Food and Agriculture Organization
of the United Nations

# RAP v1 User's Manual

[DRAFT VERSION FOR BETA TESTING]

## A.1.1. About the software

The Rapid Appraisal Procedure for pressurized irrigation systems is built on the original work of FAO and the Irrigation Training and Research Center (ITRC) of California Polytechnic State University (Burt, 2001). Rapid Appraisal Procedure (RAP) and Benchmarking – Explanation and Tools was published in 2001 and revised in 2002 as part of the FAO Irrigation and Drainage Paper 63, Modernizing Irrigation Management, - the MASSCOTE approach, Mapping System and Services for Canal Operation Techniques. The RAP tool was designed in excel spreadsheets, furthermore, explanation manual was appended to the documentation. The original RAP was framed to medium-, large-scale, open-canal systems. RAP for pressurized irrigation system is the revamped version of RAP with adjusted content and computerized user tool.

### *A.1.1.1. About the technology*

The software consists of a Windows compatible desktop app. The application is the computerized form of the RAP methodology to support users with user-friendly and easy-to-implement interface. The RAP is programmed and packaged as open-source software capable of build native exe file for Windows (x32 and x64).

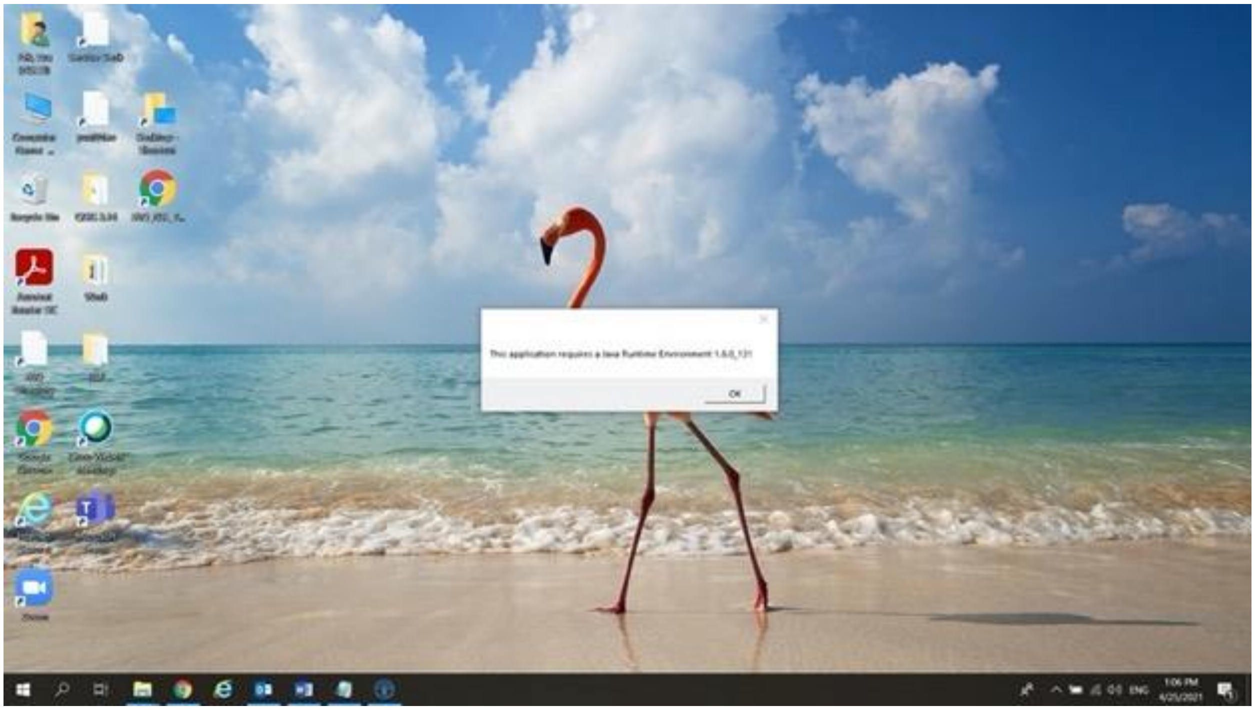
### *A.1.1.2. System requirements*

Operating system: Minimum Windows 7 (32 or 64-bit), Recommended Windows 10 (32 or 64-bit)
Processor: Minimum 1GHz, Recommended 2GHz or more
RAM: Minimum 1GB, Recommended 4GB or more
Hard drive: Minimum 100 MB
Display: Minimum 1280 x 960 resolution
Java version: Java SE Runtime Environment 8 (update 131 and above)

### *A.1.1.3. Installation and Start-up of RAP*

Download the exe file from FAO website, create a folder for the RAP software version 1 where you want to store the application and move the file to the folder. Make sure that the folder does not have write-protection. To run the application, JAVA SE Runtime Environment 8 needs to be installed on the computer. At the very first time of launching the application, the application will trigger a pop-up window showing the required JAVA version and navigating the user to the page, where it can be downloaded.

*Figure A3 - 1 Required update of Java version*

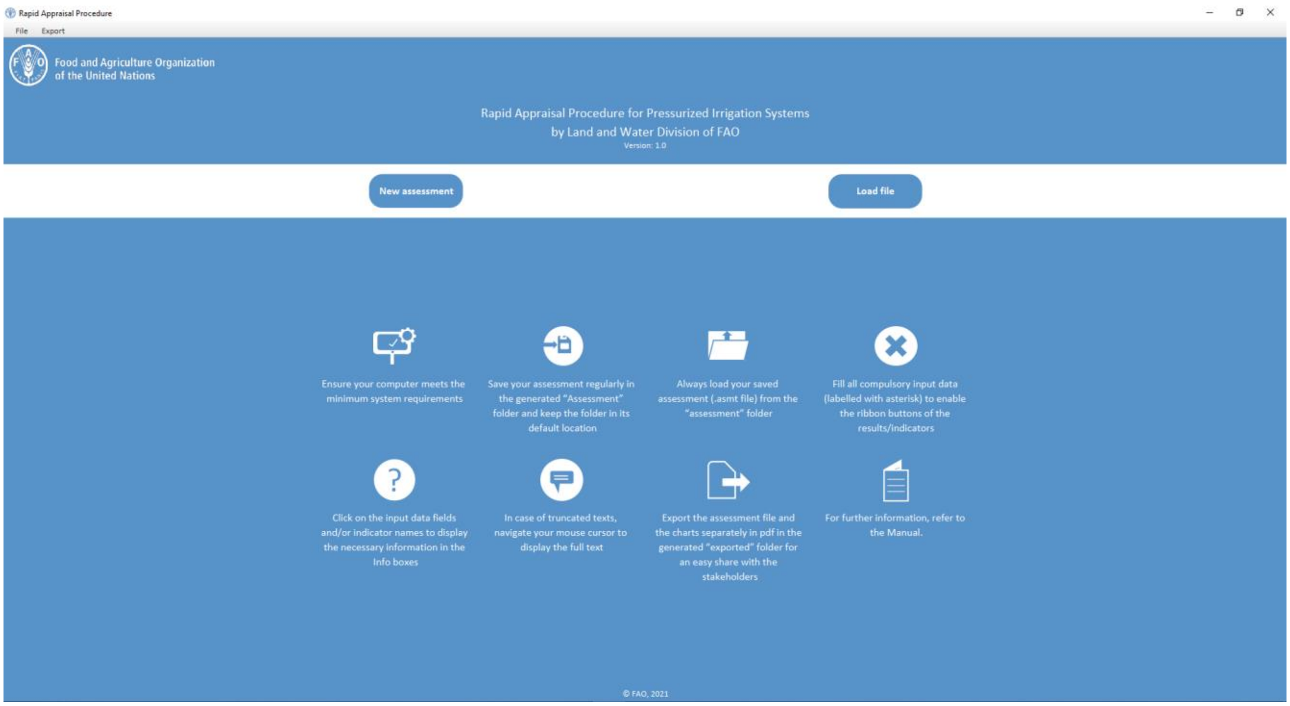



After the installation of JAVA updated version, click on the icon to run the application from rap.exe file. While, the application loads, a splash screen will appear.

*Figure A3 - 2 Splash screen*

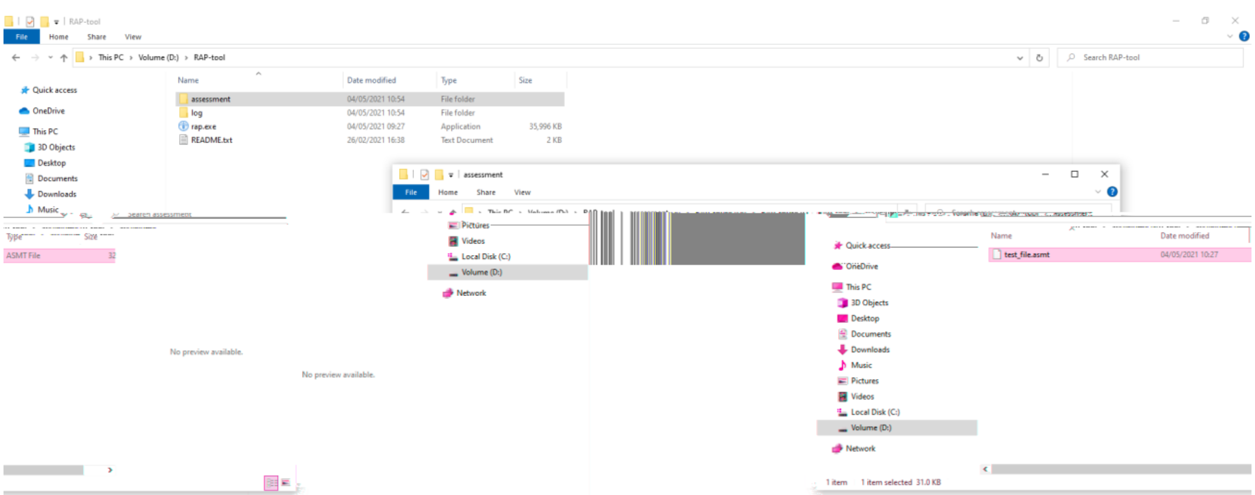

After launching the application, the landing page appears, which contains a summary about the main features of the application. Additionally, there are two buttons on the bottom, either to start a new, or load an existing assessment. These functions are also available from the "*File*" menu in the top menu bar.

*Figure A3 - 3 Landing page*



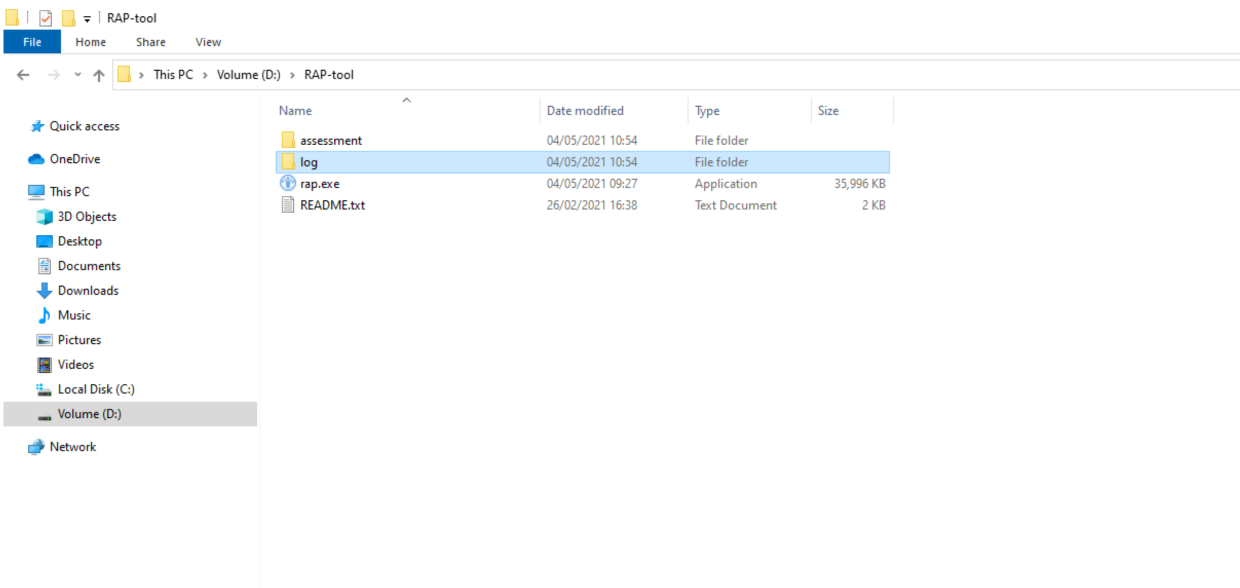

The load file option allows the import of existing assessment. Save and store the assessment as binary file with extension .asmt in the automatically created assessment subfolder. Only files stored in this folder can be opened from the application. Opening .asmt files from other locations is not possible.

*Figure A3 - 4: Assessment sub-folder and stored file with .asmt extension*



The application automatically logs detailed information about its operation while running. The location of the log file is "*log/RapidAppraisalProcedure.log*". This information may become relevant if some malfunction happens when using the application. The user need not be concerned about the log file.

*Figure A3 - 5 Log subfolder to store log file*

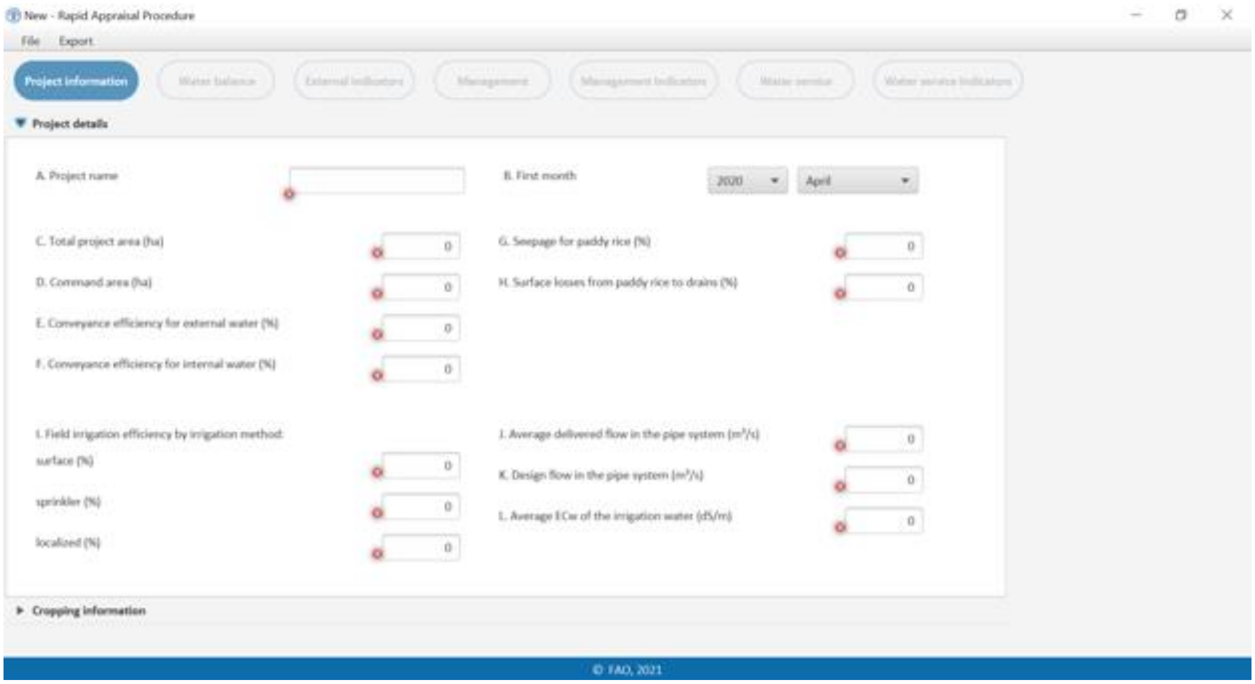



### *A.1.1.4. Main features of the software*

A.1.1.4.1. <u>User interface</u>

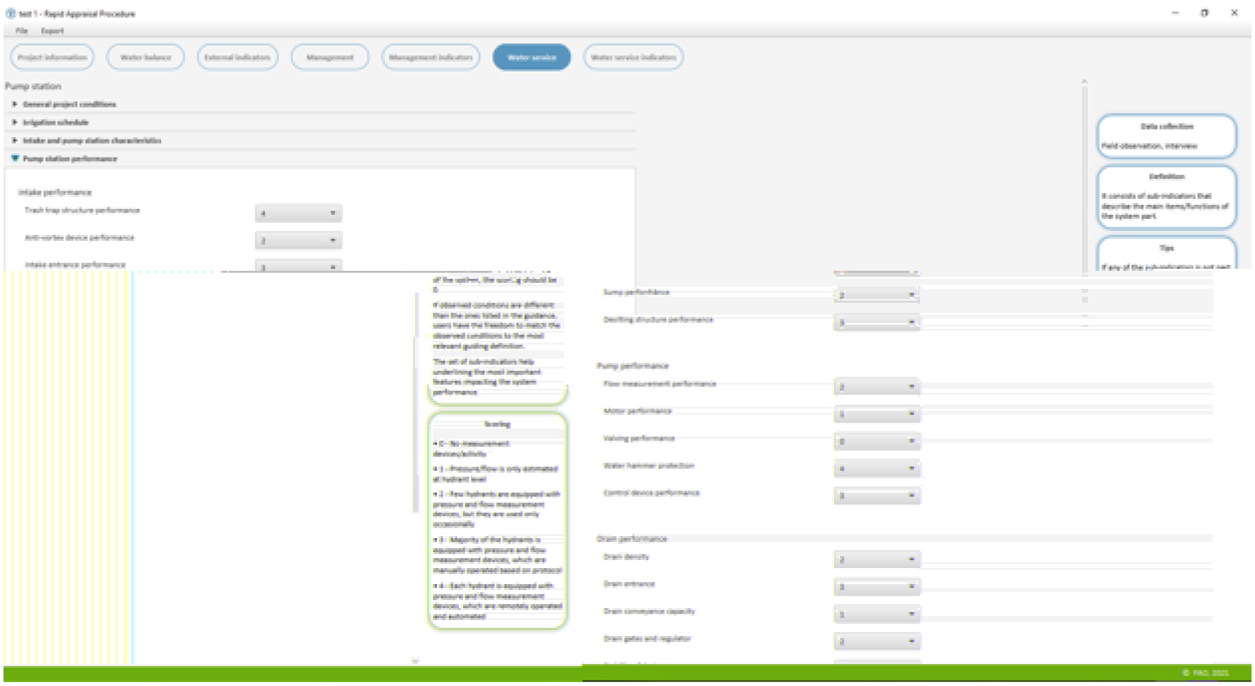
To edit an assessment the application opens the main view. It consists of 7 tabs: "*Project information*", "*Water Balance*", "*External indicators*", "*Management*", "*Management indicators*", "*Water service*", "*Water service indicators*". The ribbon buttons on the top side can be used to navigate through the chapters of the RAP. These buttons are disabled by default and would be enabled when the validation rules of relevant input data are met.

*Figure A3 - 6 Main view of the software*



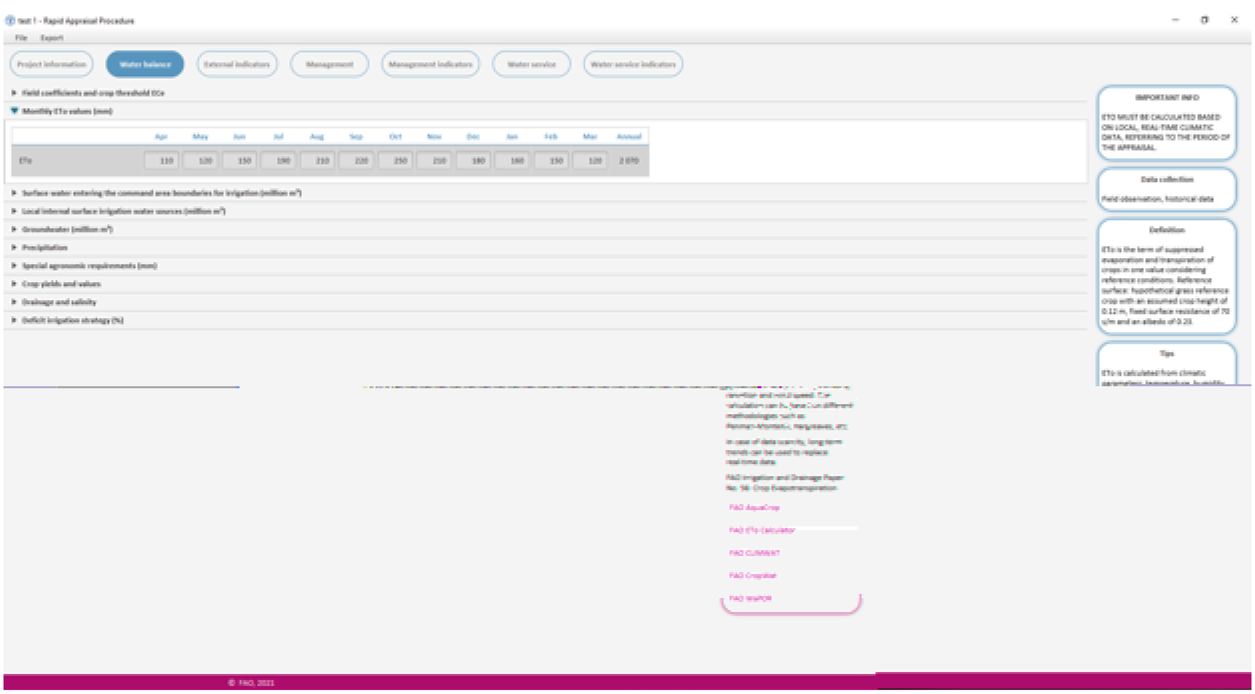

The project information and the input tabs contain standard user interface elements, like text fields, dropdown lists, checkboxes, radio buttons etc. The indicator tabs list the calculated indicator values based on the input data. Closely related indicators are grouped, and certain groups are also visualized to facilitate interpretation of the outcome.

*Figure A3 - 7 Window of assessment page*



While navigating through the different elements of the user interface, guiding information appears in the info box on the right side of the window. Depending on the currently selected element, it may include important information, definition, tips, or any specific information related to that element.

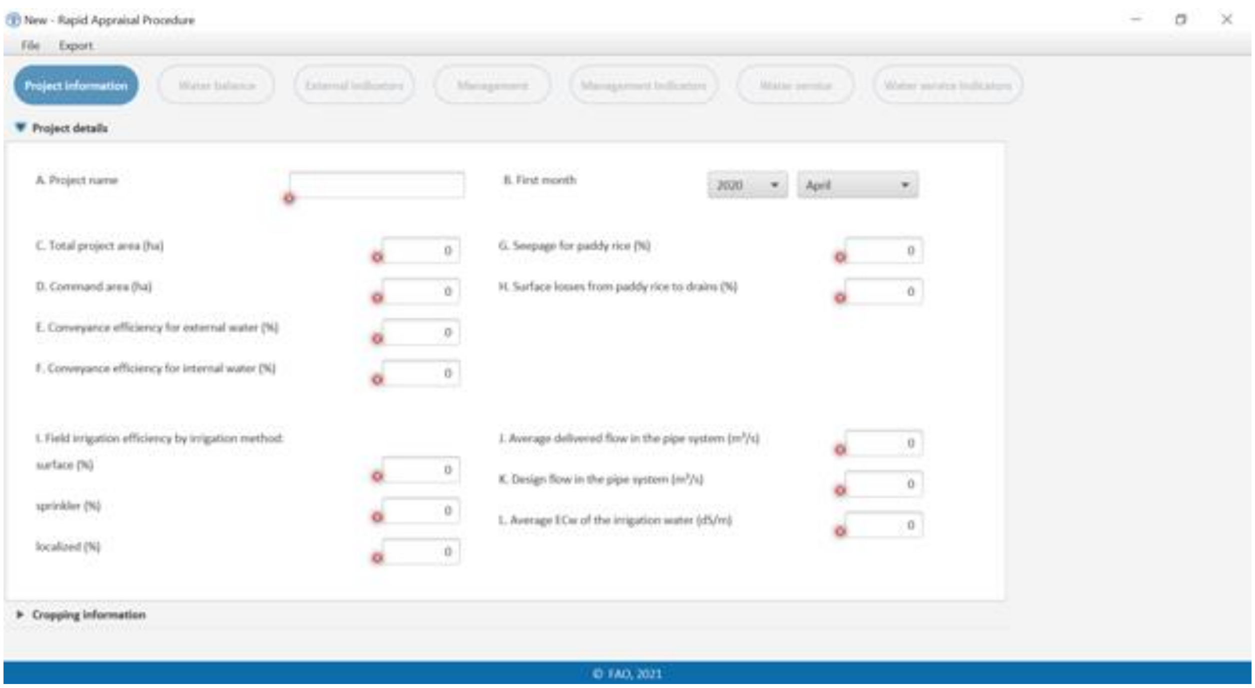
*Figure A3 - 8 Info box for user guidance*



A.1.1.4.2. <u>Input validation</u>

There are different rules that the input data provided by the user needs to fulfill. The validation rules cover cases like when a field is required, or sum of percentage values must be 100 and so on. If a field is failing to match its defined rules, a ⊗ symbol (red dot with cross) is appearing at its bottom-left corner.

*Figure A3 - 9 View of input validation rules*



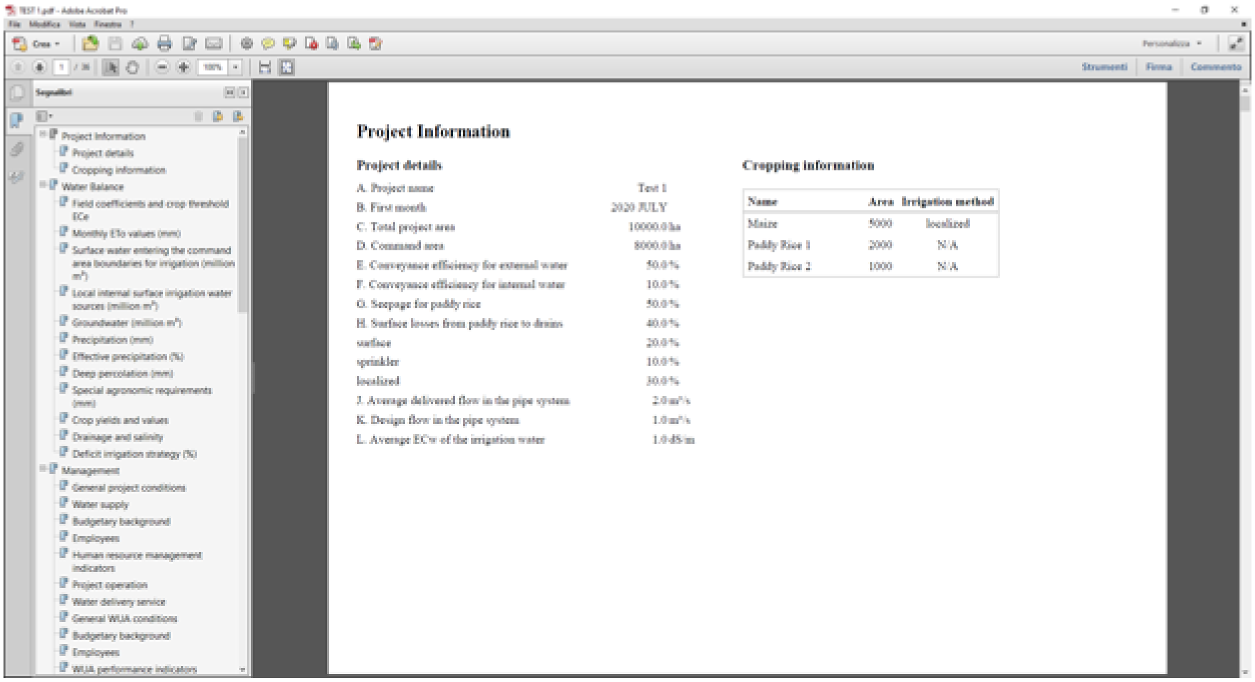

In addition, for text field inputs, it is prevented to enter an invalid or unnatural value. For example, fields containing number of people or percentage accept only integer values. When there are validation errors on a given tab, it may cause other tabs to be inaccessible. To be specific, when new assessment is started, only the project information tab is available. Fulfilling it without error enables the three input tabs, and after each input tab is properly filled, the corresponding indicator tab gets accessible.

A.1.1.4.3. <u>Exporting assessment</u>

In the "*Export*" menu, there are two options to export assessment data into standard digital formats:

- the "*Export to PDF"* option creates a PDF file with all the input and indicator values, but without the visualization artefacts (charts);
- the "*Export charts to images"* creates a compressed (*.zip) file containing all the charts.

*Figure A3 - 10 PDF export of the assessment file*




By default, exported files are created in the “*exported”* folder inside the working directory of the application, however the user can choose any other location.

## A.1.2. About the methodology

Rapid Appraisal Procedure (RAP) for pressurized irrigation system is a diagnostic tool for performance assessment related to water resource, institutional management and irrigation service (hardware and software). It aims at identifying the physical bottlenecks hampering the efficient water delivery. The ultimate goal of RAP is to obtain solid baseline assessment of the performance, against which the results of improvement/rehabilitation/modernization can be measured.

### *A.1.2.1. Application boundaries*

The following parameters describe the application boundaries of RAP for pressurized irrigation system.

1. Irrigation system type: pressurized irrigation system with pipe network from water intakes to final distributaries (hydrants) and drains.

2. Appraisal frame: system-level, not including on-farm irrigation systems.

3. Irrigation system size: small-, medium and large-scale system.

4. Methodology: rapid appraisal to acquire preliminary understanding.

5. Time-horizon: retrospective, covering one-year round operation.

6. Indicative time required: from 1 to 1.5 months (depending on the conditions and complexity of the system, the actual required time can exceed the indicated time frame).

7. Required expertise: solid knowledge related to agricultural engineering, irrigation engineering, water resource management, civil engineering or any related field.

8. Involved stakeholder: 360-degree involvement from end-users, site engineers, experts to management.

#### *A.1.2.2. General workflow*

Three chapters constitute the RAP:

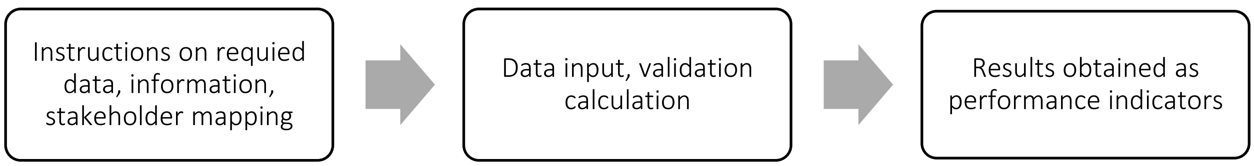
- water balance: appraisal of water resource allocation through water balancing approach between water supply and water demand;
- management (institutional and organizational): assessment of the institutional and organizational mechanism;
- water service: stocktaking of physical water distribution system through the assessment of general characteristics, performance, operation policy, condition and maintenance of physical system components.

The chapters are appraised separately, but some of the questions are overlapping and some of them are transferred from one chapter to another. However, it does not cover more than 10 percent of the questions in overall, thus giving the possibility to conduct both comprehensive and individual analyses of the chapters.

The working mechanism has three major steps:

- The required data and information indicated in the manual must be collected, structured and pre-processed in the right format, unit and scale. Depending on the subject, required information can involve interviews, questionnaires, focus-group discussion, etc. Therefore, the application of RAP requires sufficient time for preparation
- Data input and result generation is the next step of the exercise. The datasets must be correctly inserted, while the automated functions execute the calculation. The calculated data sheets and obtained results are immediately displayed, can be saved and exported.
- RAP results must be framed into the right context. In order to obtain sound baseline study, the results must be interpreted in proper manner, while both respecting the original definitions and considering the local context.

*Figure A3 - 11 Flowchart of calculation mechanism*




Related to each chapter:

- users receive basic instructions to the preparation;
- users receive sets of supporting document and applications;
- users receive information and clarification related the definitions of applied methodologies.

### A.1.3. The structure of the manual

The manual is structured as the following:

- Setting the scene: the section provides ‘virtual journey’ upon arrival to the irrigation scheme together with the recommendations on available tools for preparation.
- RAP chapters: the section is split into the three RAP chapters: water balance, management and water service. Each chapter contains the following sections:
    - Instructions: the section incorporates information related to the required data, preparatory works, involved stakeholders, data units and supporting documents to data acquisition.
    - Input workspace: the section includes clarifications and definitions of the calculation parameter, applied methodologies, data insertion, workflow, possible errors.
    - Definitions: the section includes the definitions of obtained results

The Manual also includes tips to support the assessment. Such tips are developed by case studies and field implementation and included in text boxes.

### A.1.4. Setting the scene

Modern technologies facilitate the acquisition of preliminary information that can support the field work. Global datasets have great potential to obtain data that are not instantly available. A ‘virtual journey’ in the field is strongly recommended in advance to set the scene for the appraisal. Nevertheless, RAP requires micro-data obtained through field observation, so the datasets from global repositories must be validated in the field.

