AltWater Guidance Document 2

Guidelines for future assessment of water supply and demand

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1. Introduction

This document serves as an initial guidance for the assessment of possible future water supply and water demand. The document will guide stakeholders through the assessment of potential future supply and demand. This document builds on Guidance Document 1 which focussed on present day supply and demand. The document is a supplement to the Training Workshops held in Surabaya and Maputo in March and April 2017.

This document is not intended as a comprehensive methods protocol, but as an introductory text that lays out what data are required in order to begin the assessment process. The concepts outlined here will be elaborated in more detail during these workshops and can be tailored to partner requirements. Where possible, spatial data in GIS map format should be obtained in order to facilitate more detailed spatial assessment of water supply and demand. The next guidance documents will focus on alternative water supply systems and their assessment.

2. Assessment of future water supply

Like for present-day conditions (Guidance Document 1), future water supply should be assessed according to two metrics:

a) water sources;

b) water volume.

Of these two, present day water sources (point a) are unlikely to dramatically change unless major infrastructural developments bring on-line new water supply sources (e.g. water transfers, desalination plants). However, present water sources are likely to have altered water volume characteristics (point b). For future water supply, the main items to consider include: i) the possibility of major new supply sources becoming available and; ii) expected or likely changes to current water supply volumes due to climate change. This document will introduce both of these aspects.

As was stated in Guidance Document 1, while water quality is important, it is not a key focus of AltWater. However, certain information would be useful in order to better assess alternative water supply sources. This is because the cost of supply is strongly related to the type of treatment required.

Therefore, as a minimum, it would be good to know:

i) what treatment is likely to carried out and what treatment stages are applied for water supply (this will depend on end use and water source quality/condition);

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ii) whether these stages differ for different water sources (if applicable),

iii) whether or not water meets minimum national water supply standards for quality, and what your quality assessment procedures are, and ;

iv) are these standards and procedures expected to change in the short and long term future.

a) Water sources

Regarding water sources, present day water supply sources are likely to remain important in the near and mid-term future, except for some exceptional cases (e.g. the Aral Sea, Colorado River – which already does not reach the sea in most years). It is more likely that new supply sources may come online due to major infrastructural and/or policy interventions.

When considering future water sources, major potential infrastructural developments can be considered. However, any consideration of potential new sources should be realistic or at least likely to happen (for example in water resources plans). Partners can also comment on the possible change in the relative importance of current water sources (for example is it expected for one source to decline in importance, while another increases?). As with the baseline assessment, water sources from surface water, groundwater, alternative sources and informal supply sources should be considered.

Especially important is the consideration of how you think alternative water supply sources, and their role in water supply, may change in the future. This could include information on:

i) what are the most suitable/likely/feasible alternative systems for your location based on existing or planned infrastructure (physical/technical aspects). For example, is there a wastewater collection system and to what coverage; is there a wastewater treatment plant, to what quality and is it suitable for (which) reuse? Are there plans to enhance treatment? Is there a separate sewage/drainage system?;

ii) likely uptake up new alternative water sources;

iii) likely increase or decrease in the contribution of existing sources;

iv) change in social attitudes helping or hindering the uptake of new/existing systems;

v) possible government or utility programmes to increase the uptake and contribution of alternative systems.

These latter aspects (especially ii-v) may be closely linked to institutional and governance arrangements and norms. Information on these aspects may come from local utility partners, local/national water resources plans, your own knowledge and expertise and/or local surveys and questionnaires.

As with the baseline assessment, for the future, a minimum level or information on possible changes to supply sources is required. A list of essential information to collect includes:

i) likely/possible locations and types (river, groundwater, etc.) of the sources, and any changes in these sources, especially the development of major planned or likely new sources;

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ii) the distance from the supply area in the case of surface water supply, and any elevation changes, or for groundwater, the distance from the supply area and the depth of the aquifer (if there are considerable elevation changes, is this gravity fed, or pumped), and any information regarding these aspects for new supply sources (e.g. water transfer pipes: from where, to where, what is the source, etc.);

iii) (changes to) flow rates of the river(s) and/or safe yield of the aquifer(s);

iv) (possible changes to) the number of wells or intakes (including an estimate of illegal wells if possible and where relevant);

v) if multiple sources are used, information on the seasonal/yearly variation for each source.

