STEP-BY-STEP MONITORING METHODOLOGY FOR INDICATOR 6.4.2

LEVEL OF WATER STRESS: FRESHWATER WITHDRAWAL IN PERCENTAGE OF AVAILABLE FRESHWATER RESOURCES

1. MONITORING CONTEXT

1.1 INTRODUCTION OF THE INDICATOR

Target 6.4 **By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity**

Indicator 6.4.2 **Level of water stress: freshwater withdrawal[1] in percentage of available freshwater resources**

An indicator on water stress existed already in the MDG monitoring framework, denominated "proportion of total water resources used". Although the definition of that indicator was quite near to the definition proposed for SDG indicator 6.4.2, it did not take into consideration the environmental flow requirements (EFR), being limited to considering the water needed for human activities in front of the overall water availability.

This point has been addressed in the identification of the present water stress indicator 6.4.2, leading to the following definition: the ratio between total freshwater withdrawn by all major sectors and total renewable freshwater resources, after having taken into account environmental water requirements.

Main sectors, as defined by ISIC standards, can include for example agriculture; forestry and fishing; manufacturing; electricity industry; and municipalities. The data on freshwater withdrawal are also used for the calculation of indicator 6.4.1 on water use efficiency, and the data on environmental water requirements feeds into indicator 6.6.1 on water-related ecosystems.

[1] Following the definitions of AQUASTAT, in this text withdrawal is synonymous with abstraction

1.2 Target levels for the indicator

In the MDG indicator, three levels of water stress were considered as thresholds: 25%, below which no water scarcity exists; 60%, indicating approaching scarcity, and 75%, above which strong water scarcity is identified.

However, indicator 6.4.2 introduces the concept and quantity of environmental flow requirement into its computation. This means that the water needed for the basic ecological functioning is already computed and set aside in the moment that the indicator is calculated.

Although EFR varies among different ecosystems and climates, IWMI estimates a worldwide average EFR of about 30%. When EFR is factored in the calculation of the indicator, in principle no environmental water scarcity should be considered up to a value of the indicator of 100%.

However, from the perspective of water usage for human needs, there are forms of water utilization, such as navigation or recreation, which do not imply withdrawal but still require a water flow beyond the EFR. Hence, we propose to consider serious water scarcity at 70% as indicator's value.

However, the target for each country should be determined on a case-by-case basis, considering a variety of factors such as the level of development, the population density, the availability of non-conventional sources of water and the general climatic conditions.

2. Proposed monitoring methodology

2.1 Monitoring concept and definitions

Concept: This indicator provides an estimate of pressure by all sectors on the country's renewable freshwater resources. A low level of water stress indicates a situation where the combined withdrawal by all sectors is marginal in relation to the resources, and has therefore little potential impact on the sustainability of the resources or on the potential competition between users. A high level of water stress indicates a situation where the combined withdrawal by all sectors represents a substantial share of the total renewable freshwater resources, with potentially larger impacts on the sustainability of the resources and potential situations of conflicts and competition between users.

The indicator is computed based on three components, as described below:

1. **Total renewable freshwater resources (TRWR)** are expressed as the sum of (a) internal renewable water resources (IRWR) and (b) external renewable water resources (ERWR). The term "water resources" is understood here as freshwater resources.
    a. **Internal renewable water resources** are defined as the long-term average annual flow of rivers and recharge of groundwater for a given country generated from endogenous precipitation.
    b. **External renewable water resources** refer to the flows of water entering the country, taking into consideration the quantity of flows reserved to upstream and downstream countries through agreements or treaties (and, where available, the reduction of flow due to upstream withdrawal).