### *A.1.4.1. Geographical location*

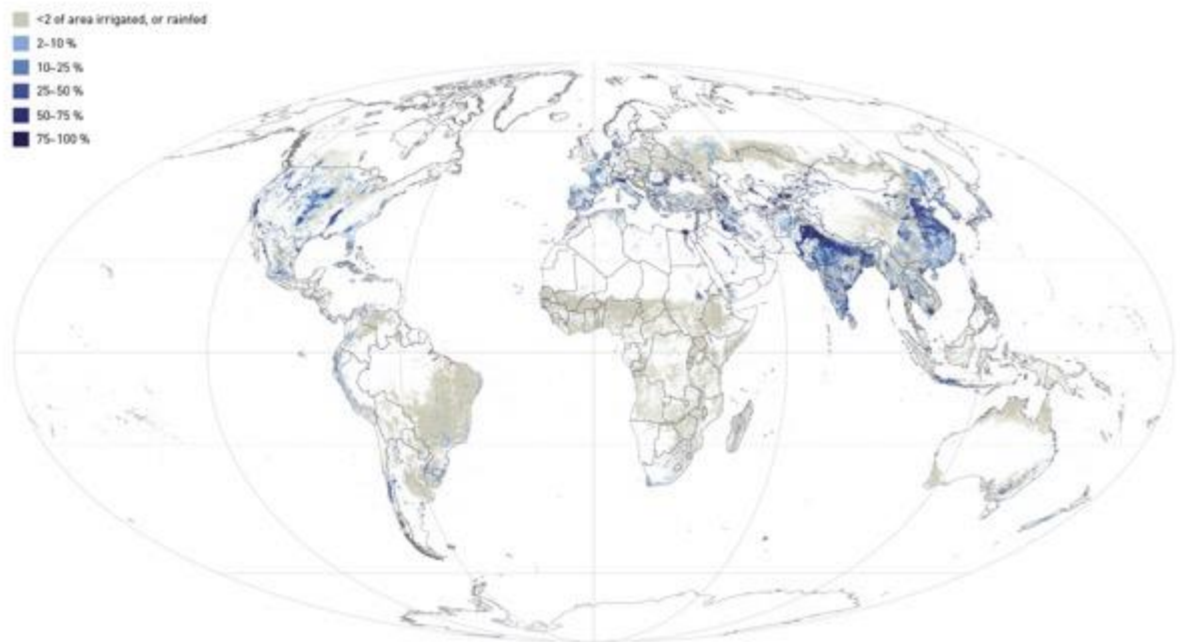
Online maps with high resolution are available, based on which the boundaries and key locations of the irrigation schemes can be identified. Open-access and easy-to-use satellite images are readily available to understand the key geographical features. It is particularly important in a sense that overview about the catchment can provide many clarifications on the water allocation issues, e.g. water resource endowment, topographical constraints.

#### A.1.4.1.1. Example

Google Earth is one of the most frequently used application suitable to a variety of devices (Google Earth, 2021). The application allows to insert paths, polygons, markers and layers. Furthermore, it has function on measuring distances, and calculating elevation.

Global Map of Irrigated Area (GMIA) by FAO is a regularly updated map displaying the area equipped for irrigation in the percentage of the total area on a raster (FAO, 2021). The GMIA involves add-in maps featuring the area equipped for irrigation and actually used for irrigation and the percentages of the area equipped for irrigation from groundwater, surface water or non-conventional sources of water. The maps are compiled from the combination of sub-national irrigation statistics with geospatial information on the position and extent of irrigation schemes. The digital information helps pre-assess the degree of equipped area, as well as the major water sources and actual use of irrigation systems.

*Figure A3 - 12 Area equipped for irrigation as percentage of land area (FAO, 2011)*



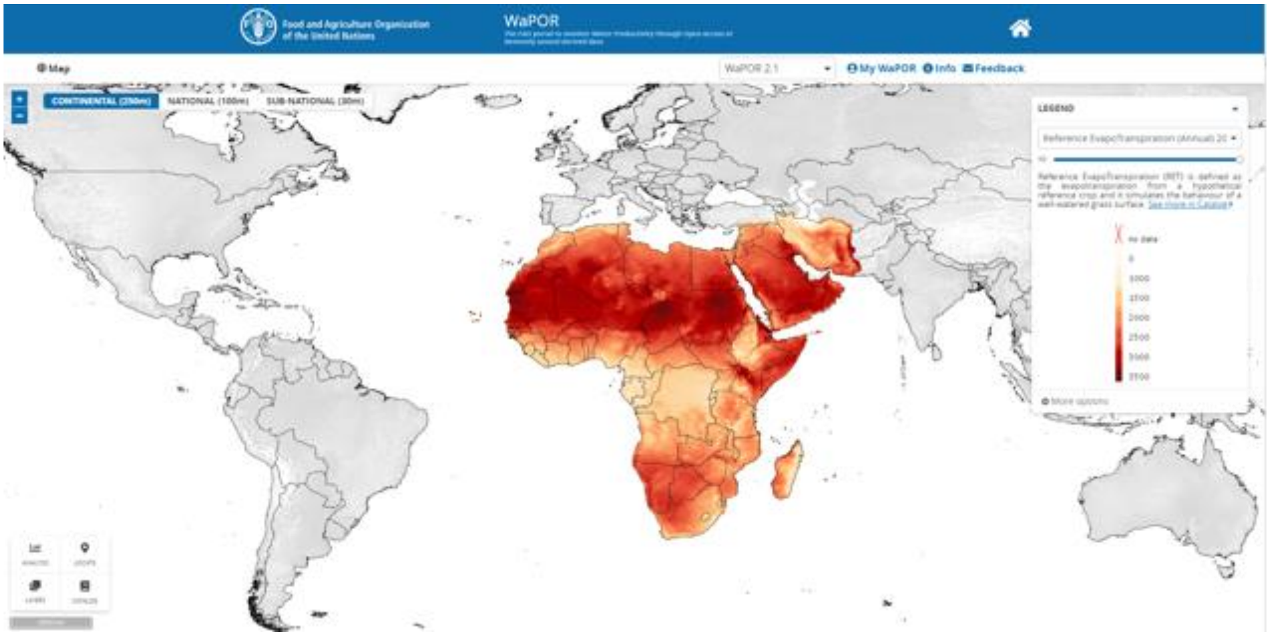

### *A.1.4.2. Climate, vegetation and agricultural water use*

Monitoring of surrounding environment can be done through highly-versatile GIS-based tools. Remote-sensing tools are often available right at sub-national level to provide readily available information regarding to climatic, hydrological, land use and agricultural parameters.

A.1.4.2.1. Example

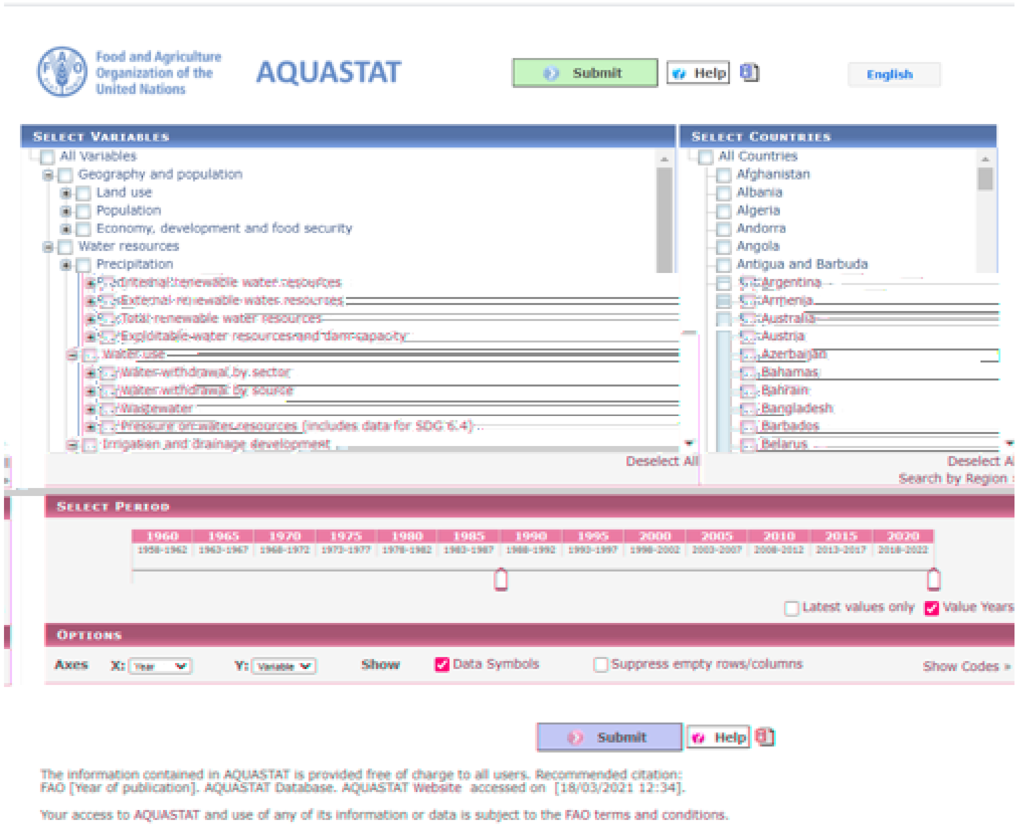
FAO's portal to monitor Water Productivity through Open-access of Remotely sensed data (WAPOR) opens new opportunities in data acquisitions through the application of global datasets (FAO, 2021). It assists countries in monitoring water productivity while providing a set of information related to climate (precipitation, evapotranspiration), vegetation (land cover), biomass production and water productivity. The maps are available in 250, 100 and 30 m spatial resolution, and can be exported in raster files.

*Figure A3 - 13 WaPOR - FAO portal: Annual reference evapotranspiration, source: FAO*




AQUASTAT is the most comprehensive global repository of water related data. The datasets are compiled by experts and frequently updated. AQUASTAT includes data at national-level, which can be utilized to contextualize the irrigation sector and irrigation performance (FAO, 2021).

*Figure A3 - 14 AQUASTAT dataset, source: FAO*



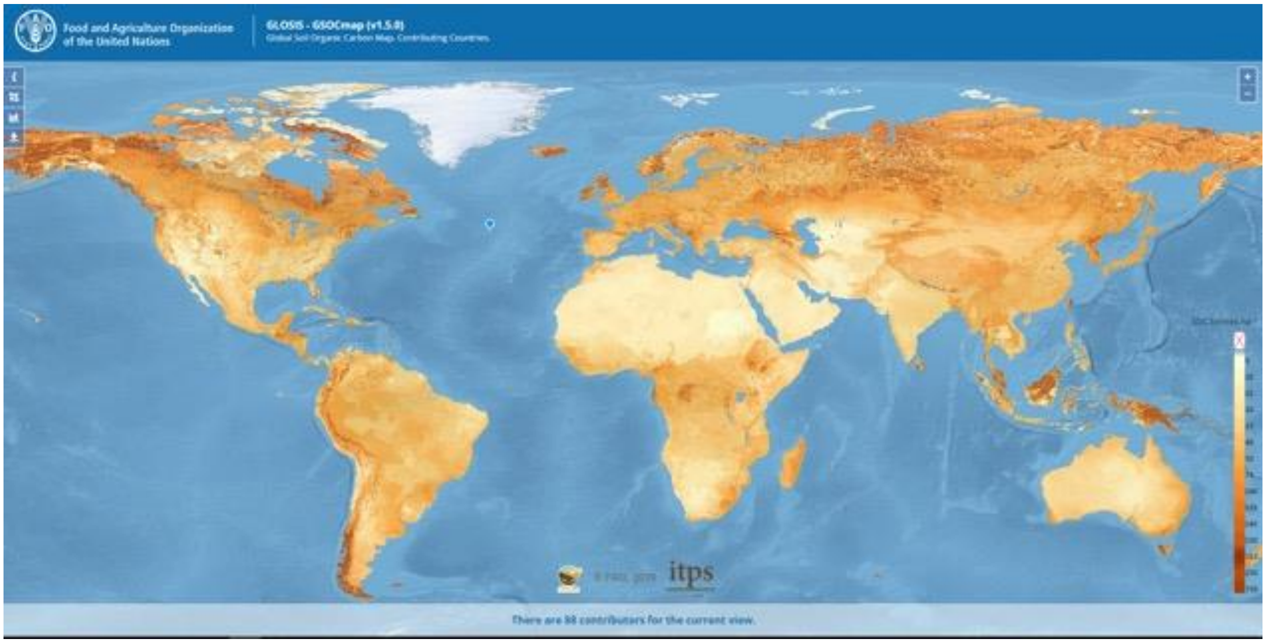

### *A.1.4.3. Soil data*

Irrigation water demand largely depends on land resources. Therefore, information related land and soil is highly desirable to reach accurate estimates related to deep percolation, effective precipitation, root zone depth etc. Although soil analysis requires field work, global statistics are available to obtain information on main characteristics.

#### A.1.4.3.1. <u>Example</u>

FAO provides diverse sets of soil maps including Global Soil Organic Carbon Map, FAO/UNESCO Soil Map of the World, Harmonized world soil database, Regional and National Soil Maps and Databases that contains open-access data for users (FAO, 2021).

*Figure A3 - 15 Global Soil Organic Carbon Map, GLOSIS - GSOCmap (source: FAO 2021)*



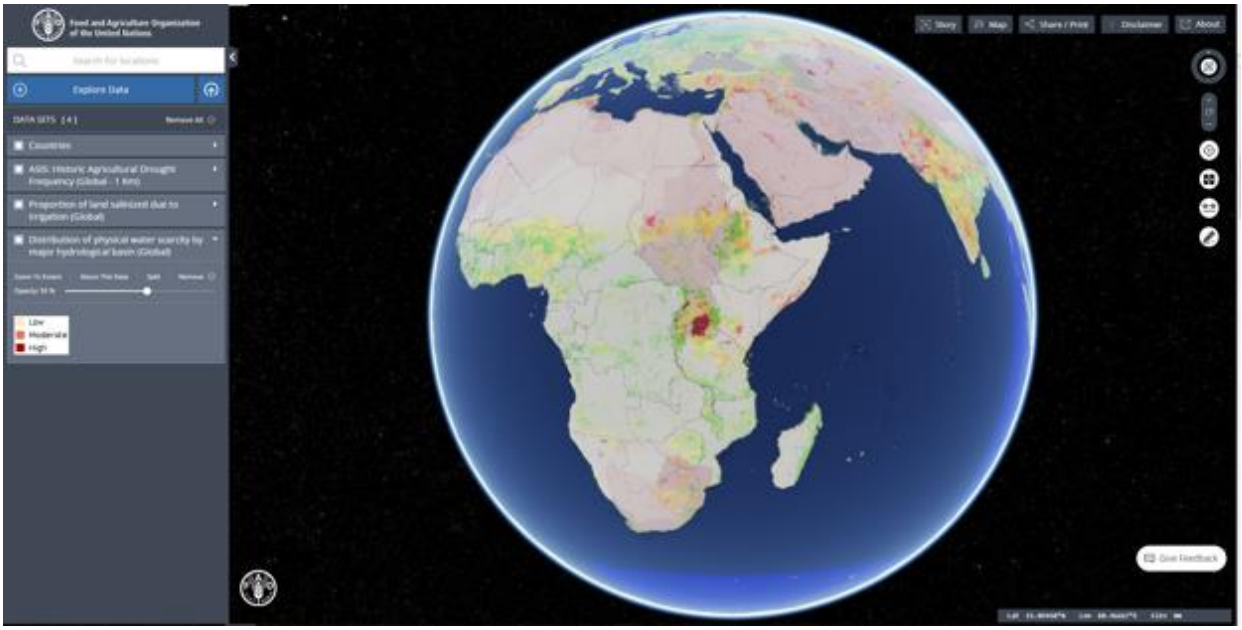

### *A.1.4.4. Global repositories to characterize agriculture and water management*

Integrated global repositories are extremely valuable tools to collect further information in order to characterize the national or sub-national agriculture, water resources and irrigation sectors. National cropping pattern, cropping and harvesting calendar, food prices, registered lands, cadastral parcels, irrigated area ratio, water resource, aridity etc. can be accessed from national and international sources to acquire a rapid overview and retrieve relevant information

#### A.1.4.4.1. <u>Example</u>

FAO Hand-in-Hand Geospatial Platform is designed to host the global datasets and statistics generated by FAO in different fields of sciences (FAO, 2021). The online platform provides open access to all datasets fostered by FAO, such as “Crops”, “Land”, “Water” and “Climate” tabs can directly support the RAP implementation.

*Figure A3 - 16 Hand-in-Hand GIS platform snapshot (source: FAO 2021)*



*A.1.4.5. Synthesis*

Together this initial data collection exercise has multiple function: data acquisition, data validation, data replacement. If in-situ measurements or observations are not available at the time of the appraisal, open-access sources can be used to construct bulk information. Such datasets should be also used to properly frame the baseline assessment and understand the prevailing trends in the irrigation scheme. However, the original scope and scale of RAP is to obtain micro-analysis. Therefore, local data and information have absolute priority throughout the appraisal.

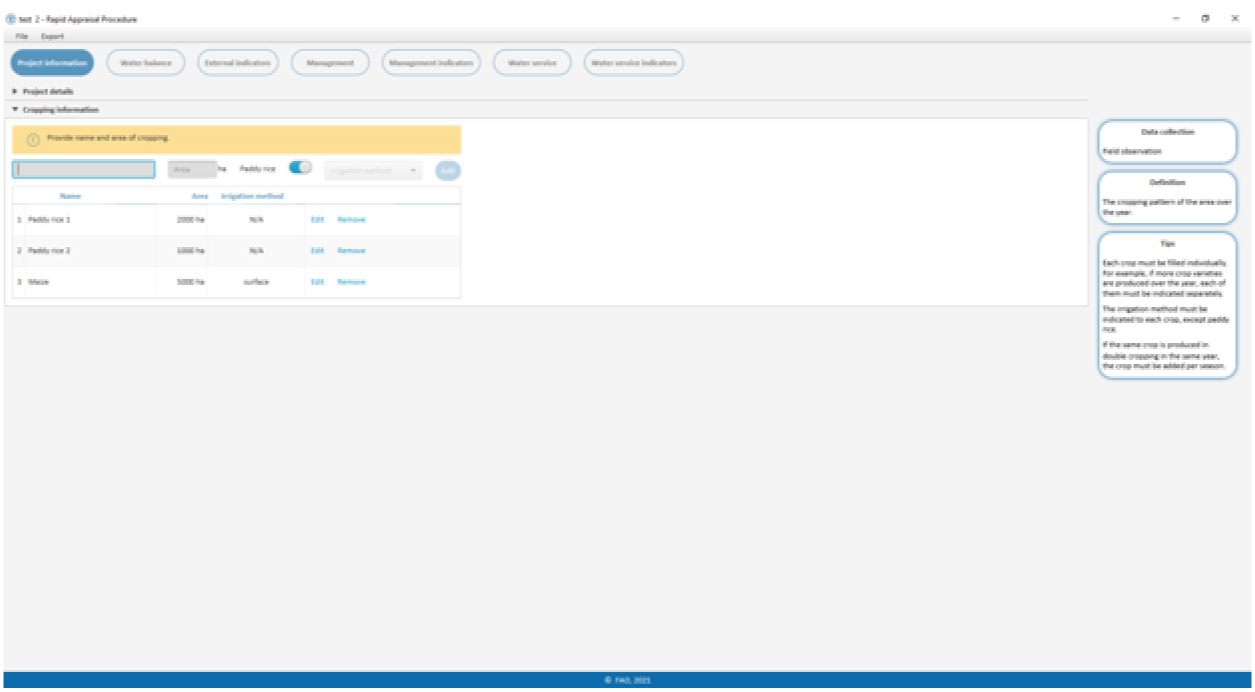
## A.1.5. Appraisal

### *A.1.5.1. Project information*

The project information tab involves the basic information about the irrigation system. It is set to determine the overall boundaries of the irrigation scheme and the basic agricultural information. The tab has two main section:

1. Project details: the overall information about the irrigation scheme include the area, irrigation type, agricultural year and efficiencies of the infrastructure.
2. Cropping information: the cropping pattern is defined per crop type, production area per crop type and irrigation method per crop.

*Figure A3 - 17: Main view of project information window*



The project information determines the basic features, therefore the data inserted into the following chapter must correspond to this. The boundaries of the command area must be defined carefully. A command area can be determined based on different approaches, and the assessment must remain consistent with command areas.

**Box A3-1 The command area selection**

The boundaries of irrigation schemes are often not straightforward. An irrigation scheme can be defined by hydrological, agricultural or administrative boundaries. It is important to be clear with the boundaries in advance. The RAP allows the identification of boundaries via water intakes belonging to the scheme or administration. However, the chapters must be filled accordingly. If the boundaries are based on the hydrological boundaries, the command area might include more management entities or shared management entity. If the boundaries are based on the administrative boundaries, multiple agricultural area can be aggregated and assessed. In case of large area, it is recommended to divide the area to sub-systems and conduct the assessment per sub-system. This will allow for a more accurate assessment and the comparison of performance across sub-systems.

#### A.1.5.1.1. Data input and calculation scheme

The input data should be filled step-by-step starting from project information. Any missing value can hamper the correct calculation. The stepwise guide below provides information on the stepwise data requirement.

Project details:

*Project name*: user defines the name of the project, preferably the name of the irrigation scheme

*First Month:* the first month of irrigation system use or cropping within the year. E.g. if the cropping starts in March, the first month of the water year will be March.

- It usually refers to the beginning of the year-round agricultural season;
- user defines the water/agricultural year when the appraisal is conducted;
- water/agricultural year does not necessary start with January;
- one year can include double season.

*Total project area (ha):*

- the total area of the irrigation scheme including the non-cropped areas, such as inspection roads, yards, infrastructure, etc.;
- arable lands without irrigation facility must be also calculated in the total project area.

*The command area (ha):* the area with irrigation facilities.

- Command area is the net cropped and irrigation area available in a year;
- in case of double cropping (multiple seasons in one calendar year), the area cropped should be calculated only once (e.g. if the arable land is 100 ha, but cropped twice per year, the command area will be 100 ha).

*Conveyance efficiency for external water (%):*

- ratio of delivered external water over external supplied water in percentage;
- the ratio expresses the water loss during transportation. E.g. leaking pipe, water loss at the joints or offtakes etc.;
- conveyance efficiency concerns the infrastructure from water intake until offtakes (deliveries) on the farm.

*Conveyance efficiency for internal project water (%):*

- ratio of delivered internal water over internal supplied water in percentage;
- the ratio expresses the water loss during transportation. E.g. leaking pipe, water loss at the joints or offtakes etc.;
- conveyance efficiency concerns the infrastructure from water intake until offtakes (deliveries) on the farm

*Seepage for paddy rice (%):*

- ratio of water applied over water infiltration from the paddies into the soil;
- the ratio expresses the average loss of water from paddies due to seepage.;
- the seepage information should be filled only if the cropping pattern includes paddy rice.

*Surface losses from paddy rice to drains (%):*

- ratio of water lost as runoff or evaporation from the paddies;
- the ratio expresses the average water loss by runoff and/or evaporation;
- the surface loss should be filled only if the cropping pattern includes paddy rice.

*Field irrigation efficiency by irrigation method (%):*

- ratio of water that can be used by the crop over water delivered to the field, in other words the efficiency of the different on-farm irrigation techniques;
- the ratio expresses the water amount utilized by the crop, including the water loss of deep percolation, runoff, evaporation and other water losses on the field;
- the ratio must be estimated per irrigation technique. Usually, surface irrigation has the lowest efficiency, while localized techniques such as drip has higher field irrigation efficiency;
- the estimates have substantial impact on the crop water requirement. 1) The water loss calculated from the efficiency is considered additional water requirement. Therefore, the less efficient the method, the more extra water requirement. 2) The leaching requirement is calculated as per irrigation method. The leaching requirement of high-frequency irrigation methods differs from the low-frequency methods. Therefore, the accurate estimate of the irrigation efficiency is of utmost importance;

- existing irrigation techniques must be estimated and the field must be filled.

*Average delivered flow ($m^3/s$):*

- the average discharge conveyed through the conveyance system during a usual irrigation event;
- averaged delivered flow can differ from the design discharge defined by the designer.

*Design flow in the pipe system ($m^3/s$):*

- the design discharged defined during the design and implementation phase of irrigation system.

*Average electrical conductivity (ECw) of the irrigation water (dS/m):*

- average value of electrical conductivity of irrigation water during typical irrigation event;
- the value must be determined in due time of irrigation. If historical data is available, the most typical value must be selected during the most frequent irrigation/cropping period;
- the calculation assumes good to excellent quality of water. It is not likely that ECw of irrigation water is higher than the threshold of crop tolerance. This must be taken into consideration while defining ECw.

Cropping information:

*Cropping information:*

- the cropping pattern of the area over the year;
- Each crop type and variety must be filled individually. For example, if more crop varieties are produced over the year, each of them must be indicated separately;
- the irrigation method must be indicated to each crop, except paddy rice.
- if the same crop is produced in double-cropping in the same year, the crop must be added per season.

### *A.1.5.2. Water balance*

The water balance chapter aims at matching the bulk water supply and bulk water demand at system level:

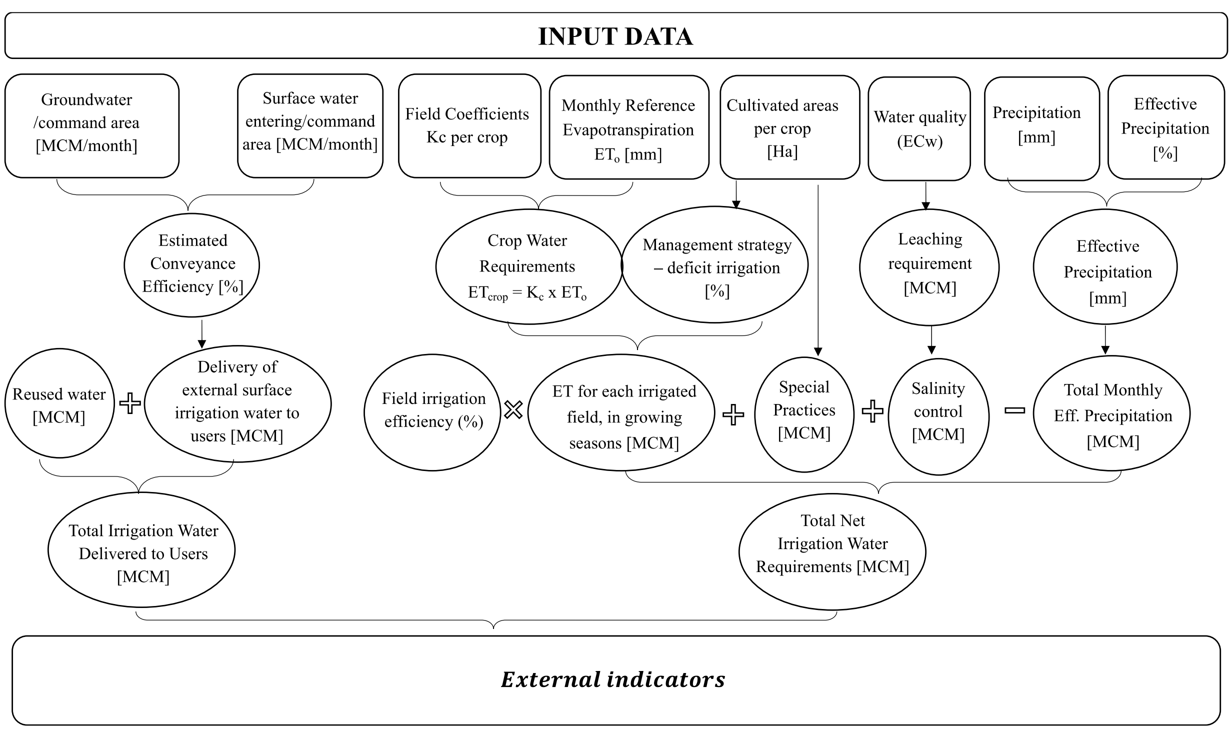
3. Water supply: the surface- and groundwater resources are categorized under "external" and "internal" water resources, depending whether the water enters the command area from outside or it is sourced directly within the command area. Water reuse is considered

as additional water supply (recirculated). The water supply is corrected with conveyance efficiencies.

4. Water demand: water demand is calculated in sequence. ET-based crop water requirement is scaled at command area level, and effective precipitation is subtracted from the net water requirement of command area. In case of deficit irrigation, the crop water requirement can be altered based on the deficit irrigation strategy. Additional water demand is calculated by considering the salinity control and special irrigation practices. The total net irrigation water requirement is corrected by the field irrigation efficiency, depending on the type of on-farm irrigation system.

The main external indicators of the water balance chapter include the obtained ratio of water supply and water demand. Depending on both cases of oversupply and water scarcity, the ratio shows the magnitude of the imbalance between water sources and required water demand.

*Figure A3 - 18 Flowchart of indicator calculation in Water Balance chapter*




## A.1.5.2.1. Preparation of the input file

The water balance chapter builds on one-year-round data related to agriculture, agricultural water, conveyance system and climate. It is recommended to request the available information prior to the field visit. The chapter requires secondary data collection, literature review, historical data and field observation.

*Table A3 - 1 Data input support of Water Balance chapter*

| Required data | Unit | Time-step | Supporting documents | Methodology |
|---|---|---|---|---|
| Agriculture | | | | |
| cropping pattern of the area | ha | year | - | historical data |
| cultivated area size per crop | ha | monthly | - | historical data |
| crop coefficient (Kc) | - | monthly | • FAO Irrigation and Drainage Paper No. 56: Crop Evapotranspiration<br>• FAO Irrigation and drainage paper 66: Crop yield response to water | literature review, historical data, field observation |
| salt tolerance threshold (ECe) | dS/m | year | • FAO Irrigation and Drainage Paper 29: Water quality for agriculture | literature review, historical data |
| special water requirement of the crop | mm | monthly | • FAO Irrigation and drainage paper 66: Crop yield response to water | literature review, historical data, field observation |
| crop yield | tons | season | - | historical data, field observation |
| crop value | local currency | season | - | secondary data, historical data, field observation |
| regulated deficit irrigation strategy | % | monthly | - | historical data, field observation |
| Agricultural water | | | | |
| irrigation water pumped into the command area | million $m^3$ | monthly | - | historical data, field observation |
| other irrigation water entering the command area | million $m^3$ | monthly | - | historical data, field observation |
| direct farmer usage of surface water inside the command area (recirculated water) | million $m^3$ | monthly | - | historical data, field observation |
| project authority usage of surface water inside command area - (recirculated water) | million $m^3$ | monthly | - | historical data, field observation |
| groundwater pumped by farmers inside the command area | million $m^3$ | monthly | - | historical data, field observation |
| groundwater pumped by project authorities inside the command area | million $m^3$ | monthly | - | historical data, field observation |
| groundwater pumped from the aquifer remaining outside the command area | million $m^3$ | monthly | - | historical data, field observation |
| groundwater pumped outside the command area brought into | million $m^3$ | monthly | - | historical data, field observation |
| salinity of the irrigation water | dS/m | monthly | - | historical data, field observation |

| | | | | |
|---|---|---|---|---|
| salinity of the drainage | dS/m | monthly | - | historical data, field observation |
| annual depth to the shallow water table | m | year | - | historical data, field observation |
| change in shallow water table | m | year | - | historical data, field observation |
| Chemical Oxygen Demand (COD) of the irrigation water | mgm/L | year | - | historical data, field observation |
| Chemical Oxygen Demand (COD) of the drain water | mgm/L | year | - | historical data, field observation |
| Biological load (BOD) of the irrigation water | mgm/L | year | - | historical data, field observation |
| Biological load (BOD) of the drain water | mgm/L | year | - | historical data, field observation |
| **Climate** | | | | |
| reference evapotranspiration (ETo) of the command area | mm | monthly | • FAO Irrigation and Drainage Paper No. 56: Crop Evapotranspiration<br>• FAO AquaCrop: http://www.fao.org/land-water/databases-and-software/aquacrop/en/<br>• FAO ETo Calculator: http://www.fao.org/land-water/databases-and-software/eto-calculator/en/<br>• FAO CLIMWAT: http://www.fao.org/land-water/databases-and-software/climwat-for-cropwat/en/<br>• FAO CropWat: http://www.fao.org/land-water/databases-and-software/cropwat/en/<br>• FAO WaPOR: http://www.fao.org/land-water/databases-and-software/wapor/en/ | literature review, secondary data, historical data, field observation |
| precipitation | mm | monthly | • FAO CLIMWAT: http://www.fao.org/land-water/databases-and-software/climwat-for-cropwat/en/<br>• FAO WaPOR: http://www.fao.org/land-water/databases-and-software/wapor/en/ | literature review, secondary data, historical data, field observation |
| rate of effective precipitation (eff.precip) | % | monthly | • FAO Irrigation and Drainage Paper No. 25: Effective rainfall in irrigated agriculture | literature review, historical data, field observation |

| | | | | |
|---|---|---|---|---|
| deep percolation of precipitation | mm | monthly | • FAO Irrigation and Drainage Paper No. 45: Guidelines for designing and evaluating surface irrigation systems<br>• FAO: Irrigation Water Management: Irrigation Water Needs. Training manual no. 3 | literature review, historical data, field observation |
| Conveyance system | | | | |
| estimated conveyance efficiency for external water | % | year | • FAO Irrigation Water Management Training manual: Irrigation Scheduling | field observation |
| estimated conveyance efficiency for internal project well water | % | year | • FAO Irrigation Water Management Training manual: Irrigation Scheduling | field observation |
| estimated seepage for paddy rice | % | year | • FAO Irrigation Water Management Training manual: Irrigation Scheduling | Field observation |
| estimated surface losses from paddy rice to drains | % | year | • FAO Irrigation Water Management Training manual: Irrigation Scheduling | literature review, historical data, field observation |
| estimated field irrigation efficiency for other crops (surface, sprinkler, localized) | % | year | • FAO Irrigation Water Management Training manual: Irrigation Scheduling | literature review, historical data, field observation |
| average delivered flow in the pipe system | m3/s | year | Design, plans, master plans, technical drawings, manufacturer recommendations | Field observation, interview |
| design flow in the pipe system | m3/s | year | Design, plans, master plans, technical drawings, manufacturer recommendations | Field observation, interview |
| external water deep percolating during conveyance | % | year | • FAO Irrigation Water Management Training manual: Irrigation Scheduling | Historical data, field observation |
| delivered water deep percolating on-farm | % | year | • FAO Irrigation Water Management Training manual: Irrigation Scheduling | Historical data, field observation |

### A.1.5.2.2. Involved stakeholders

The chapter is data-intense, therefore, it requires preparation prior to the field visit. The majority of the questions can be filled by historical data collected from the scheme. However, if historical data is not available, expert benchmarking within field visit is required to estimate the values.