Information on possible future water sources should be known to local city water utilities, councils and local academic experts. This information might also be in local/national water resources plans. Please use your networks in order to gather this information for your cities.

When considering spatial data, the sources and which regions they supply could be included, as well as information on elevation differences, distances to the supply centre, use of the source, and so on. As mentioned before, any information on existing alternative water supply sources should also be included. This can also include information on wastewater collection system (pipes, WWTP), stormwater runoff and storage (e.g. where in the city).

Finally for water sources, and linking to the impacts of climate changes (see below), it is worth considering potential indirect effects of climate change on water source quality. For example, there has been a link reported in Australia between the increased incidence and severity of bushfires resulting from higher temperatures, increased runoff and sediment runoff, and a corresponding increase in suspended sediments entering lakes and reservoirs used for water supply, therefore lowering source water quality. This has implications for treatment prior to use. Similarly, climate impacts may have indirect impact on local source water quality, and it will be useful to think about these possibilities.

b) Future water supply volumes

For each water source, an estimate of possible water volume contributing to urban water supply is required. By summing the change to each source, we get a good idea of the potential future total urban water supply, and the change relative to the present day.

As was mentioned in Guidance Document 1, for traditional supply sources such as rivers, lakes and groundwater, local water utilities and companies will have a good idea of total supply volumes from each source for the baseline. Likewise, the supply volumes from desalination plants (where applicable) are also well known the plant operators and utilities for the baseline. In the case of alternative sources already being implemented, consulting with the operators and users of these systems will provide an initial estimate for baseline conditions.

However, climate change and infrastructural changes (linked to urban development and growth – e.g. supply growth can lead to a consequent increase in wastewater volumes that could potentially be re-used) are likely to change the volume of water supply from each source in the future. This section will outline the information to consider when making assessments of potential changes to water supply volumes, and where to get this information.

To recap, and as for the baseline assessment, a list of essential information to collect includes:

i) average potential changes to volume of water supplied from each source (in m3/day, m3/month, m3/year) relative to the baseline;

ii) potential changes to monthly and/or seasonal variations in supply (if any);

iii) possible changes to total population serviced/covered by the water supply system, and what fraction of the population may be served by which source;

iv) information on possible changes in service level, including number of hours of supply per day, types of service (household, public standpipe, kiosk, etc.), level of coverage in the population;

v) information on possible changes to peak factors would also be useful. For example, a utility's average capacity may be ample, but they may have trouble supplying everyone at peak times.

Guidance Document 1 offered a brief overview of calculation methods for estimating the volume contribution from rainwater and stormwater harvesting systems, and these methods were elaborated in the Leader City training workshops in March and April 2017. These methods will not be repeated here. This section will focus on how to estimate water resources changes from climate change and from infrastructural developments. The information here is a brief overview. More details were provided during the training workshops.

This section is now split into two sections: i) water supply volumes from infrastructure; ii) water supply changes from climate change.

i) potential water supply changes from infrastructure development

Information on likely future infrastructure development will come from local or national sources. Will developments be likely to increase or decrease supply (if water is transferred out of the basin)?

Main infrastructure development types include:

-construction of new dams/reservoirs (where possible)

How many may be built?

Where?

Estimated capacity?

Local resource allocation? – for who? How much? Priorities of water use?

When may the development come online? (i.e. when will the water be available?)

Cost?

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-Water transfer projects

Is the water coming into or out of the basin?

Where is water coming from/going to?

Capacity of the transfer? Likely flow rates?

When will the project come online?

Energy costs?

Financial cost?

-New groundwater developments

Where? How close to the demand centre?

Capacity/sustainable yield?

Allocation for your city?

When are they expected to come online?

Is the water sustainable? (i.e. is the aquifer renewable or comprised of 'fossil groundwater'?)

Cost?

-Other infrastructure development and projects that may affect supply?

Planned infrastructure upgrades/programmes → reduction in non-revenue water; improve system efficiency; improvements in metering and water accounting

Expected growth in cities/towns? Expected growth in local agriculture or industry (increased demand → supply implications → greater volumes of wastewater generation?