2. **Total freshwater withdrawal (TWW)** is the volume of freshwater extracted from its source (rivers, lakes, aquifers) for agriculture, industries and municipalities. It is estimated at the country level for the following three main sectors: agriculture, municipalities (including domestic water withdrawal) and industries (including cooling of thermoelectric plants). Freshwater withdrawal includes primary freshwater (water not withdrawn before), secondary freshwater (water previously withdrawn and returned to rivers and groundwater, such as discharged treated wastewater and discharged agricultural drainage water) and fossil groundwater. It does not include direct use of non-conventional water, i.e. direct use of treated wastewater, direct use of agricultural drainage water and desalinated water. TWW is in general calculated as being: [the sum of total water withdrawal by sector] minus [direct use of wastewater, direct use of agricultural drainage water and use of desalinated water]. In formula:

$$TWW = \sum ww_s - \sum du_u$$

where:

TWW = Total freshwater withdrawal

ww_s = Water withdrawal for sector "s". s = agriculture, industry, energy, etc.

du_u = Direct water use from source "u". u = direct use of wastewater, direct use of agricultural drainage water and use of desalinated water.

3. **Environmental flow requirements (EFR.)** are the quantities of water required to sustain freshwater and estuarine ecosystems. Water quality and also the resulting ecosystem services are excluded from this formulation which is confined to water volumes. This does not imply that quality and the support to societies which are dependent on environmental flows are not important and should not be taken care of. They are indeed taken into account by other targets and indicators, such as 6.3.2, 6.5.1 and 6.6.1. Methods of computation of EFR are extremely variable and range from global estimates to comprehensive assessments for river reaches. For the purpose of the SDG indicator, water volumes can be expressed in the same units as the TWW, and then as percentages of the available water resources.

2.2 Recommendations on country process for monitoring

As data from different sectors and sources are needed for the computation of this indicator, it is necessary that a national coordination is in place in order to assure the timely and consistent collection of the data.

2.3 Recommendations on spatial and temporal coverage

The data for this indicator should be collected annually. However, a reporting period up to three years can still be considered acceptable.

Within the SDG process, the indicator has to be reported at country level. Nonetheless, data collection at sub-national level would be advisable wherever possible, as that would provide a kind of information much more useful for decision making and implementation of water management plans. The disaggregation of the information at sub-national level should be done by basin units, collecting the data at the relevant level and considering the possible artificial transfer of water between basins.

2.4 Monitoring ladder

The methodology for 6.4.2 – recognizing that countries have different starting points when it comes to water stress monitoring – allows countries to begin monitoring efforts at a level in line with their national capacity and available resources, and from there advance progressively.

1. As a first level, the indicator can be populated with estimations based on national data aggregated to the country level. If needed, data can be retrieved from internationally available databases on water availability and withdrawals by different sectors. Inclusion of estimation of environmental flow requirements based on literature values.
2. Moving on to the next level, the indicator can be populated with nationally produced data, which increasingly can be disaggregated to the sub-national basin unit level. Inclusion of estimation of environmental flow requirements based on literature values.
3. For more advanced levels, the nationally produced data have high spatial and temporal resolution (e.g. geo-referenced and based on metered volumes) and can be fully disaggregated by source (surface water/groundwater) and use (economic activity). Literature values of environmental flow requirements are refined by national estimations.

3. Data sources and collection

3.1 Data requirements to compute the indicator

In order to be able to disaggregate the indicator, it would be advisable that the components described above are in turn computed by aggregating the variables per subsector, as follows:

3.1.1 Total renewable water resources (km^3/year)

Total Renewable Water Resources (TRWR) are the sum of internal and external renewable water resources.

Internal Renewable Water Resources (IRWR) (km^3/year)

The long-term average annual flow of rivers and recharge of aquifers generated from endogenous precipitation (resources produced within the territory), taking into consideration the overlap between them.

External Renewable Water Resources (ERWR) (km^3/year)

The part of the country's renewable water resources that is not generated within the country. The ERWR include inflows from upstream countries (groundwater and surface water), and part of the water of border lakes or rivers. It takes into consideration the quantity of flows reserved to upstream and downstream countries through agreements or treaties.

3.1.2 Agricultural water withdrawal (km^3/year)

Annual quantity of self-supplied water withdrawn for irrigation, livestock and aquaculture purposes. It includes water from primary renewable freshwater resources and secondary sources of water, as well as water from over-abstraction of renewable groundwater or withdrawal of fossil groundwater, direct use of agricultural drainage water and (treated) wastewater, and desalinated water.