The following stakeholders are recommended to be involved:

- project office and scheme management;
- national authority storing relevant data;

- site engineers;
- water user association, irrigation association, farmers' organization etc.

A.1.5.2.3. Requested time

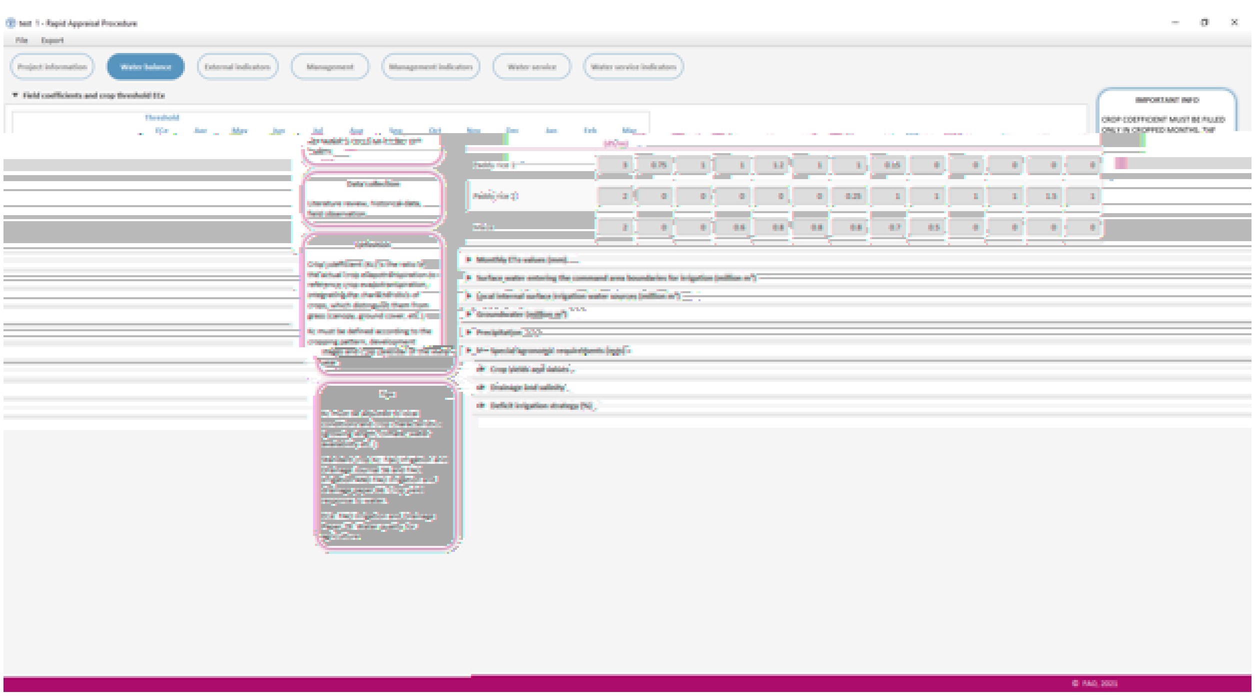
The preparatory works require more-or-less 2 weeks, depending on the scheme size, data availability and complexity of the scheme. If data cannot be obtained within the indicated timeframe, expert benchmarking methods and observation can complement the missing data.

A.1.5.2.4. Data input and calculation scheme

*Crop Coefficient and crop threshold:*

- crop coefficient must be filled only in cropped months, the remaining cells must be left empty;
- crop coefficient (Kc) is the ratio of the actual crop evapotranspiration to reference crop evapotranspiration, integrating the characteristics of crops, which distinguish them from grass (canopy, ground cover, etc.);
- Kc must be defined according to the cropping pattern, development stages and crop calendar of the water year;
- Kc must be adjusted to local conditions and crop characteristics (growing length, climate, water availability etc.);
- threshold of crop salt tolerance to soil salinity (ECe) is the average soil salinity tolerated by the crop and measured as soil saturation extract.

*Figure A3 - 19 Main view of crop coefficient table*



*Monthly reference evapotranspiration values (mm):*

- the reference evapotranspiration (ETo) is the term of suppressed evaporation and transpiration of crops in one value considering reference conditions. The reference surface is hypothetical grass reference crop with an assumed crop height of 0.12 m, fixed surface resistance of 70 s/m and an albedo of 0.23;
- ETo is calculated from climatic parameters: temperature, humidity, radiation and wind speed. The calculation can be based on different methodologies such as Penman-Monteith, Hargreaves, etc.;
- ETo must be calculated based on local climatic data, referring to the period of the appraisal;
- in case of data scarcity, long-term trends can be used to replace the appraisal year data.

*Surface water entering the command area boundaries for irrigation (million m$^3$):*

- the total monthly volume of surface water entering the scheme;
- this refers only to the irrigation water imported into the scheme;
- only the water coming from outside of the irrigation scheme must appear in this table. Such categorization indicates the dependency on external/internal irrigation water source;
- the table is split into varieties of water sourced from outside of the scheme: Irrigation water pumped into the command area from main surface water source, Other irrigation water entering the command area from external source.

*Local internal surface irrigation water sources (million m$^3$):*

- the total monthly volume of local internal surface irrigation water.
- only the water coming from inside of the irrigation scheme must appear in this table. Such categorization indicates the dependency on external/internal irrigation water source.
- the table requires only the volumes related to irrigation water. If the water is stored internally, but not utilized for irrigation water, it should not be considered. For example, reservoir in the command area without conveying water from it should not be calculated as water source.
- the table is split into varieties of local internal surface irrigation water: direct farmer usage of surface water inside the command area, Project authority usage of surface water inside command area

*Groundwater data (million m$^3$):*

- the total monthly volume of groundwater for irrigation;
- the table is split into varieties of groundwater: groundwater pumped by farmers inside the command area, groundwater pumped by the Project Authorities inside the command area, Groundwater pumped from the aquifer remaining outside the command area, Groundwater pumped outside the command area brought into the command area.

- if groundwater abstraction is informal, the amount of withdrawn water should not be indicated here, as it would distort the perception about the sufficiency of irrigation water;
- the table requires the volumes related only to irrigation water.

**Box A3-2 Discharge measurement**

Many irrigation schemes do not apply discharge monitoring. Consequently, discharge history is not available at the time of the appraisal. However, the flow in pressurized irrigation systems is more predictable than in open-canal systems. It is recommended conducting discharge measurement campaign, whereas flow measurement devices are installed both in the pump station and on selected hydrants. Discharge measurement must be conducted both at water intake (pump station) and distribution level (hydrant). Discharge measurement in the pump station must be conducted in a typical irrigation day, when the water level of the water sources is around the average. Consultation with the pump operators helps understand the frequency and duration of irrigation events, thus the estimation of the water supply. Evidence shows if more hydrant operates at the same time and the irrigation schedule is not adjusted to the system configuration, the discharge received is unequal amongst the hydrants. Therefore, it is important to profile the irrigation practices (number of simultaneously operating hydrants, position of hydrants, time of irrigation etc.) and conduct random measurements simultaneously.

*Precipitation (mm):*

- the precipitation refers to the overall precipitation in the command area, referring to the period of the appraisal;
- if precipitation data is not available, the data can be replaced with average long-term trends;
- precipitation value must be filled in each month within and out of the crop calendar;
- effective precipitation (%) is the rate of precipitation that actually reaches the root zone. This is the available amount of precipitation for the plant, expressed in percentage;
- it is not recommended to calculate effective precipitation if the daily rainfall is less than 5 mm. Below 5 mm, the estimated effective precipitation should be 0;
- if it is assumed that the amount of precipitation in the month before cropping is sufficient to maintain the soil moisture, the effective precipitation of last month can be manually added to the first month of the cropping. However, it requires proper calculation to equal the ratio of the next month;
- deep percolation of precipitation (mm) is the amount of precipitation that deep percolates from the root zone into deeper layers. This part of the precipitation is not effective, because it is no longer available to the plant.;
- deep percolation cannot exceed the precipitation minus the effective precipitation together with runoff (calculated from field irrigation efficiency);
- your estimate of external water that deep percolates during conveyance is the water loss from conveyance structure. For example, the deep percolation from unlined canals can

lead to significant water loss. The estimate cannot exceed the total amount of water loss calculated from estimated conveyance efficiency for external water (Project information). For example, if your estimation of conveyance efficiency for external water is 80 %, this value cannot exceed the indicated 20% water loss (100 – estimated conveyance efficiency for external water);
- your estimate of delivered water that deep percolates on-farm is the water loss on the farm due to irrigation inefficiency. The estimate cannot exceed the proportional estimated field irrigation efficiency to cropped area size and the indicated and the proportional seepage for paddy rice to the cropped area size.

*Special Agronomic Requirements (mm):*

- the special agronomic requirement refers to any additional irrigation water need beyond the crop water requirement. Such special requirement can be the pre-wetting of soil to prepare seedbeds, pre-irrigation of paddies, etc.;
- special agronomic requirement must be inserted only in the corresponding months, when the additional water need appears.

*Crop Yields and Values:*

- typical yield is the average yield productivity of crop in tons/ha;
- farmgate selling price refers to the average trigger price received by farmers for 1 ton of harvested crop.

*Drainage and Salinity information:*

- the table includes variety of water quality-related information, whereas average salinity of the irrigation water is already defined in the Project information section;
- the average salinity of the drainage outflow from command area (dS/m) requires time-series of salinity measurement. It is recommended to conduct measurement during or right after irrigation event;
- the average annual depth to the shallow water table (m) requires information about the level of groundwater table or subsurface water. This information has utmost importance to understand the possible cause of salinity, therefore, it should be monitored throughout the year in terms of both frequency and duration;
- the change in the shallow water table depth over the last 5 years, (-) decrease, (+) increase (m) is the deviation from the average depth to both positive and negative depth. If the shallow groundwater table frequently reaches the root zone, it can cause salinity, therefore, it should be monitored throughout the year in terms of both frequency and duration;
- the amount of oxygen equivalents consumed in the chemical oxidation of organic matter. It is an indicator of organic matter of the water. The Chemical Oxygen Demand of the

irrigation water requires water quality measurement. In particular, if the irrigation scheme applies reused water, the information must be carefully evaluated;

- the amount of oxygen equivalents consumed in the chemical oxidation of organic matter. It is an indicator of organic matter of the water. The Chemical Oxygen Demand of the drainage water requires water quality measurement. In particular, if the irrigation scheme applies reused water, the information must be carefully evaluated;
- the amount of oxygen consumed by microorganism to decompose organic matter. The Biological Oxygen Demand of the irrigation water requires water quality measurement. In particular, if the irrigation scheme applies reused water, the information must be carefully evaluated;
- the amount of oxygen consumed by microorganism to decompose organic matter. The Biological Oxygen Demand of the drainage water requires water quality measurement. In particular, if the irrigation scheme applies reused water, the information must be carefully evaluated.

*Deficit irrigation strategy (%):*

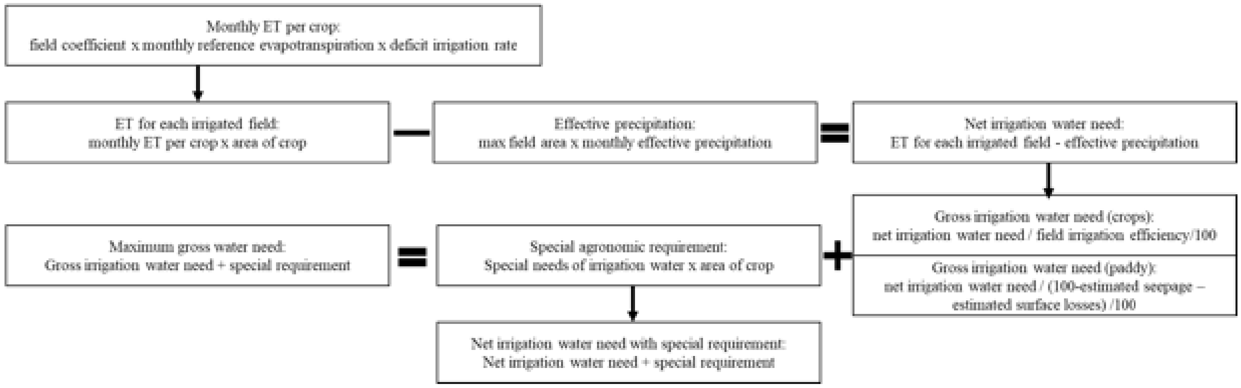
- deficit (or regulated deficit) irrigation is a method to optimize crop water productivity by applying irrigation water during certain growth stages. Deficit irrigation means that the crop is exposed to a certain level of water stress either during a particular period or throughout the whole growing season;
- some of the irrigation scheme hit by water scarcity applied regulated deficit irrigation, whereas crops are exposed to certain level of water stress temporally or throughout the season, which do not entail any/significant yield loss;
- in case of deficit irrigation, only a certain level of crop water requirement is satisfied. The percentage, frequency and duration of regulated deficit irrigation is defined by the management;
- the table requires the rate of satisfied water requirement in percentage. Only those months must be filled, through which the management applies deficit irrigation.

**Box A3-3 Deficit irrigation strategy**

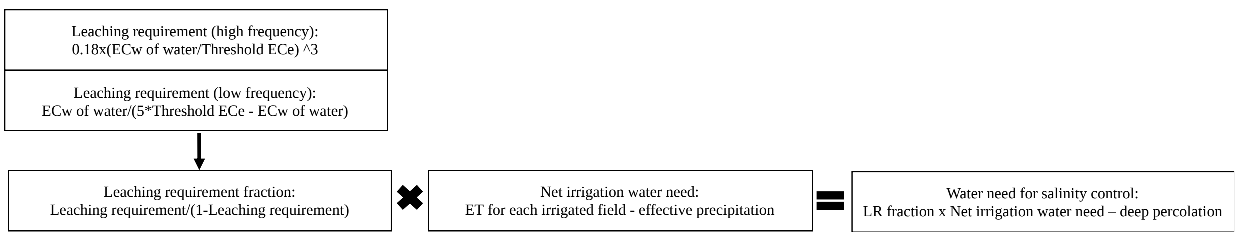
Deficit irrigation strategy must be always considered as a management strategy. In order to create such irrigation plan, the management must know the crop water requirement and understand the yield response to water stress. The regulated deficit must be driven by demand side and not by supply side. If management does not know the crop water requirement, thus the water deficit occurs by insufficient knowledge and poor irrigation practices, it cannot be considered deficit irrigation strategy.

The following stepwise calculation schemes explain how interim and final results are obtained. The charts include the considered equations in workflow.

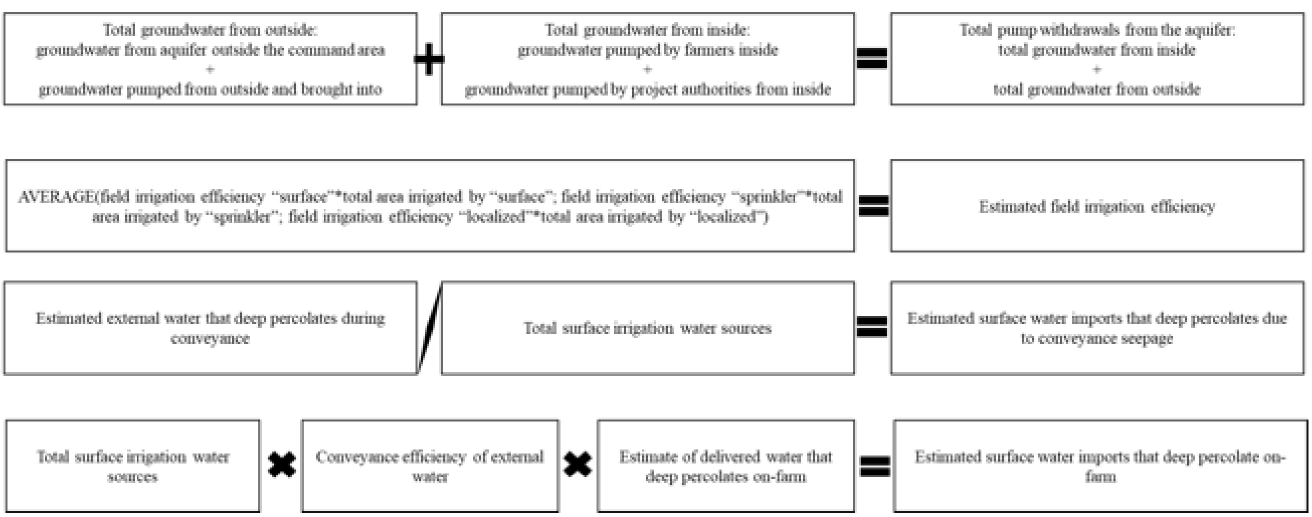
## Crop water requirement calculation

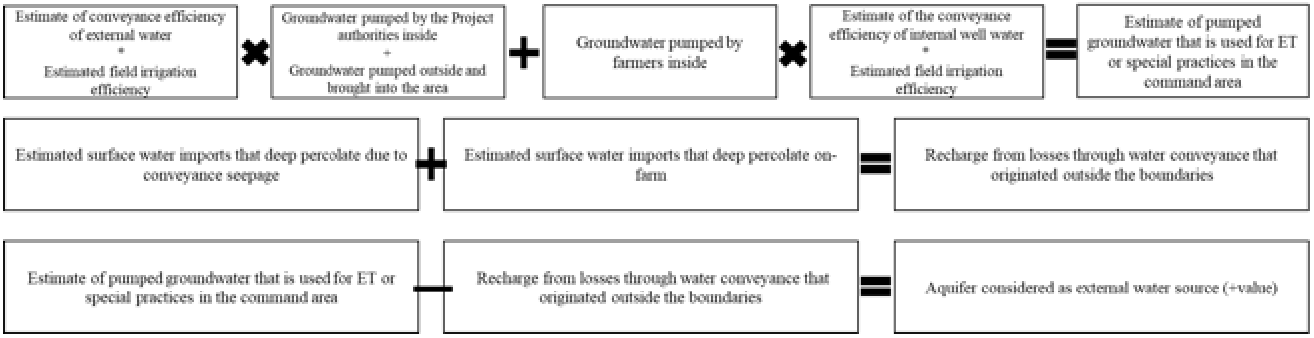



## Water need for salinity control

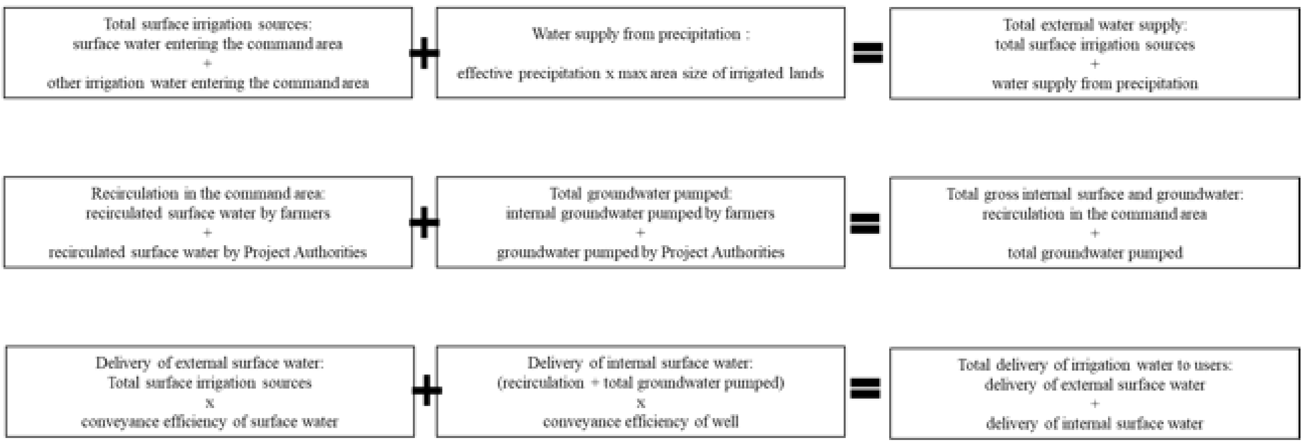



## Groundwater storage and recharge





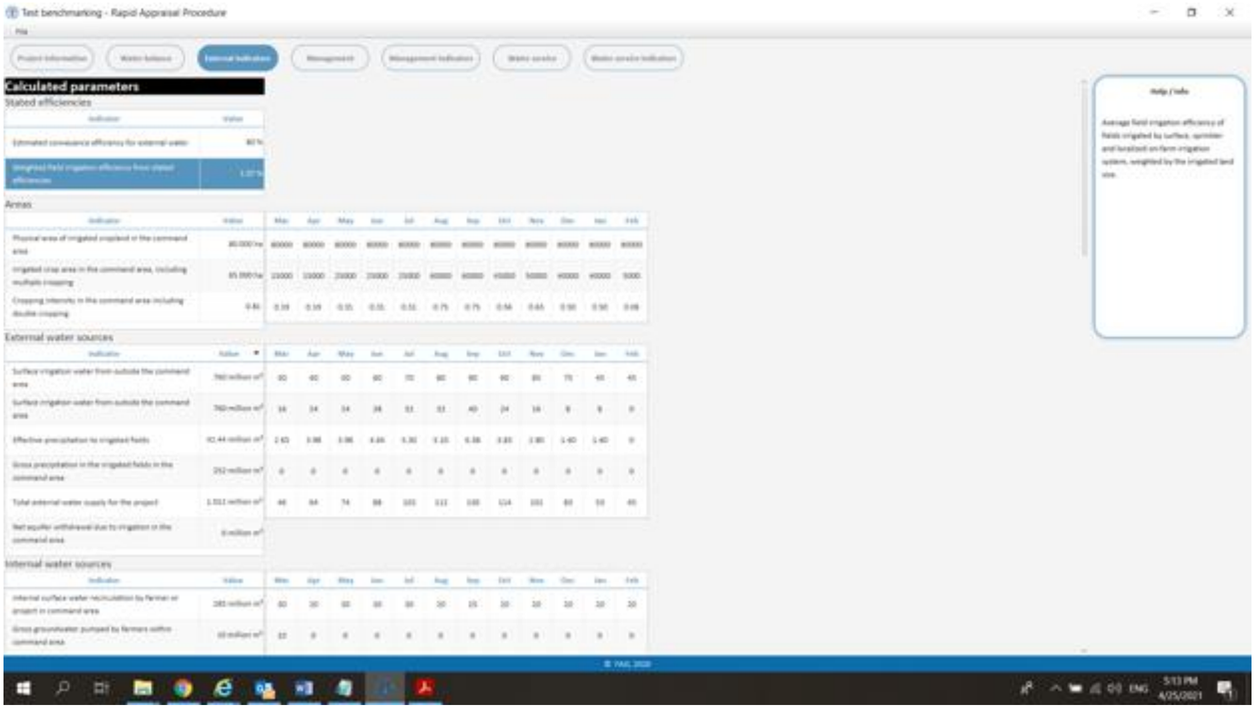

Water supply




### *A.1.5.3. Water balance and External indicators*

The results of Water Balance chapter are summarized in the External indicators. The External indicators express the hydrological performance. If the minimum obligatory information are filled in the input page, the External Indicators button is activated and results are displayed.

*Figure A3 - 20 Main view of the External indicators window*




The External Indicator page includes the summary of calculated parameters, the external indicators and environmental indicators. The calculated parameters are the sub-results and summary of input values. The external indicators are the performance indicators, based on which the appraisal can be interpreted. The environmental indicators are the transferred values from the input sheets, which should be interpreted based on the national requirements, local particularities and the vulnerability to changes in water quality.

*Table A3 - 2 Calculated parameters of External indicators*

| Indicator | Units | Definition |
|---|---|---|
| **Calculated parameters** | | |
| estimated conveyance efficiency for external water | % | Transferred value from “Data input and calculation scheme”:<br>• ratio of delivered external water over external supplied water in percentage;<br>• the ratio expresses the water loss during transportation, e.g. Leaking pipe or leakage at joints are considered water loss;<br>• conveyance efficiency is applied to the infrastructure from water intake until offtakes (deliveries) on the farm. |
| weighted field irrigation efficiency from stated efficiencies | % | Transferred value from “Data input and calculation scheme”:<br>• average field irrigation efficiency of fields irrigated by surface, sprinkler and localized on-farm irrigation system, weighted by the irrigated land size. |

| | | |
|---|---|---|
| physical area of irrigated cropland in the command area | ha | Transferred value from "Data input and calculation scheme":<br>• command area is the net cropped and irrigation area available in a year, regardless the number of crops produced in sequence;<br>• in case of double cropping (multiple seasons in one calendar year), the command area should not be calculated twice. |
| irrigated crop area in the command area, including multiple cropping | ha | Transferred value from "Data input and calculation scheme":<br>• cropped area size including double cropping.<br>• in case of land is used in multiple seasons, the accumulated land size is displayed, e.g. if 200 ha land is cropped two times per year, the irrigated crop area is 400 ha in the year |
| cropping intensity in the command area including double cropping | % | The ratio of irrigated crop area and physical area of irrigation cropland. It shows the utilization rate of the area, the higher the intensity the more utilized the area. Cropping intensity can be increased by double-cropping or intercropping:<br><br>• if 100 percent of available command area is cropped and/or double-cropped, the value is to be =>100 percent;<br>• if less than 100 percent of available command area is cropped and double-cropped areas still do not make up the 100 percent of the available command area, the value is to be =<100 percent. |
| surface irrigation water from outside the command area | million $m^3$ | The indicator expresses the total surface irrigation water entering the area, calculated as the following:<br><br>A+B<br><br>A: Irrigation water pumped into the command area from main surface water source<br>B: Other irrigation water entering the command area from external source |
| gross precipitation in the irrigated fields in the command area | million $m^3$ | The indicator expresses the gross precipitation received by the command area equipped with irrigation facilities, calculated as the following:<br>A*B<br>A: Total precipitation<br>B: Command area with irrigation facilities |
| effective precipitation to irrigated fields | million $m^3$ | The indicator expresses the effective part of precipitation in the cropped area. This indicator is different from the gross precipitation in the irrigated fields, because it measures only the effective precipitation in the cropped area. Cropped area does not necessarily correspond to the command area, as farmers can decide to set aside a portion of land. The indicator considers only the potential fraction of precipitation utilized by the crops in the water year, calculated as the following:<br><br>A*B<br><br>A: Maximum field area of crops<br>B: Effective precipitation |
| net aquifer withdrawal due to irrigation in the command area | million $m^3$ | The indicator expresses the difference between pumped groundwater used for irrigation and recharge from water conveyance losses. The aquifer recharge from conveyance loss is expected to be low, as pipes have normally very low water loss. However, if earth reservoir or water tank exist in the irrigation scheme, it can result substantial recharge. The indicator is calculated only if the groundwater recharge is sufficient to supply water for irrigation, calculated as the following:<br>A – B<br><br>IF(A>B) → A-B; otherwise=0<br><br>A: Estimate of pumped groundwater used for ET or special practices<br>B. Recharge from losses through water conveyance outside the boundaries |

| | | |
|---|---|---|
| total external water supply for the project | million $m^3$ | The indicator expresses the total amount of water from outside of the irrigation scheme, and the gross precipitation in the area, calculated as the following:<br><br>A+B+C<br><br>A: Surface irrigation water from outside the command area<br>B: Gross precipitation in the irrigated fields in the command area<br>C: Net Aquifer withdrawal due to the irrigation in the command area |
| total external irrigation supply for the project | million $m^3$ | The indicator expresses the total amount of irrigation water from outside of the irrigation scheme. Unlike the total external water supply, this indicator does not include the precipitation, so it indicated the sufficiency of water supply without rain, calculated as the following:<br><br>A+B<br><br>A: Surface irrigation water from outside the command area<br>B: Net Aquifer withdrawal due to the irrigation in the command area |
| internal surface water recirculation by farmer or project in command area | million $m^3$ | The indicator expresses the total recirculated water by farmers and project authorities, calculated as the following:<br><br>A+B<br><br>A: Direct farmer usage of surface water inside the command area/recirculated<br>B: Project Authority usage of surface water inside command area/recirculated |
| gross groundwater pumped by farmers within command area | million $m^3$ | Transferred value from "Data input and calculation scheme". It is equal to the groundwater pumped by farmers inside the command area. |
| groundwater pumped by project authorities and applied to the command area | million $m^3$ | Transferred value from "Data input and calculation scheme". It is equal to the groundwater pumped by the project authorities inside the command area. |
| total groundwater pumped and dedicated to the command area | million $m^3$ | The indicator expresses the total groundwater pumped by farmers and project authorities, calculated as the following:<br><br>A+B<br><br>A: Gross groundwater pumped by farmers within command area<br>B: Groundwater pumped by project authorities and applied to the command area |
| groundwater pumped by project authorities and applied to the command area, minus net groundwater withdrawal | million $m^3$ | The indicator expresses the difference of total groundwater pumped by project authorities and net aquifer contribution, calculated as the following:<br><br>A – B<br><br>A: Groundwater pumped by project authorities and applied to the command area<br>B: Net aquifer withdrawal due to irrigation in the command area |
| estimated total gross internal surface water and groundwater | million $m^3$ | The indicator expresses the total amount of internal surface and groundwater including recirculated and groundwater by both farmers and Project Authorities, calculated as the following:<br>A+B+C<br><br>A: Internal surface water recirculation by farmer or project in command area<br>B: Gross groundwater pumped by farmers within command area<br>C: Groundwater pumped by project authorities and applied to the command area, minus net groundwater withdrawal |

| | | |
|---|---|---|
| conveyance efficiency of internal water sources stated by internal authority | % | Transferred value from "Data input and calculation scheme":<br>• this estimated ratio of delivered internal water over internal supplied water in percentage;<br>• the ratio expresses the water loss during transportation. E.g. leaking pipe or offtakes are considered as water loss;<br>• conveyance efficiency concerns the infrastructure from water intake until offtakes (deliveries) on the farm. |
| gross total annual volume of project authority irrigation supply | million $m^3$ | The indicator expresses the total amount of external and internal water supplied – but not yet delivered – by the project authority to the users including surface water, groundwater and recirculated water, calculated as the following:<br><br>A+B+C<br><br>A: Groundwater pumped by project authorities and applied to the command area, minus net groundwater withdrawal<br>B: Surface irrigation water from outside the command area<br>C: Project Authority usage of surface water inside command area |
| delivery of external surface irrigation water to users - using stated conveyance efficiency | million $m^3$ | The indicator expresses the delivered external water amount to users through correcting total supplied external water by conveyance efficiency, calculated as the following:<br><br>A*B<br><br>A: Surface irrigation water from outside the command area<br>B: Conveyance efficiency for external water |
| all other irrigation water to users | million $m^3$ | The indicator expresses all other delivered irrigation water to users including internal water and groundwater (recirculated and groundwater) corrected by conveyance efficiency for internal water, calculated as the following:<br><br>A+B+(C*D)+(E*F)+(G*D)<br><br>A: Gross groundwater pumped by farmers within command area<br>B: Direct farmer usage of surface water inside the command area<br>C: Project Authority usage of surface water inside command area<br>D: Conveyance efficiency for internal recirculation<br>E: Groundwater pumped from outside the command area<br>F: Conveyance efficiency for external water<br>G: Groundwater pumped inside the command area |
| total irrigation water deliveries to users, reduced for conveyance efficiencies | million $m^3$ | The indicator expresses total delivered irrigation water including external and internal water sources excluding conveyance losses, calculated as the following:<br><br>A+B<br><br>A: Delivery of external surface irrigation water to users corrected by conveyance efficiency<br>B: All other irrigation water to users |
| total irrigation water (internal plus external) as intermediate value | million $m^3$ | The indicator expresses total irrigation water supply external and internal water sources, calculated as the following:<br><br>A+B<br><br>A: Estimated total gross internal surface water and groundwater<br>B: Total external irrigation supply for the project |
| overall conveyance efficiency of project authority delivered water | % | The indicator expresses the aggregated conveyance efficiency of both external and internal water at system level |

| | | |
|---|---|---|
| average delivered flow in the pipe system | $m^3/s$ | Transferred value from "Data input and calculation scheme":<br>• the average discharge conveyed through the conveyance system during an average irrigation event;<br>• averaged delivered flow can differ from the design discharge defined by the designer. |
| design flow in the pipe system | $m^3/s$ | Transferred value from "Data input and calculation scheme":<br>• the design discharged defined during the design and implementation phase of irrigation system. |
| ET of irrigated fields in the command area | million $m^3$ | The indicator expresses the total ET-based irrigation requirement of the cropped command area, not considering effective precipitation. |
| ET of irrigation water in the command area | million $m^3$ | The indicator expresses the total ET-based irrigation requirement of the cropped command area reduced by the effective precipitation. |
| irrigation water needed for salinity control | million $m^3$ | The indicator expresses the total irrigation water need for leaching requirement to control salinity based on salinity of irrigation water and threshold of crop salt tolerance in the cropped command area. |
| irrigation water needed for special practices | million $m^3$ | The indicator expresses the total irrigation water need for special practices in the cropped command area. |
| total net irrigation water requirements | million $m^3$ | The indicator expresses the total irrigation water need reduced by the effective precipitation, calculated as the following:<br>A+B+C<br><br>A: ET of irrigation water in the command area<br>B: Irrigation water needed for salinity control<br>C: Irrigation water needed for special practices |
| External Indicators | | |
| peak net irrigation requirement for field, including any special requirements | $m^3/s$ | The indicator expresses the required aggregated discharge in peak water requirement in the cropped command area. |
| design discharge of irrigation water flows per hectare | l/s | The indicator expresses the required discharge in peak water requirement per hectare. |
| relative water supply for the irrigated part of the command area (RWS) | none | Ratio of total external water supply of the project over total net irrigation water requirement. The net irrigation water requirement includes ET-based water requirement, water requirement for special practices and water requirement for salinity control, reduced by effective precipitation |
| annual command area irrigation efficiency (ACAIE) | % | Rate of total net irrigation water requirement (including ET-based water requirement, water requirement for special practices and water requirement for salinity control, reduced by effective precipitation) over surface irrigation water from outside the command area and net aquifer withdrawal:<br><br>• the indicator matches the effective water supply from outside the command area and the net irrigation requirement. However, this indicator is not reduced by the conveyance losses. Therefore, it can be considered a baseline value for optimal conveyance conditions;<br>• the larger the deviation from 100 percent the larger the imbalance. Values close to 100 percent indicates the better performance. |
| field irrigation efficiency (FIE) | % | Rate of total net irrigation water requirement (including ET-based water requirement, water requirement for special practices and water requirement for |