Contribution of informal settlements? Contribution of informal water suppliers?

ii) potential water supply changes from climate change

While human decisions can directly impact water supply through infrastructure projects, climate change impacts on water supply cannot be directly controlled. It is important to get an idea of the range of likely change that may come about with respect to water resources due to climate change impacts. Climate change will act to alter water supply in two main ways:

1) by changing local temperature at different times of the year and;

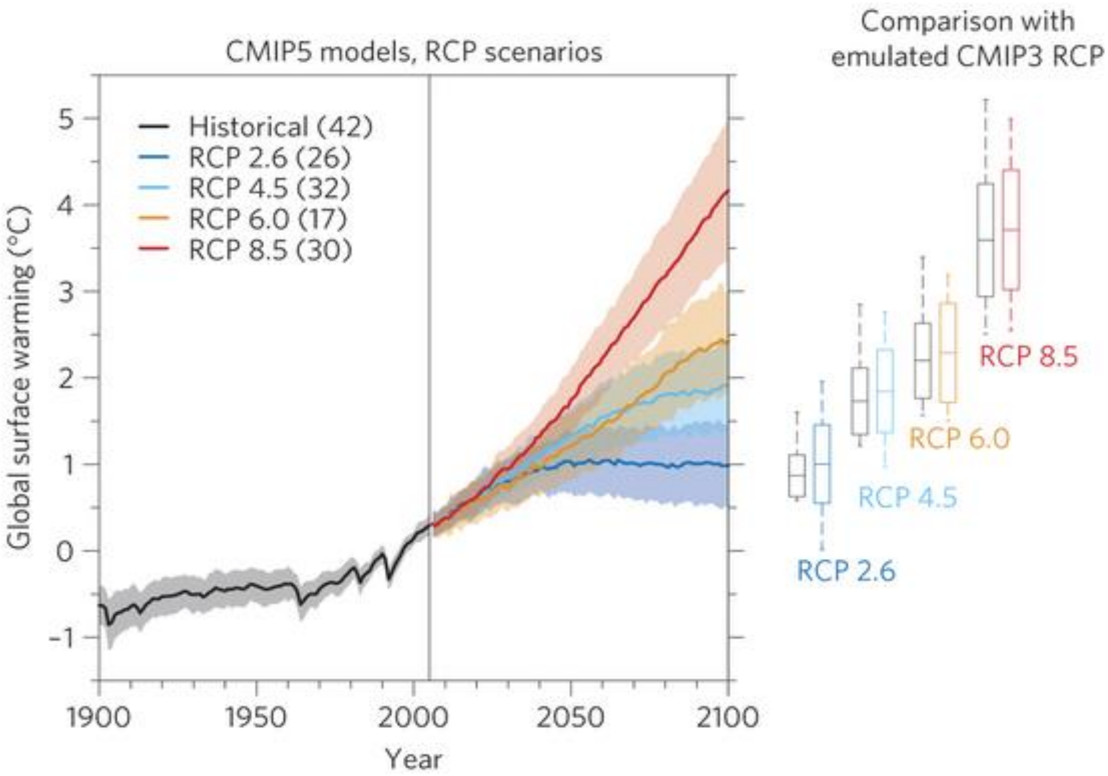
2) by changing local rainfall in terms of totals, timings, intensity and spatial distribution.

Points (1) and (2) act together to change hydrological cycles, with impacts on water resources and supply (volumes, timing, spatial distribution). Points (1) and (2) also act to change not only longer term trends, but also the occurrence and severity of short term extreme events such as tropical storms and heavy rainfall.

Local estimates for potential changes to temperature and rainfall may be available, but if not, then a good source of recent data that is free to use can be found on the World Bank data repository (http://sdwebx.worldbank.org/climateportal/). This data is easy to search, is of reasonable resolution, covers the whole world, and can be extracted for specific locations, so you can get locally relevant information.

