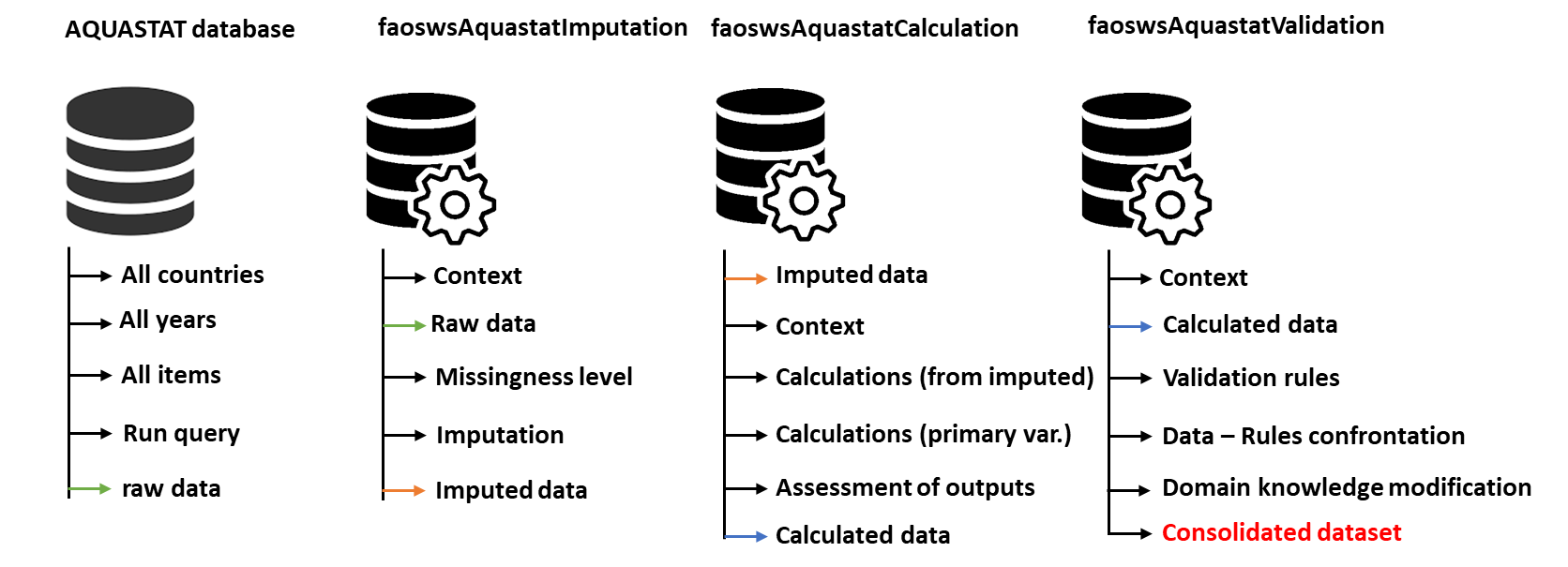
**AQUASTAT Domain (Methodological workflow)**

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**About this document**

This document describes the framework regarding the migration of the FAO-AQUASTAT analytical data procedures into the SWS framework (Fig. 1). The AQUASTAT - SWS migration represents FAO efforts to allocate interdepartmental statistical procedures into a single platform, facilitating and improving the analytical/statistical value chains of the whole organization. The AQUASTAT - SWS migration framework has three main modules, connected through their outputs: **faoswsAquastatImputation**; **faoswsAquastatCalculation**; **faoswsAquastatValidation.** In this document, whenever the term elements is used, it will be referring to either *indicator* or *variable/component*. The term *indicator* is used to define a composed variable (the left-hand side of the formulas) relevant in the AQUASTAT database context while the term variables refers to as components or dimensions of an indicator (the right-hand side of the formulas). It is an important distinction given that variables are processed separately from indicators along the data analytical value chain as seen in the next sections of this document. For definitions of the indicator and variables, please check the ***Annex 1*.** Notice that relevant AQUASTAT elements (indicator/variables) in the ***Annex 1*** are those described in the calculation rules provided by the AQUASTAT-SWS migration focal point (***Annex* 2**).



**Figure 1**. The Aquastat domain on SWS runs in three modules connected through their outputs.

**Aquastat database data formation**

With the migration of the Aquastat domain and the aquastat dataset into SWS finalized, the natural step is to identify the relevant elements that are already elsewhere in the SWS. For example, **Total area of the country** already resides in SWS in the domain “*Land*” and dataset “*land\_use\_dissemination*”. The questions addressed here is: What are the Aquastat elements in SWS occurring in other SWS data domains? The answer of this question is the clear definition of the datasets feeding the Aquastat database before downstream data processing.