Water withdrawal for irrigation (km^3/year)

Annual quantity of water withdrawn for irrigation purposes. It includes water from primary renewable freshwater resources and secondary sources of water, as well as water from over-abstraction of renewable groundwater or withdrawal of fossil groundwater, direct use of agricultural drainage water and (treated) wastewater, and desalinated water.

Water withdrawal for livestock (watering and cleaning) (km^3/year)

Annual quantity of water withdrawn for livestock purposes. It includes water from primary renewable freshwater resources and secondary sources of water, as well as water from over-abstraction of renewable groundwater or withdrawal of fossil groundwater, direct use of agricultural drainage water and (treated) wastewater, and desalinated water. It includes livestock watering, sanitation, cleaning of stables, etc. It does not include water withdrawal for irrigated fodder, meadows and pastures, which is included in the water withdrawal for irrigation above. It also does not include the water withdrawal for the preparation of products derived from animals, which is included in industrial water withdrawal below. If connected to the public water supply network, water withdrawn for livestock is included in municipal water withdrawal.

Water withdrawal for aquaculture (km^3/year)

Annual quantity of water withdrawn for aquaculture. It includes water from primary renewable freshwater resources and secondary sources of water, as well as water from over-abstraction of renewable groundwater or withdrawal of fossil groundwater, direct use of agricultural drainage water and (treated) wastewater, and desalinated water. Aquaculture is the farming of aquatic organisms in inland and coastal areas, involving intervention in the rearing process to enhance production and the individual or corporate ownership of the stock being cultivated.

This sector corresponds to the ISIC sector A (1-3).

3.1.3 Industrial water withdrawal (incl. for cooling of thermoelectric plants) (km^3/year)

Annual quantity of water withdrawn for industrial uses. It includes water from primary renewable freshwater resources and secondary sources of water, as well as over-abstraction of renewable groundwater or withdrawal of fossil groundwater and potential use of desalinated water or direct use of (treated) wastewater. This sector refers to self-supplied industries not connected to the public distribution network.

Industrial water withdrawal does not include hydropower, but it is recommended to include in this sector the losses for evaporation from artificial lakes used for hydropower production. Information can be found at http://www.fao.org/3/a-bc814e.pdf and http://www.fao.org/nr/water/aquastat/dams/index.stm#evaporation.
This sector corresponds to the ISIC sectors B [5-9]; C [10-33], D [35] and F [41-43]

3.1.4 Municipal water withdrawal (km^3/year)

Annual quantity of water withdrawn primarily for the direct use by the population. It includes water from primary renewable freshwater resources and secondary sources of water, as well as potential over-abstraction of renewable groundwater or withdrawal of fossil groundwater and the potential use of desalinated water or direct use of treated wastewater. It is usually computed as the total water withdrawn by the public distribution network. It can include that part of the industries, which is connected to the municipal network.

It is recommended to use the AQUASTAT questionnaires and the AQUASTAT water resources templates to collect the data required for the computation of the indicator. That will allow to upload directly the data into the AQUASTAT database, as appropriate since FAO is the custodian of the indicator face to the UNSC. As an alternative, the tables presented in SEEA-Water can be used.

This sector corresponds to the ISIC sector E [36].

3.1.5 Environmental flow requirements

Determination of the EFR can be done by application of various methods ranging from a simple hydrological approach to comprehensive holistic models. The approach should progressively take into account the variability of flow regime during time and space, leading to the most recent Hydraulic /Habitat models (Parasiewicz, 2007)

Information on the estimation of EFR can be found at:
http://waterdata.iwmi.org/Applications/Global_Assessment_Environmental_Water_Requirements_Scarcity/