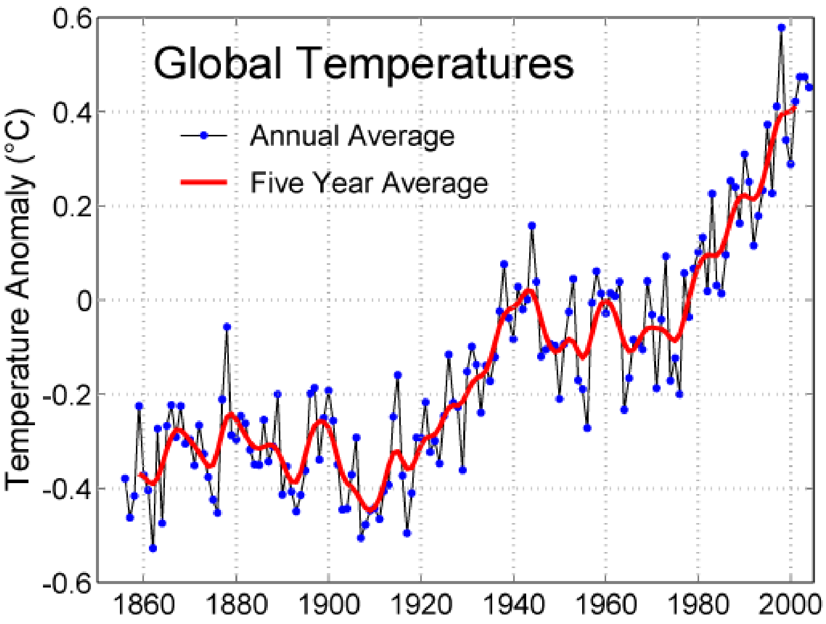
Because the future is not known, it is common to use scenarios to get an idea of the range of possible outcomes. Even though some outcomes may be extreme, and may be less likely to happen, they still could happen. Scenarios give an idea of the total range of possibilities and of what is more extreme, and therefore less likely.

Recent climate change information is available online (see Section 4). This data from the World Bank collects results from a recently completed international collaboration known as the Coupled Model Intercomparison Project 5th Phase (CMIP5). The CMIP5 results include global data with good resolution for historical data on temperature and precipitation. Apart from historical data, future predictions from 2020 to 2100, split into three time slices, are available from a number of global climate models. The World Bank website has collected global forecasts from all the models and for all the time slices and made it available for free. It is possible to get information for local areas by selecting these on a map interface. Therefore, it is possible to get information on local possible temperature and precipitation changes, including uncertainty, up to 2100.



Climate: temperature changes

One of the main ways that climate change will impact water resources is through changes to local temperatures. Although the exact amount and direction (positive or negative relative to the present day) of temperature change is not known, there is reasonable agreement about the likely range of change (see Section 4 for data sources). Globally, the general trend is one of increase surface temperature, however local variability around this average picture is considerable.



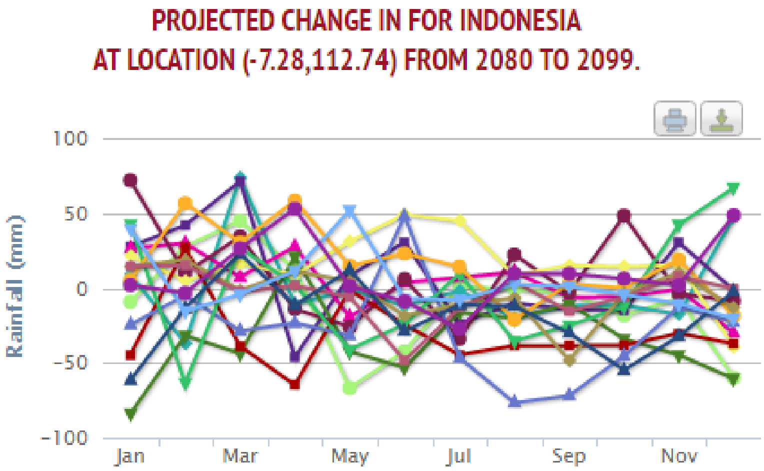
Temperature changes are important for a couple of main reasons. Firstly, changes to temperature will alter evaporation rates, and therefore losses from lakes, reservoir surfaces, canals and field irrigated with flood irrigation for example will be affected, especially if temperatures are expected to rise. This can have an effect on surface water resource availability especially. Second, evapotranspiration (ET) from plants and crops will be affected. Increases to temperature generally increase ET rates. In practice, this may mean an increase in irrigated agricultural water demand, even if the area of agriculture and the crop type does not change. The total crop water demand can still change. For ET, there are many web tools (e.g. see http://wcatlas.iwmi.org/Default.asp) that give reference and crop ET for any location globally based on coordinates. There are also well-known equations (e.g. Penman-Monteith, Hargreaves equation) that can be used to estimate ET based on meteorological conditions, including temperature. Therefore, based on estimates of future temperate conditions, changes in ET can be assessed. Because estimation of ET is not the focus of AltWater, this topic is not discussed further. However it is also worth pointing out that if large scale irrigation extension programmes are being considered, various ministries may have estimates for the additional water requirements of such schemes.

