

# Water preprocessor

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## Series pulled into water preprocessor

Table	Definition	Source
SeriesWaterFossilWithdrawal	Water withdrawal from fossil water aquifers	UNESCO N
SeriesWaterResFossil	Water withdrawal from fossil water aquifers	UNESCO N
SeriesWaterResGroundAfrica	Water withdrawal from fossil water aquifers for African countries	Quantitativ
SeriesWasterwaterTreated	Wastewater: treated volume (10 <sup>9</sup> m3/yr)	AQU BATC
SeriesWastewaterProduced	Wastewater: produced volume (10 <sup>9</sup> m3/yr)	AQU BATC
SeriesWastewaterTreatedReused	Treated wastewater reused (10 <sup>9</sup> m3/yr)	AQU BATC
SeriesWaterDesalinated	Desalinated Water Produced	AQU BATC
SeriesWaterGroundWithD	Ground Water Withdrawal	AQU BATC
SeriesWaterResExploitGround	Exploitable: regular renewable groundwater (10 <sup>9</sup> m3/yr)	AQU BATC
SeriesWaterResExploitSurface	Exploitable: total renewable surface water (10 <sup>9</sup> m3/yr)	AQU BATC
SeriesWaterResOverlap	Overlap between surface and groundwater	AQU BATC
SeriesWaterResTotalExploit	Water resources: total exploitable	AQU BATC
SeriesWaterResTotalRenew	Water resources: total renewable (actual)	AQU BATC
SeriesWaterResTotalRenewGround	Total renewable groundwater (actual) (10 <sup>9</sup> m3/yr)	AQU BATC
SeriesWaterResTotalRenewSurface	Total renewable surface water (actual)	AQU BATC

SeriesWaterSurfaceWithD	Surface Water Withdrawal	AQU BATC
SeriesWaterTotalWithdSources	Total water withdrawal (summed by sources)	AQU BATC
SeriesWaterWithdAgriculture	Agricultural water withdrawal	AQU BATC
SeriesWaterWithdIndustrial	Industrial water withdrawal	AQU BATC
SeriesWaterWithdMunicipal	Municipal water withdrawal	AQU BATC
SeriesLandIrrActual%Equip	Area equipped for irrigation: actually irrigated, %	AQU BATC

## Water demand

Start with demand. Read in water demand data by sector (municipal, industrial, agriculture, and total) and fill holes if we have 3 of those 4. Then fill holes for each sector using the same equations we would use to forecast those variables. Then normalize with total water demand (by sector) if there are data.

### Fill holes

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If we have 3 of the 4 components of water demand (municipal, industrial, agriculture, and total by sector) then we can deduce the 4th.

For example,

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WatWithdMun}_c = \text{WatWithdTotalSector}_c - \text{WatWithdInd}_c - \text{WatWithdAg}_c$$**

We do the same for each sector as well as  $\text{WatWithdTotalSector}$ .

### Municipal water demand

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Use  $\text{SeriesWaterWithdMunicipal}$  to initialize municipal water demand ( $\text{WatWithdMun}$ ).

If null, then calculate urban population:

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{UrbanPercent} = \frac{\text{POPURBAN}_c}{\text{POP}_c}$$**

Then estimate municipal water demand using the equation: "MunDemandPC (Linear) versus GDP2011PCPPP(MOSTRECENT) (Log) AND Connections" which is in  $\text{AnalFunc}$ .

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{Prediction} = (x_1 * \ln(\text{GDPPCP}_c)) + (x_2 * \ln(\text{UrbanPercent})) + (x_3 * \ln(\text{WATSAFE}_{\{c,3\}})) + b$$**

Multiply municipal water demand per capita by the size of the urban population.

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server**

"https://wikimedia.org/api/rest\_v1/"):  $\text{WatWithdMun}_c = \text{Prediction} * \text{POPURBAN}_r$

## Industrial water demand

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Use SeriesWaterWithdIndustrial to initialize industrial water demand (WatWithdInd).

If null, then estimate using manufacturing value added. The equation is, "WaterWithdIndustrial(MOSTRECENT minus elec) (Linear) versus Man (Linear)" and is in TablFunc.

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"):  $\text{Prediction} = x_c * \text{VADD}_{\{c, \text{manufacturing}\}}$**

## Agricultural water demand

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Initialize agriculture water demand using SeriesWatWithdAg. If null, estimate using land irrigated.

Initialize land irrigated (LANDIRAREAACTUAL) using SeriesLandIrActual%Equip.

If null, set to 90 (percent).

Multiply by land equipped for irrigation:

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"):  $\text{LANDIRAREAACTUAL}_r = \text{LANDIRAREAACTUAL}_c * (\text{CLandIrAreaEquip}_c / 100)$**

If LANDIRAREAACTUAL is still null, then set to 0.001.