**Table 1**. The table shows the elements in *Aquastat domain – Aquastat dataset* in SWS that: **i**) are already on other SWS datasets (\*); **ii)** only occur in the Aquastat domain. Notice that the elements described here are those used in the calculation rules provided by the AQUASTAT – SWS focal point.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Element | Element Name | SWS  domain | SWS  dataset | SWS Element Code |
| 4100\* | Total area of the country | Land | land\_use\_dissemination | 5115 |
| 4101\* | Arable land area | Land | land\_use\_dissemination | 5710 |
| 4102\* | Permanent crops area | Land | land\_use\_dissemination | 5011 |
| 4103\* | Cultivated area (arable land + permanent crops) | Land | land\_use\_dissemination | 5522 |
| 4104\* | Total population | Population | population\_unpd | 511 |
| 4105\* | Rural population | Population | population\_unpd | 551 |
| 4106\* | Urban population3 | Population | population\_unpd | 561 |
| 4107\* | Population density | calculated | calculated | 4107 |
| 4112\* | Gross Domestic Product (GDP) | faostat\_datasets | faostat\_macro\_ind | 22008 |
| 4150 | Long-term average annual precipitation in volume | Aquastat | aquastat | 4150 |
| 4154 | Groundwater produced internally | Aquastat | aquastat | 4154 |
| 4155 | Surface water produced internally | Aquastat | aquastat | 4155 |
| 4156 | Overlap between surface water and groundwater | Aquastat | aquastat | 4156 |
| 4157 | Total internal renewable water resources (IRWR) | Aquastat | aquastat | 4157 |
| 4158 | Total internal renewable water resources per capita | Aquastat | aquastat | 4158 |
| 4160 | Surface water: inflow not submitted to treaties | Aquastat | aquastat | 4160 |
| 4162 | Surface water: inflow secured through treaties | Aquastat | aquastat | 4162 |
| 4164 | Surface water: accounted inflow | Aquastat | aquastat | 4164 |
| 4168 | Surface water: accounted flow of border rivers | Aquastat | aquastat | 4168 |
| 4170 | Surface water: accounted part of border lakes (actual) | Aquastat | aquastat | 4170 |
| 4174 | Surface water: outflow to other countries secured through treaties | Aquastat | aquastat | 4174 |
| 4176 | Surface water: total external renewable | Aquastat | aquastat | 4176 |
| 4182 | Water resources: total external renewable | Aquastat | aquastat | 4182 |
| 4185 | Total renewable surface water | Aquastat | aquastat | 4185 |
| 4187 | Total renewable groundwater | Aquastat | aquastat | 4187 |
| 4188 | Total renewable water resources | Aquastat | aquastat | 4188 |
| 4190 | Total renewable water resources per capita | Aquastat | aquastat | 4190 |
| 4192 | Dependency ratio | Aquastat | aquastat | 4192 |
| 4193 | Exploitable: regular renewable surface water | Aquastat | aquastat | 4193 |
| 4194 | Exploitable: irregular renewable surface water | Aquastat | aquastat | 4194 |
| 4195 | Exploitable: regular renewable groundwater | Aquastat | aquastat | 4195 |
| 4196 | Total exploitable water resources | Aquastat | aquastat | 4196 |
| 4197 | Total dam capacity | Aquastat | aquastat | 4197 |
| 4250 | Agricultural water withdrawal | Aquastat | aquastat | 4250 |
| 4251 | Municipal water withdrawal | Aquastat | aquastat | 4251 |
| 4252 | Industrial water withdrawal | Aquastat | aquastat | 4252 |
| 4253 | Total water withdrawal | Aquastat | aquastat | 4253 |
| 4254 | Agricultural water withdrawal as % of total water withdrawal | Aquastat | aquastat | 4254 |
| 4255 | Municipal water withdrawal as % of total withdrawal | Aquastat | aquastat | 4255 |
| 4256 | Industrial water withdrawal as % of total water withdrawal | Aquastat | aquastat | 4256 |
| 4257 | Total water withdrawal per capita | Aquastat | aquastat | 4257 |
| 4260 | Irrigation water requirement | Aquastat | aquastat | 4260 |
| 4263 | Total freshwater withdrawal (primary and secondary) | Aquastat | aquastat | 4263 |
| 4264 | Desalinated water produced | Aquastat | aquastat | 4264 |
| 4265 | Direct use of treated municipal wastewater | Aquastat | aquastat | 4265 |
| 4271 | Agricultural water requirement as % of agricultural water withdrawal | Aquastat | aquastat | 4271 |
| 4273 | Agricultural water withdrawal as % of total renewable water resources | Aquastat | aquastat | 4273 |
| 4275 | MDG 7.5. Freshwater withdrawal as % of total renewable water resources | Aquastat | aquastat | 4275 |
| 4300 | Total cultivated area drained | Aquastat | aquastat | 4300 |
| 4303 | Area equipped for irrigation drained | Aquastat | aquastat | 4303 |
| 4304 | Non-irrigated cultivated area drained | Aquastat | aquastat | 4304 |
| 4305 | % of total cultivated area drained | Aquastat | aquastat | 4305 |
| 4307 | Irrigation potential | Aquastat | aquastat | 4307 |
| 4308 | Area equipped for full control irrigation: surface irrigation | Aquastat | aquastat | 4308 |
| 4309 | Area equipped for full control irrigation: sprinkler irrigation | Aquastat | aquastat | 4309 |
| 4310 | Area equipped for full control irrigation: localized irrigation | Aquastat | aquastat | 4310 |
| 4311 | Area equipped for full control irrigation: total | Aquastat | aquastat | 4311 |
| 4312 | Area equipped for irrigation: equipped lowland areas | Aquastat | aquastat | 4312 |
| 4313 | Area equipped for irrigation: total | Aquastat | aquastat | 4313 |
| 4314 | Flood recession cropping area non-equipped | Aquastat | aquastat | 4314 |
| 4315 | Cultivated wetlands and inland valley bottoms non-equipped | Aquastat | aquastat | 4315 |
| 4316 | Area equipped for irrigation: spate irrigation | Aquastat | aquastat | 4316 |
| 4317 | Total agricultural water managed area | Aquastat | aquastat | 4317 |
| 4318 | Area equipped for irrigation: actually irrigated | Aquastat | aquastat | 4318 |
| 4319 | % of agricultural water managed area equipped for irrigation | Aquastat | aquastat | 4319 |
| 4320 | Area equipped for irrigation by groundwater | Aquastat | aquastat | 4320 |
| 4321 | Area equipped for irrigation by surface water | Aquastat | aquastat | 4321 |
| 4322 | Area equipped for irrigation by mixed surface water and groundwater | Aquastat | aquastat | 4322 |
| 4323 | % of area equipped for irrigation by groundwater | Aquastat | aquastat | 4323 |
| 4324 | % of area equipped for irrigation by surface water | Aquastat | aquastat | 4324 |
| 4325 | % of area equipped for irrigation by mixed surface water and groundwater | Aquastat | aquastat | 4325 |
| 4326 | Area equipped for power irrigation (surface water or groundwater) | Aquastat | aquastat | 4326 |
| 4327 | % of area equipped for irrigation power irrigated | Aquastat | aquastat | 4327 |
| 4328 | % of the area equipped for irrigation actually irrigated | Aquastat | aquastat | 4328 |
| 4330 | % of irrigation potential equipped for irrigation | Aquastat | aquastat | 4330 |
| 4331 | % of the cultivated area equipped for irrigation | Aquastat | aquastat | 4331 |
| 4379 | Total harvested irrigated crop area (full control irrigation) | Aquastat | aquastat | 4379 |
| 4400 | Area salinized by irrigation | Aquastat | aquastat | 4400 |
| 4445 | % of area equipped for irrigation salinized | Aquastat | aquastat | 4445 |
| 4446 | % of area equipped for irrigation drained | Aquastat | aquastat | 4446 |
| 4448 | Other agricultural water managed area | Aquastat | aquastat | 4448 |
| 4450 | Freshwater withdrawal as % of internal renewable water resources | Aquastat | aquastat | 4450 |
| 4451 | Direct use of agricultural drainage water | Aquastat | aquastat | 4451 |