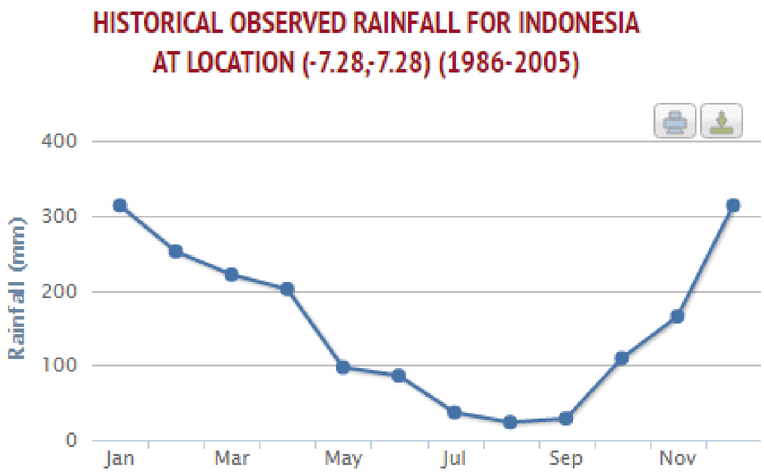
Finally, temperature increases may lead to higher urban water demand, which in turn will have implications for supply. The urban demand increase may come from a number of sources including urban green space demand increase (related to ET changes), and domestic demand increases in response to temperature changes. Estimating future urban water demand is tricky, and usually simple estimates of changes in overall population and per-capita demand are used based on national predictions of growth and development.

If the demand from multiple sectors (urban, agriculture, environment) increase, this his implications for the total stress placed on water supply sources. If the supply remains the same or decreases, then increasing demand will place increasing pressure on resources, possibly leading to unsustainable extraction rates and/or conflict between water users. This is a good reason to diversify water supply source options.

Climate: rainfall changes

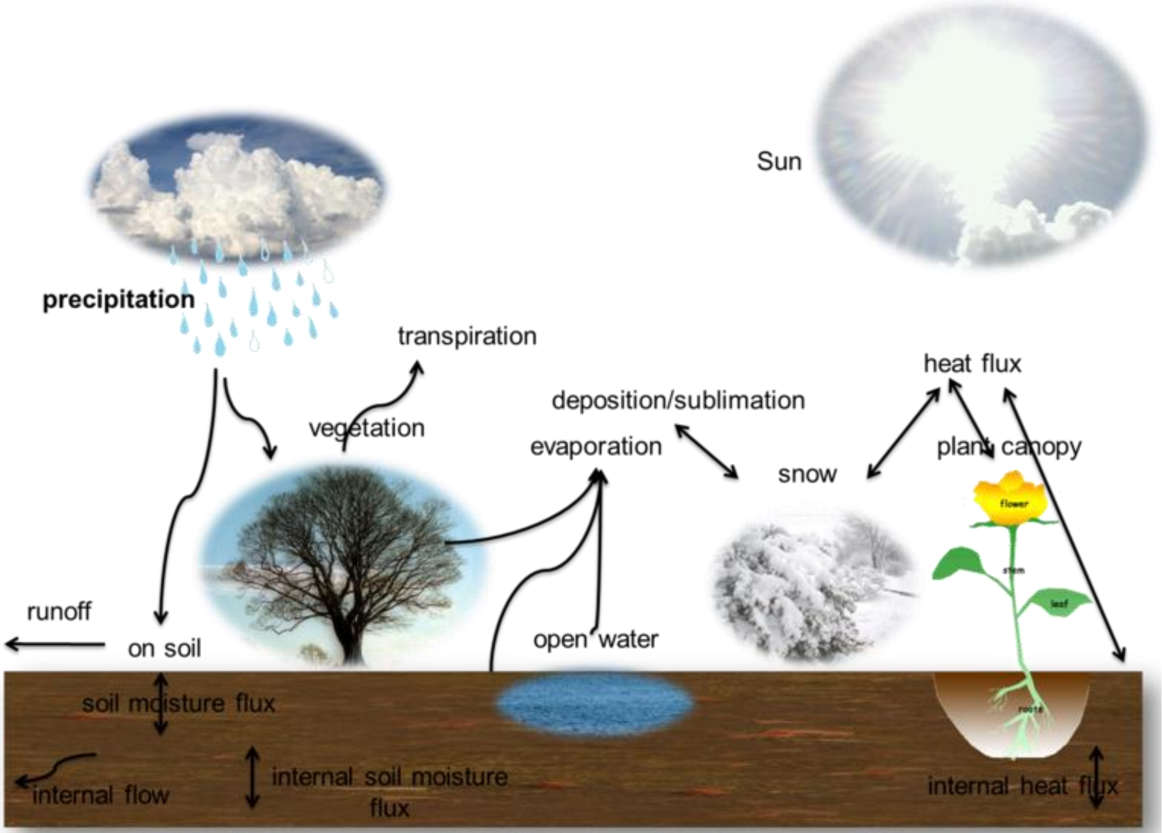
Changes to rainfall are much more uncertain, and many models struggle to agree on either the magnitude or the direction of possible changes relative to the present day – there is much more future uncertainty in future precipitation than for temperature. The example below shows the model variability in estimated changes to temperature for Surabaya for the period 2080-2099. As can be seen, the variation in estimates is wide, making it difficult to plan for future changes in precipitation.