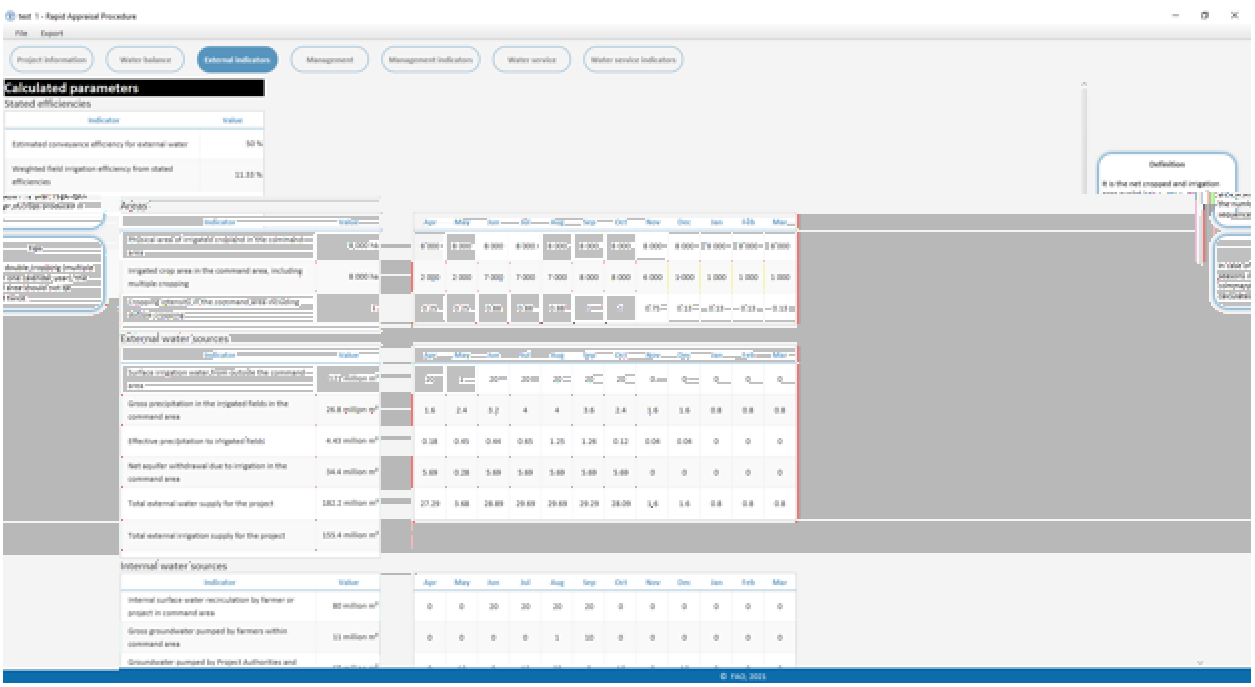
<table>
<tr><td></td><td></td><td>salinity control, reduced by effective precipitation) and total delivered water (external and internal surface and groundwater resources corrected by conveyance efficiency):<ul><li>the indicator expresses the sufficiency of delivered water amount to meet net irrigation water requirement that is reduced by effective precipitation;</li><li>the indicator is dynamic. If water oversupply occurs, the total net irrigation water requirement is measured over the total delivered water. If water scarcity occurs, the total delivered water is measured over total net irrigation water requirement. Negative sign (-) indicates water scarcity, while positive value indicates water oversupply or overall balance (100%);</li><li>the larger the deviation from 100 percent the larger the imbalance. Values close to 100 percent indicates the better performance.</li></ul></td></tr>
<tr><td>relative actual flow (RAF)</td><td>None</td><td>The ratio of average delivered flow in the pipe system over the required discharge for in case of peak net irrigation requirement for field:<ul><li>the ratio shows the balance between maximum required discharge and average supplied discharge in case of continuous flow;</li><li>the ratio matches the requirement with the actual supply, thus pinpointing the sufficiency of average discharge to meet required discharge;</li><li>this ratio is a benchmarking value to be compared with Relative System Capacity (RAF). It shows the difference between actual and design flow. The larger the difference, the larger the decline in performance.</li></ul></td></tr>
<tr><td>relative system capacity (RSC)</td><td>None</td><td>The ratio design flow in the pipe system over the required discharge for in case of peak net irrigation requirement for field:<ul><li>the ratio shows the balance between maximum required discharge and design discharge in case of continuous flow;</li><li>the ratio matches the requirement with the design capacity, thus pinpointing the potential capacity gaps of the default system design.</li></ul></td></tr>
<tr><td>peak gross irrigation requirement, including all inefficiencies</td><td>$m^3/s$</td><td>The indicator expresses the required aggregated discharge including the expected conveyance losses.</td></tr>
<tr><td>total annual value of agricultural production (TAVAP)</td><td>USD</td><td>The indicator expresses the total generated revenue of agricultural production in the command area in the given year.</td></tr>
<tr><td>unit annual value of agricultural production (UAVAP)</td><td>USD/ ha</td><td>The indicator expresses the average revenue generation per hectare in the given year.</td></tr>
<tr><td colspan="3">Environmental indicators</td></tr>
<tr><td>average salinity of the irrigation supply</td><td>dS/m</td><td>Transferred value from “Data input and calculation scheme”:<ul><li>average value of electrical conductivity of irrigation water during typical irrigation event;</li><li>the value must be determined in due time of irrigation. If historical data is available, the most typical value must be selected during the most frequent irrigation/cropping period;</li></ul></td></tr>
</table>

| | | |
|---|---|---|
| | | • the calculation assumes good to excellent quality of water. It is not likely that ECw of irrigation water is higher than the threshold of crop tolerance. This must be taken into consideration while defining ECw;<br>• the indicator must be assessed in the context of the crop salt tolerance, the water supply amount, the climate and soil type. |
| average salinity of the drainage water | dS/m | Transferred value from "Data input and calculation scheme":<br>• the Average salinity of the drainage outflow from command area (dS/m) requires time-series of salinity measurement. It is recommended to conduct measurement during or right after irrigation event;<br>• the indicator must be assessed in the context of the crop salt tolerance, the water supply amount, the climate and soil type. |
| average BOD of the irrigation supply (biological) | mgm/ liter | Transferred value from "Data input and calculation scheme":<br>• the Biological Oxygen Demand of the irrigation water requires water quality measurement. In particular, if the irrigation scheme applies reused water, the information has utmost importance;<br>• the BOD value must be assessed in the context of the national regulations on water quality. |
| average BOD of the drainage water (biological) | mgm/ liter | Transferred value from "Data input and calculation scheme":<br>• the Biological Oxygen Demand of the drainage water requires water quality measurement. In particular, if the irrigation scheme applies reused water, the information has utmost importance;<br>• the BOD value must be assessed in the context of the national regulations on water quality. |
| average COD of the irrigation supply (chemical) | mgm/ liter | Transferred value from "Data input and calculation scheme":<br>• the Chemical Oxygen Demand of the irrigation water requires water quality measurement. In particular, if the irrigation scheme applies reused water, the information has utmost importance;<br>• the COD value must be assessed in the context of the national regulations on water quality. |
| average COD of the drainage water (chemical) | mgm/ liter | Transferred value from "Data input and calculation scheme":<br>• the Chemical Oxygen Demand of the drainage water requires water quality measurement. In particular, if the irrigation scheme applies reused water, the information has utmost importance;<br>• the COD value must be assessed in the context of the national regulations on water quality. |
| average depth to the shallow water table | m | Transferred value from "Data input and calculation scheme":<br>• the Average annual depth to the shallow water table (m) requires information about the level of groundwater table or subsurface water. This information has utmost importance to understand the possible cause of salinity, therefore, it should be monitored throughout the year in terms of both frequency and duration. |
| change in shallow water table depth over last 5 years | m | Transferred value from "Data input and calculation scheme":<br>• the Change in the shallow water table depth over the last 5 years, (-) decrease, (+) increase (m) is the deviation from the average depth to both positive and negative depth. If the shallow groundwater table frequently reaches the rootzone, it can cause salinity, therefore, it |

| | | |
|---|---|---|
| | | should be monitored throughout the year in terms of both frequency and duration. |

Analysis of aggregated annual indicators would be misleading as off-season water supply compensates the water deficit in critical vegetation period. To better understand and appraise the indicators, the results are displayed in monthly breakdown.

*Figure A3 - 21 View of disaggregated results of the External indicators*



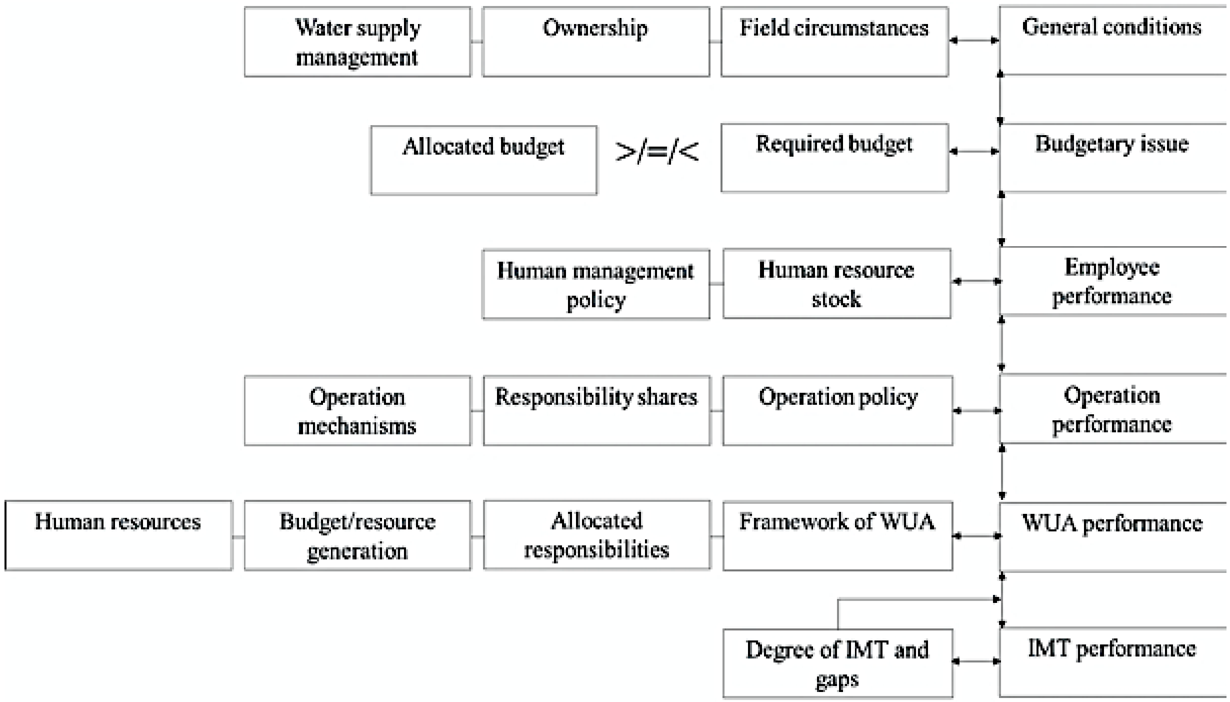

## *A.1.5.4. Management*

The management chapter aims at introducing the institutional setting of the irrigation scheme layered into two interdependent management levels:

1. Project management: the sub-chapter refers to the authority level of public investment in irrigation system construction, implementation, development and operation and maintenance. Usually, project management is assigned to state authorities that are responsible for overall management of the "project", whereas project indicates the establishment, operation and maintenance, and development of public irrigation scheme.
2. Water User Association: the sub-chapter refers to the co-management of the irrigation system, whereas farmers or farmers' representatives are involved into management. The WUA is considered as autonomous authority but working closely with or complementing the project authority.

The chapter structure differs from the Water Balance chapter, as it provides a “catchall” list of different management perspectives. The list of input data serves as systematic stocktaking of relevant information describing and characterizing the efficiency of institutional management.

*Figure A3 - 22 Flowchart of the Management chapter*




A.1.5.4.1. Preparation of the input file

The management chapter builds on the characteristics and information related institutional managements including general institutional settings, budgetary issues, employment, operation performance, WUA performance and degree of irrigation management transfer. It is recommended to share the data requirement and survey with relevant institutions in advance. This can facilitate the data collection before arriving to the management office. The chapter requires secondary data collection, screening official records, interviews and expert observation.

*Table A3 - 3 Data input support of Management chapter*

| Required data | Unit | Time-step | Data source/ Supporting institute | Methodology |
|---|---|---|---|---|
| **General Project Conditions/Management** | | | | |
| average net farm size | ha | annual average | project office | secondary data, field observation, interview |

| | | | | |
|---|---|---|---|---|
| number of water users | - | annual average | project office | secondary data, field observation, interview |
| typical field size | ha | annual average | project office | secondary data, field observation, interview |
| number of offtakes (hydrants) that are physically operated by paid employees | - | - | project office | secondary data, field observation, interview |
| land consolidation exists on % of the project area | % | - | project office | secondary data, field observation, interview |
| share of drinking water in pumped water supplies in the project area | % | - | project office | secondary data, field observation, interview |
| ownership of land | % | - | project office | secondary data, field observation, interview |
| field irrigation description | % | - | - | field observation |
| Water supply/Management | | | | |
| water source | - | - | project office | secondary data, field observation, interview |
| live Storage Capacity of reservoir | million $m^3$ | annual | project office | secondary data, field observation, interview |
| times per year when majority of system is shut down without water | - | annual | project office | secondary data, field observation, interview |
| typical total annual duration of pressurized system shutdown | days | annual average | project office | secondary data, field observation, interview |
| volume of gross irrigation water officially allocated to the project | million $m^3$ | annual | project office | secondary data, field observation, interview |
| maximum flow rate officially allocated to the project | $m^3/s$ | - | project office | secondary data, field observation, interview |

| | | | | |
|---|---|---|---|---|
| Budgetary background/Management | | | | |
| land ownership | - | - | project office | secondary data, interview |
| annual actual budget | local currency/year | 5 years average | project office | secondary data, interview |
| budget sources | % | 5 years average | project office | secondary data, interview |
| annual required budget | local currency/year | 5 years average | project office | secondary data, interview |
| Employees/Management | | | | |
| number of employees | - | annual average | project office | secondary data, interview |
| average years a typical professional employee works for the project | - | annual average | project office | secondary data, interview |
| operation staff number in the field | - | annual average | project office | secondary data, interview |
| salaries | local currency/year | 5 years average | project office | secondary data, interview |
| visitor's estimate of the adequacy of the actual dollars and in-kind services that is available (from all sources) to sustain adequate O&M with the present mode of operation | % | - | - | field observation |
| Human resource management indicators | | | | |
| frequency and adequacy of training of operators and middle managers | score | - | - | field observation |
| availability of written performance rules | score | - | - | field observation |

| | | | | |
|---|---|---|---|---|
| power of employees to make decisions | score | - | - | field observation |
| ability of the project to dismiss employees with cause | score | - | - | field observation |
| rewards for exemplary service | score | - | - | field observation |
| Project operation | | | | |
| umbrella Water User Association | score | - | - | field observation, interview |
| annual operation Policies | - | - | project office | secondary data, field observation, interview |
| daily operation policies | - | | project office | secondary data, field observation, interview |
| how are flow changes in the pipe system computed and adjusted? | - | | project office | secondary data, field observation, interview |
| what daily or weekly instructions for field persons does the office give? | - | | project office | secondary data, field observation, interview |
| Computers (either central or on-site) used for operation | score | | - | field observation |
| computers used for billing and record management | score | | - | field observation |
| Water Delivery Service | | | | |
| stated water delivery service that pump station provides to the pipe system (public authority perspective) | score | - | project office | interview |

| | | | | |
|---|---|---|---|---|
| stated water delivery service provided for sub-pipelines operated by a paid employee (public authority perspective) | score | - | project office | interview |
| stated water delivery service received by individual units - fields and farms (public authority perspective) | score | - | project office | interview |
| General WUA conditions | | | | |
| project area for which WUAS meet the following descriptions | % | - | WUA, project office | secondary data, interview |
| WUA area | ha | - | WUA, project office | secondary data, interview |
| WUA age | years | - | WUA, project office | secondary data, interview |
| functions of a typical WUA | - | - | WUA, project office | secondary data, interview |
| are there written rules in the WUA regarding proper behavior of farmers and employees? | - | - | WUA, project office | field observation, interview |
| number of fines levied by a typical active WUA in the past year | - | - | WUA, project office | field observation, interview |
| governing board of WUA | - | - | WUA, project office | field observation, interview |
| General WUA conditions | | | | |
| annual actual budget | local currency/year | 5 years average | WUA, project office | secondary data, interview |
| budget sources | % | - | WUA, project office | secondary data, interview |

| | | | | |
|---|---|---|---|---|
| annual required budget | local currency/year | 5 years average | WUA, project office | secondary data, interview |
| water charges | - | - | WUA, project office | secondary data, interview |
| fee collection efficiency | % | - | WUA, project office | secondary data, interview |
| what group collects the water charges? | - | - | WUA, project office | secondary data, interview |
| basis of water charge and amount of the charge | - | - | WUA, project office | secondary data, interview |
| type of volumetric water charge | - | - | WUA, project office | secondary data, interview |
| special charge for private well usage | - | - | WUA, project office | secondary data, interview |
| annual value of in-kind services or contributions by water users | local currency/year | 5 years average | WUA, project office | secondary data, interview |
| frequency of in-kind services | - | - | WUA, project office | secondary data, interview |
| farmers participation in in-kind services | % | - | WUA, project office | secondary data, interview, field observation |
| Employees | | | | |
| number of employees | - | annual average | WUA, project office | secondary data, interview, field observation |
| average years a typical professional employee works for the project (anticipated) | years | annual average | WUA, project office | secondary data, interview, field observation |
| how many of the operation staff actually work in the field? | - | annual average | WUA, project office | secondary data, interview, field observation |

| | | | | |
|---|---|---|---|---|
| salaries | local currency/year | 5 years average | WUA, project office | secondary data, interview |
| WUA performance indicators | | | | |
| actual ability of the strong Water User Associations to influence real-time water deliveries | score | - | WUA | interview |
| ability of the WUA to rely on effective outside help for enforcement of its rules | score | - | WUA | interview |
| legal basis for the WUAs | score | - | WUA | interview |
| financial strength of WUAS | score | - | WUA | interview |
| Level of Irrigation Management Transfer | | | | |
| responsibility share of O&M activities | - | - | WUA, farmers | interview, field observation |

A.1.5.4.2. Involved stakeholders

The chapter can be completed by preliminary investigation and field visit. The majority of the questions rely on secondary data, interview and field visit. The following stakeholders are recommended to be involved:

- project office and scheme management;
- responsible public authority;
- water user associations, irrigation associations, farmers' organization etc.

A.1.5.4.3. Requested time

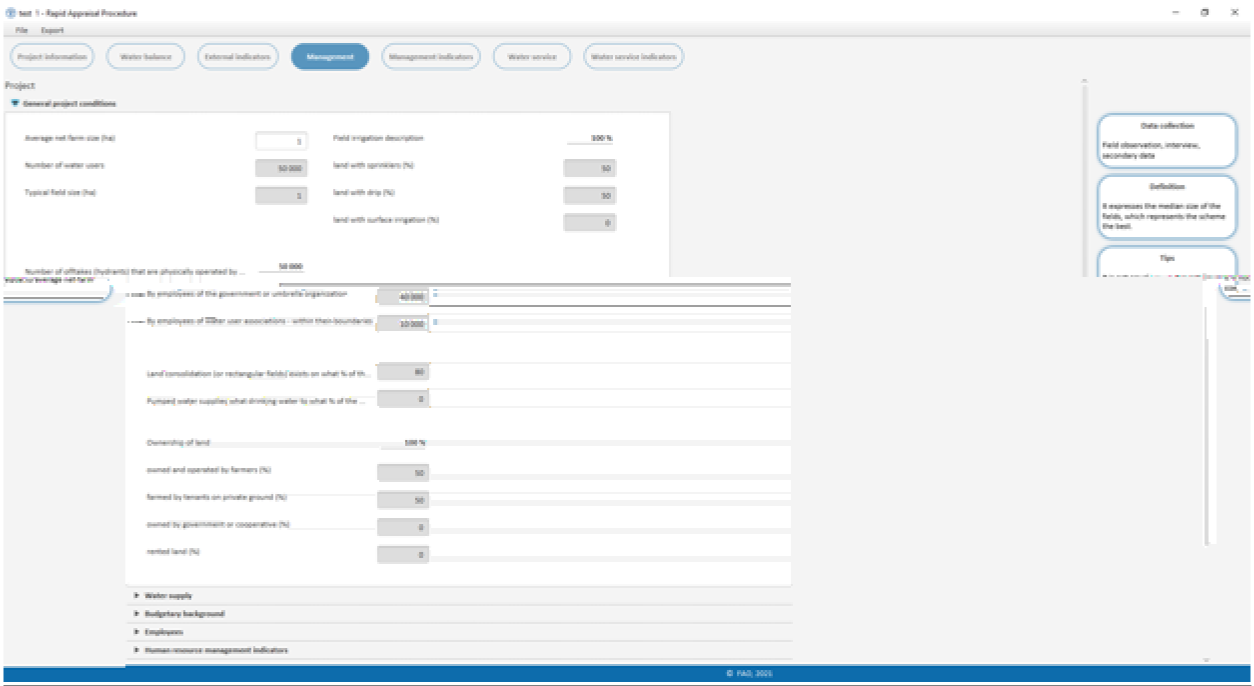
The work can be conducted directly, involving Project Office, WUA or other relevant authorities. The task should be implemented within not more than 1 week.

A.1.5.4.4. Data input and calculation scheme

Recommendations: the input data should be used as structured stocktaking of different parameters about management performance. Therefore, it is recommended to analyze the indicators together with the input data during write-up.

General Project Conditions:

*Figure A3 - 23 Main view of the general project conditions section*




*Average net farm size (ha):* the net farm size refers to the size of cropped land per land user or any specific characterization of farm under the same management unit (i.e. farmer, household, farmers' collective, etc.).

*Number of water users:* total number of water users in the scheme, limited to agricultural water users.

*Typical field size (ha):* this is not equal to average net farm size. Typical size means the median size of the fields. The size that represents the scheme the best.

*Number of offtakes that are physically operated by paid employees – by employees of the government or umbrella organizations*: offtake refers to the distribution equipment operated under the authority of employees of government/umbrella organizations. For example, if authorities are responsible to divert water from main pipe to branches i.e. through butterfly valves, only these offtakes should be calculated. If authorities are responsible to operate final offtakes, such as hydrants, those should be calculated.

*Number of offtakes that are physically operated by paid employees – by employees of the water user association*: offtake refers to the distribution equipment operated under the authority of employees of WUA. For example, if WUA is responsible to divert water from main pipe to branches i.e. through butterfly valves, only these offtakes should be calculated. If WUA is responsible to operate final offtakes, such as hydrants, those should be calculated.

*Land consolidation existing on certain % of the project area:* the ratio of land size over total land area that has undergone any kind of consolidation to rationalize agricultural production.

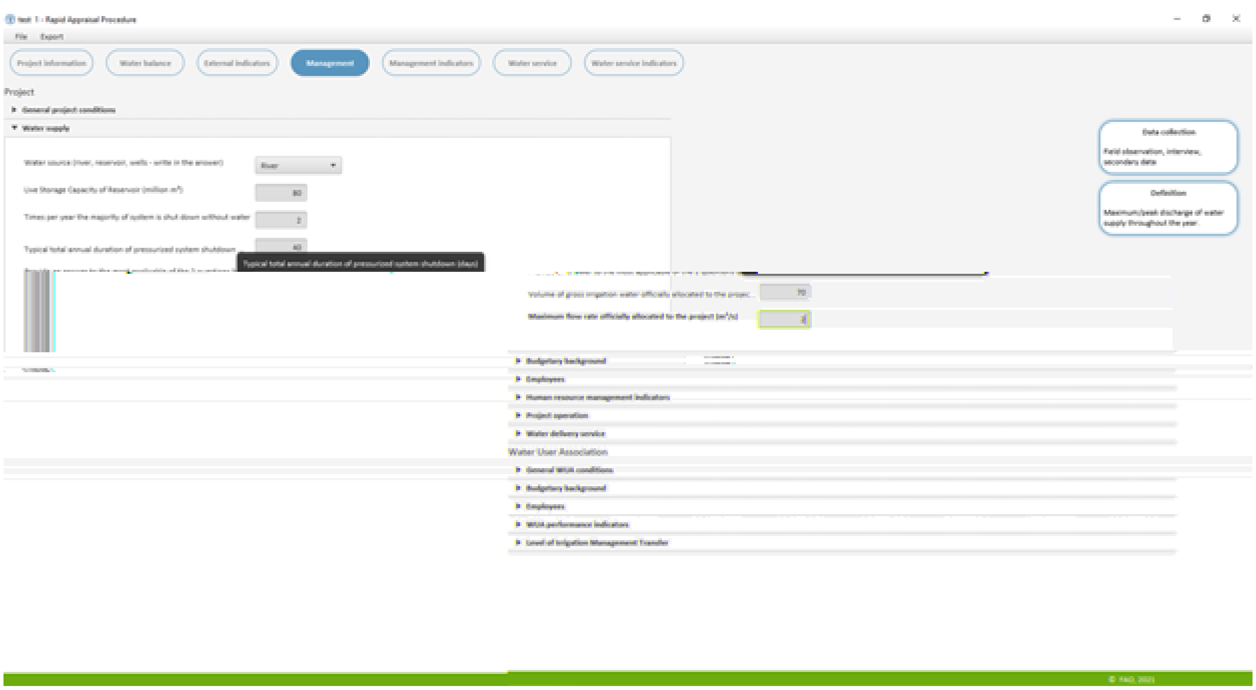
*Pumped water supplies for drinking water (%):* ratio of drinking water over total pumped water.

*Ownership of the land (%):* share of farmers' land ownership.

*Field irrigation description (%):* share of on-farm irrigation systems.

<u>Water supply:</u>

*Figure A3 - 24 Main view of the water supply section*



*Water source*: water source, from where irrigation water is supplied.

*Live storage capacity of reservoir (million m3):* if water is sourced from reservoir, live storage (dynamic) capacity of the reservoir.

*Times/year the majority of system is shut down without water:*

- off-irrigation period including the unintentional system closure (e.g. failure);
- this can indicate the performance flaws; a higher number of occasions might refer to serious performance issues.

*Typical total annual duration of pressurized system shutdown (days):*

- the typical duration of off period in days;
- this must be assessed in the context of the crop water requirement. If the annual duration exceeds the tolerance of crops' water stress, the indicator might be important to be flagged.

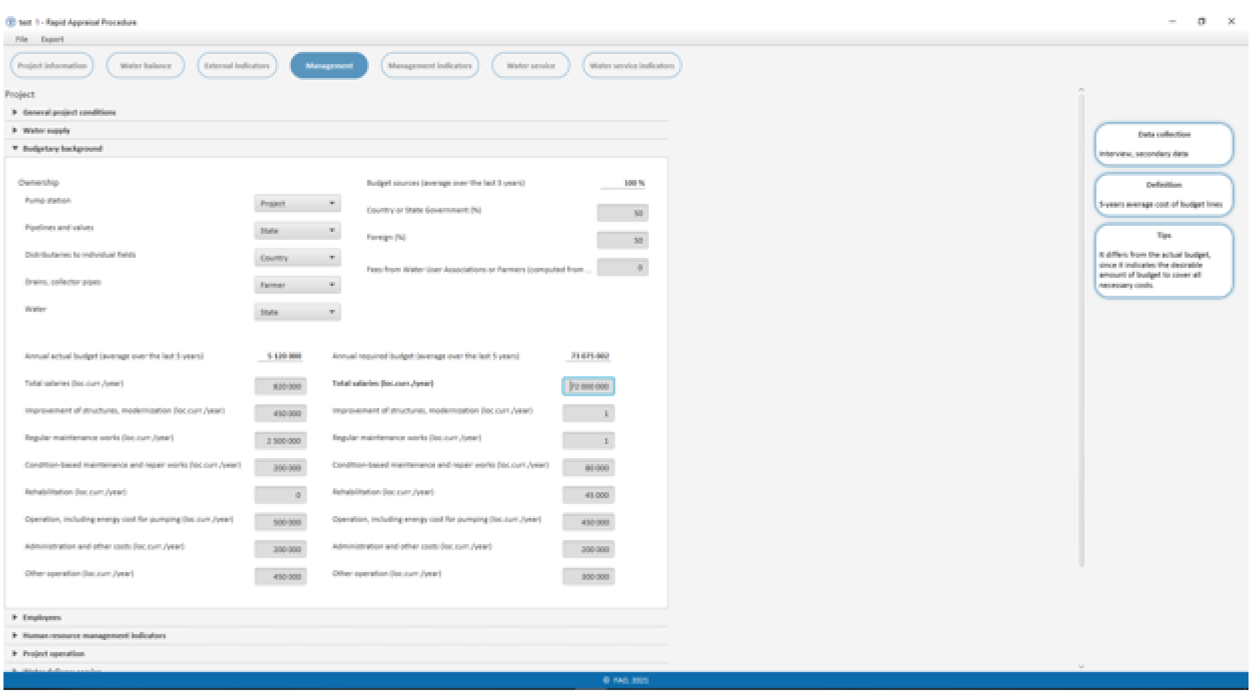
*Volume of gross irrigation water officially allocated to the project per year (million m3):*

- total water supply allocated by the project authority annually;
- this indicator refers back to the calculation of water supply.

*Maximum flow rate officially allocated to the project (m3/s):* maximum/peak discharge of water supply throughout the year.

<u>Budgetary background:</u>

*Figure A3 - 25 Main view of the budgetary background section*



*Ownership*: the ownership of typical system component shared amongst country, state, project or farmers.

*Annual actual budget:*

- 5-years average cost of budget lines;
- if budget accounting has different cost categorization, it is recommended to seek for the most corresponding budget line.

*Budget source*

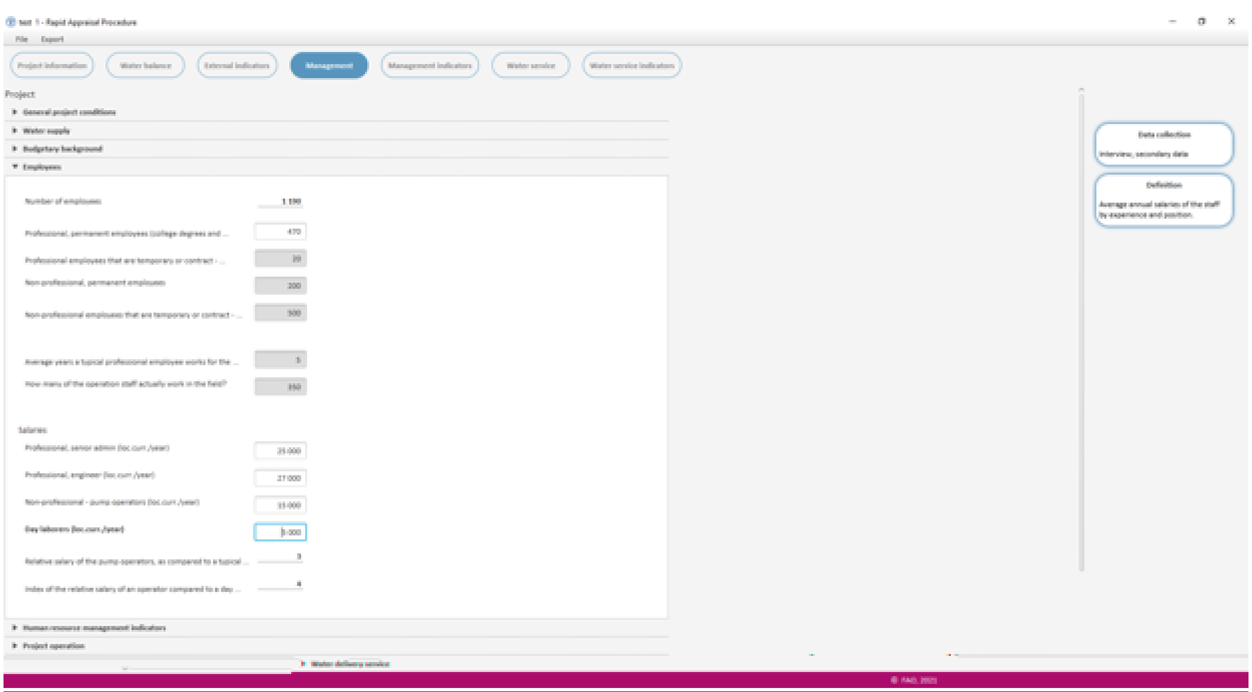
- 5-years average cost of budget lines.
- budget source refers to the total budget of the irrigation scheme that can consist of different sources.

*Annual required budget*

- 5-years average cost of budget lines;
- the required budget differs from the actual budget. This indicate the desirable amount of budget to cover all necessary costs.