**Discontinuity of elements.**

Some AQUASTAT domain elements are sourced from dissemination platforms (e.g. FAOSTAT) where they have been discontinued. Thus, there is no point in keeping them in the Aquastat database. The proposal is to discontinue those elements. The elements would have a legacy dataset until the last year in which they were disseminated and then discontinued onwards. Below the proposed list of AQUASTAT elements to discontinue.

|  |  |  |  |
| --- | --- | --- | --- |
| Element | Element Name |  | Source |
| 4108 | Population economically active in agriculture |  | FAOSTAT (Employment)/ILO |
| 4109 | Male population economically active in agriculture |  | FAOSTAT (Employment)/ILO |
| 4110 | Female population economically active in agriculture |  | FAOSTAT (Employment)/ILO |
| 4449 | Population economically active |  | FAOSTAT (Employment)/ILO |

Based on the proposed discontinuity of above elements, the AQUASTAT database to be used through the next data processing steps will be built from four SWS domains (**Fig. 2**).



**Figure 2.** Proposed SWS domains to the formation of the AQUASTAT database. Numbers are the elements from each of the SWS sources.

**The faoswsAquastatImputation module**

**Context**

Due to the difficulty of obtaining credible country-level water statistics annually, the existing high data missingness in the AQUASTAT database represents an initial challenge before computation of relevant water resource indicators. There is no such a thing as a golden choice when it comes to the imputation of missing values, especially in cases where the missingness is high in low-frequency data, a reality for the majority of country-level data in the AQUASTAT database. Thus, the application of medium-high complex imputation methods to AQUASTAT variables is unfeasible.

The current AQUASTAT effort to reduce the blocking effects of the high data missingness on the calculation of water-related indicators lies within the use of a replacement approach where indicators are calculated according to priority rules applied every 5-year intervals of country-level time-series. This approach, however, has flaws such as the calculation of indicators based on values with annual mismatch and does not ensure the full filling in of the variable time series. On this basis, the imputation module comes to fill in variables *a priori* paving the way to the calculation of indicators without the flaws of the 5-year interval workaround. Below the description of each step taken in the faoswsAquastatImputation module.

**Imputation**

The goal of imputation module is to fill the NAs presents in all variables time-series at the country-level. The final imputed datasets are used in the *faoswsAquastatCalculation module*. The proposal is to drive imputations according to the nature of each variable in the datasets. The raw dataset will be subdivided into two categories: 1) Datasets with variables without the possibility of being imputed, i.e. the whole country –level time-series is empty; 2) Datasets with variables with the possibility of being imputed. The datasets with variables with the potential to be imputed will subsequently be broken down into the following datasets: a) dataset where variables have zero variance and no missing values; b) dataset where variables have zero variance and *at least one* missing value; c) dataset where variables have nonzero variance and *at least* one missing values. The dataset where the whole time-series is empty, and that with zero variance and without missing values will not be imputed. The datasets described in *b* and *c* will be imputed by last observation carried forward and linear imputation, respectively. The Fig. 3 shows the proposed imputation workflow.



**Figure 3**. Imputation workflow based on **split-apply-combine approach**. Split the data according to the possibility of imputation and type of imputation. Apply (or not) the imputations accordingly. Combine non-imputed and imputed datasets at the country level and then select the relevnt elements/variables to use in the calculations.