Use LANDIRAREAACTUAL to estimate agricultural water demand using the equation: "WaterWithdAgriculture(MOSTRECENT) (Linear) versus Irrigated land (Linear)"

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"):  $\text{WatWithdAg}_c = x * \text{LANDIRAREAACTUAL}_c + b$**

## Normalize with total demand

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If we have data for total water demand (WatWithdTotalSector) but it does not match with the sum of our sectors, we normalize the sectors to match the total data. For example,

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"):  $\text{WatWithdMun}_c = (\text{WatWithdMun}_c / \text{WatTotalDemand}) * \text{WatWithdTotalSector}_c$**

where

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WatTotalDemand} = \sum_{\text{sector}}^3 \text{WaterDemand}_{\text{c,sector}}$$**

## **Water withdrawal growth rates**

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Initialize water withdrawal growth rates (WaterWithdrawalSurfaceGR, WaterWithdrawalGroundGR, WaterWithdrawalFossilGroundGR) using the "getAnnualGrowthRate" function and the tables: SeriesWatWithdSurface, SeriesWatWithDGround, and SeriesWatWithDFossilGround.

## **Total and exploitable renewable resources**

Initialize total renewable surface water resources (WatResTotalRenewSurface) using SeriesWaterResTotalRenewSurface.

Initialize total renewable groundwater resources (WatResTotalRenewGround) using SeriesWaterResTotalRenewGround.

Initialize total renewable water resources (WatResTotalRenew) using SeriesWaterResTotalRenew.

### **Fill holes**

If WatResTotalRenewGround is null but WatResTotalRenewSurface and WaterResTotalRenew are not null, then:

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WatResTotalRenewGround}_c = \text{WaterResTotalRenew}_c - \text{WatResTotalRenewSurface}_c$$**

If WatResTotalRenewSurface is null, but WatResTotalRenewGround and WaterResTotalRenew are not null, then:

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WatResTotalRenewSurface}_c = \text{WaterResTotalRenew}_c - \text{WatResTotalRenewGround}_c$$**

If WaterResTotalRenew is null, but WatResTotalRenewGround and WatResTotalRenewSurface are not null, then:

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WaterResTotalRenew}_c = \text{WatResTotalRenewSurface}_c + \text{WatResTotalRenewGround}_c$$**

**WaterResTotalRenew\_c=WatResTotalRenewGround\_c+WatResTotalRenewSurface\_c  
}**

If we do not have data for any of them, estimate total using land area:

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WaterResTotalRenew}_c = x * \text{LANDAREA}_c$$**

and then assume surface water is 71 percent of total and ground water is 29 percent.

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WatResTotalRenewGround}_c = 0.29 * \text{WaterResTotalRenew}_c$$**

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WatResTotalRenewSurface}_c = 0.71 * \text{WaterResTotalRenew}_c$$**

If we only have data for total, then assume surface is 71 percent and groundwater is 29 percent.

If we only have surface then assume surface is 71 percent of total:

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WaterResTotalRenew}_c = \text{WatResTotalRenewSurface}_c / 0.71$$**

and that groundwater is 29 percent of total.

If we only have data for groundwater then assume groundwater is 29 percent of total:

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WaterResTotalRenew}_c = \text{WatResTotalRenewGround}_c / 0.29$$**

and that surface is 71 percent of total.

Subtract overlap between surface and groundwater out. Initialize overlap with SeriesWaterResOverlap.

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WatResTotalRenewSurface}_c = \frac{\text{WatResTotalRenewSurface}_c}{\text{WaterResTotalSurfaceGround}_c} * (\text{WaterResTotalSurfaceGround}_c - \text{Overlap}_c)$$**

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response**

**("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/":** 
$$\text{WatResTotalRenewGround}_c = \frac{\text{WatResTotalRenewGround}_c}{\text{WaterResTotalSurfaceGround}_c} * (\text{WaterResTotalSurfaceGround}_c - \text{Overlap}_c)$$

If we have data for total renewable water resources (TRWR) but not TRWR surface and ground then we estimate based on the total using global averages. If we do not have data for exploitable surface and ground water resources we estimate using TRWR surface and ground resources.

If WatResTotalRenewGround is still 0 then: **Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"):** 
$$\text{WatResTotalRenewGround}_c = 0.29 * \text{WaterResTotalRenew}_c$$

If WatResTotalRenewSurface is still 0 then: **Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"):** 
$$\text{WatResTotalRenewSurface}_c = 0.71 * \text{WaterResTotalRenew}_c$$

If WatResExploitRenewGround is 0 then: **Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"):** 
$$\text{WatResExploitRenewGround}_c = 0.89 * \text{WatResTotalRenewGround}_c$$

If WatResExploitRenewSurface is 0 then: **Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"):** 
$$\text{WatResExploitRenewSurface}_c = 0.36 * \text{WatResTotalRenewSurface}_c$$

WatResExploitRenewSurface was initialized using SeriesWaterResExploitSurface and WatResExploitRenewGround was initialized using SeriesWaterResExploitGround.

If total exploitable is 0 then use sum of surface and ground: **Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"):** 
$$\text{WaterResTotalExploit}_c = \text{WatResExploitSurface}_c + \text{WatResExploitRenewGround}_c$$

If total renewable is still 0 then use sum of surface and ground: **Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"):** 
$$\text{WaterResTotalRenew}_c = \text{WatResTotalRenewSurface}_c + \text{WatResTotalRenewGround}_c$$

## Withdrawals (by source)

AQUASTAT includes fossil water withdrawals in their groundwater withdrawal data so we must subtract it out.