<u>Employees:</u>

*Figure A3 - 26 Main view of the Employees section*



*Number of employees*: total number of employees distinguished by experience and contract type.

*Average years a typical professional employee works for the project:* the turnover in the staff indicating the average duration of employees working in the project.

*Operation staff actually working in the field:*

- this refers to the staff physically working on the field regardless she/he is professional or non-professional;
- this includes all types of employees.

*Salaries*: average annual salaries of the staff by experience and position.

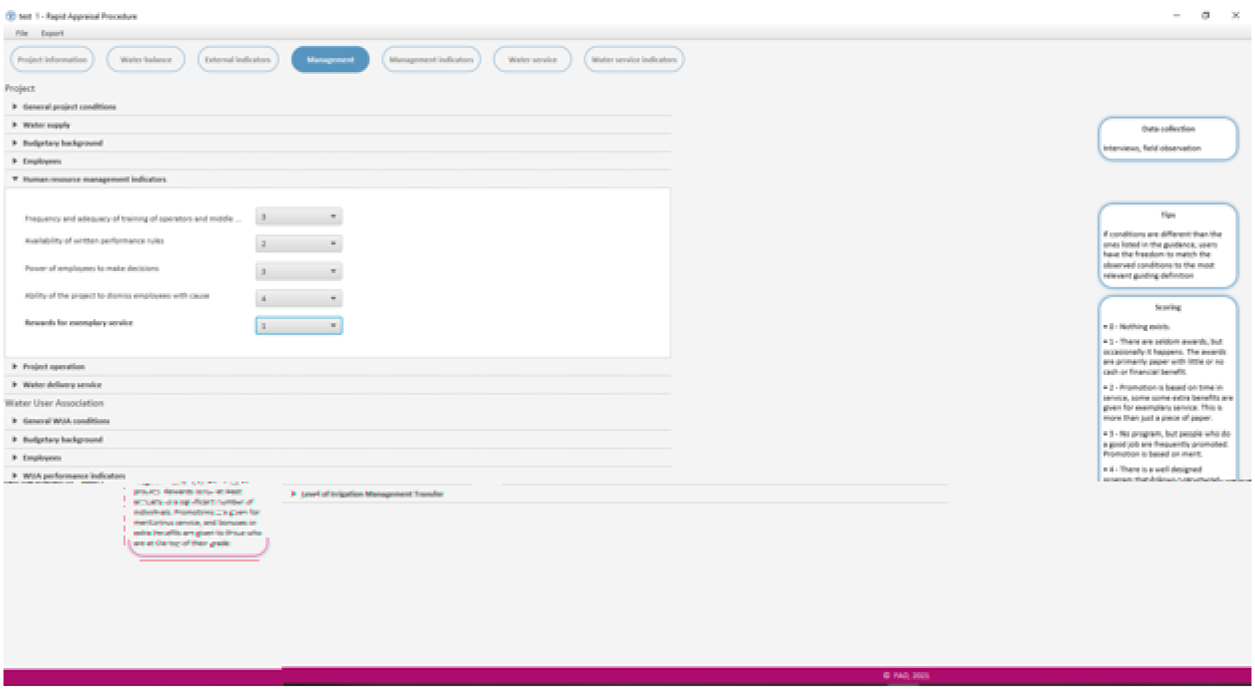
*Relative salary of the pump operators, as compared to a typical day laborer:* the result is calculated the ratio of the average salary of pump operators and day laborer.

*Index of relative salary of an operator compared to a day laborer:* the indicator assesses the adequacy of salary ratio of pump operators and day laborer. The index calculation applies the following scoring plan:

- 0 (<1) – very poor
- 1 (1-1.5) – poor
- 2 (1.5-2) – medium
- 3 (2-2.5) – good
- 4 (>2.5) – very good

<u>Human resource management indicators:</u>

*Figure A3 - 27 Main view of the human resource management indicators section*



*Frequency and adequacy of training of operators and middle managers.*

- this should include employees at all levels of the distribution system, not only those who work in the office;
- scoring based on guidance listed under the indicator;
- the scoring should be based on interviews and field observation;
- if conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition.

*Availability of written performance rules:*

- scoring based on guidance listed under the indicator;
- the scoring should be based on interviews and field observation;
- if conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition.

*Power of employees to make decisions*

- scoring based on guidance listed under the indicator;
- the scoring should be based on interviews and field observation;
- if conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition.

*Ability of the project to dismiss employees with cause*

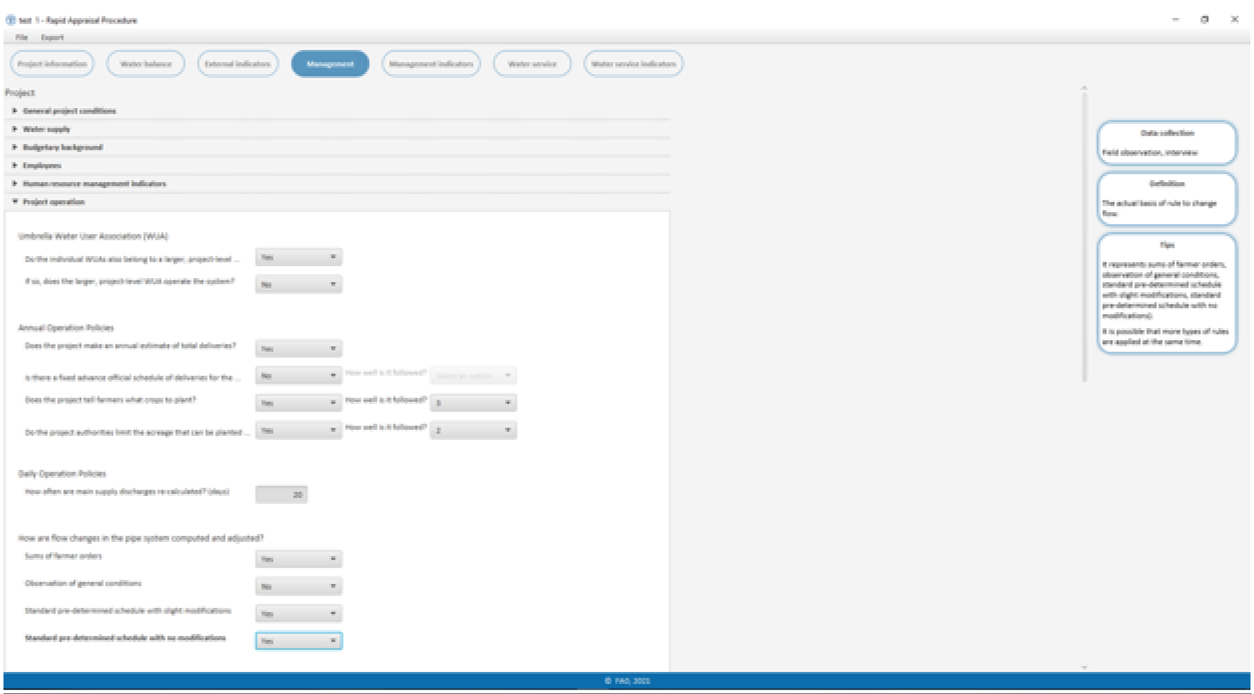
- scoring based on guidance listed under the indicator;
- the scoring should be based on interviews and field observation;
- if conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition.

*Rewards for exemplary service*

- scoring based on guidance listed under the indicator;
- the scoring should be based on interviews and field observation;
- if conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition.

<u>Project operation:</u>

*Figure A3 - 28 Main view of the project operation section*



*Umbrella Water User Association – a. individual WUAs belonging to larger WUA:* the question refers to the fact if WUAs belong to any higher-level WUA that coordinates, oversees, etc. its operation.

*Umbrella Water User Association – b. individual WUAs belonging to larger WUA:* the question should be answered only if the answer to the previous question (a) is “yes”.

*Annual operation policies – annual estimate of total deliveries:*

- the question requires information if there is any estimation about the required water amount to be delivered in given year;
- estimate of total deliveries might assume that the water supply is based on water requirement.

*Annual operation policies – fixed advance official schedule:*

- if there is any official schedule established, the question should be answered with "yes". In later question, user should estimate the actual compliance with this rule, whereas 4 is the excellent execution of planned schedule and 0 is the non-compliance with the schedule;
- if there is no official schedule, it is important to understand the principles of water distribution.

*Annual operation policies – crops to plant:* if there is any rule on cropping pattern, the question should be answered with "yes". In later question, user should estimate the actual compliance with this rule, whereas 4 is the excellent execution of crop selection and 0 is the non-compliance with the crop selection.

*Annual operation policies – limited acreage that can be planted to various crops:* if there is any rule on production limit, the question should be answered with "yes". In later question, user should estimate the actual compliance with this rule, whereas 4 is the excellent execution of limit and 0 is the non-compliance with the limit.

*Daily operation policies – recalculation of main supply discharge (days):*

- the frequency of recalculation of provided discharge;
- a frequent recalculation might assume a flexible and adjustable water distribution.

*Flow changes in the pipe system computed and adjusted:*

- the actual basis of rule to change flow (sums of farmer orders, observation of general conditions, standard pre-determined schedule with slight modifications, standard pre-determined schedule with no modifications);
- it is possible that more types of rules are applied at the same time.

*Daily or weekly instructions for field persons:*

- the question refers to four dimensions including pump operation, butterfly valves and other distribution devices, flow metering and flow rates at all offtakes;

- if given dimension applies to the irrigation system, the question should be answered with "yes. If the answer is "yes", successive questions should be further answered;
- the first successive question is the application of the computers to carry-out the task. The question should be answered with "yes" or "no";
- the second successive question is based on the estimation of the user. User should estimate the actual compliance with this rule, whereas 4 is the excellent execution of the task and 0 is the non-compliance with the established rules.

*Computers used for operation:*

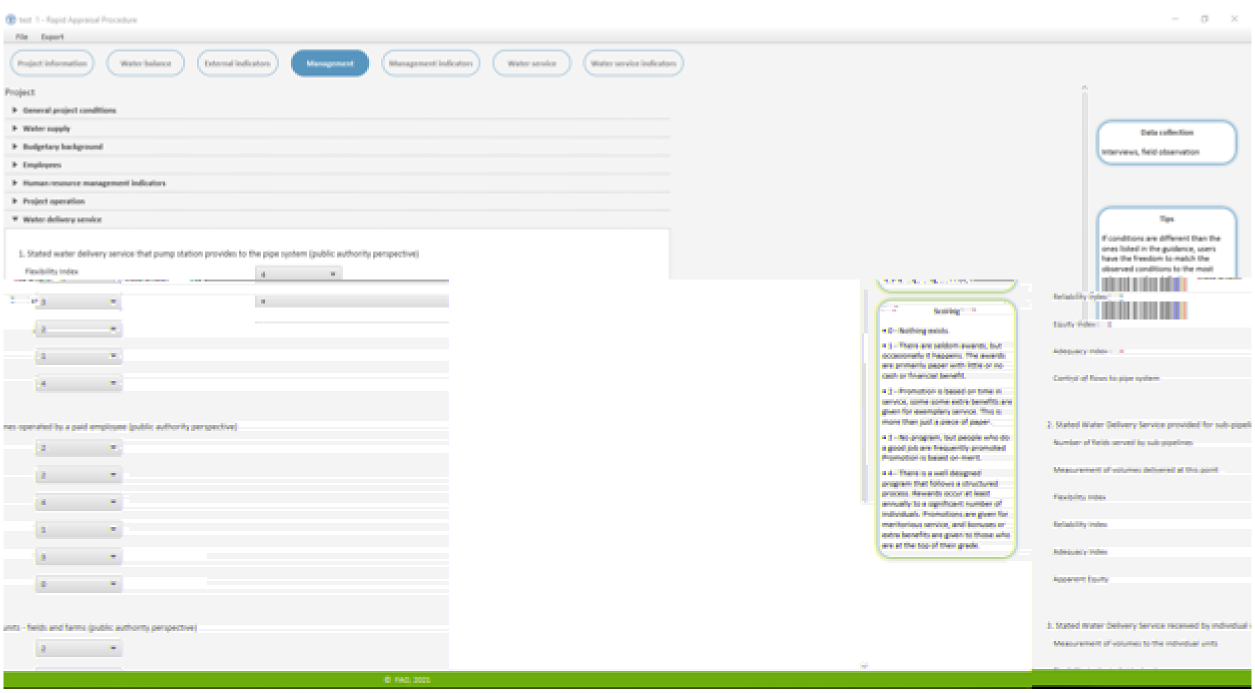
- scoring based on guidance listed under the indicator;
- the scoring should be based on interviews and field observation;
- if conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition.

*Computers used for billing and record management*

- scoring based on guidance listed under the indicator;
- the scoring should be based on interviews and field observation;
- if conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition.

Water Delivery Service

*Figure A3 - 29 Main view of water delivery service section in the Project block*



*Stated water delivery service that pump station provides to the pipe system:*

- The composite indicator consists of five sub-indicators: flexibility, reliability, equity, adequacy and control of flow;
- Scoring is based on guidance listed under the sub-indicator;
- The sub-indicators should be evaluated considering only the system from pump station to main pipe system, not including the branch-pipes;
- The scoring should be based on the answers of the management/public authorities. “Stated” water delivery service refers to the perception of the management. In order words, how the authorities evaluate the performance of the water delivery along the defined sub-indicators.

*Stated water delivery service provided for sub-pipelines operated by a paid employee:*

- the composite indicator consists of six sub-indicators: number of fields by sub-pipelines (branches), measurement of volumes delivered at this point, flexibility, reliability, equity, and adequacy;
- scoring is based on guidance listed under the sub-indicator;
- the sub-indicators should be evaluated considering only the system at sub-pipelines if it is operated by paid employees;
- the scoring should be based on the answers of the management/public authorities. “Stated” water delivery service refers to the perception of the management. In order words, how the authorities evaluate the performance of the water delivery along the defined sub-indicators.

*Stated water delivery service received by individual units - fields and farms:*

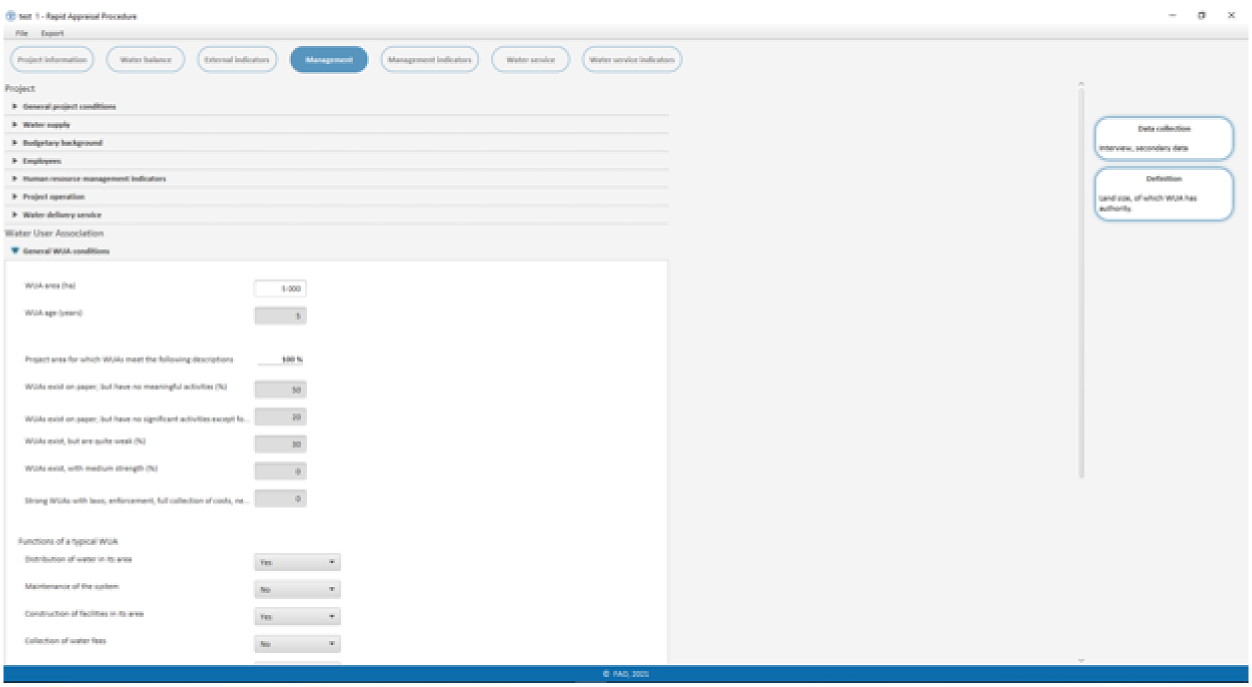
- the composite indicator consists of five sub-indicators: measurement of volumes delivered at this point, flexibility, reliability, equity, and adequacy;
- scoring is based on guidance listed under the sub-indicator;
- the sub-indicators should be evaluated considering only the received service by individuals/farms or farmers;
- the scoring should be based on the answers of the management/public authorities. “Stated” water delivery service refers to the perception of the management. In order words, how the authorities evaluate the performance of the water delivery along the defined sub-indicators.

Box A3-4 Water Delivery Service indicators

The Water Delivery Service (WDS) indicators are the backbone of the RAP. They are constructed to steer the management towards more service-oriented mindset. The WDS indicators match the evaluation by management with the evaluation of farmers. However, the WDS indicators represent the perception of the stakeholders. For example, farmers perceiving the water distribution equal does not necessarily mean that they receive equal discharge from engineering point of view, or vice-versa. The aim of the WDS is to understand the discord between the management and farmers. Therefore, it is always recommended surveying the management and farmers independently from each other. Otherwise, the two groups might influence each other.

## General WUA conditions:

*Figure A3 - 30 Main view of the general WUA conditions section*



**Box A3-5 Assessment of multiple WUAs**

If users decide to define the boundaries of the assessed area as per the hydrological boundaries, it might incorporate more WUAs at the same time. If more WUAs operate in the irrigation scheme, the user can decide to analyze the WUAs separately or apply average values.

If WUAs are analyzed separately, the Internal Indicators must be interpreted per WUA. In this case, the user can decide to create multiple assessment files. The Water Balance and Water Service chapters are filled identically, and the Management chapter is filled as per individual WUAs. Even if the user analyses a multi-stakeholder irrigation scheme, the Water Balance and Water Service part should be interpreted as a whole.

Evidence shows that relatively close and/or neighboring WUAs have different management mechanisms and performance. Therefore, if average values and analysis are applied to the total area, the Internal Indicators must be interpreted with the assumptions that performance of WUAs can significantly differ from one place to another.

*WUA description per project area:*

- the ratio of descriptive characteristics over total land size should be estimated;
- in particular in large irrigation schemes, the power of WUA might differ, or more WUAs can operate. It should be evaluated based on field observation, how effectively WUA/s can operate;
- the entire area must be taken into consideration, thus the total value must reach 100 percent.

*WUA area (ha):* land size, of which WUA has authority.

*WUA age (years):* the current age of the WUA from its establishment.

*Functions of the typical WUA*:

- each function should be evaluated and answered by “yes” or “no”;
- after the identification of the functions, the effectiveness and efficiency of the WUA in the specific role must be assessed to understand the bottlenecks.

*Written rules in the WUA regarding proper behavior of farmers/employees:*

- the question should be answered by “yes” or “no”;
- if there is no written rule, it must be assessed whether the lack of rule leads to discord/anomalies or the system is operated smoothly.

*Number of fines levied by a typical active WUA in the past year:*

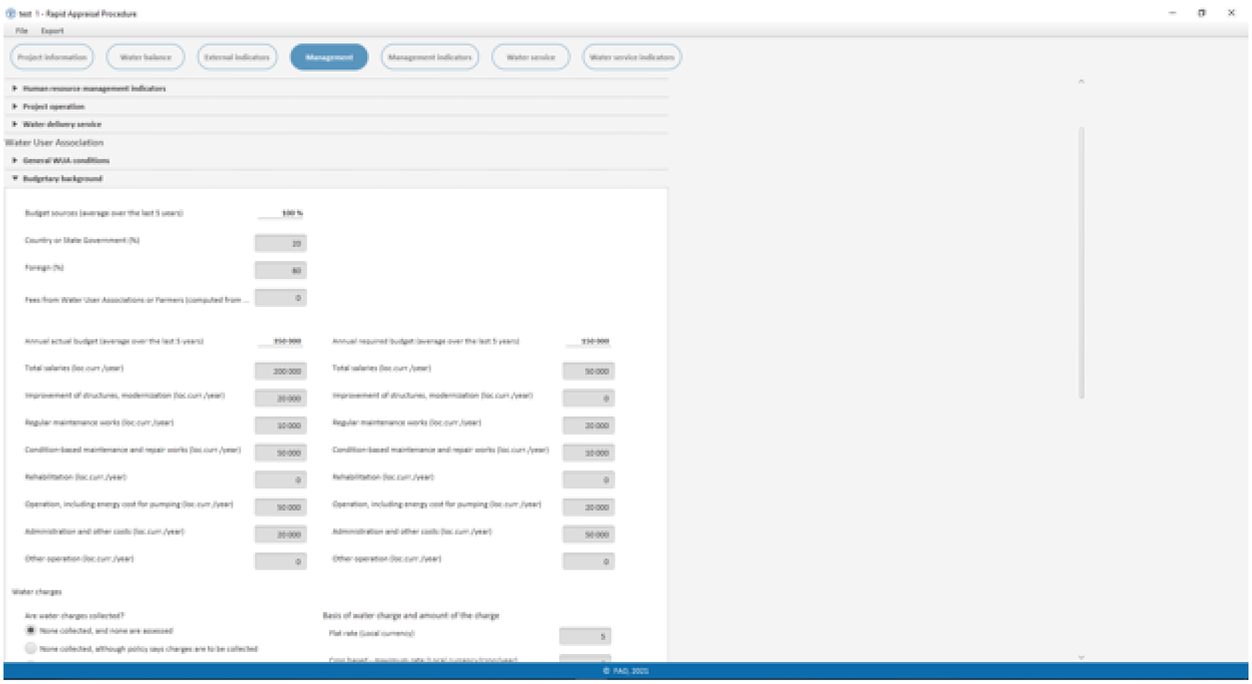
- the actual number of fines issued by the WUA, following non-compliance of any of the rules;
- if there is no fine issued, it must be assessed whether it is the result of the full compliance with rules or the lack of capability to enforce compliance.

*Governing Board of WUA:* the question refers to the modality how governing board is set-up, either based on election, appointment or by government.

Food and Agriculture Organization
of the United Nations

Budget:

*Figure A3 - 31 Main view of the Budget section in the WUA block*




*Annual actual budget:*

- 5-years average cost of budget lines;
- if budget accounting has different cost categorization, it is recommended to seek for most corresponding budget line.

*Budget source*

- 5-years average cost of budget lines;
- budget source refers to the total budget of the irrigation scheme that can consist of different sources.

*Annual required budget*

- 5-years average cost of budget lines
- the required budget differs from the actual budget. This indicate the desirable amount of budget to cover all necessary costs

*Water charges:* the question refers to the modality how water charges are collected.

*Group collection the water charges:* the authorized entity who physically collects the fee from the members.

*Basis of the water charge and the amount of the charge:* the question refers to the defined modality of calculating water fee. Depending on the applied basis, the average water fee should be indicated. If more bases are applied at the same time, each one should be indicated.

*Fee collection efficiency:*

- the actual ratio (%) of collected water fee over the expected amount of water fee, if every member paid the defined amount of fee. The ratio is an important indicator of the farmers' satisfaction with the water service and/or ability to pay. If the collection efficiency is low, the reason must be identified and explained;
- estimated total annual water charges refers to the total amount of actually collected water fee in local currency;
- based on the fee collection efficiency and the actually collected fee, the planned budget is calculated automatically. This indicated how the amount of budget that was expected if all members paid the defined fee.

*Special charge for private well usage*: if there is any private well, owned and operated by individuals, the question should be answered related to the water charge, basis of charge (unit) and the collection efficiency.

*Percentage of the total project (including WUA) Operation and Maintenance (O&M) collected as in-kind services, and/or water fees from water users:*

- the ratio of cost spent exclusively on O&M activities (regular maintenance works, condition-based maintenance and repair works, rehabilitation, operation including energy cost for pumping.) from the total collected in-kind service and water fee from farmers;
- in order to obtain results, relevant parts of WUA-related tables must be filled.

*Calculated Indicator of O&M sources:* The index calculation applies the following scoring plan:

- 0 (<40%) – very poor
- 1 (40-60%) – poor
- 2 (60-75%) – medium
- 3 (75-90%) – good
- 4 (>90%)– very good

*Annual value of in-kind services or contributions by water users:*

- in-kind services refer to any non-financial, but commonly agreed contribution to operate and maintain the system. For example, farmers can provide their labor work in constructions instead of paying contribution to contract personals;
- the question should be answered based on documentations and field observations, and estimation should be given on the monetary value of such in-kind service.
- the accuracy of estimation should be accurate as it will be calculated to the overall financial contribution of farmers to manage the irrigation system;
- frequency of the in-kind services should be also estimated;
- the rate of farmers who provide in-kind services should be estimated.

*Rate of the total budget spent on modernization of the irrigation system over O&M costs (project and WUA):*

- this refers to the rate of budget spend on system improvement compared to the O&M costs spend by both project authority and WUAs;
- in order to obtain results, relevant parts of WUA-related tables must be filled.

*Calculated indicator of the modernization budget:* The index calculation applies the following scoring plan:

- 0 (<5%) – very poor
- 1 (5-10%) – poor
- 2 (10-15%) – medium
- 3 (15-20%) – good
- 4 (>20%) – very good

*Visitor's estimate of the adequacy of the actual dollars and in-kind services that is available (from all sources) to sustain O&M with the present mode of operation (%):*

- estimation of the adequacy of actual fund based on field observation and interview;
- this should be estimated based on the judgment of expert while taking into account the conditions, management, system performance.

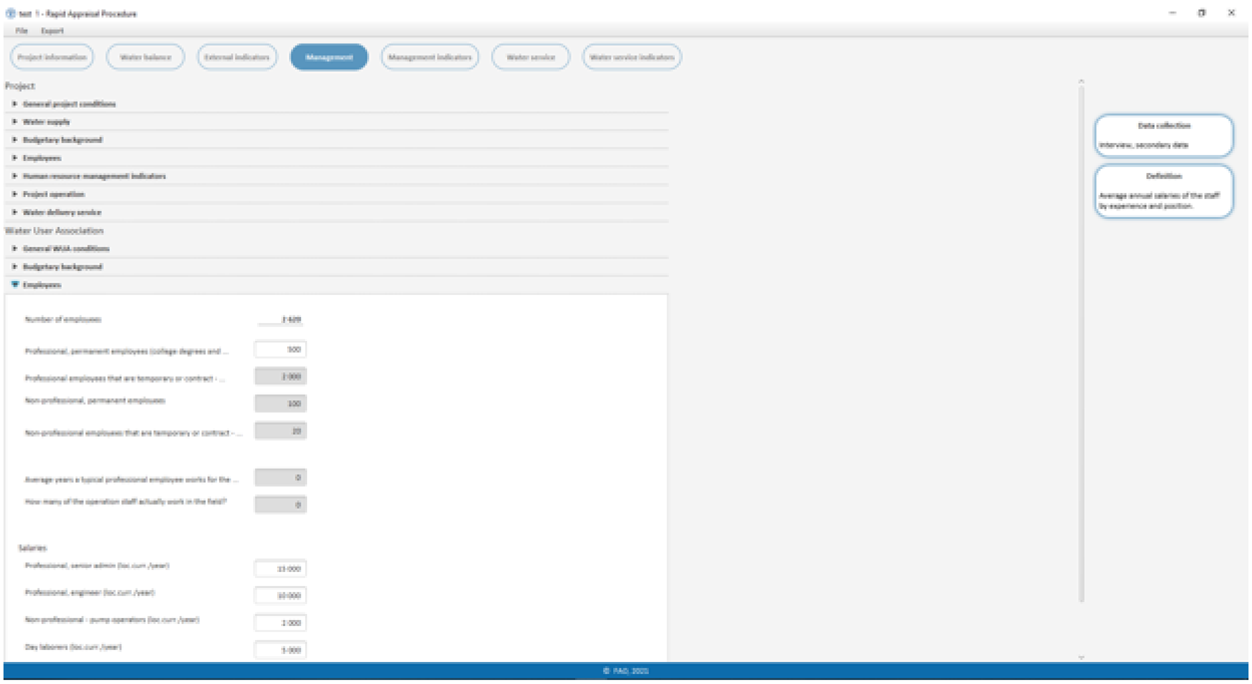
*Calculated Indicator of O&M adequacy:* The index calculation applies the following scoring plan:

- 0 (<40%) – very poor
- 1 (40-60%) – poor
- 2 (60-75%) – medium
- 3 (75-90%) – good
- 4 (>90%)– very good

*Type of volumetric water charge*: the question should be filled only if the basis of water charge is volumetric.

Employees:

*Figure A3 - 32 Main view of the Employees section in WUA block*



*Number of employees:* total number of employees distinguished by experience and contract type.

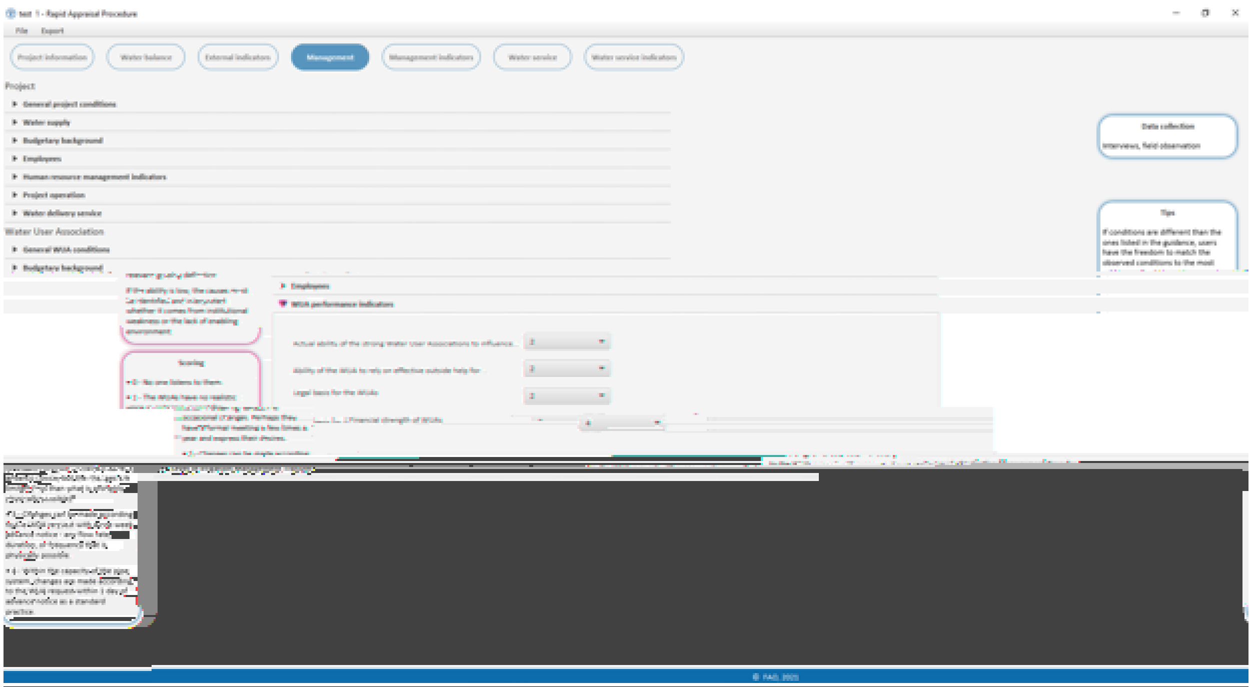
*Average years a typical professional employee works for the project:* the turnover in the staff indicating the average duration of employees working in the project.

*Operation staff actually working in the field:* this refers to the staff physically working on the field regardless she/he is professional or non-professional.

*Salaries*: average annual salaries of the staff by experience and position.

WUA performance indicators:

*Figure A3 - 33 Main view of the WUA performance indicators*




*Ability of the strong WUA to influence real-time water deliveries*

- scoring based on guidance listed under the indicator;
- the scoring should be based on interviews and field observation;
- if conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition;
- if the ability is low, the causes must be identified and interpreted whether it comes from institutional weakness or the lack of enabling environment.

*Ability of the WUA to rely on effective outside help for enforcement of its rules*

- scoring based on guidance listed under the indicator;
- the scoring should be based on interviews and field observation;
- if conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition;
- if the ability is low, the causes must be identified and interpreted whether it is the result of the lack of mechanism or the low capacity of the organization.