**Testing imputation**

The AQUASTAT team is particularly interested in the indicators composing the **SDG 6.4.1** (Water Use Efficiency; Irrigated Agriculture Water Use Efficiency; Industrial Water Use Efficiency) and the **SDG 6.4.2** (Water stress). Thus**,** the first action is to test the effects of imputation on the calculation of these SDG indicators **(**Table 1**)**. A test dataset with 43 randomly selected countries will be used to assess the output of the imputation workflow described in the **Fig 2**.

|  |  |  |  |
| --- | --- | --- | --- |
| **Table 1**. Variables to use in the imputation | | | |
| **Variables** | **Variables code** | **Need for Imputation** | **Evolution** |
| **SDG 6.4.2** |  |  |  |
| Total freshwater withdrawal (primary and secondary) | 4263 | YES | Increase, Stable or decrease |
| Total water withdrawal | 4253 | YES | **Increase**, Stable or decrease |
| Desalinated water produced | 4264 | YES | **Increase**, Stable or decrease |
| Direct use of treated municipal wastewater | 4265 | YES | **Increase**, Stable or decrease |
| Direct use of agricultural drainage water | 4451 | YES | Increase, Stable or decrease |
| Total renewable water resources | 4188 | NO |  |
| Environmental Flow Requirements | 4549 | NO |  |
| SDG 6.4.1 |  |  |  |
| Agricultural water withdrawal | 4250 | YES | Increase, Stable or decrease |
| Municipal water withdrawal | 4251 | YES | **Increase**, Stable or decrease |
| Industrial water withdrawal | 4252 | YES | Increase, Stable or decrease |
| Total water withdrawal | 4253 | YES | **Increase**, Stable or decrease |
| Total harvest irrigated crop area (full control irrigation) | 4379 | YES | Increase, Stable or decrease |
| Area equipped for full control irrigation actually irrigated | 4312 | YES | Increase, Stable or decrease |
| Area equipped for full control irrigation | 4311 | YES | Increase, Stable or decrease |
| Area equipped for irrigation | 4313 | YES | Increase, Stable or decrease |
| Area equipped for irrigation: actually irrigated | 4318 | YES | Increase, Stable or decrease |
| Agriculture, value added to GDP | 4548 | NO |  |
| Services, value added to GDP | 4546 | NO |  |
| Industry, value added to GDP | 4547 | NO |  |

**Imputation assessment**

In this step, the imputed datasets are compared at the variable level within countries. The output is:

1. The number of imputed values.
2. Congruence level among methods.

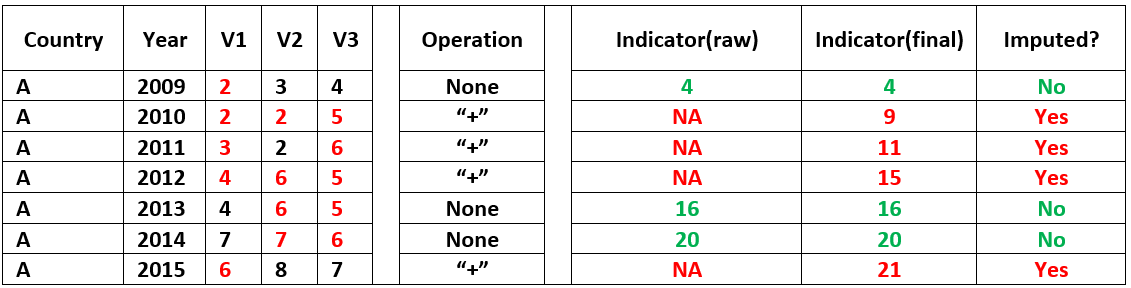
**The faoswsAquastatCalculation module**

**Context**

This module consists of a set of chained operations that ultimately results in a dataset with the relevant Aquastat indicators. The calculation rules (set of arithmetical formulas with the indicator code in the left-hand side and variables in the right-hand side, ***Annex 2***) provided by the AQUASTAT team are confronted against each of the imputed datasets coming from the faoswsAquastatImputation. The term "confrontation" is used to represent the chained data processing operations that take the imputed datasets and output datasets containing the relevant AQUASTAT indicators.

Before going ahead, however, it is important to highlight that the indicators in AQUASTAT may already have observed values coming from different official or semi-official sources. It means that in this module the non-missing values of the indicators are preserved from being replaced by the output of the calculations (Table 2).

**Table 2**. Example showing the principle adopted in the *faoswsAquastatCalculation* module regarding the replacement of missing values in AQUASTAT indicators. Notice that non-missing values are preserved after the calculation based on imputed datasets.