3.1.6 Other definitions

- Freshwater: Water occurring on the earth's surface in glaciers, lakes and rivers (i.e. surface water), and underground in aquifers (i.e. groundwater). Its key factor is a low concentration of dissolved salts. The term excludes rainwater, water stored in the soil (soil moisture), untreated wastewater, seawater and brackish water.
- Wastewater: Water which is of no further immediate value to the purpose for which it was used or in the pursuit of which it was produced because of its quality, quantity or time of occurrence. However, wastewater from one user can be a potential supply to another user elsewhere. Cooling water is not considered to be wastewater.
- Direct use of treated municipal wastewater: Treated municipal wastewater (primary, secondary, tertiary effluents) directly used, i.e. with no or little prior dilution with freshwater during most of the year.
- Direct use of agricultural drainage water: Agricultural drainage water is water withdrawn for agriculture but not consumed and returned. It can be recovered and reused and thus is considered to be a secondary source of water, contrary to primary water resources, which are the renewable freshwater resources. Like desalinated water and wastewater, it is also considered as a type of non-conventional water.

Desalinated water produced: Water produced annually by desalination of brackish or salt water. It is estimated annually on the basis of the total capacity of water desalination installations.

Units of volume:

1 km^3 = 1 billion m^3 = 1000 million m^3 = 10^9 m^3

3.2 Sources of data – short and long term

3.2.1 Globally available data:

All the data needed for the compilation of the indicator can be found in the AQUASTAT database of FAO. Using AQUASTAT data would be probably the simplest way to compile the indicator in the short term. However, it must be considered that AQUASTAT is a repository of data, but it does not produce new data. That means that without a specific effort by the countries, no update, and consequently no monitoring, could be done. This is due to the absence until now of a regular reporting system, which should indeed be put in place within the SDG process. Hence, in order to monitor the indicator over the years, a national data collection process needs to be established in each country.

3.2.2 National data:

National-level data must be provided for the indicator. If data are available at sub-national level they should also be provided, especially for larger countries or countries with marked climatic differences within their territory. The most advisable units to be used for this exercise are river basins, aggregated according to the circumstances of each country. A map of the country showing the administrative boundaries (provinces or districts) and basin boundaries should be provided with the questionnaire.

A specific questionnaire for the preparation of the indicators of target 6.4 is available as annex 1a to this document and a template developed specifically for water resources is available as annex 1b. As the questionnaire is quite related with the general AQUASTAT questionnaire, the AQUASTAT guidelines are a useful reference:

http://www.fao.org/nr/water/aquastat/sets/aq-5yr-guide_eng.pdf.

No specific field survey is expected to be undertaken to answer the questionnaire. A complete field survey would involve too much time and would be too costly. Information can be collected through an in-depth scanning of all existing reports and maps dealing with water resources and water use in the country.

3.2.3 Institutions

In the institution table (sheet 4 of the questionnaire), provide complete information on the main institutions dealing with water resources, their development and management, where complementary information can be obtained. For each institution, please indicate the organization types and the fields of activity. Further details can be given on the types of activities such as research, development, planning, training, extension and education, monitoring and statistics.

3.3 Recommendations on data management

3.3.1 Data quality

As a general rule, the most recent available data must be provided and always with its reference source. Some data become outdated faster than other do and judgment with regards to the reliability of a source will have to be made on a case by case basis. In some cases, if the latest data are known to be outdated, it should be mentioned in the "comments" column of the questionnaire. All information judged to be relevant must be provided in the "comments" column. If there is not enough space in the "comments" column, use a separate file (in Word or Excel) containing more explanations or clarifications. If data for different previous years are available they are also very welcome in order to be able to make time series and these can be given in a separate Excel file.

If different sources give significantly different figures (especially for the same year), a critical analysis will be necessary to choose the figure that is most likely to represent reality. The other figures together with the sources can be referred to in the comments.

All comments will also be analyzed and a selection of these comments will be made and included as metadata in the database following the EURO-SDMX structure. For more information on this see http://www.fao.org/nr/water/aquastat/metadata/index.stm.

Moreover, a fully-fledged Quality Control/Quality Assurance (QC/QA) mechanism should be put in place, in order to ensure the quality of the data collection process and its outcome. A final verification of the data with those from independent sources, if available, would be also advisable.