As with temperature, rainfall changes are important for water supply for a number of reasons. Changes to precipitation totals obviously will have an impact on gross water supply totals (assuming all other things remain unchanged). Runoff totals may change – this could be estimated through (physically-based) hydrological modelling using precipitation change estimates. Infiltration could also be affected, leading to impacts on groundwater recharge and groundwater resource totals. Rainfall patterns may change, possibly leading to more intense storms and more flood flows. This might mean a less stable water supply over time. All this means that not only may supply totals changes, but that the timing of supply could also change. This may have implications for urban water supply, and with the changes due to temperature, diversifying supply to enhance resilience will be critical, especially to supply water for non-essential/non-drinking purposes in order to minimise the pressure on traditional sources.

Impacts to the hydrological cycle



(Chen et. al., 1996, 1997; Chen and Dudhia, 2001; Ek et. al., 2003; Koren et. al., 1999)

As mentioned above, changes in temperature and precipitation may have impacts on the hydrological cycle in terms of:

-rate of cycling of water through a system;

-volumes of water passing through a system;

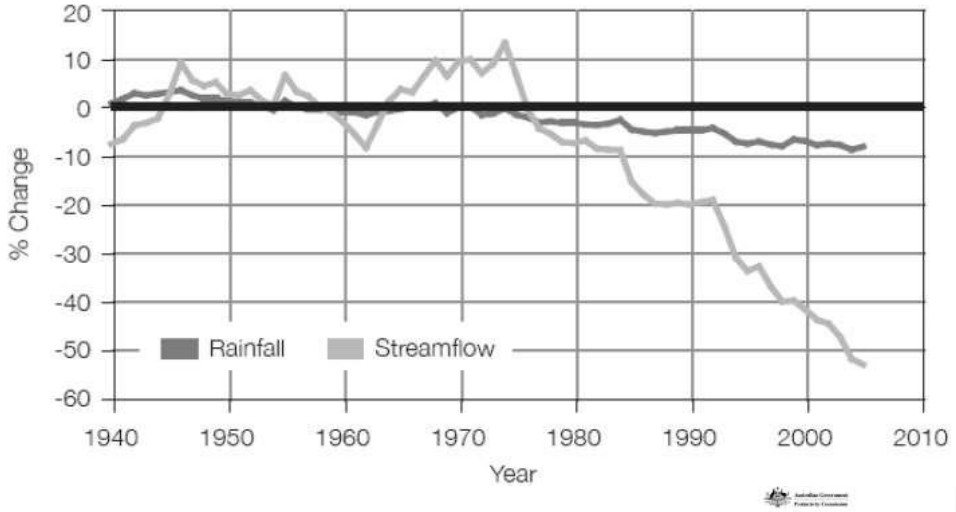
-timing of different events in the hydrological cycle;

-spatial changes within the cycle.

Also of importance is the concept of non-linearity of change. For example, studies in Australia show that a small change in precipitation can lead to large changes in streamflow (see the figure below). It is important to try and understand how changes in the climate may impact local hydrology, and how this may affect water supply.