**The “Primary Variable” Approach**

Besides the calculation of indicators based on imputed datasets, this module also calculates the AQUASTAT indicators based on the current approach developed by the AQUASTAT team. Some indicators have the so-called "primary variables", which are used as a proxy of the indicator in case of missingness of other variables composing the indicator. To illustrate how this approach works, let the indicator 4311 to be the sum of the variables 4308, 4309 and 4310 in a country A and time series TS. For each 5-year interval in the TS, the 4311 indicators are calculated following:

*Option 1*. If all variables are not missed in the 5-year TS interval, then: 4311 = 4308 + 4309 + 4310;

*Option 2*. If only 4310 is missing, then: 4311 = 4308 + 4309;

*Option 3*. If only 4309 is missing, then: 4311 = 4308 + 4310;

*Option 4*. If only 4308 is missing, then: 4311 = 4309 + 4310;

*Option 5*. If both 4309 and 4310 are missing, then: 4311 = **4308** (the primary variable);

*Option 6*. If both 4308 and 4310 are missing, then: 4311 = 4309;

*Option 7*. If both 4308 and 4309 are missing, then: 4311 = 4310

Notice the hierarchy stressing the importance of the variables for the indicator. In this specific example, the primary variable of the indicator 4311 is 4308 because its value is used as the primary surrogate of the indicator in case of all five first options fail.

To implement this methodology is necessary to define the window in which the country-level time-series will be a subdivided. In line with the AQUASTAT team, a 5-year window has been chosen, and the time-series of all countries need to harmonise to have the same length and to be divisible by five.

**Assessment of Outputs**

With the final calculations, it is the time of assessing whether the values of indicators are sound. Therefore, a combination of analytical and domain knowledge approach is requested. Charts with the indicator time series from each imputation method plus the primary variable approach are confronted against each other at the national level so that patterns may be identified, providing evidence towards a winner approach. Also, another criteria used to judge the indicator outputs is the resemblance between the observed value of the indicator (raw) and the value that the indicator would take if it were missing. The idea behind this criteria is that the imputation method providing the closest value to the already existing indicator value would theoretically be the one with the “highest” credibility.

**The faoswsAquastatValidation module**

**Context**

This module is designed to check if the indicators and variables after the imputation live up to expectations pre-defined by set validation rules given by AQUASTAT. The logic used here is to confront data (with indicators and variables) against the pre-defined set of rules so that dataset modifications based on domain knowledge are easy to make.

**The Data**

In the validation context, the data used are taken from the *faoswsAquastatCalculation* module.

**The Set of Rules**

A set of validation rules that need to be checked as one of the steps before the clearance for the dissemination of the data.

**The Data – Rules Confrontation**

Once defined rules and the data, the data are confronted against the rules so that violations can be identified and data-level amendments made based on domain knowledge. The data-rules confrontation returns how and where the rules did not pass so that it is possible to identify:

1. The years in each country time-series where the validation rules were violated;
2. The variables that contributed to the violation of the rules;
3. The flags associated with the violation.

**Domain knowledge modification**

The potential violations found in the confrontation are modified by defining a set of modification rules to the data based on domain knowledge. It requests a close interaction between the SWS team and AQUASTAT to make a consolidated dataset ready for the next steps of the database update/dissemination.

**An AquaShiny application for the AQUASTAT team**

The Aquastat validation and modification based on domain knowledge can be incorporated in a web application which natively runs in R (Shiny applications). The idea of the application is to separate the R internals from domain knowledge by allowing users to write and upload calculation/validation/modification rules separately from the processing of writing the R engine working under the hood. It will enable AQUASTAT experts to only focus on the rules rather than dealing with the hassles involving programming.

In the app, the user interface will allow the user to enter with whatever number of rules, and by a click to run options of calculation of indicators/variables, validation of user-defined rules, or modification of datasets based on user-defined rules. For example, let's say that the user has identified an error in a value of a variable X in the country A and year YYYY, possibly a typo. Also, let’s suppose that the error is X = 10 and the correct value should be 100. By selecting the country, the year, and write/upload a simple modification rule such as “if (X == 10) X = 100” in the app user interface, the dataset will automatically update based on the knowledge of the user. That is just a simple example of rules that read by the app and applied to the dataset. There are more slightly complex operations such as the validation of a given indicator/variable again based on the user knowledge. For example, the user wants to assert that in the country Z all the values of the time-series for the indicator/variable X are not superior/inferior to the values of the variables Y and D. To accomplish this, the user needs to select the country and the years of the time-series as well as set the validation rules, for example, X < Y, X < D. If any of these two validations is violated the app outputs a table indicating the location of the violation making it easy for the user to set medication rules to fix the data.

**Final remarks**

In the light of this document, it is possible to affirm that the migration of the AQUASTAT database statistical procedures into the SWS framework is feasible. If the option is to strive for full country-level time-series, the main challenge remains as the choice and tunning of imputations to produce consist statistics. However, the full migration of AQUASTAT database to SWS needs to be done.