4. Step-by-step data collection and computation of indicator

4.1.1 Step 1

A national institution will be identified/appointed with the task to compile the indicator. That institution will carry out a review of all the national, sub-national and basin unit sources of relevant data, such as maps, reports, yearbooks and articles. The collection will focus on the most recent data, but without excluding any potential sources of information. Also partial data, by time or area, will be collected, such as data produced by local projects. Older data shall also be collected for reference. The data collected will be compared with those available on AQUASTAT.

4.1.2 Step 2

A participatory analysis of the outcome of step 1 will be done through a technical meeting of all the involved institutions. The final dataset to be used for the baseline will be selected. Possible older datasets will also be indicated if available, to be used to produce a preliminary backward timeline.

4.1.3 Step 3

The indicator will be computed following the indications of the metadata and these guidelines, using the dataset(s) identified in step 2.

The indicator is calculated with the following formula:

$$Water\ Stress\ (\%) = \frac{TWW}{TRWR - EFR.} * 100$$

Where:

- TWW = Total freshwater withdrawn, where year to which it refers will be provided
- TRWR = Total renewable freshwater resources
- EFR = Environmental flow requirements

4.1.4 Step 4

The outcome of step 3 will be discussed and commented in a national workshop among national and possible international actors. Needs and constrains for the implementation of a constant monitoring of the indicator will be identified, and the steps to be undertaken to overcome them will be indicated.

Example

Example of calculation of the indicator under the MDG framework.

Country: Argentina

Indicator:
Percent of freshwater resources withdrawn (%)

Calculation rule:
100 * Total freshwater withdrawal (surface water + groundwater) / Water resources: total renewable

Definition:
Total freshwater withdrawn in a given year, expressed in percentage of the total renewable water resources (TRWR). This parameter is an indication of the pressure on the renewable water resources.

Comments:
The two variables considered for this indicator are highly aggregated, therefore, almost all methodological differences in underlying variables will be reflected on this indicator. Most markedly, the treatment of outflows and return flows are not well agreed upon in the international community, and amongst countries. AQUASTAT, Eurostat, and UNSD values used for this indicator represent the Long-Term Annual Average (LTAA).

Reporting Agency: FAO – AQUASTAT

This indicator is calculated as:
100 * Total freshwater withdrawal (surface water + groundwater) / Water resources: total renewable

Total freshwater withdrawal (surface water + groundwater)	FAO – AQUASTAT	37.69 (10^9 m3/yr)	2011
Total renewable water resources	FAO – AQUASTAT	876.2 (10^9 m3/yr)	2012
Percent of freshwater resources withdrawn (%)	FAO – AQUASTAT	4.3%	

which represents the latest values available for these variables.

Other UN Agencies also gather data on the variables used in this indicator, as follows:

Total renewable water resources	UNSD (United Nations Statistics |Division)	814 (10^9 m3/yr)	2009

The main difference with the present definition is the treatment of the environmental flow requirements. In the MDG indicator shown in this example they were considered only in the estimation thresholds of the indicator, after the actual calculation would take place. In the SDG they will be explicitly factored in the equation. This development is designed to increase the reliability of the indicator and its usefulness as a tool to inform water management decisions.

5. Background proposed indicator and methodology

This indicator derives from the indicator 7.5 on water stress that was applied during the MDG process, defined as "Proportion of total water resources used, percentage". It has been selected in order to ensure continuity with that process, and for its intrinsic importance for the assessment of the water resources of a country.

The Food and Agriculture Organization of the United Nations (FAO) has been responsible for compiling data and calculating this indicator at the international level during the MDG period. This is done through its Global Water Information System (AQUASTAT) country surveys since 1994. These surveys are carried out every ten years, on average.

AQUASTAT data are obtained through detailed questionnaires filled in by national experts and consultants who collect information from the different institutions and ministries having water-related issues in their mandate. In order to complement the data collection and to inform the quality control and assessment process, literature and information at the country and sub-country and river basin level are reviewed including national policies and strategies; water resources and irrigation master plans; national reports, yearbooks and statistics; reports from projects; international surveys; results and publications from national and international research centres; and the Internet.