*Legal basis for the WUAs*

- scoring based on guidance listed under the indicator;
- the scoring should be based on interviews and field observation;

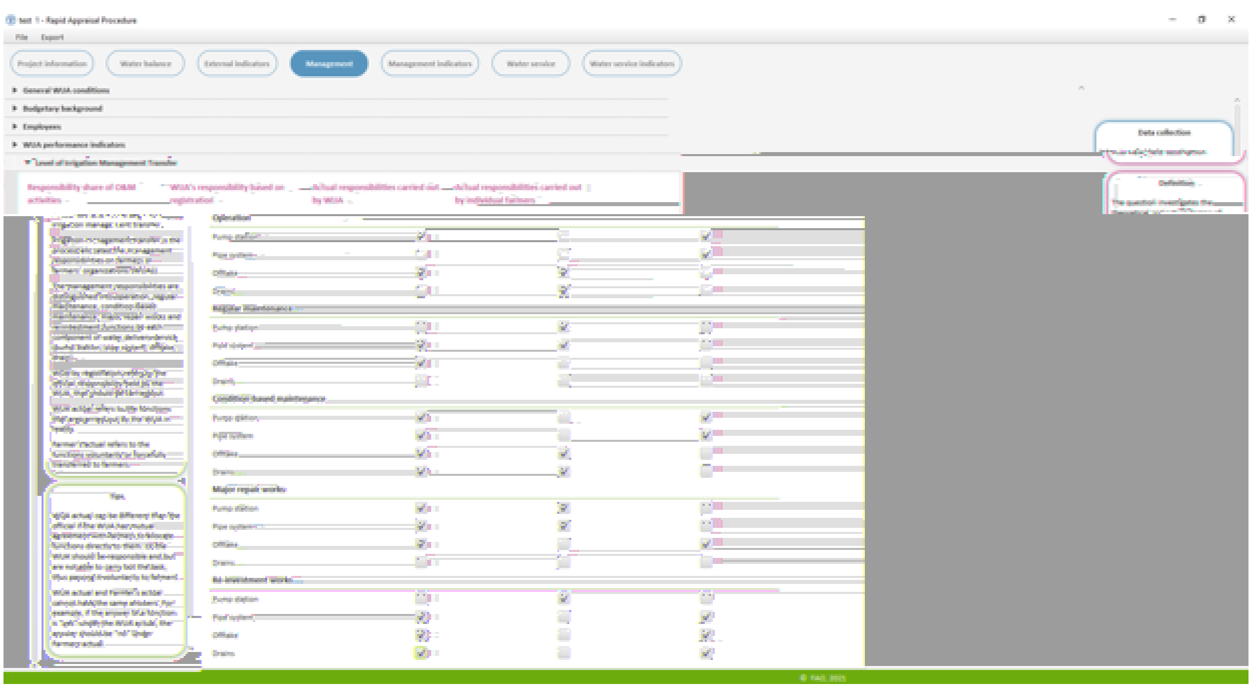
- if conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition;
- legal basis must be interpreted always in the context of the national regulation.

*Financial strength of WUAs*

- scoring based on guidance listed under the indicator;
- the scoring should be based on interviews and field observation;
- if conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition;
- if the financial strength is low, it must be assessed whether it is the result of low management performance or the ability of WUA to elevate resources.

<u>Level of Irrigation Management Transfer:</u>

*Figure A3 - 34 Main view of the irrigation management transfer section*



This section investigates the theoretical and actual degree of irrigation management transfer. Irrigation management transfer is the process allocating the management responsibilities to farmers or farmers' organizations (WUAs). The management responsibilities are distinguished into operation, regular maintenance, condition-based maintenance, major repair works and re-investment functions at each management level of the water delivery service (pump station, pipe system, offtake, drain):

- WUA by registration refers to the official responsibility held by the WUA that should be carried out;
- WUA actual refers to the functions that are carried out by the WUA in reality. This can be different than the official if the WUA has mutual agreement with farmers to allocate functions directly to them. Or, the WUA should be responsible and but are not able to carry out the task, thus passing it voluntarily to farmers;
- farmers actual refers to the functions voluntarily or forcefully transferred to farmers;
- the WUA actual and Farmers actual cannot have the same answers. For example, if the answer of a function is “yes” under the WUA actual, the answer should be “no” under Farmers actual.

Box A3-6 Irrigation management transfer

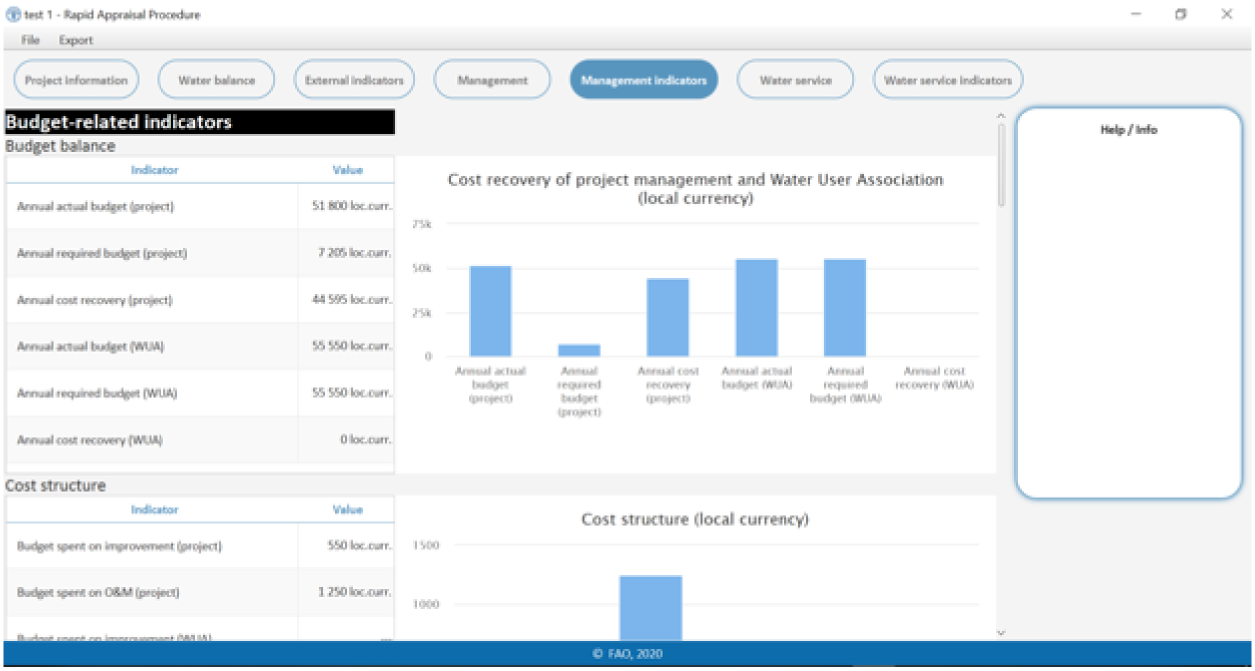
The definition of participatory irrigation management (PIM) and irrigation management transfer (IMT) are often used interchangeably. Although, they represent different stages of management transfer. PIM is the type of management when farmers take over management responsibilities, but certain supervision or contribution from the state is maintained. IMT is the full turnover, when state hands over all management responsibility to farmers. Like in most of the cases, the IMT in the software can be used interchangeably with PIM.

WUA responsibilities are usually defined by national law. Therefore, the official responsibility must be understood from the constitution document of the WUA, together with national legislation. The difference between official and actual responsibilities can be easily understood from farmers, who are the direct “service receivers”. In optimal cases, the official and actual responsibilities should not differ. However, most of the WUAs are not able to properly carry out their tasks due to different issues, and they informally shift management tasks to farmers.

### *A.1.5.5. Management indicators*

The Management indicators are calculated to provide an appraisal of institutional and organizational performance. Not all input data/information are directly analyzed as performance indicator. While preparing the analysis and narrative of the chapter, it is important to understand that both the input data/information and the Indicators are necessary to compile a comprehensive report. While the input data/information helps users to properly frame the assessment, they provide underlying information about the results.

*Figure A3 - 35 Main view of the Management indicators*




The Management indicator page has 5 clusters that systematically analyze the performance. These clusters are budget related indicators, employees, operation, WUA indicators, level of irrigation management transfer.

*Table A3 - 4 Calculated parameters of the Management indicators*

| Indicator | Units | Definition |
|---|---|---|
| | | Budget related indicators |
| budget balance | Local currency | • The budget balance compares the actual budget with the required budget separately at project and WUA level.<br>• The annual cost recovery is the difference between actual and required budget. If the required budget is higher than the actual, it indicates budget deficit in negative value. This should be interpreted as the missing amount that should be allocated to cover all necessary costs. If there is surplus, it means that the available budget is higher than the required, thus assuming budget reserve and high liquidity.<br>• The analysis is conducted separately to project and WUA. |
| cost structure | Local currency | • The cost structure compares the expenditures on improvement/modernization with the expenditures on O&M at project and WUA level. |

| | | |
|---|---|---|
| | | • "Improvement" includes the cost line related to improvement and modernization. This considers only those activities that adds to the current function/value of the irrigation scheme.<br>• O&M includes the cost lines related to all operation and maintenance activities that are directly related to the day-to-day scheme management.<br>• Ratio of improvement and O&M is transferred value from the "rate of the total budget spent on modernization of the irrigation system over O&M costs (project and WUA)". This refers to the rate of budget spend on system improvement compared to the O&M costs spend by both project authority and WUAs.<br>• The budget deficit/surplus for improvement compares the actual costs of improvement to the required costs of improvement at project and WUA level. If the actual expenses of improvement are less than the required, it indicates deficit in negative value. If the actual cost of improvement is higher than the required cost, it indicates over-spending. |
| budget indicators | - | • Ratio (%) of users' contribution to overall budget is the rate of water charge actually collected from users by WUA over the sum of actual annual budget of project and WUA. Too low ratio would indicate that water fee is negligible compared to the overall budget of the irrigation scheme. Ratio close to 100 percent would indicate that the scheme is financed mostly from the water fees.<br>• Annual fee collection efficiency is transferred value. The actual ratio (%) of collected water fee over the expected amount of water fee, if every member paid the defined amount of fee.<br>• Ratio (%) of in-kind services and collected water fee from users indicates the value of in-kind services over the total collected water fee.<br>• Total O&M cost (local currency) per project area is the sum of all direct and indirect costs related to O&M and paid by the project (total salaries, regular maintenance works, condition-based maintenance and repair works, rehabilitation, operation, including energy cost for pumping, administration and other costs and other operation) per project area<br>• Total O&M cost (local currency) per project area is the sum of all direct and indirect costs related to O&M and paid by the WUA (total salaries, regular maintenance works, condition-based maintenance and repair works, rehabilitation, operation, including energy cost for pumping, administration and other costs and other operation) per project area<br>• Improvement cost (local currency) per project area is the cost related to improvement and modernization, paid by the project per project area<br>• Improvement cost (local currency) per project area is the cost related to improvement and modernization, paid by the WUA per project area |
| Employees | | |

| | | |
|---|---|---|
| staff | - | • Number of employees financed by the project is transferred values from the aggregated number of paid employees by the project regardless their positions.<br>• Number of employees financed by the WUAS is transferred values from the aggregated number of paid employees by the WUA regardless their positions.<br>• Number of project employees per project area is the number of employees per hectare paid by the project.<br>• Number of project employees per project area is the number of employees per hectare paid by the WUA.<br>• Number of professional project staff is the aggregated number of professional employees paid by the project, not including the permanent non-professionals and temporary non-professionals.<br>• Number of professional project staff is the aggregated number of professional employees paid by the WUA, not including the permanent non-professionals and temporary non-professionals. |
| indicators of human resource management | - | • The indicators are transferred values, whereas adequate score should be given, based on guidance.<br>• Together, the indicators can be visualized in one composite indicator/chart to compare the performance of human resource management per dimensions. |
| salaries | - | • Share of salaries in total costs of project indicates the rate of salaries over the total project budget.<br>• Share of salaries in total costs of project indicates the rate of salaries over the total WUA budget.<br>• Ratio of non-professional to professional salaries of the project indicates the difference between salary levels between non-professional and professional paid by the project.<br>• Ratio of non-professional to professional salaries of the project indicates the difference between salary levels between non-professional and professional paid by the WUA. |
| **Operation** | | |
| operation policies | - | • The indicators are transferred values, whereas adequate score should be given, based on guidance.<br>• Together, the indicators can be visualized in one composite indicator/chart to compare the compliance of operation policies per dimensions. |
| **WUA indicators** | | |
| Water User Associations performance | - | • The indicators are transferred values, whereas adequate score should be given, based on guidance.<br>• Together, the indicators can be visualized in one composite indicator/chart to compare the WUA performance per dimensions. |

| Level of Irrigation Management Transfer | | |
|---|---|---|
| WUA official responsibility | - | • The scores are transferred values indicating how many of the management activities per system components are official assigned to the WUA.<br>• Four management activities are assigned to each system components. The value shows the fraction of the officially assigned tasks from the four. E.g. 2/4 indicates that two activities are assigned from the four. |
| WUA actual responsibility | - | • The scores are transferred values indicating how many of the management activities per system components are actually taken by the WUA.<br>• Four management activities are assigned to each system components. The value shows the fraction of the actually taken tasks from the four. E.g. 2/4 indicates that two activities are taken from the four. |
| actual responsibilities of individual farmers | - | • The scores are transferred values indicating how many of the management activities per system components are actually taken by the farmers.<br>• Four management activities are assigned to each system components. The value shows the fraction of the actually taken tasks from the four. E.g. 2/4 indicates that two activities are taken from the four. |

Appropriate visualization helps understand the relationships amongst different indicators, where some of the indicators can outperform and underperform. The visual objects can be exported in pdf file.

*Figure A3 - 36 Exported chart from the Management indicators*

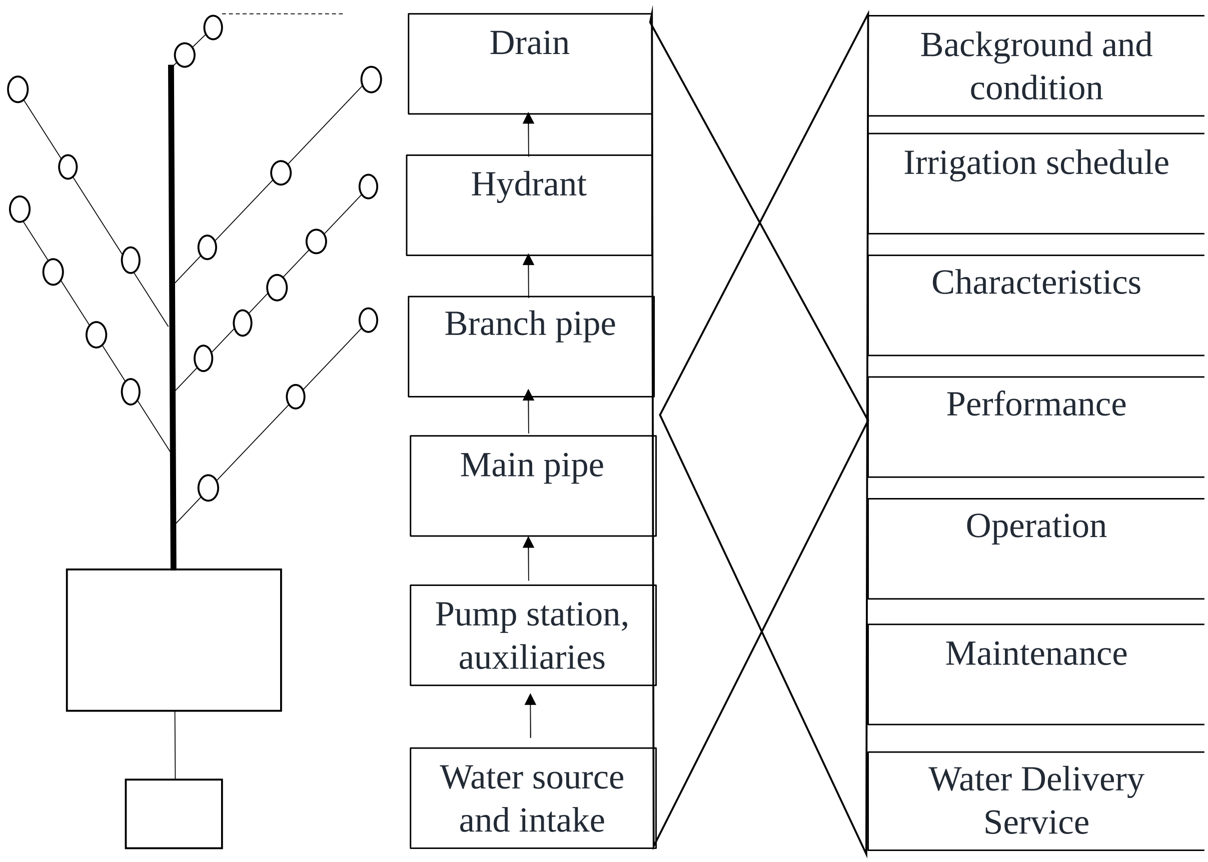

### *A.1.5.6. Water Service*

The water service chapter aims at appraising the physical infrastructure from water intake to the drains. The questionnaire provides sequential analysis of the levels of the infrastructure at system level – not including the on-farm irrigation technique: intake, pump station, main pipe, branch pipes, deliveries (hydrants) and drains. The appraisal is phased into two sub-chapters, complementing each other:

1. Pump station: the sub-chapter refers to those parts of the irrigation system, which are usually managed by higher-level institutions, and not directly by farmers. Usually, WUA or governmental authority is responsible to operate the overall water withdrawal at pump station level and drains, while farmers are usually responsible to operate the water distribution at farm level. Although this setting is not practiced equally everywhere in this way, the format of the chapter does not hamper the appraisal at different management setting.
2. Pipes and deliveries: the sub-chapter refers to those parts of the irrigation system, which are usually managed by farmers, such as pipe network and deliveries (hydrant).

The chapter structure is similar to the Management chapter, it provides a “catchall” list of the infrastructure characteristics, irrigation schedule, performance, operation, maintenance and water delivery service at each infrastructure level. The list of input data functions as systematic stocktaking of relevant information describing and characterizing the performance of the physical infrastructure. Furthermore, composite indicators are crafted to provide systematic evaluation of performance.

*Figure A3 - 37 Flowchart of the Water service appraisal*




A.1.5.6.1. Preparation of the input file

The water service chapter builds on appraising the physical infrastructure component by component. The chapter builds on field observation, but some of the data is available from the manufacturer or system design.

*Table A3 - 5 Data input support of Water service chapter*

| Required data | Unit | Time-step | Supporting documents | Methodology |
|---|---|---|---|---|
| **General project condition** | | | | |
| type of water source | - | - | - | Field observation, interview |
| type of water | - | - | - | field observation, interview |
| number of systems relies on the same water source | - | - | cadastral maps | field observation, interview |

| | | | | |
|---|---|---|---|---|
| position of the system compared to other systems using the same source | - | - | cadastral maps | field observation |
| average number of days when the water/piezometric level does not reach the minimum required | . | annual | - | field observation, interview |
| type of system | - | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation |
| pipeline type | - | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation |
| range of altitude of the area | m | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation |
| soil textural class of the system | - | - | - | field observation, interview, sampling |
| gypsum concentration of soil | % | - | - | field observation, interview, sampling |
| sulphate concentration of soil | % | - | - | field observation, interview, sampling |
| average groundwater depth during the year from the pipe level | m | annual | - | field observation, interview |
| number of days when shallow groundwater reaching the pipe occurs during the year | day/year | annual | - | field observation, interview |
| possible waterlogging and/or salination | - | - | - | field observation, interview |

| | | | | |
|---|---|---|---|---|
| required continuous flowrate based on peak water requirement of command area | l/s | - | - | field observation, interview |
| average working hours of the system per day | hour | seasonal | - | field observation, interview |
| required flowrate according to elasticity based on peak water requirement of command area (l/s) | l/s | seasonal | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| number of water users within the irrigated area | - | seasonal | design, plans, master plans, technical drawings, field surveying | field observation, interview |
| total length of pipeline | m | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| total length of main line | m | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| total lengths of other feeder/sub-branches | m | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| number of sub-systems in the pipe system | - | - | design, plans, master plans, technical drawings | field observation, interview |
| average size of sub-systems | ha | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |

| | | | | |
|---|---|---|---|---|
| position of sub-systems | - | - | design, plans, master plans, technical drawings | field observation, interview |
| average number of farmers per sub-system | - | - | design, plans, master plans, technical drawings | field observation, interview |
| branching type of the system | - | - | design, plans, master plans, technical drawings | field observation, interview |
| operating pressure range at hydrant level | bar | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| basis of carrying capacity of the system | - | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| number of gate valves | - | - | design, plans, master plans, technical drawings | field observation, interview |
| number of drains | - | - | design, plans, master plans, technical drawings | field observation, interview |
| number of distributaries | - | - | design, plans, master plans, technical drawings | field observation, interview |
| average land size served by distributaries | ha | - | design, plans, master plans, technical drawings | field observation, interview |
| technique of on-farm irrigation | - | - | - | field observation, interview |
| layout of the system | - | - | design, plans, master plans, technical drawings | field observation, interview |
| Irrigation schedule | | | | |

| | | | | |
|---|---|---|---|---|
| what % of the time is the flow officially scheduled at intake level | % | seasonal | WUA, project Office | interview, field observation |
| what % of the time is the flow actually scheduled at intake level | % | seasonal | WUA, farmers | interview, field observation |
| what % of the time is the flow officially scheduled at distributaries (hydrant) level | % | seasonal | WUA, project office | interview, field observation |
| what % of the time is the flow actually scheduled at distributaries (hydrant) level | % | seasonal | WUA, farmers | interview, field observation |
| Intake and pump station characteristics | | | | |
| altitude of the station | m | - | design, plans, master plans, technical drawings | field observation, interview |
| distance of station from water source - vertical | m | - | design, plans, master plans, technical drawings | field observation, interview |
| distance of station from water source - horizontal | m | - | design, plans, master plans, technical drawings | field observation, interview |
| intake classification | - | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| number of pumps in the pump station | - | - | design, plans, master plans, technical drawings | field observation, interview |
| number of pumps operating simultaneously | - | - | design, plans, master plans, technical drawings | field observation, interview |

| | | | | |
|---|---|---|---|---|
| number of pumps operating sequential | - | - | design, plans, master plans, technical drawings | field observation, interview |
| number of stand-by pumps | - | - | design, plans, master plans, technical drawings | field observation, interview |
| type of simultaneously operating pumps | - | - | design, plans, master plans, technical drawings | field observation, interview |
| type of pumps operating sequential | - | - | design, plans, master plans, technical drawings | field observation, interview |
| type of stand-by pumps | - | - | design, plans, master plans, technical drawings | field observation, interview |
| energy supply | - | - | design, plans, master plans, technical drawings | field observation, interview |
| total head | m | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| maximum design capacity of the pump | l/s | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| type of pressure control device | - | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| type of pressure measurement device | - | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |

| | | | | |
|---|---|---|---|---|
| average pressure during operating hours | m | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| pressure in peak period | m | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| magnitude of the variation in pressure | m | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| average delivered discharge on daily base | $m^3/h$ | seasonal | design, plans, master plans, technical drawings, manufacturer recommendations | historical data, field observation |
| magnitude of the variation in discharge | $m^3$ | rotation | design, plans, master plans, technical drawings, manufacturer recommendations | historical data, field observation |
| average energy consumption per hour | kWh | seasonal | design, plans, master plans, technical drawings, manufacturer recommendations | historical data, field observation |
| peak energy consumption per hour | kWh | rotation | design, plans, master plans, technical drawings, manufacturer recommendations | historical data, field observation |
| the overall design efficiency of the pumps | % | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |

| | | | | |
|---|---|---|---|---|
| estimated actual efficiency of the pumps | % | - | design, plans, master plans, technical drawings | field observation, interview |
| ability to variate the head pressure according to the water demand | - | - | design, plans, master plans, technical drawings | field observation, interview |
| type of drain | - | - | design, plans, master plans, technical drawings | field observation, interview |
| removal of excess water from field drains | - | - | design, plans, master plans, technical drawings | field observation, interview |
| area served by field drains | ha | - | design, plans, master plans, technical drawings | field observation, interview |
| area served by main collector drains | ha | - | design, plans, master plans, technical drawings | field observation, interview |
| **Pump station performance** | | | | |
| intake performance | - | - | - | field observation, interview |
| pump performance | - | - | - | field observation, interview |
| drain performance | - | - | - | field observation, interview |
| **Pump station operation** | | | | |
| operation policy | - | - | - | field observation, interview |
| operation personnel | - | - | - | field observation, interview |
| **Pump station maintenance** | | | | |
| condition of pump station | - | - | - | field observation, interview |
| maintenance infrastructure | - | - | - | field observation, interview |
| **Water Delivery Service** | | | | |

| | | | | |
|---|---|---|---|---|
| actual water delivery service that pump station provides to the pipe system (water user perspective) | - | - | - | field observation, interview |
| actual water delivery service provided to sub-pipelines operated by a paid employee (water user perspective) | - | - | - | field observation, interview |
| actual water delivery service received by individual units - fields and farms (water user perspective) | - | - | - | field observation, interview |
| Pipes and deliveries characteristics | | | | |
| diameter of main pipe/s | m | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| nominal pressure of main pipe/s | bar | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| working pressure of main pipe/s | bar | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| average discharge in main pipe/s | l/s | seasonal | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| material of main pipe/s | - | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |

| | | | | |
|---|---|---|---|---|
| diameter of of sub-pipelines/branches | m | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| nominal pressure of sub-pipelines/branches | bar | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| working pressure of sub-pipelines/branches | bar | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| average discharge in sub-pipelines/branches | l/s | seasonal | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| material of sub-pipelines/branches | - | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| average depth of main pipeline - if buried | m | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| average depth of branch pipeline - if buried | m | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| corrosion protection | - | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| flexibility of the pipe | - | - | design, plans, master plans, technical drawings, | field observation, interview |

| | | | | |
|---|---|---|---|---|
| | | | manufacturer recommendations | |
| bedding of the pipe | - | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| internal lining | - | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| number of nodes in the pipelines/non-hydrant type | - | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| type of joints | - | - | design, plans, master plans, technical drawings | field observation, interview |
| number of nodes in the pipelines/hydrant type | - | - | Design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| type of joints | - | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| number of control equipment throughout the system | - | - | design, plans, master plans, technical drawings | field observation, interview |
| total number of shut-off valves throughout the system | - | - | design, plans, master plans, technical drawings | field observation, interview |
| total number of shut-off valves between main and branch pipes | - | - | design, plans, master plans, technical drawings | field observation, interview |

| | | | | |
|---|---|---|---|---|
| total number of check valves throughout the system | - | - | design, plans, master plans, technical drawings | field observation, interview |
| total number of pressure regulating device in the main pipe | - | - | design, plans, master plans, technical drawings | field observation, interview |
| total number of metering devices throughout the system | - | - | design, plans, master plans, technical drawings | field observation, interview |
| total number of auxiliary devices throughout the system | - | - | design, plans, master plans, technical drawings | field observation, interview |
| total number of filters throughout the system | - | - | design, plans, master plans, technical drawings | field observation, interview |
| total number of hydrants in the system | - | - | design, plans, master plans, technical drawings | field observation, interview |
| typical area size served by one hydrant | ha | - | design, plans, master plans, technical drawings | field observation, interview |
| typical number of farms served by one hydrant | - | - | design, plans, master plans, technical drawings | field observation, interview |
| typical number of hydrants serving one farm | - | - | design, plans, master plans, technical drawings | field observation, interview |
| typical number of hydrants operating simultaneously | - | - | design, plans, master plans, technical drawings | field observation, interview |
| nominal diameter of hydrants | mm | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |

| | | | | |
|---|---|---|---|---|
| nominal design pressure in the hydrant | bar | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| range of working pressure in the hydrant | bar | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| range of pressure regulator in the hydrant | bar | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| maximum discharge | l/s | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| average working discharge | l/s | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| range of flow regulator in the hydrant | bar | - | design, plans, master plans, technical drawings, manufacturer recommendations | field observation, interview |
| required hydrant elasticity as per design | - | - | design, plans, master plans, technical drawings | field observation, interview |
| hydrant type | - | - | design, plans, master plans, technical drawings | field observation, interview |
| hydrant design | - | - | design, plans, master plans, technical drawings | field observation, interview |
| Pipes and deliveries performance | | | | |

| | | | | |
|---|---|---|---|---|
| pipe performance | - | - | - | field observation, interview |
| hydrant performance | - | - | - | field observation, interview |
| Pipes and deliveries operation | | | | |
| operation policy | - | - | - | field observation, interview |
| operation personnel | - | - | - | field observation, interview |
| Pipes and deliveries maintenance | | | | |
| condition of pipes and hydrants | - | - | - | field observation, interview |
| maintenance infrastructure | - | - | - | field observation, interview |

A.1.5.6.2. <u>Involved stakeholders</u>

The chapter can be completed based on a field visit. The majority of the questions rely on expert observation, existing technical documentations and drawings, and manufacturer specifications. The following stakeholders are recommended to be involved:

- site engineer;
- constructer/manufacturer;
- water user associations, irrigation associations, farmers' organization etc.

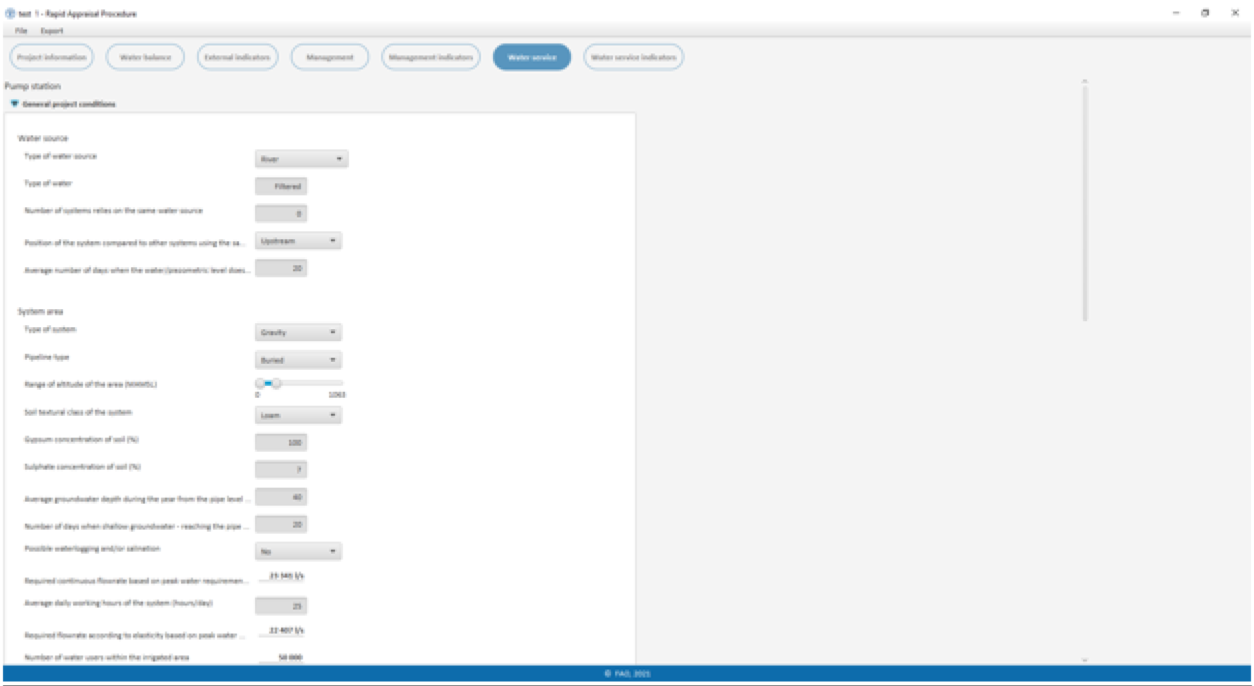
A.1.5.6.3. <u>Requested time</u>

The task should be implemented within not more than 2 week, balancing between field and desktop work.

A.1.5.6.4. <u>Data input and calculation scheme</u>

<u>General Project Conditions:</u>

*Figure A3 - 38 Main view of general project conditions section in the Pump station block*



*Type of water source*: the origin or the place of water, from where the water is pumped.

*Type of water*: source of water whether it is freshwater, recirculated or both freshwater and recirculated water.

*Number of systems relying on the same water sources:*

- the number of independent irrigation schemes sourcing water from the same origin;
- for example, if multiple irrigation schemes are supplied by the same branch canal/reservoir.

*Position of the system compared to other systems using the same sources:*

- the upstream, middle or downstream position of the system compared to other systems sourcing water from the same origin;
- the position might be absolute or relative term;
- if the position is assessed in absolute term, it should be expressed based on the geometric mean;
- if the position is assessed in relative term, the vulnerability of the system to other systems' management should be expressed.

*Average number of days when the water/piezometric level does not reach the minimum required:*

- the average number of days during the periods, when the water/piezometric level is lower than the required, hampering the pump operation;
- the periods can last shorter or longer than a day, therefore, the average number of days should be estimated;
- only those periods must be taken into account when the low water/piezometric level effectively disables the pumping.

*Type of system*: type of the system, whether the conveyance is gravity-fed or pressurized.

*Pipeline type*: type of the pipeline, whether it is buried, surface or suspended.

*Range of altitude of the area:*

- range of the altitude in the irrigation scheme;
- the range should be calculated per the difference between lowest and highest points.

*Soil textural class of the system*: soil class, whether it is sand, loam, silt or clay.

*Gypsum concentration of soil:*

- concentration of gypsum in the soil surrounding the buried pipes;
- the concentration must be assessed in the light of its effect on the buried pipes and the potential ability to cause corrosion.

*Sulphate concentration of soil:*

- concentration of sulphate in the soil surrounding the buried pipes;
- the concentration must be assessed in the light of its effect on the buried pipes and the probability of the sulphate attack inducing corrosion.

*Average groundwater depth during the year, measured from the pipe level:*

- the average distanced between the buried pipe and the groundwater table;

- the groundwater depth must be assessed in the light of its potential effect on the buried pipe (corrosion, flushing out, etc.)

*Number of days when shallow groundwater reaching the pipe occurs during the year:* the total number of days in a year, when the groundwater level reaches the buried pipe.

*Possible waterlogging and/or salinization*: the probability of waterlogging or salinization due to the malfunctioning irrigation system or management.

*Required continuous flowrate based on peak water requirement of command area:*

- continuous flowrate refers to the situation, when water supply is based on continuous flow (24/7), therefore, farmers have access to this flowrate over the year;
- the calculation is based on the assumption that the system capacity is designed as per the peak requirement;
- the required continuous flowrate is calculated from the maximum monthly crop water requirement of the irrigation scheme, assuming that the irrigation is always on;
- the calculation is based on peak water demand, coming from the most water consuming month;
- the calculated value provides baseline information for the on-demand system design.