Figure 1.2 **Variation of rainfall and streamflow in south-west Australia**

Percentage change from long-term average



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3. Assessment of future water demand

In addition to the water supply to the city, an estimate of water demand is also required. As with supply, this can be split into two categories:

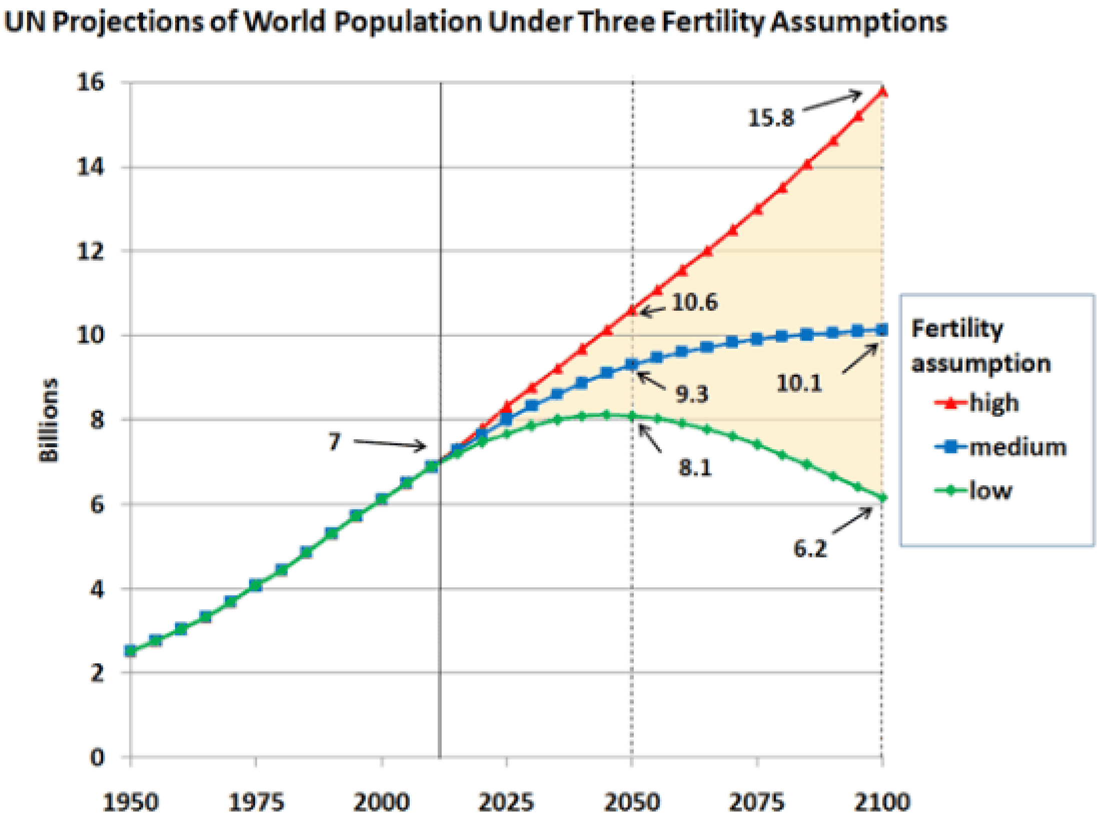
a) water users;

b) water volume.

This section will briefly discuss how the identified demands for the baseline may change, and what may drive those changes.

i) Changes due to population change (volume impacts)

Exactly how the population may change is not known, so usually a range of possible options (e.g. low, medium and high growth rates) are used to account for the most likely outcomes (see figure below).