Data obtained from national sources are systematically reviewed to ensure consistency in definitions and consistency in data from countries located in the same river basin. A methodology has been developed by AQUASTAT and rules established to compute the different elements of national water balances. Guidance can be found at:

http://www.fao.org/nr/water/aquastat/sets/index.stm

Estimates are based on country information, complemented, when necessary, with expert calculations based on unit water use figures by sector, and with available global datasets. In the case of conflicting sources of information, the difficulty lies in selecting the most reliable one. In some cases, water resources figures vary considerably from one source to another. There are various reasons for such differences, including differing computation methods, definitions or reference periods, double counting of surface water and groundwater or of transboundary river flows. Moreover, estimates of long-term average annual values can change due to the availability of better data from improvements in knowledge, methods or measurement networks.

Where several sources result in divergent or contradictory information, preference is given to information collected at the national or sub-national level rather than at regional or world levels. Moreover, except in the case of evident errors, official sources are privileged. As regards shared water resources, the comparison of information between countries makes it possible to verify and complete data concerning the flows of transboundary rivers and to ensure data coherence at the river basin level. In spite of these precautions, the accuracy, reliability and frequency with which information is collected vary considerably by region, country and category of information. Information is completed using models and/or remote sensing (for example to estimate irrigation areas for the calculation of agricultural water withdrawal) when necessary.

Regional and global level aggregations are obtained by applying the same procedure as for country level computation.

AQUASTAT data on water resources and use are published when new information becomes available on the FAO-AQUASTAT website at http://www.fao.org/nr/aquastat.

Modelled data are used with caution to fill gaps while capacity is being developed. Data on water resources can be modelled by using GIS-based hydrological models. Data on water withdrawal are estimated by sector on the basis of standard unit values of water withdrawal. When data are modelled it always should be indicated, as is done in the AQUASTAT database, so as to avoid that modelers use modelled data for their models.

6. REFERENCES

Food and Agricultural Organization of the United Nations. AQUASTAT - FAO's Global Water Information System. Rome. Website http://www.fao.org/nr/aquastat.

The following resources of specific interest to this indicator are available:

- AQUASTAT glossary: http://www.fao.org/nr/water/aquastat/data/glossary/search.html
- AQUASTAT Main country database: http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en
- AQUASTAT Water use: http://www.fao.org/nr/water/aquastat/water_use/index.stm
- AQUASTAT Water resources: http://www.fao.org/nr/water/aquastat/water_res/index.stm
- AQUASTAT publications dealing with concepts, methodologies, definitions, terminologies, metadata, etc.: http://www.fao.org/nr/water/aquastat/catalogues/index.stm
- AQUASTAT Quality Control: http://www.fao.org/nr/water/aquastat/sets/index.stm
- AQUASTAT Guidelines: http://www.fao.org/nr/water/aquastat/sets/aq-5yr-guide_eng.pdf
- For surface water, environmental water requirement databases include: http://waterdata.iwmi.org/apps/flow_management_classes/
- http://www.iwmi.cgiar.org/resources/models-and-software/environmental-flow-calculators/. Environmental water requirement data for groundwater bodies will be available at IWMI by the end of 2015.
- UNSD/UNEP Questionnaire on Environment Statistics – Water Section :
  http://unstats.un.org/unsd/environment/questionnaire.htm
  http://unstats.un.org/unsd/environment/qindicators.htm
- Framework for the Development of Environment Statistics (FDES 2013) (Chapter 3): http://unstats.un.org/unsd/environment/FDES/FDES-2015-supporting-tools/FDES.pdf
- OECD/Eurostat Questionnaire on Environment Statistics – Water Section
- International Recommendations for Water Statistics (IRWS) (2012): http://unstats.un.org/unsd/envaccounting/irws/
- Parasiewicz, P. 2007. The MesoHABSIM model revisited. River research and applications, 23/8/2007: http://onlinelibrary.wiley.com/doi/10.1002/rra.1045/abstract