|  |  |
| --- | --- |
| ***Annexe 1***. List of 87 code representing the relevant AQUASTAT indicators and variables processed by the Aquastat modules in the SWS | |
| **Code** | **Definition** |
| 4100 | Total area of the country |
| 4101 | Arable land area |
| 4102 | Permanent crops area |
| 4103 | Cultivated area (arable land + permanent crops) |
| 4104 | Total population |
| 4105 | Rural population |
| 4106 | Urban population |
| 4107 | Population density |
| 4108 | Population economically active in agriculture |
| 4109 | Male population economically active in agriculture |
| 4110 | Female population economically active in agriculture |
| 4112 | Gross Domestic Product (GDP) |
| 4150 | Long-term average annual precipitation in volume |
| 4154 | Groundwater produced internally |
| 4155 | Surface water produced internally |
| 4156 | Overlap between surface water and groundwater |
| 4157 | Total internal renewable water resources (IRWR) |
| 4158 | Total internal renewable water resources per capita |
| 4160 | Surface water: inflow not submitted to treaties |
| 4162 | Surface water: inflow secured through treaties |
| 4164 | Surface water: accounted inflow |
| 4168 | Surface water: accounted flow of border rivers |
| 4170 | Surface water: accounted part of border lakes (actual) |
| 4174 | Surface water: outflow to other countries secured through treaties |
| 4176 | Surface water: total external renewable |
| 4182 | Water resources: total external renewable |
| 4185 | Total renewable surface water |
| 4187 | Total renewable groundwater |
| 4188 | Total renewable water resources |
| 4190 | Total renewable water resources per capita |
| 4192 | Dependency ratio |
| 4193 | Exploitable: regular renewable surface water |
| 4194 | Exploitable: irregular renewable surface water |
| 4195 | Exploitable: regular renewable groundwater |
| 4196 | Total exploitable water resources |
| 4197 | Total dam capacity |
| 4250 | Agricultural water withdrawal |
| 4251 | Municipal water withdrawal |
| 4252 | Industrial water withdrawal |
| 4253 | Total water withdrawal |
| 4254 | Agricultural water withdrawal as % of total water withdrawal |
| 4255 | Municipal water withdrawal as % of total withdrawal |
| 4256 | Industrial water withdrawal as % of total water withdrawal |
| 4257 | Total water withdrawal per capita |
| 4260 | Irrigation water requirement |
| 4263 | Total freshwater withdrawal (primary and secondary) |
| 4264 | Desalinated water produced |
| 4265 | Direct use of treated municipal wastewater |
| 4271 | Agricultural water requirement as % of agricultural water withdrawal |
| 4273 | Agricultural water withdrawal as % of total renewable water resources |
| 4275 | MDG 7.5. Freshwater withdrawal as % of total renewable water resources |
| 4300 | Total cultivated area drained |
| 4303 | Area equipped for irrigation drained |
| 4304 | Non-irrigated cultivated area drained |
| 4305 | % of total cultivated area drained |
| 4307 | Irrigation potential |
| 4308 | Area equipped for full control irrigation: surface irrigation |
| 4309 | Area equipped for full control irrigation: sprinkler irrigation |
| 4310 | Area equipped for full control irrigation: localized irrigation |
| 4311 | Area equipped for full control irrigation: total |
| 4312 | Area equipped for irrigation: equipped lowland areas |
| 4313 | Area equipped for irrigation: total |
| 4314 | Flood recession cropping area non-equipped |
| 4315 | Cultivated wetlands and inland valley bottoms non-equipped |
| 4316 | Area equipped for irrigation: spate irrigation |
| 4317 | Total agricultural water managed area |
| 4318 | Area equipped for irrigation: actually irrigated |
| 4319 | % of agricultural water managed area equipped for irrigation |
| 4320 | Area equipped for irrigation by groundwater |
| 4321 | Area equipped for irrigation by surface water |
| 4322 | Area equipped for irrigation by mixed surface water and groundwater |
| 4323 | % of area equipped for irrigation by groundwater |
| 4324 | % of area equipped for irrigation by surface water |
| 4325 | % of area equipped for irrigation by mixed surface water and groundwater |
| 4326 | Area equipped for power irrigation (surface water or groundwater) |
| 4327 | % of area equipped for irrigation power irrigated |
| 4328 | % of the area equipped for irrigation actually irrigated |
| 4330 | % of irrigation potential equipped for irrigation |
| 4331 | % of the cultivated area equipped for irrigation |
| 4379 | Total harvested irrigated crop area (full control irrigation) |
| 4400 | Area salinized by irrigation |
| 4445 | % of area equipped for irrigation salinized |
| 4446 | % of area equipped for irrigation drained |
| 4448 | Other agricultural water managed area |
| 4449 | Population economically active |