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WatWithDGround}_c = \text{WatWithDGround}_c - \text{WatWithDFossilGround}_c$$**

The fossil water reserve data we have (WaterResGroundAfrica) also includes both renewable and fossil, so we must subtract out renewable.

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WATERRESFOSSIL}_c = \text{WaterResGroundAfrica}_c - \text{WatResTotalRenewGround}_c$$**

If we do not have fossil water data resources (WATERRESFOSSIL) but we do have fossil water withdrawals (WatWithDFossilGround) then we estimate that withdrawals are 10 percent of reserves.

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WATERRESFOSSIL}_c = 10 * \text{WatWithDFossilGround}_c$$**

If we have no data for either fossil water reserves or withdrawals, then assume they are 0.

If we have data for both total renewable withdrawals and groundwater withdrawals, we estimate surface water withdrawals:

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WatWithDSurface}_c = \text{WatWithDTotalSources}_c - \text{WatWithDGround}_c$$
 [check this]**

If we have data for both total renewable withdrawals and surface water withdrawals, we estimate groundwater withdrawals:

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WatWithDGround}_c = \text{WatWithDTotalSources}_c - \text{WatWithDSurface}_c$$**

If we have total water withdrawal, but not for surface and ground then we estimate using global averages:

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WatWithDSurface}_c = 0.67 * \text{WatWithDTotalSources}_c$$
 Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WatWithDGround}_c = 0.33 * \text{WatWithDTotalSources}_c$$**

If we do not have data for total withdrawals, or surface, or ground, then estimate total using demand and then global averages for surface and ground.

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WatWithDSurface}_c=0.67*\text{TotalDemand}_c$$** Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WatWithDGround}_c=0.33*\text{TotalDemand}_c$$
 [make sure this is OK, feel like we're missing the third piece in this branch of the logic]

## Wastewater

Initialize produced wastewater (WastewaterProduced) using **SeriesWastewaterProduced**

Initialize treated wastewater (WastewaterTreated) using **SeriesWasterwaterTreated**

Initialize treated and reused wastewater (WastewaterTreatedReused) using **SeriesWastewaterTreatedReused**

If we have data for both wastewater produced and wastewater treated and the data says that treated > produced we change volume treated to a portion of produced. This is because a country cannot treat more wastewater than is produced and is probably from a problem in taking the most recent data i.e. we are taking different years for treated v. produced.

If WastewaterTreated > WasteWaterProduced then

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WastewaterTreated}_c=0.95*\text{WastewaterProduced}_c$$**

The same logic that applies to the relationship between treated wastewater and produced wastewater applies to the relationship between treated wastewater and treated-and-reused wastewater i.e. if we have data for both and treated and reused exceeds treated then we know there is a problem with the data and assume that the country reused 95% of treated wastewater.

If WastewaterTreatedReused > WastewaterTreated then

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WastewaterTreatedReused}_c=0.95*\text{WastewaterTreated}_c$$**

If we do not have data for wastewater produced then we estimate using municipal water demand.

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WastewaterProduced}_c=x*\text{WatWithDMun}_c+b$$**

If treated wastewater is still greater than produced wastewater then that means that there



was data for treated wastewater but not produced wastewater and that the equation we used to estimate produced wastewater (using Mun demand) was an underestimation. We correct for this by assuming these countries treat 80% of their produced wastewater.

If WastewaterTreated > WastewaterProduced then **Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WastewaterProduced}_c = \text{WastewaterTreated}_c * 1.2$$**

If WastewaterTreated is still 0 then use GDP per capita (2011) to estimate the portion of produced wastewater that's treated. The equation is called: "WastewaterTreated pct of produced (Linear) versus GDP2011PCPPP(MOSTRECENT) (Log)"

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{TreatedPortionProduced}_c = x * \text{GDPPCP}_c + b$$** **Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WastewaterTreated}_c = \text{TreatedPortionProduced}_c * \text{WastewaterProduced}_c$$**

If WastewaterTreatedReused is still null, then assume it is 66 percent of WastewaterTreated **Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WasteWaterTreatedReused}_c = 0.66 * \text{WastewaterTreated}_c$$**

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## Total water supply

Before calculating total water supply, we need to add secondary water into exploitable surface water. Secondary water is treated wastewater that is not directly reused.

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WatResExploitRenewSurface}_c + \text{WatResExploitRenewSurface}_c + \text{WastewaterTreated}_c - \text{WastewaterTreatedReused}_c$$**

Calculate total water supply

**Failed to parse (SVG (MathML can be enabled via browser plugin): Invalid response ("Math extension cannot connect to Restbase.") from server "https://wikimedia.org/api/rest\_v1/"): 
$$\text{WATERTOTALSUPPLY}_c = \text{WatWithDFossilGround}_c + \text{WatResExploitRenewSurface}_c + \text{WatResExploitRenewGround}_c + \text{WastewaterTreatedReused}_c + \text{WATERDESALINATED}_c$$**

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