*Average working hours of the system per day:*

- the average number of hours per irrigation day when the irrigation is on;
- this refers to the number of hours in irrigation days, and not in off-season.

*Required flowrate according to elasticity based on peak water requirement of the command area:*

- the calculation is the ratio of required continuous flowrate in peak period and the average working hours of the system;
- the value expresses the required system capacity considering the prevailing the irrigation practices (average working hours in irrigation days);
- the value can be compared to the actual design capacity to assess the adequacy, any negative deviation from the required flowrate assumes insufficient water supply in peak periods.

*Number of water users within the irrigated area*: number of farmers in the area.

*Total length of the pipeline:*

- the total length of all pipelines (main, branches) in the distribution system;
- this does not include the laterals of the on-farm irrigation systems;
- total length of the pipelines allows the assessment of the design, whether it is sufficiently optimized.

*Total length of the main line:*

- the total length of the main distribution line;
- total length of the main pipe allows the assessment of the design, whether it is sufficiently optimized.

*Total length of other feeder/sub-branches:*

- the total length of all feeder/sub-branches;
- this does not include the laterals of the on-farm irrigation systems;
- total length of the branches allows the assessment of the design, whether it is sufficiently optimized;
- the length of the branches allows the assessment of the network, whether it provides sufficient coverage for all farms.

*Number of sub-systems in the pipe system:*

- the total number of the sub-systems, which are separated by nodes;
- the number of sub-system allows the assessment of the management;
- the management and performance of the sub-systems might vary, therefore, a narrative on the individual performance can complement the assessment.

*Average size of sub-systems:*

- total area irrigated by an adjacent system separated from the other by nodes;
- the area size can vary amongst the sub-systems, therefore it is desirable to collect information on the largest and smallest systems and prepare a comparative analysis.

*Position of sub-systems:*

- number of sub-systems positioned in upstream, middle or downstream areas.
- the calculation can be based on geometric distribution or the exposure of sub-systems to the activity of upstream sub-systems;
- the question refers to the symmetry of the layout, and the potential inferiority of downstream systems.

*Average number of farms per sub-system:* number of farms supplied by one sub-system separated from other farms by nodes.

*Branching type of the system:* the design of the branch lines, whether they are branched (each outlet is supplied by one line) or looped (each outlet is supplied by multiple lines).

*Operating pressure range at hydrant level:*

- the minimum required pressure to operate the hydrant;
- pressure in hydrants can significantly vary throughout the system, therefore the operating pressure should be compared to the measured pressure to assess the pressure adequacy;

- in many larger systems, hydrants operate simultaneously, therefore, it is important to assess the pressure during simultaneous operation.

*Basis of carrying capacity of the system:*

- the basis of the system design, whether it is designed per crop water requirement (actual peak water demand at system level), allocation from national water budget (pre-defined water requirement of each crop as ceiling of water supply) or allocation by rotational schedule (supply-driven distribution based on periodically distributed supply);
- it is important to assess the adequacy of the design, and understand whether the design of the system allows adequate water service or it is a constraining factor.

*Number of gate valves*: number of valves responsible for water distribution and control in the system.

*Number of drains:*

- number of drains connected to the farms;
- the drain capacity and density must be assessed against the irrigation practices, on-farm irrigation technique, soil type, amount of supplied water and the land management practices;
- insufficient drain, particularly in heavy soil might drive to salinity, therefore, the drain assessment must be contextualized in potential scenarios of mismanagement.

*Number of distributaries:*

- number of final offtakes supplying water directly to the farms (most frequently hydrants);
- this does not include the on-farm irrigation systems.;
- the number of offtakes depends on many factors, for example the capacity of offtake in the context of the land size, the land structure and tenure, the original distribution layout etc.; therefore, the number of offtakes must be assessed in the context of the supplied land and required water supply.

*Average land size served by distributaries:*

- the average size supplied by one offtake;
- the size of the land must be assessed in the context of the capacity of the offtake, and the irrigation schedule to understand if the design of distributaries is adequate.

*Technique of on-farm irrigation:*

- type of on-farm irrigation system, whether it is a surface, drip or sprinkler irrigation system;
- the on-farm irrigation system might give information on the design principles of the distribution system;

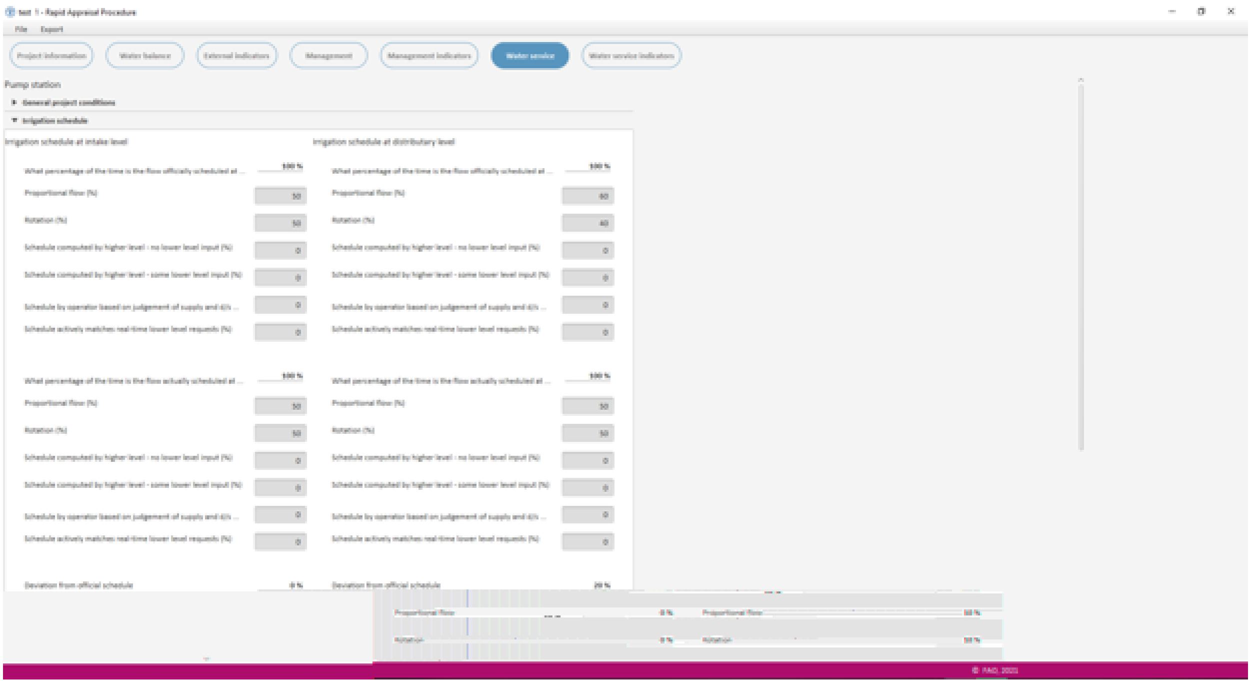
- the on-farm irrigation system is not discussed and evaluated further in the RAP.

*Layout of the system:*

- location of the final distributaries as per compared to the water sources;
- calculated number of final distributaries close or far from the water sources.

<u>Irrigation schedule:</u>

*Figure A3 - 39 Main view of irrigation schedule section in Pump station block*



*What percentage of the time is the flow officially scheduled at intake level:*

- the official schedule of the pump station to withdraw water from the water source to the system;
- the official schedule refers to the schedule agreed by the authorities and/or managers on the water allocation quota and the type of schedule;
- the official schedule can include one type of allocation policy or a mixed type.

*What percentage of the time is the flow actually scheduled at intake level:*

- the actual schedule of the pump station to withdraw water from the water source to the system;
- the actual schedule refers to the schedule followed in the reality;
- the actual schedule does not necessary reflect on the official schedule;
- the actual schedule can include one type of allocation policy or a mixed type.

*Deviation from official schedule:*

- the difference between the official and actual schedule at pump station level;
- this refers to the degree of compliance with the official schedule;
- the higher the deviation the lower the compliance with the official schedule.

*What percentage of the time is the flow officially scheduled at distributaries level:*

- the official schedule of the distributaries to supply water to the farms;
- the official schedule refers to the schedule agreed by the authorities and/or managers on the water allocation quota and the type of schedule;
- the official schedule can include one type of allocation policy or a mixed type.

*What percentage of the time is the flow actually scheduled at distributaries level:*

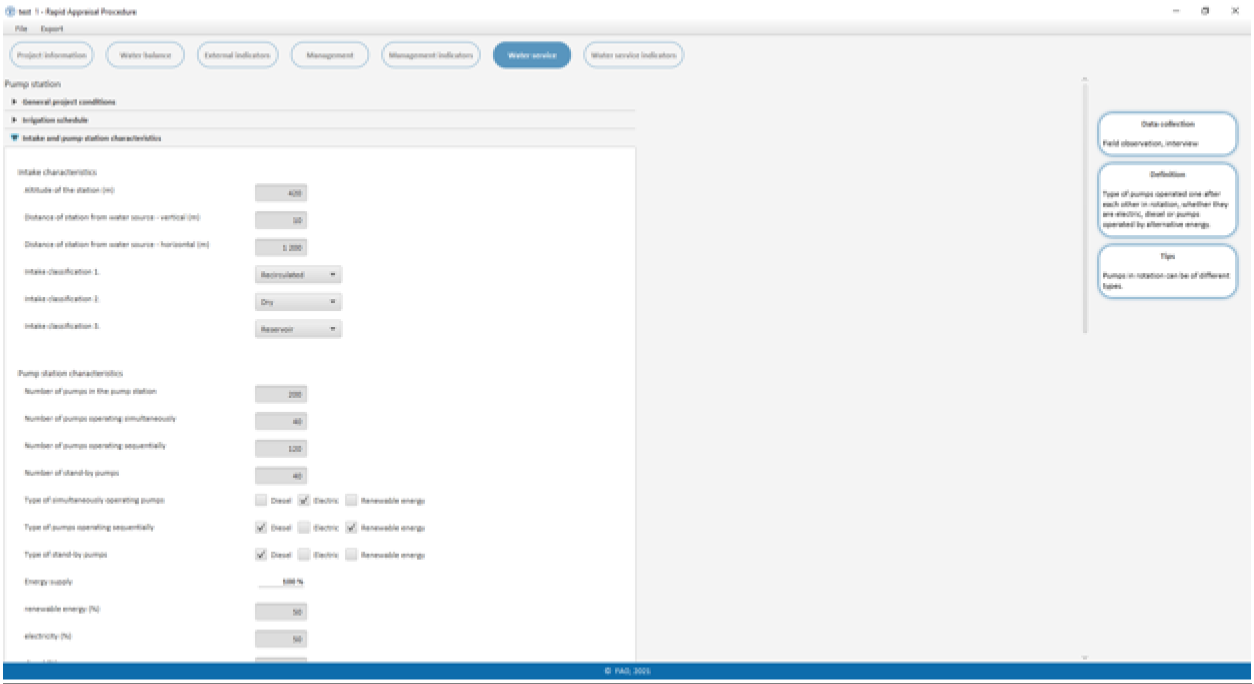
- the actual schedule of the distributaries to supply water to the farms;
- the actual schedule refers to the schedule followed in the reality;
- the actual schedule does not necessary reflect on the official schedule;
- the actual schedule can include one type of allocation policy or a mixed type.

*Deviation from official schedule:*

- the difference between the official and actual schedule at distributaries level;
- this refers to the degree of compliance with the official schedule;
- the higher the deviation the lower the compliance with the official schedule.

<u>Intake and pump station characteristics:</u>

*Figure A3 - 40 Main view of pump station characteristics section in Pump station block*



*Altitude of the station*: the altitude of the pump station.

*Distance of station from water sources - vertically:*

- the lifting height of water from source to the pump station;
- this gives a partial information on the total head, however, further information is required to calculate the total head.

*Distance of station from water sources – horizontally*: the horizontal move of water from source to the pump station.

*Intake classification 1*.: type of intake whether it is submerged or exposed.

*Intake classification 2*.: type of intake whether it is wet or dry intake.

*Intake classification 3.:* type of intake whether it is river, reservoir or canal intake.

*Number of pumps in the pump station:*

- number of the pump in the station, including the back-up pumps;
- beyond the number, it is important to categorize the pumps as per the number of different types and capacities.

*Number of pumps operating simultaneously*: number of pumps operating at the same time in irrigation period.

*Number of pumps operating sequential:*

- number of pumps operated one after each other in rotation;
- this is most commonly applied in pump stations with continuous supply.

*Number of stand-by pumps*: number of pumps provided as back-up equipment in case of failure.

*Type of simultaneously operating pumps:*

- type of pumps operating at the same time whether they are electric, diesel or pumps operated by alternative energy;
- simultaneous pumps are of the same type.

*Type of pumps operating sequential:*

- type of pumps operated one after each other in rotation, whether they are electric, diesel or pumps operated by alternative energy;
- pumps in rotation can be different.

*Energy supply:*

- the share of energy sources;

- one system can be supplied by different energy sources;
- the ratio must be set up according to the annual consumption.

*Total head:*

- the required pressure to move fluids through a system;
- total head depends on the system configuration and layout;
- the total head must be justified by any kind of pump selection study.

*Maximum design capacity of the pump:*

- the maximum discharge supplied, when the system is fully operational and all pumps are on;
- the design capacity must be compared to the peak water requirement to understand the adequacy of supply.

*Type of pressure control device:*

- description of the type of pressure control device if it exists;
- it might be important to assess the suitability of the pressure control.

*Type of pressure measurement device:*

- description of the type of pressure measurement device if it exists;
- it might be important to assess the suitability of the pressure measurement device;
- existence of pressure measurement device refers to the availability of historical datasets;

*Average pressure during operating hours:*

- the measured average pressure in a typical irrigation day;
- this does not refer to the peak demand, but rather to a normal operation mode;
- if more pumps are operated simultaneously, the average pressure must be taken into account.

*Pressure in peak period:*

- the maximum pressure registered during irrigation season;
- this baseline information gives an idea on the sufficiency of the design capacity of the system.

*Magnitude of the variation in pressure:*

- the average change in pressure during operation in a typical irrigation day;
- a large deviation from the design pressure might indicate some problem in the system (clogging, broken parts, etc.), therefore, the varying pressure must be assessed in the context of the design pressure and/or irrigation practices.

*Average delivered discharge on daily base:*

- the average water supply per day in a typical irrigation day;
- the average daily discharge must be assessed in the context of the water demand and the system capacity;
- if the average discharge is significantly different than the design discharge, the reasons behind must be investigated. Such reason can be the oversized design, declined performance, etc.

*Magnitude of the variation in discharge:*

- the average change in the discharge during operation. In a typical irrigation day;
- a large deviation from the design discharge might indicate some problem in the system (clogging, broken parts, etc.), therefore, the varying discharge must be assessed in the context of the design discharge and/or irrigation practices.

*Average energy consumption per hour:*

- average energy use for irrigation as per the typical irrigation practices;
- the average energy consumption might give information on the cost-efficiency of the system, while analyzing the ratio of energy consumption per delivered discharge;

*Peak energy consumption per hour*: the maximum energy consumption occurring during the season.

*The overall design efficiency of the pumps:*

- the overall design efficiency is the theoretical ratio of the water to the power;
- the average design efficiency of the pumps as per the manufacturer recommendation;
- the design efficiency is a baseline indicator to be compared to the actual efficiency.

*The estimated actual efficiency of the pumps:*

- the actual efficiency of the pumps;
- this can be significantly lower than the design efficiency, depending on the configuration, layout, condition, etc.;
- actual efficiency is an indicator of the performance of the system; a too high consumption might refer to structural (poor pump selection, design failure etc.) or operation (poor maintenance, inadequate irrigation practices, etc.) issues.

*Ability to variate the head pressure according to the water demand*: degree of the equipment of the pump station whether the head pressure can be modified or not.

*Type of drain:* type of drain whether it is surface drainage, tubewell drainage or subsurface drainage.

*Removal of excess water from field drains:* type of excess water removal whether it is gravity-fed or pumped.

*Area served by field drains:*

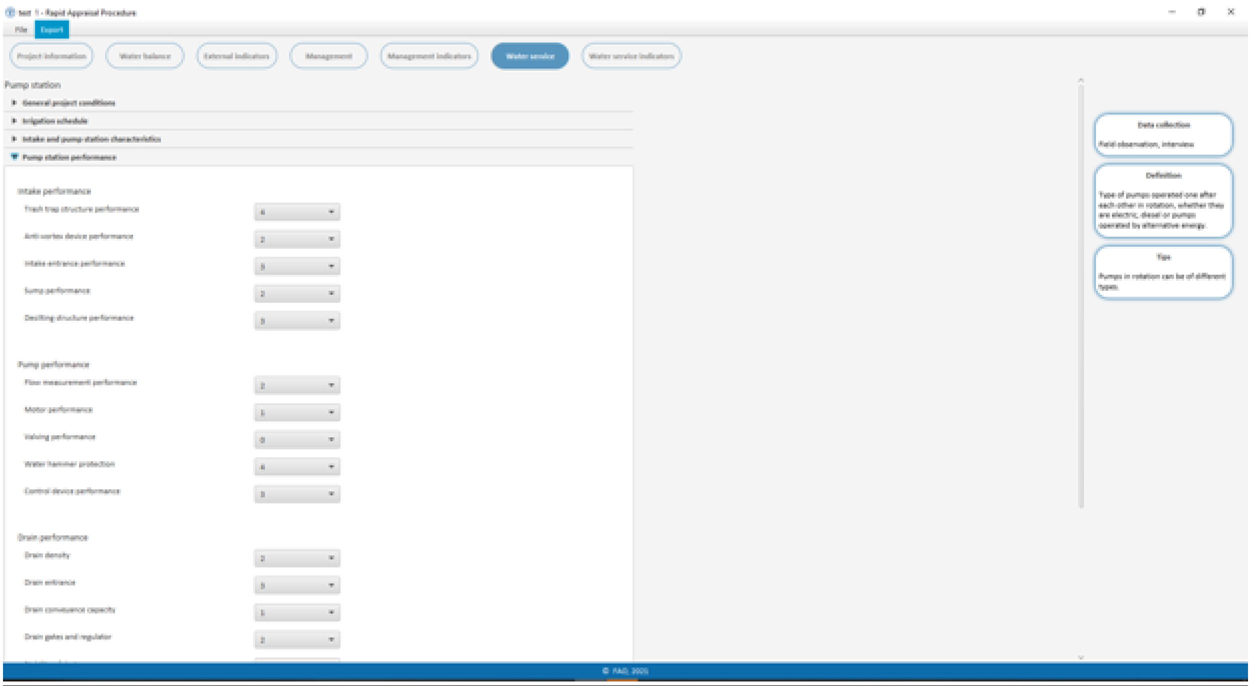
- the typical size of the area served by one field drain;
- it might be important to assess whether the drain is well-sized and suitable for serving the area.

*Area served by main collector drain:*

- the size of the area connected to the main drain collector;
- it might be important to assess the capacity and the suitability of the main collector.

<u>Pump station performance:</u>

*Figure A3 - 41 Main view of pump station performance section in Pump station block*



*Intake performance*

- the indicator consists of sub-indicators that describe the main items/functions of the system part;
- the set of sub-indicators help underlining the most important features impacting the system performance;
- scoring based on guidance listed under each sub-indicator;
- if any of the sub-indicators is not part of the system, the scoring should be 0;
- the scoring (0-4) should be based on field observation and interview;
- if observed conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition.

Food and Agriculture Organization of the United Nations

*Pump performance*

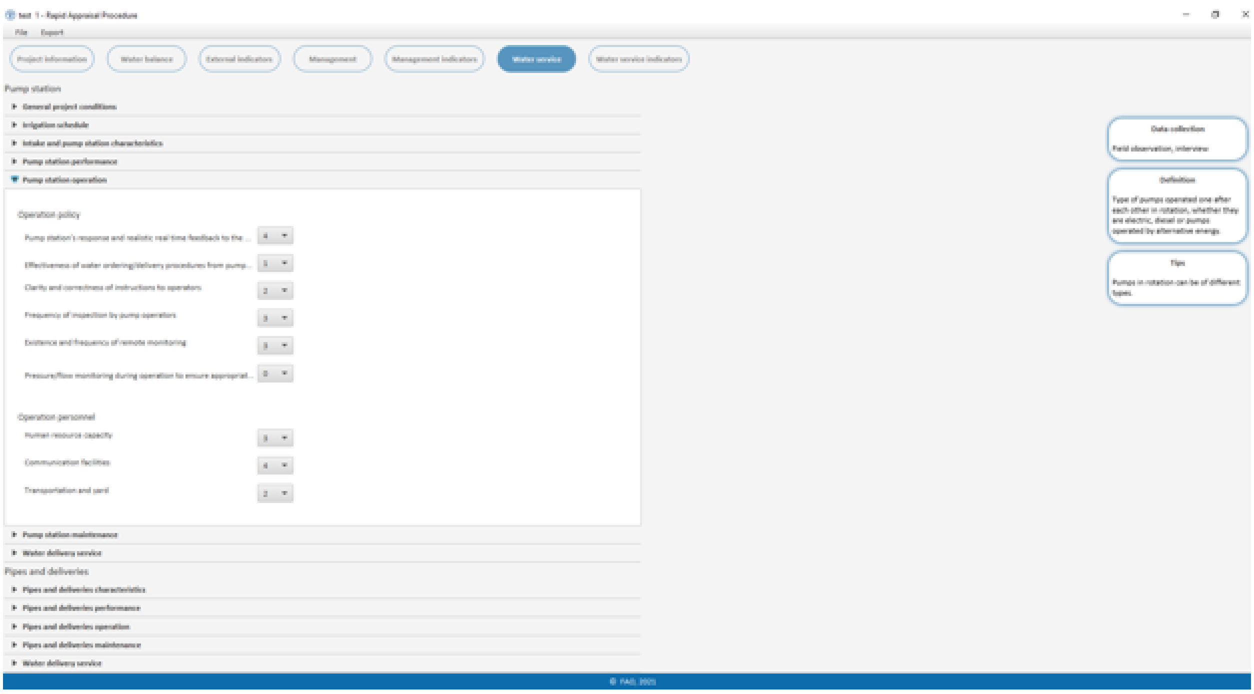
- the indicator consists of sub-indicators that describe the main items/functions of the system part;
- the set of sub-indicators help underlining the most important features impacting the system performance;
- scoring based on guidance listed under each sub-indicator;
- if any of the sub-indicators is not part of the system, the scoring should be 0;
- the scoring (0-4) should be based on field observation and interview;
- if observed conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition

*Drain performance*

- the indicator consists of sub-indicators that describe the main items/functions of the system part;
- the set of sub-indicators help underlining the most important features impacting the system performance;
- scoring based on guidance listed under each sub-indicator;
- if any of the sub-indicators is not part of the system, the scoring should be 0;
- the scoring (0-4) should be based on field observation and interview;
- if observed conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition.

<u>Pump station operation:</u>

*Figure A3 - 42 Main view of pump station operation section in Pump station block*



*Operation policy*

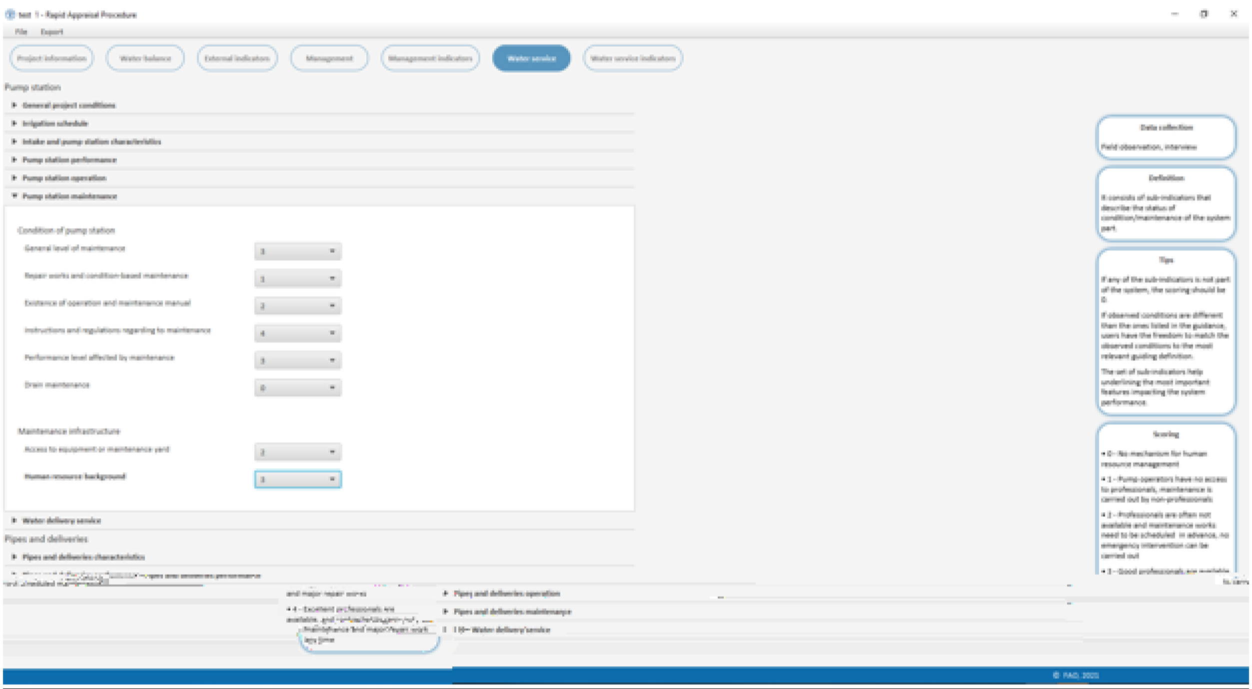
- the indicator consists of sub-indicators that describe the main management functions;
- the set of sub-indicators help underlining the most important management features impacting the system performance;
- scoring based on guidance listed under each sub-indicator;
- if any of the sub-indicators does not exist in the system, the scoring should be 0;
- the scoring (0-4) should be based on field observation and interview;
- if observed conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition.

*Operation personnel*

- the indicator consists of sub-indicators that describe the main management functions;
- the set of sub-indicators help underlining the most important management features impacting the system performance;
- scoring based on guidance listed under each sub-indicator;
- if any of the sub-indicators does not exist in the system, the scoring should be 0;
- the scoring (0-4) should be based on field observation and interview;
- if observed conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition.

<u>Pump station maintenance:</u>

*Figure A3 - 43 Main view of pump station maintenance section in Pump station block*



*Condition of pump station*

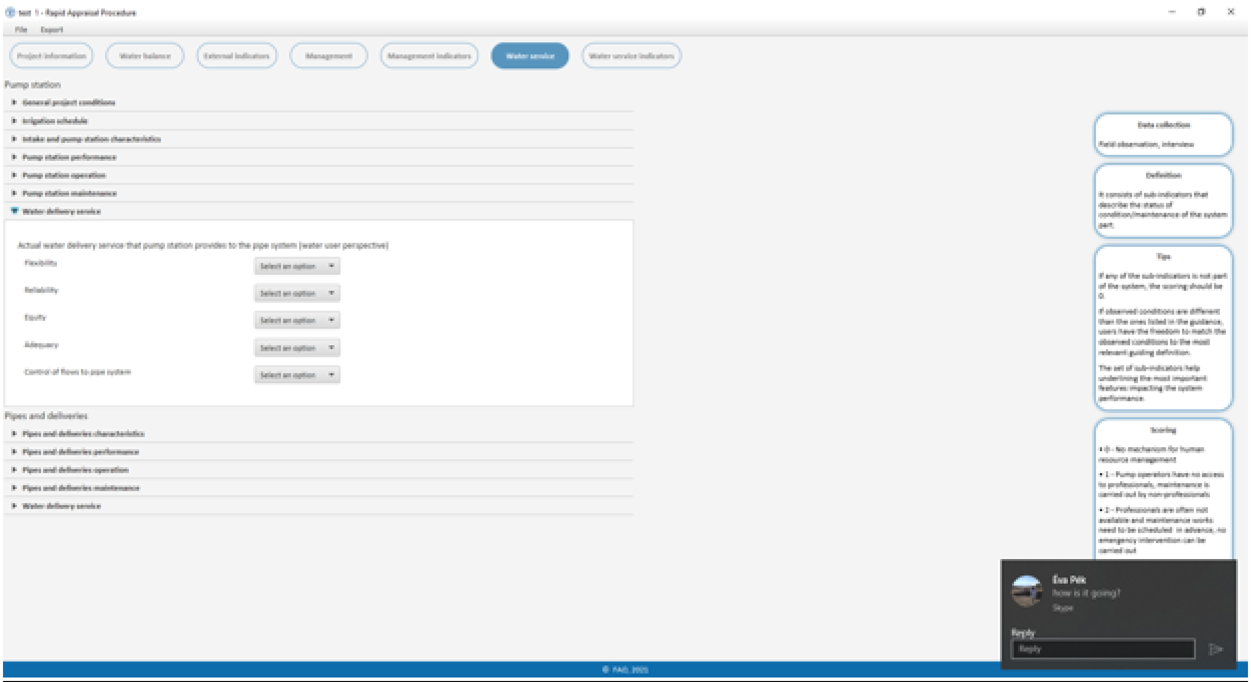
- the indicator consists of sub-indicators that describe the status of condition/maintenance of the system part;
- the set of sub-indicators help underlining the most important features impacting the system performance;
- scoring based on guidance listed under each sub-indicator;
- if any of the sub-indicators does not exist in the system, the scoring should be 0;
- the scoring (0-4) should be based on field observation and interview;
- if observed conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition

*Maintenance infrastructure*

- the indicator consists of sub-indicators that describe the status of condition/maintenance of the system part;
- the set of sub-indicators help underlining the most important features impacting the system performance;
- scoring based on guidance listed under each sub-indicator;
- if any of the sub-indicators does not exist in the system, the scoring should be 0;
- the scoring (0-4) should be based on field observation and interview;
- if observed conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition.

<u>Water Delivery Service:</u>

*Figure A3 - 44 Main view of Water Delivery Service section in Pump station block*

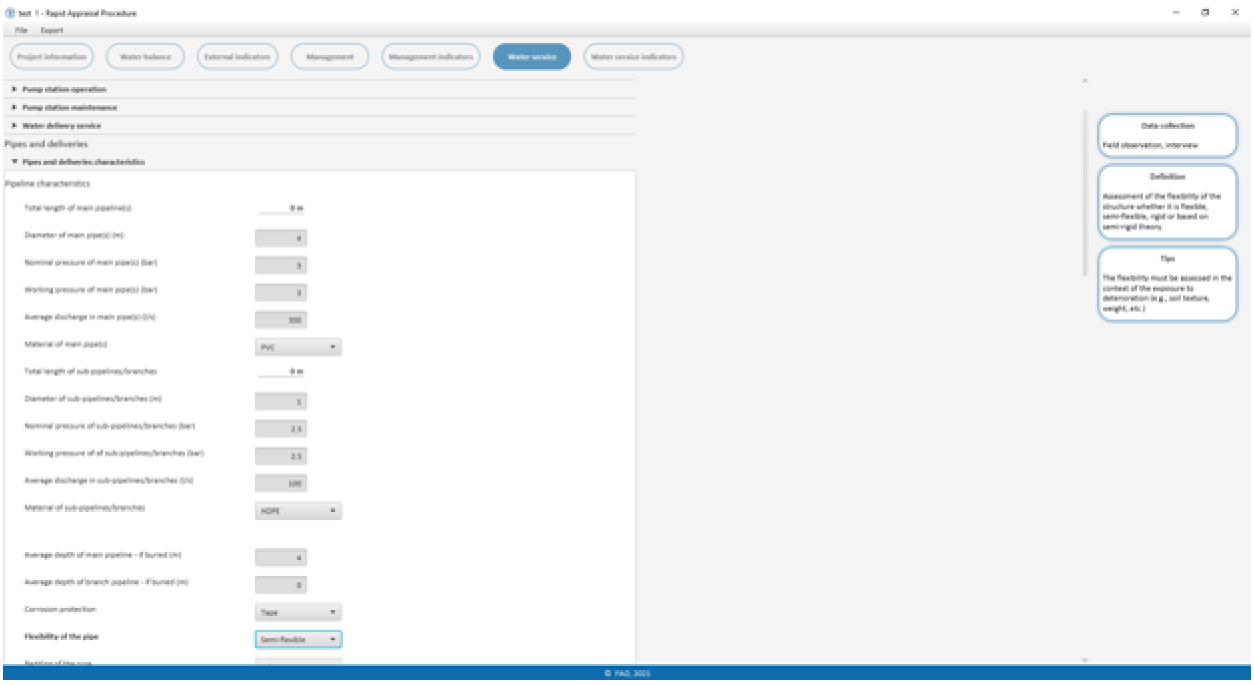



*Actual water delivery service that pump station provides to the pipe system (water user perspective):*

- The composite indicator consists of five sub-indicators: flexibility, reliability, equity, adequacy and control of flow;
- Scoring is based on guidance listed under the sub-indicator;
- The sub-indicators should be evaluated considering only the system from pump station to main pipe system, not including the branch-pipes;
- The scoring should be based on the answers of the users. “Actual” water delivery service refers to the perception of the farmers directly. In order words, how the farmers evaluate the performance of the water delivery along the defined sub-indicators.

<u>Pipes and deliveries characteristics:</u>

*Figure A3 - 45 Main view of pipes and deliveries characteristics section in the Pipes and deliveries block*



*Total length of main pipeline/s:* the length of the main distribution pipe.

*Diameter of main pipe/s:* inner diameter of the main distribution pipe.

*Nominal pressure of main pipe/s:* the design pressure of the pipe, indicating the mechanical strength.

*Working pressure of main pipe/s:*

- internal maximum allowable pressure in a given point of the pipe;
- it might be important to assess the working pressure in the context of the pump station size and the required pressure of the distributaries;
- if the distributaries are connected to the pressurized on-farm techniques, the need for booster pump or high-pressure pump must be assessed.