| 4450 | Freshwater withdrawal as % of internal renewable water resources |
| 4451 | Direct use of agricultural drainage water |
| 4100 | Total area of the country |
| 4101 | Arable land area |
| 4102 | Permanent crops area |
| 4103 | Cultivated area (arable land + permanent crops) |
| 4104 | Total population |
| 4105 | Rural population |
| 4106 | Urban population |
| 4107 | Population density |
| 4108 | Population economically active in agriculture |
| 4109 | Male population economically active in agriculture |
| 4110 | Female population economically active in agriculture |
| 4112 | Gross Domestic Product (GDP) |
| 4150 | Long-term average annual precipitation in volume |
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| 4156 | Overlap between surface water and groundwater |
| 4157 | Total internal renewable water resources (IRWR) |
| 4158 | Total internal renewable water resources per capita |
| 4160 | Surface water: inflow not submitted to treaties |
| 4162 | Surface water: inflow secured through treaties |
| 4164 | Surface water: accounted inflow |
| 4168 | Surface water: accounted flow of border rivers |
| 4170 | Surface water: accounted part of border lakes (actual) |
| 4174 | Surface water: outflow to other countries secured through treaties |
| 4176 | Surface water: total external renewable |
| 4182 | Water resources: total external renewable |
| 4185 | Total renewable surface water |
| 4187 | Total renewable groundwater |
| 4188 | Total renewable water resources |
| 4190 | Total renewable water resources per capita |
| 4192 | Dependency ratio |
| 4193 | Exploitable: regular renewable surface water |
| 4194 | Exploitable: irregular renewable surface water |
| 4195 | Exploitable: regular renewable groundwater |
| 4196 | Total exploitable water resources |
| 4197 | Total dam capacity |
| 4250 | Agricultural water withdrawal |
| 4251 | Municipal water withdrawal |
| 4252 | Industrial water withdrawal |
| 4253 | Total water withdrawal |
| 4254 | Agricultural water withdrawal as % of total water withdrawal |
| 4255 | Municipal water withdrawal as % of total withdrawal |
| 4256 | Industrial water withdrawal as % of total water withdrawal |
| 4257 | Total water withdrawal per capita |
| 4260 | Irrigation water requirement |
| 4263 | Total freshwater withdrawal (primary and secondary) |
| 4264 | Desalinated water produced |
| 4265 | Direct use of treated municipal wastewater |
| 4271 | Agricultural water requirement as % of agricultural water withdrawal |
| 4273 | Agricultural water withdrawal as % of total renewable water resources |
| 4275 | MDG 7.5. Freshwater withdrawal as % of total renewable water resources |
| 4300 | Total cultivated area drained |
| 4303 | Area equipped for irrigation drained |
| 4304 | Non-irrigated cultivated area drained |
| 4305 | % of total cultivated area drained |
| 4307 | Irrigation potential |
| 4308 | Area equipped for full control irrigation: surface irrigation |
| 4309 | Area equipped for full control irrigation: sprinkler irrigation |
| 4310 | Area equipped for full control irrigation: localized irrigation |
| 4311 | Area equipped for full control irrigation: total |
| 4312 | Area equipped for irrigation: equipped lowland areas |
| 4313 | Area equipped for irrigation: total |
| 4314 | Flood recession cropping area non-equipped |
| 4315 | Cultivated wetlands and inland valley bottoms non-equipped |
| 4316 | Area equipped for irrigation: spate irrigation |
| 4317 | Total agricultural water managed area |
| 4318 | Area equipped for irrigation: actually irrigated |
| 4319 | % of agricultural water managed area equipped for irrigation |
| 4320 | Area equipped for irrigation by groundwater |
| 4321 | Area equipped for irrigation by surface water |
| 4322 | Area equipped for irrigation by mixed surface water and groundwater |
| 4323 | % of area equipped for irrigation by groundwater |
| 4324 | % of area equipped for irrigation by surface water |
| 4325 | % of area equipped for irrigation by mixed surface water and groundwater |
| 4326 | Area equipped for power irrigation (surface water or groundwater) |
| 4327 | % of area equipped for irrigation power irrigated |
| 4328 | % of the area equipped for irrigation actually irrigated |
| 4330 | % of irrigation potential equipped for irrigation |
| 4331 | % of the cultivated area equipped for irrigation |
| 4379 | Total harvested irrigated crop area (full control irrigation) |
| 4400 | Area salinised by irrigation |
| 4445 | % of area equipped for irrigation salinised |
| 4446 | % of area equipped for irrigation drained |
| 4448 | Other agricultural water managed area |
| 4449 | Population economically active |
| 4450 | Freshwater withdrawal as % of internal renewable water resources |
| 4451 | Direct use of agricultural drainage water |

