) [%]
100	Salt solubility [g/liter]
16	Shape factor for effect of soil water content gradient on capillary rise
Settings for temperature program parameters (3 parameters)	
12.0	Default minimum temperature (°C) if no temperature file is specified
28.0	Default maximum temperature (°C) if no temperature file is specified
3	Default method for the calculation of growing degree days

Settings for 10-day or monthly rain program parameters (4 parameters)	
1	Procedure to estimate daily rainfall (when input is 10-day/monthly rainfall) (1 = USDA-SCS procedure)
70	Percentage of 10-day or monthly rainfall which is effective (when Procedure (option 2) is a fixed percentage)
2	Number of showers in a decade for run-off estimate (when input is 10-day/monthly rainfall)
5	Parameter for reduction of soil evaporation (when input is 10-day/monthly rainfall)