*Average discharge in main pipe/s:*

- the average delivered discharge in the main pipe in a typical irrigation day;
- this must be assessed in the light of the water requirement;
- if the delivered discharge in the main pipe is sufficient, but water scarcity occurs in any part of the system, the water allocation policy must be revised and causes must be identified.

*Material of main pipe/s:*

- type of the pipe material (MSP, DIP, GRP, PVC, HDPE, RCC, RCCP, PSC, BWSC);
- the material of the main pipe depends on external (soil type, soil texture, depth of buried pipe, exposure to external pressure, etc.) and internal (required pressure/discharge, maintenance facilities etc.) factors, therefore, the selected material must be assessed in the context of the system conditions.

*Total length of sub-pipelines/branches:*

- the total length of all feeder/sub-branches, but not including the on-farm irrigation systems;
- it is important to assess the layout of the system, the differences in branch sizing and the supplied area per branches.

*Nominal pressure in the sub-pipelines/branches*: the design pressure of the pipe, indicating the mechanical strength.

*Working pressure in the sub-pipe/branches:*

- internal maximum allowable pressure in a given point of the pipe;
- it might be important to assess the working pressure in the context of the pump station size, main pipe and the required pressure of the distributaries;
- if the distributaries are connected to the pressurized on-farm techniques, the need for booster pump or high-pressure pump must be assessed.

*Average discharge in sub-pipe/branches:*

- the average delivered discharge in an average size branch pipe in a typical irrigation day;
- this must be assessed in the light of the water requirement;
- if the delivered discharge in the main pipe is sufficient, but water scarcity occurs in any part of the system, the water allocation policy must be revised and causes must be identified.

*Material of sub-pipelines/branches:*

- type of the pipe material (MSP, DIP, GRP, PVC, HDPE, RCC, RCCP, PSC, BWSC);
- the material of the main pipe depends on external (soil type, soil texture, depth of buried pipe, exposure to external pressure, etc.) and internal (required pressure/discharge, maintenance facilities etc.) factors, therefore, the selected material must be assessed in the context of the system conditions.

*Average depth of main pipeline:*

- average depth of buried pipe measured from the surface;
- the trench of the pipeline must be assessed in the context of the groundwater depth, soil depth, soil type and exposure to external pressures (e.g. heavy machines);
- the trench must be assessed whether it allows regular inspection of troubleshooting.

*Average depth of branch pipeline:*

- average depth of buried pipe measured from the surface;
- the trench of the pipeline must be assessed in the context of the groundwater depth, soil depth, soil type and exposure to external pressures (e.g. heavy machines);
- the trench must be assessed whether it allows regular inspection of troubleshooting.

*Corrosion protection:*

- type of corrosion protection whether it is cement coating, metal coating, painting, tape coating, other or no protection;
- it is important to take note of the corrosion protection and assess its efficiency.

*Flexibility of the pipe:*

- assessment of the flexibility of the structure whether it is flexible, semi-flexible, rigid or based on semi-rigid theory;
- the flexibility must be assessed in the context of the exposure to deterioration (e.g. soil texture, weight, etc.)

*Bedding of the pipe:*

- type of bedding whether it is concrete, sand or granular fill, fine granular fill or no specific bedding;
- *the bedding must be assessed in the context of the depth of trench, the pipe type and* exposure to deterioration (e.g. soil texture, weight, etc.)

*Internal lining:*

- type of lining whether it is corrosion resistant, cement lining, concrete lining, other or no lining;
- the lining must be assessed in the context of exposure to external factors.

*Number of nodes in the pipelines/non-hydrant type:*

- nodes indicate the structures separating the sub-systems in the system;
- this refers only to the nodes for control and distribution, but not for final delivery.

*Type of joints:*

- type of joints whether they are socket and spigot, flanged, mechanical, flexible or expansion;
- the type must be investigated whether it is suitable for the conditions and pressure;
- the quality of the joints must be evaluated to understand the persistence of these critical system parts.

*Number of control equipment throughout the system:*

- control equipment include the following type of equipment: shut-off valve, check valve, metering devices and auxiliary devices;
- the number of control equipment is the total number of the abovementioned valves and devices.

*Total number of shut-off valves throughout the system:*

- number of the shut-off valves of different types throughout the system;
- the efficiency and suitability of these equipment must be assessed in the context of the system as a whole.

*Total number of shut-off valves between main and branch pipes:*

- number of the shut-off valves of different types between main and branch pipes;
- the efficiency and suitability of these equipment must be assessed in the context of the system as a whole.

*Total number of check valves throughout the system:*

- number of the check valves of different types throughout the system;
- the efficiency and suitability of these equipment must be assessed in the context of the system as a whole.

*Total number of pressure regulating device throughout the system:*

- number of pressure regulating equipment (valve, device, etc.) throughout the system;
- the efficiency and suitability of these equipment must be assessed in the context of the system as a whole.

*Total number of metering devices throughout the system:*

- number of metering devices (pressure or flow) throughout the system;
- the efficiency and suitability of these equipment must be assessed in the context of the system as a whole.

*Total number of auxiliary devices throughout the system:*

- number of auxiliary devices (air valves, safety valves) in the system;

- the efficiency and suitability of these equipment must be assessed in the context of the system as a whole.

*Total number of filters (gravel, hydro-cyclone, screen, disk, automatic self-cleaning) throughout the system:*

- number of filters of different types throughout the system;
- the efficiency and suitability of these equipment must be assessed in the context of the system as a whole.

*Total number of hydrants in the system:*

- the total number of hydrants as final offtake to farms;
- the hydrant density and layout must be estimated to understand the water allocation policy.

*Typical area size served by one hydrant:*

- the typical farm size per hydrant;
- the capacity of the hydrant must be estimated in the light of the area size;
- one hydrant might serve more than one farm, or more hydrant might serve one farm.

*Typical number of farms served by one hydrant:*

- the typical number of farms per hydrant, if one hydrant supplies one or more farms;
- this question refers to the land structure and is typically valid in smallholder systems.

*Typical number of hydrants serving one farm:*

- the typical number of hydrants per farm, if more hydrants supply one farm;
- this question refers to the land structure and is typically valid in systems with medium or larger size lands.

*Typical number of hydrants operating simultaneously:*

- the number of hydrants working simultaneously in irrigation periods;
- this refers to the hydrants operating exactly at the same time;
- if more hydrants operate at the same time, the irrigation schedule must be investigated.

*Nominal diameter of hydrants*: inner diameter of the hydrant.

*Nominal design pressure in the hydrant:* the working pressure of the hydrant.

*Range of working pressure in the hydrant*: difference between minimum required and maximum pressure in the hydrant to operate.

*Range of pressure regulator in the hydrant:*

- if the hydrant is equipped with pressure regulator, the range of pressure set in the hydrant;
- if the hydrant is not equipped with regulator, the reasons must be identified.

*Maximum discharge:*

- the maximum outlet discharge of the hydrant;
- this must be measured when the hydrant operates individually (not simultaneously with other hydrants);

*Average working discharge:*

- the average discharge of the hydrant in irrigation period;
- the average discharge must be measured in typical irrigation day;
- the average discharge must be assessed in the context of water requirement and the maximum discharge.

*Range of flow regulator in the hydrant:* the required pressure to operate the flow regulator, if the hydrant is equipped with regulator;

*Peak water demand at hydrant level:*

- maximum evapotranspiration-based water requirement per hectare, calculated from the most water demanding month;
- this does not include the other water requirements (leaching, special practices, system losses, etc.);
- this refers to crop water requirement calculated from the evapotranspiration.

*Required hydrant elasticity as per design:*

- elasticity indicates the “degree of freedom” to select irrigation practices;
- the elasticity means that the hydrant capacity is adjusted to the irrigation practices;
- elasticity is an important term, because calculating the capacity merely from the crop water requirement would require continuous flow; however, it is unlikely that farmers have the opportunity to irrigate continuously over the season;
- the degree of freedom must be estimated according to different criteria (e.g. duration and frequency of irrigation, number of farmers in the system, irrigation schedule, type of on-farm equipment, etc.).
- the capacity of the hydrant must be assessed not only according to the crop water requirement but in the context of the hydrant elasticity.

*Required hydrant capacity:*

- the calculated hydrant capacity according to the evapotranspiration-based crop water requirement, hydrant elasticity and the typical land size served by the hydrant;

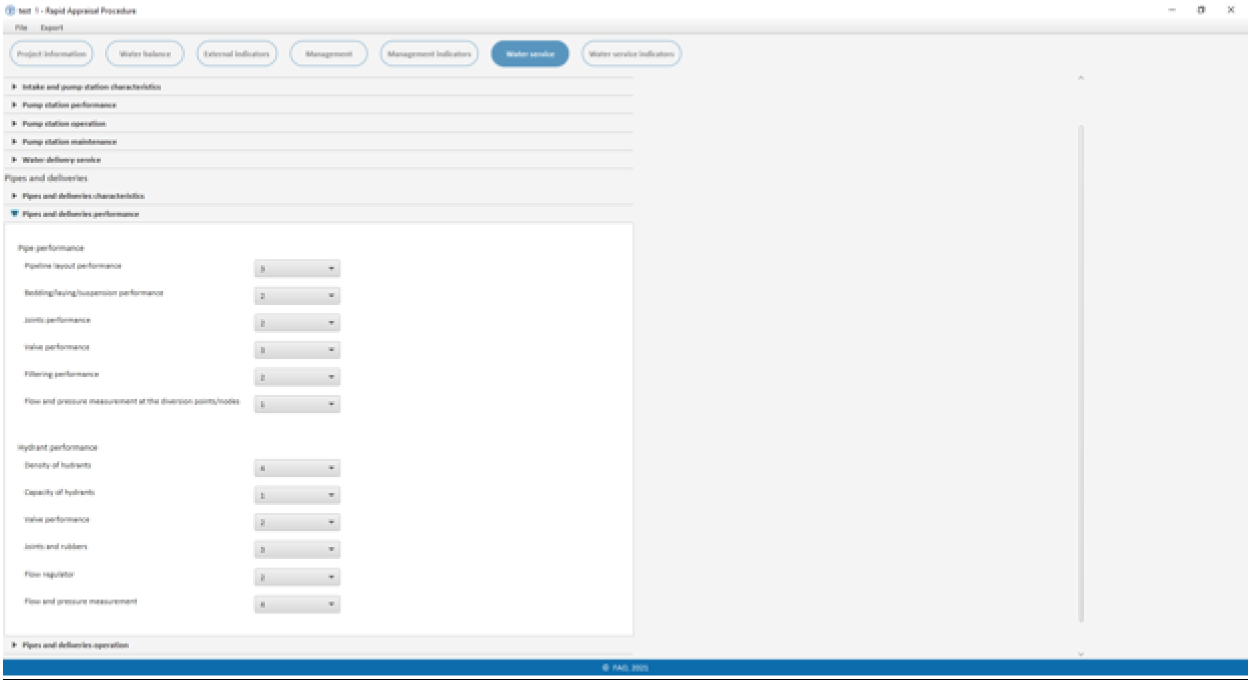
- this does not include the leaching requirement, special water requirements and other water needs (e.g. water losses);
- the calculated hydrant capacity must be compared to the design capacity of the hydrants.

*Hydrant type:* type of hydrant whether it is in-ground or surface.

*Hydrant design*: type of hydrant whether it is dry-barrel, wet-barrel, warm-climate, flush or flushing.

<u>Pipes and deliveries performance:</u>

*Figure A3 - 46 Main view of pipes and deliveries performance section in the Pipes and deliveries block*



*Pipe performance*

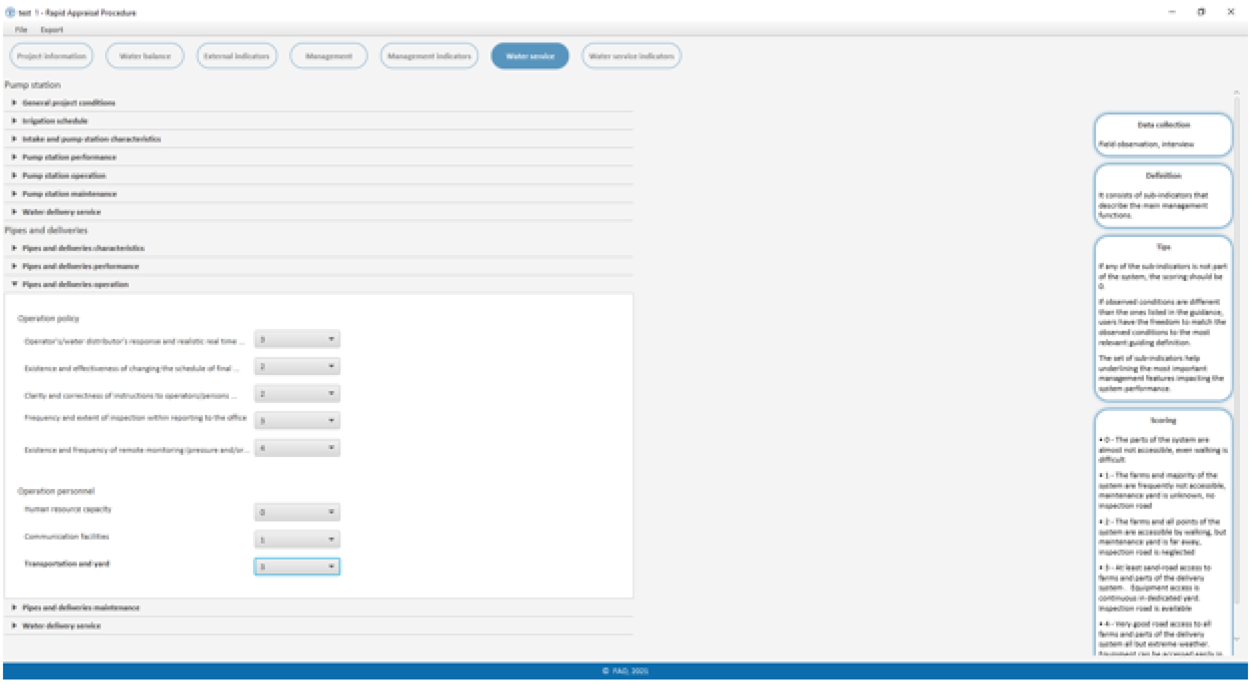
- the indicator consists of sub-indicators that describe the main items/functions of the system part;
- the set of sub-indicators help underlining the most important features impacting the system performance;
- scoring based on guidance listed under each sub-indicator;
- if any of the sub-indicators is not part of the system, the scoring should be 0;
- the scoring (0-4) should be based on field observation and interview;
- if observed conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition.

*Hydrant performance*

- the indicator consists of sub-indicators that describe the main items/functions of the system part;
- the set of sub-indicators help underlining the most important features impacting the system performance;
- scoring based on guidance listed under each sub-indicator;
- if any of the sub-indicators is not part of the system, the scoring should be 0;
- the scoring (0-4) should be based on field observation and interview;
- if observed conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition.

Pipes and deliveries operation

*Figure A3 - 47 Main view of pipes and deliveries operation section in the Pipes and deliveries block*



*Operation policy*

- the indicator consists of sub-indicators that describe the main management functions;
- the set of sub-indicators help underlining the most important management features impacting the system performance;
- scoring based on guidance listed under each sub-indicator;
- if any of the sub-indicators does not exist in the system, the scoring should be 0;
- the scoring (0-4) should be based on field observation and interview;
- if observed conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition.

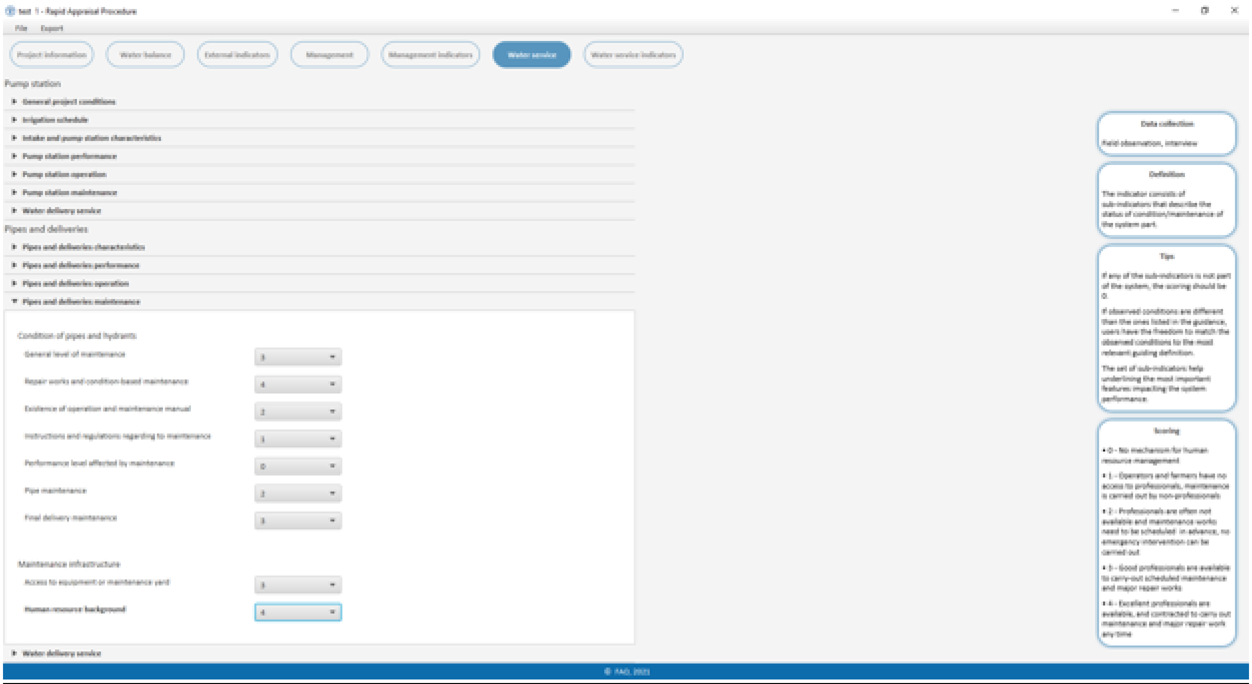
*Operation personnel*

- the indicator consists of sub-indicators that describe the main management functions;

- the set of sub-indicators help underlining the most important management features impacting the system performance;
- scoring based on guidance listed under each sub-indicator;
- if any of the sub-indicators does not exist in the system, the scoring should be 0;
- the scoring (0-4) should be based on field observation and interview;
- if observed conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition.

Pipes and deliveries maintenance

*Figure A3 - 48 Main view of pipes and deliveries maintenance section in the Pipes and deliveries block*



*Condition of pipes and hydrants*

- the indicator consists of sub-indicators that describe the status of condition/maintenance of the system part;
- the set of sub-indicators help underlining the most important features impacting the system performance;
- scoring based on guidance listed under each sub-indicator;
- if any of the sub-indicators does not exist in the system, the scoring should be 0;
- the scoring (0-4) should be based on field observation and interview;
- if observed conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition.

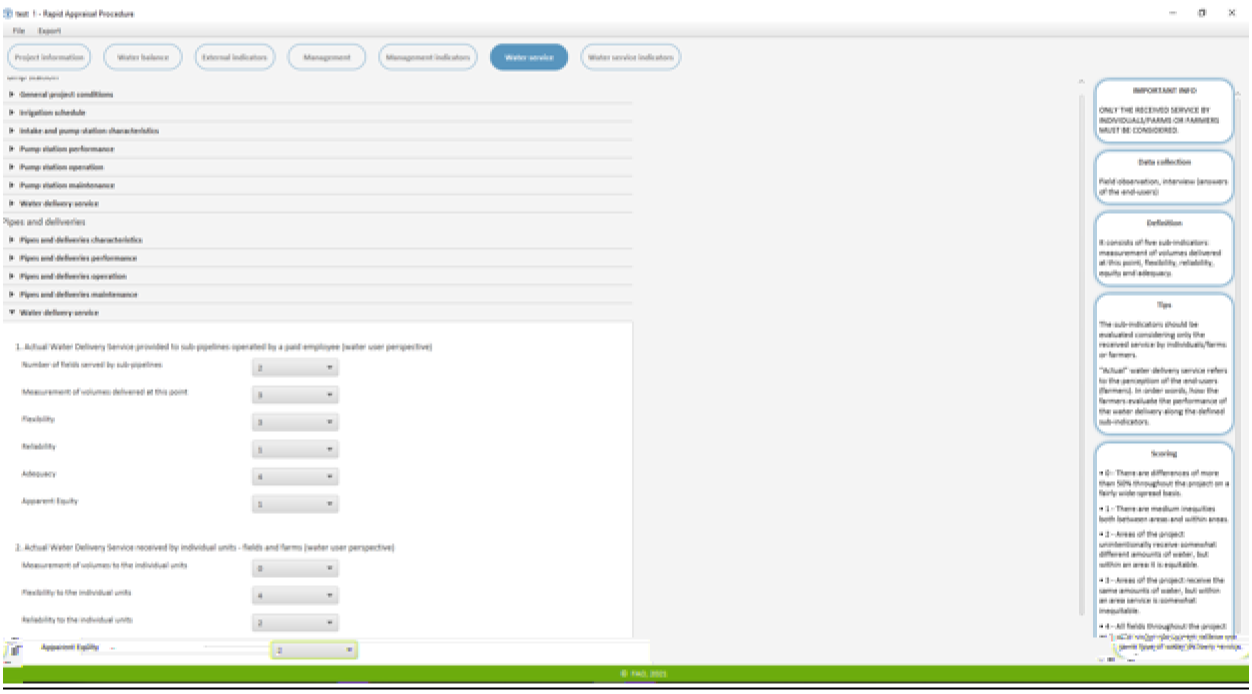
*Maintenance infrastructure*

- the indicator consists of sub-indicators that describe the status of condition/maintenance of the system part;

- the set of sub-indicators help underlining the most important features impacting the system performance;
- scoring based on guidance listed under each sub-indicator;
- if any of the sub-indicators does not exist in the system, the scoring should be 0;
- the scoring (0-4) should be based on field observation and interview;
- if observed conditions are different than the ones listed in the guidance, users have the freedom to match the observed conditions to the most relevant guiding definition.

<u>Water Delivery Service</u>

*Figure A3 - 49 Main view of water delivery service section in the Pipes and deliveries block*



*Actual water delivery service provided to sub-pipelines operated by a paid employee (water user perspective):*

- the composite indicator consists of six sub-indicators: number of fields by sub-pipelines (branches), measurement of volumes delivered at this point, flexibility, reliability, equity, and adequacy;
- scoring is based on guidance listed under the sub-indicator;
- the sub-indicators should be evaluated considering only the system at sub-pipelines if it is operated by paid employees;
- the scoring should be based on the answers of the end-users. "Actual" water delivery service refers to the perception of the end-users (farmers). In order words, how the farmers evaluate the performance of the water delivery along the defined sub-indicators.

*Actual water delivery service received by individual units - fields and farms (water user perspective):*

- the composite indicator consists of five sub-indicators: measurement of volumes delivered at this point, flexibility, reliability, equity, and adequacy;
- scoring is based on guidance listed under the sub-indicator;
- the sub-indicators should be evaluated considering only the received service by individuals/farms or farmers;
- the scoring should be based on the answers of the end-users. “Actual” water delivery service refers to the perception of the end-users (farmers). In order words, how the farmers evaluate the performance of the water delivery along the defined sub-indicators.

### *A.1.5.7. Water service indicators*

The Water Service chapter results in Internal indicators 2. that are constructed to interpret the physical water service performance. The definitions are explained according to the structure of Internal indicators.

However, not all input data/information are directly analysed in the Internal Indicators. While preparing the analysis and narrative of the chapter, it is important to understand that both the input data/information and the Internal Indicators are necessary to compile a meaningful report. While the input data/information helps users to properly frame the assessment, they provide underlying information about the achieved indicators. While it is recommended to use the input data/information to set the scene and introduce the management, the Internal Indicators are the outputs, meaning the results of the performance assessment.

*Table A3 - 6 Calculated parameters of Water service indicators*

| Indicator | Units | Definition |
|---|---|---|
| | System capacity and delivery | |
| design capacity related to peak crop water requirement | unit | • The indicator expresses the ratio of pump capacity and the peak crop water requirement.<br>• If the ratio is less than 100 percent, the pump capacity does not supply sufficient water to meet the peak water requirement.<br>• If the ratio is more than 100 percent, the pump capacity exceeds the peak water requirement<br>• The numerator refers to the total pump station capacity, and the nominator refers to the peak water requirement, calculated from the month with highest water demand. |
| criticality of pump capacity | - | • The qualitative assessment of the Design capacity related to peak crop water requirement:<br>o 0 (<80%) – very poor<br>o 1 (80-85%) – poor<br>o 2 (85-90%) – medium<br>o 3 (90-95%) – good<br>o 4 (>95%) – excellent |
| deviation from irrigation schedule at pump station | % | • The difference between official and actual irrigation schedule at pump station level.<br>• The indicator shows the compliance with the official irrigation schedule, the higher the deviation the higher the non-compliance. |

| | | |
|---|---|---|
| | | • The indicator calculates the deviation from the official schedule, therefore it takes account only of types indicated in the official schedule. |
| deviation from irrigation schedule at deliveries | % | • The difference between official and actual irrigation schedule at hydrant level.<br>• The indicator shows the compliance with the official irrigation schedule, the higher the deviation the higher the non-compliance.<br>• The indicator calculates the deviation from the official schedule, therefore it takes account only of types indicated in the official schedule. |
| criticality of irrigation schedule at pump station | - | • The indicator shows the compliance with the irrigation schedule. It is based on the calculated deviation of actual irrigation schedule from the official irrigation schedule at pump station level. The higher the deviation the lower the compliance.<br>• The qualitative assessment of the Irrigation schedule at pump station:<br>o 0 (>80%) – very critical<br>o 1 (60-80%) – critical<br>o 2 (40-60%) – medium<br>o 3 (20-40%) – good<br>o 4 (<20%) – excellent |
| criticality of irrigation schedule at deliveries | - | • The indicator shows the compliance with the irrigation schedule. It is based on the calculated deviation of actual irrigation schedule from the official irrigation schedule at final deliveries level. The higher the deviation the lower the compliance.<br>• The qualitative assessment of the Irrigation schedule at final deliveries:<br>o 0 (>80%) – very critical<br>o 1 (60-80%) – critical<br>o 2 (40-60%) – medium<br>o 3 (20-40%) – good<br>o 4 (<20%) – excellent |
| criticality of actual pump delivery capacity | - | • The qualitative assessment of the criticality of actual pump delivery capacity, calculated from the input data ‘estimated actual efficiency of the pumps’:<br>o 0 (<80%) – very critical<br>o 1 (80-85%) – critical<br>o 2 (85-90%) – medium<br>o 3 (90-95%) – good<br>o 4 (>95%) – excellent |
| criticality of hydrant capacity | - | • The indicator is calculated as the ratio of maximum hydrant discharge and required hydrant capacity.<br>• The required hydrant capacity is calculated from the peak water demand at hydrant level, the typical area size served by a hydrant and the indicated required hydrant elasticity:<br>o 0 (<80%) – very critical<br>o 1 (80-85%) – critical<br>o 2 (85-90%) – medium<br>o 3 (90-95%) – good<br>o 4 (>95%) – excellent |
| Performance | | |
| intake performance | - | • The indicators are transferred values, whereas adequate score should be given, based on guidance. |

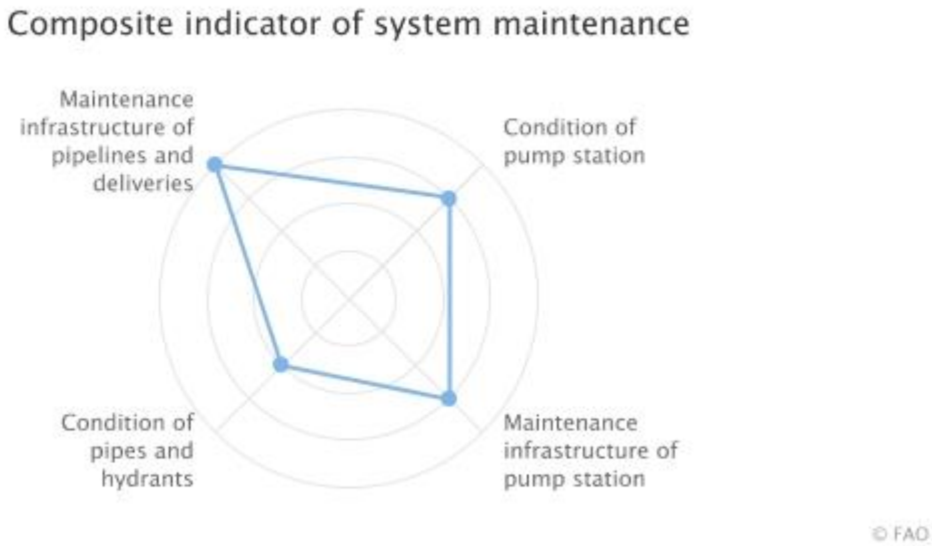
| | | |
|---|---|---|
| | | • Together, the indicators can be visualized in one composite indicator/chart to compare the intake performance per dimensions. |
| pump performance | - | • The indicators are transferred values, whereas adequate score should be given, based on guidance.<br>• Together, the indicators can be visualized in one composite indicator/chart to compare the pump performance per dimensions. |
| drain performance | - | • The indicators are transferred values, whereas adequate score should be given, based on guidance.<br>• Together, the indicators can be visualized in one composite indicator/chart to compare the drain performance per dimensions. |
| pipe performance | - | • The indicators are transferred values, whereas adequate score should be given, based on guidance.<br>• Together, the indicators can be visualized in one composite indicator/chart to compare the pipe performance per dimensions. |
| hydrant performance | - | • The indicators are transferred values, whereas adequate score should be given, based on guidance.<br>• Together, the indicators can be visualized in one composite indicator/chart to compare the hydrant performance per dimensions. |
| composite indicators of system performance | - | • The summary of composite indicator displays the overall performance of the system parts.<br>• It gives information on the comparative performance of the system parts. |
| Operation | | |
| pump station operation policy | - | • The indicators are transferred values, whereas adequate score should be given, based on guidance.<br>• Together, the indicators can be visualized in one composite indicator/chart to compare the effectiveness of pump station operation policy per dimensions. |
| pump station personnel | - | • The indicators are transferred values, whereas adequate score should be given, based on guidance.<br>• Together, the indicators can be visualized in one composite indicator/chart to compare the effectiveness of pump station personnel per dimensions. |
| pipes and deliveries operation policy | - | • The indicators are transferred values, whereas adequate score should be given, based on guidance.<br>• Together, the indicators can be visualized in one composite indicator/chart to compare the effectiveness of pipes and deliveries operation policy per dimensions. |
| pipe and deliveries personnel | - | • The indicators are transferred values, whereas adequate score should be given, based on guidance.<br>• Together, the indicators can be visualized in one composite indicator/chart to compare the effectiveness of pipe and deliveries personnel per dimensions. |
| composite indicators of system operation | | • The summary of composite indicator displays the overall effectiveness of operation policies. |

| | | |
|---|---|---|
| | | • It gives information on the comparative performance of the operation policies. |
| Maintenance | | |
| condition of pump station | - | • The indicators are transferred values, whereas adequate score should be given, based on guidance.<br>• Together, the indicators can be visualized in one composite indicator/chart to compare the condition of pump station per dimensions. |
| maintenance infrastructure of pump station | - | • The indicators are transferred values, whereas adequate score should be given, based on guidance.<br>• Together, the indicators can be visualized in one composite indicator/chart to compare the maintenance infrastructure of pump station per dimensions. |
| condition of pipes and hydrants | - | • The indicators are transferred values, whereas adequate score should be given, based on guidance.<br>• Together, the indicators can be visualized in one composite indicator/chart to compare the condition of pipes and hydrants per dimensions. |
| maintenance infrastructure of pipelines and deliveries | - | • The indicators are transferred values, whereas adequate score should be given, based on guidance.<br>• Together, the indicators can be visualized in one composite indicator/chart to compare the maintenance infrastructure of pipelines and deliveries per dimensions. |
| composite indicators of system maintenance | - | • The summary of composite indicator displays the overall effectiveness of operation policies<br>• It gives information on the comparative performance of the system maintenance. |
| Water Delivery Service | | |
| composite indicator of water delivery service that pump station provides to the pipe system | - | • The comparison between the indicators of the water delivery service from pump station to pipe system.<br>• The indicator compares the stated and actual water service, meaning the perspective of management and perspective of end-users.<br>• It shows the discord between the perceptions of farmers and the management. Therefore, whenever the difference between the indicators is high, the issue must be flagged and described. |
| Composite indicator of water delivery service provided for sub-pipelines operated by a paid employee | - | • The comparison between the indicators of water delivery service for sub-pipelines.<br>• The indicator compares the stated and actual water service, meaning the perspective of management and perspective of end-users.<br>• It shows the discord between the perceptions of farmers and the management. Therefore, whenever the difference between the indicators is high, the issue must be flagged and described. |
| Composite indicator of water delivery service received by individual units | - | • The comparison between the indicators of water delivery service received by individual units.<br>• The indicator compares the stated and actual water service, meaning the perspective of management and perspective of end-users. |

| | | |
|---|---|---|
| | | • It shows the discord between the perceptions of farmers and the management. Therefore, whenever the difference between the indicators is high, the issue must be flagged and described. |

Similar to the management chapter, the indicators are visualized in charts. The visual objects can be exported in pdf file.

*Figure A3 - 50 Exported chart from the Water service chapter*




## A.1.6. Update information about the RAP software

The manual is designed to the RAP software v1 launched in May 2021. Any change will be documented in the Revision History file appended to the RAP software on the dedicated webpage.