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| ***Annexe 2***. List of arithmetic formulas to calculate relevant AQUASTAT database indicators (the left-hand side). The right-hand side of the formula defines the indicator while the left-hand side the variables/components. To definitions, please refer to Annexe 1 of this document |
| [4103] = [4101] + [4102] |
| [4105] = [4104] - [4106] |
| [4107]=[4104]/([4100]/100) |
| [4108]=[4109]+[4110] |
| [4150] = [4100] \* [4155] / 100000 |
| [4157]=[4154]+[4155]-[4156] |
| [4158]=[4157]\*1000000/[4104] |
| [4164]=[4160]+[4162]+[4168] |
| [4176]=[4160]+[4162]+[4168]-[4174] |
| [4182]=[4176]+[4452] |
| [4185]=[4176]+[4155] |
| [4187]=[4154]+[4452] |
| [4188]=[4185]+[4187]-[4156] |
| [4190]=[4188]\*1000000/[4104] |
| [4192]=100\*([4164]+[4452])/([4164]+[4452]+[4157]) |
| [4509]= [4193]+[4194] |
| [4196]=[4509]+[4195] |
| [4253]=[4251]+[4252]+[4250] |
| [4254]=[4250]/[4253]\*100 |
| [4255]=[4251]/[4253]\*100 |
| [4256]=[4252]/[4253]\*100 |
| [4257]= [4253]\*1000000/[4104] |
| [4263]=[4253]-[4264]-[4265]-[4451] |
| [4271]= 100\*[4260]/[4250] |
| [4273]=100\*[4250]/[4188] |
| [4275]=100\*[4263]/[4188] |
| [4300]=[4303]+[4304] |
| [4305]=100\*[4300]/[4103] |
| [4311]=[4308]+[4309]+[4310] |
| [4313]= [4311]+[4312]+[4316] |
| [4317]= [4313]+[4314]+[4315] |
| [4319]=100\*[4313]/[4317] |
| [4323]= 100\*[4320]/[4313] |
| [4324]=100\*[4321]/[4313] |
| [4325]=100\*[4322]/[4313] |
| [4327]=100\*[4326]/[4313] |
| [4328]=100\*[4318]/[4313] |
| [4330]= 100\*[4313]/[4307] |
| [4331]=100\*[4313]/[4103] |
| [4445]=100\*[4400]/[4313] |
| [4446]=100\*[4303]/[4313] |
| [4448]=[4314]+[4315] |
| [4450]=100\*[4263]/[4157] |
| [4455]=100\*[4454]/[4101] |
| [4456]=[4160]+[4162]+[4168]+[4170] |
| [4457]=[4251]\*1000000/[4104] |
| [4458]=[4112]/[4104]/1000 |
| [4459]= [4309]+[4310] |
| [4462]= 100\*[4379]/[4461] |
| [4463]=100\*[4461]/[4311] |
| [4464]=100\*[4379]/[4461] |
| [4466]=100\*[4465]/[4313] |
| [4467]=100\*[4263]/[4253] |
| [4468]=[4251]\*1000000/[4106] |
| [4470]=100\*[4103]/[4100] |
| [4471]=1000000\*[4197]/[4104] |
| [4514]=100\*[4513]/[4313] |
| [4527]=100\*[4526]/[4313] |
| [4531]= [4252]\*1000000/[4104] |
| [4532]=[4250]\*1000000/[4104] |
| [4538]=100\*[4108]/[4449] |
| [4540]=100\*[4539]/[4313] |
| [4550]=100\*[4263]/([4188]-[4549]) |
| [4551]=([4552]\*[4254])+([4553]\*[4256])+([4554]\*[4255]) |
| [4552]= (([4548]\*[4555]/100)/[4250])/1000000000 |
| [4553]=([4546]/[4252])/1000000000 |
| [4554]= ([4547]/[4251])/1000000000 |
| [4555]=1/(1+((1-([4556]/100))/(([4556]/100)\*[4557]))) |
| [4556]=100\*[4379]/[4101] |
| [4103] = [4101] + [4102] |
| [4105] = [4104] - [4106] |
| [4107]=[4104]/([4100]/100) |
| [4108]=[4109]+[4110] |
| [4150] = [4100] \* [4155] / 100000 |
| [4157]=[4154]+[4155]-[4156] |
| [4158]=[4157]\*1000000/[4104] |
| [4164]=[4160]+[4162]+[4168] |
| [4176]=[4160]+[4162]+[4168]-[4174] |
| [4182]=[4176]+[4452] |
| [4185]=[4176]+[4155] |
| [4187]=[4154]+[4452] |
| [4188]=[4185]+[4187]-[4156] |
| [4190]=[4188]\*1000000/[4104] |
| [4192]=100\*([4164]+[4452])/([4164]+[4452]+[4157]) |
| [4509]= [4193]+[4194] |
| [4196]=[4509]+[4195] |
| [4253]=[4251]+[4252]+[4250] |
| [4254]=[4250]/[4253]\*100 |
| [4255]=[4251]/[4253]\*100 |
| [4256]=[4252]/[4253]\*100 |
| [4257]= [4253]\*1000000/[4104] |
| [4263]=[4253]-[4264]-[4265]-[4451] |
| [4271]= 100\*[4260]/[4250] |
| [4273]=100\*[4250]/[4188] |
| [4275]=100\*[4263]/[4188] |
| [4300]=[4303]+[4304] |
| [4305]=100\*[4300]/[4103] |
| [4311]=[4308]+[4309]+[4310] |
| [4313]= [4311]+[4312]+[4316] |
| [4317]= [4313]+[4314]+[4315] |
| [4319]=100\*[4313]/[4317] |
| [4323]= 100\*[4320]/[4313] |
| [4324]=100\*[4321]/[4313] |
| [4325]=100\*[4322]/[4313] |
| [4327]=100\*[4326]/[4313] |
| [4328]=100\*[4318]/[4313] |
| [4330]= 100\*[4313]/[4307] |
| [4331]=100\*[4313]/[4103] |
| [4445]=100\*[4400]/[4313] |
| [4446]=100\*[4303]/[4313] |
| [4448]=[4314]+[4315] |
| [4450]=100\*[4263]/[4157] |
| [4455]=100\*[4454]/[4101] |
| [4456]=[4160]+[4162]+[4168]+[4170] |
| [4457]=[4251]\*1000000/[4104] |
| [4458]=[4112]/[4104]/1000 |
| [4459]= [4309]+[4310] |
| [4462]= 100\*[4379]/[4461] |
| [4463]=100\*[4461]/[4311] |
| [4464]=100\*[4379]/[4461] |
| [4466]=100\*[4465]/[4313] |
| [4467]=100\*[4263]/[4253] |
| [4468]=[4251]\*1000000/[4106] |
| [4470]=100\*[4103]/[4100] |
| [4471]=1000000\*[4197]/[4104] |
| [4514]=100\*[4513]/[4313] |
| [4527]=100\*[4526]/[4313] |
| [4531]= [4252]\*1000000/[4104] |
| [4532]=[4250]\*1000000/[4104] |
| [4538]=100\*[4108]/[4449] |
| [4540]=100\*[4539]/[4313] |
| [4550]=100\*[4263]/([4188]-[4549]) |
| [4551]=([4552]\*[4254])+([4553]\*[4256])+([4554]\*[4255]) |
| [4552]= (([4548]\*[4555]/100)/[4250])/1000000000 |
| [4553]=([4546]/[4252])/1000000000 |
| [4554]= ([4547]/[4251])/1000000000 |
| [4555]=1/(1+((1-([4556]/100))/(([4556]/100)\*[4557]))) |
| [4556]=100\*[4379]/[4101] |