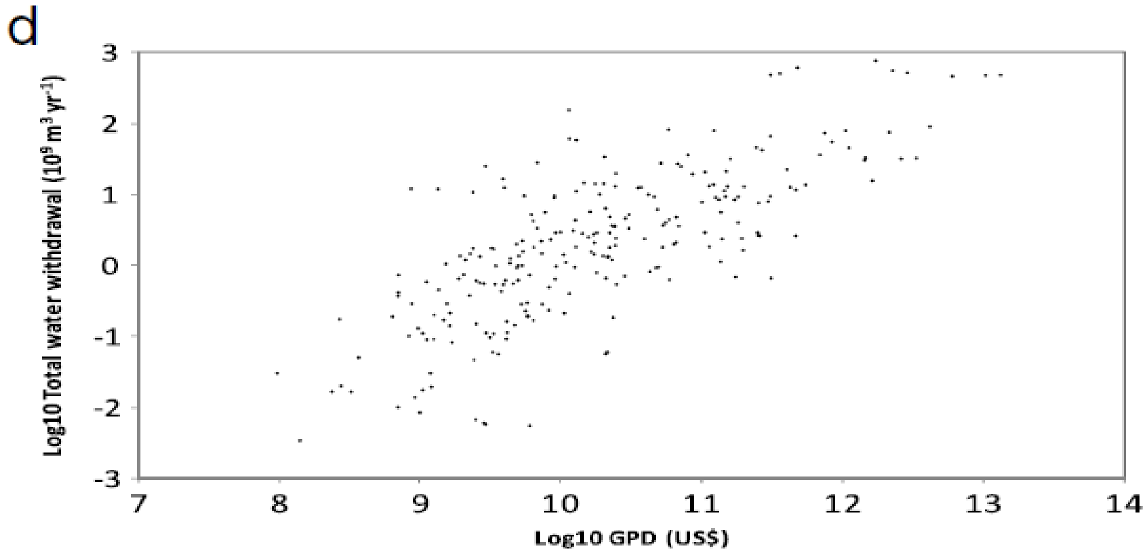
National and sometimes even city-level statistics may be available for these estimates. Then, assuming all other things being unchanged, the demand from the urban population is calculated from the estimated population for a given year multiplied by the average per-capita demand (which also may change, see point (iii) below). This will at least give a rough estimate of the domestic demand due to population change.

ii) Change due to sectoral changes (user and volume impacts)

This information is likely to be known locally. Local or national development plans may contain the information needed here. Basically, are there any major anticipated changes to different economic sectors that may significantly change future demand? For example, is there a plan to greatly expand a certain type of agriculture? Or is there a plan to grow manufacturing that required a high water demand? Is tourism expected to grow? These sectoral changes may have urban water demand and water competition implications. National and local information should be consulted to account for any expected or planned changes that may impact on water demand.

iii) Change due to socio-economic factors (user and volume impacts)

There is some evidence of a link between (per-capita) GDP and water demand per-capita (see figure below; Sušnik, 2015). Generally, as people get richer, they demand more water, but apparently only up to a limit. After this limit, water demand, per-capita, appears to start decreasing.



The initial increase is due to people having more disposable income, and being able to afford more devices such as washing machines, dishwashers, etc. These demand water. However, at a certain point, national investments in water efficiency (in the supply network, and in consumer goods) start to outweigh per-capita increases, and the per-capita demand starts to drop (the water demand is decoupled from economic development). However, it is worth noting that estimating per-capita demand changes due to socio-economic development is very difficult, and maybe impossible due to the large uncertainty involved. Another way to estimate future per-capita demand is simply to extrapolate historical trends, but again this has large uncertainty.

So while some estimate of per-capita demand changes due to socio-economic factors should be attempted, it should also be recognised that there will be a lot of uncertainty in this estimate.

4. Data sources and information

There are many data sources for the items discussed in this Note. Some of these include (but are not limited to):

-local and national water resource management plans

-local and national development plans

-local and national statistics office population forecast estimates

-think-tank reports (e.g. UN Water, World Bank, IIASA)

-for online global estimates, the UN and World Bank both have databases on estimated population changes. This is usually only available at national level.

UN: http://www.un.org/en/development/desa/population/.

World Bank: http://data.worldbank.org/data-catalog/population-projection-tables

-for estimating crop water requirements, reference evapotranspiration and crop coefficient values (see the Training Workshop material) can be obtained from:

Reference evapotranspiration: http://wcatlas.iwmi.org/Default.asp

Crop coefficients: http://www.fao.org/docrep/X0490E/x0490e0b.htm

-Global temperature and precipitation data from the CMIP5 experiments have been collected and made available by the World Bank. See http://sdwebx.worldbank.org/climateportal/

Sušnik J. 2015. Economic metrics to estimate current and future resource use, with a focus on water withdrawals. Sustainable Production and Consumption. 2: 109-127. DOI: 10.1016/j.spc.2015.05.003

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