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In water constrained political economies, a simple equation can be used to demonstrate how the best potential can be unlocked from the total available stock of water. This is expressed as follows:

$$Q \times F = Y$$

Where Q is the stock value of water, expressed as the volume of the total national water resource that is available at a high assurance of supply level at any one time; F is the multiplier value of water as a flux; and Y is the total water supply needed at a high assurance of supply to sustain the desired economic development potential of the country at any moment in time.

From this simple equation it becomes evident that if Q is a constant (because almost all readily available sources have been developed such as in South Africa – see Ashton *et al.,* 2008), with a value of say $10 \times 10^9 m^3 yr^1$ (10 billion cubic metres of water per year), and if F is 1, then the value of Y would be $10 \times 10^9 m^3 yr^1$. Stated simplistically then, the total economic development potential of the country dependent on water (Y) would be constrained by the volume of water available at a high assurance of supply (Q). If, however, the F value is ≤ 1, say for argument purposes 1.2, then a different outcome is possible, because the value of Y then becomes $12 \times 10^9 m^3 yr^1$. Now, assuming the same logic applies, if the F value becomes 2, meaning that the multiplier value of water as a flux allows the total national stock to be used twice, then the value of Y becomes $20 \times 10^9 m^3 yr^1$, or double that of Q. Seen in this light, it is the flux value of water (F) that becomes the determining factor of the economic development potential of a water-constrained country, and not the actual resource available at a high assurance of supply (Q).

The South African case is presented in Figure 1 below. This shows that the total national water resource available at a high assurance of supply based on current technology is $38 \times 10^9 m^3 yr^1$. Even on a low water use estimate the future demand for water by 2035 will be $65 \times 10^9 m^3 yr^1$, which leaves a deficit of $27 \times 10^9 m^3 yr^1$ (see NWRS, 2004; and Ashton *et al.,* 2008, for more details of the foundation of these calculations).

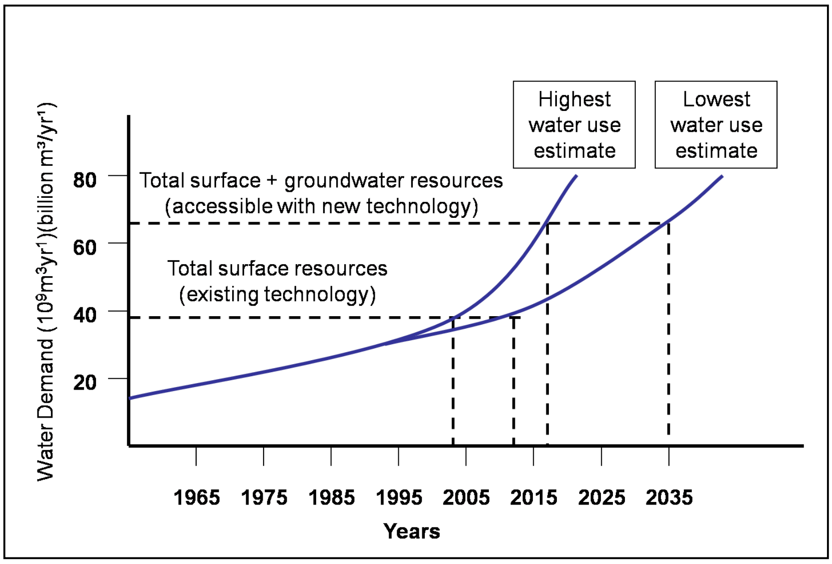

Figure 1: The availability of South Africa's surface water resources based on two developmental trajectories showing that even with lower water use the country has reached the limit of its surface water resource (redrawn from CSIR, 2008a:19).

If one applies the equation Q × F = Y, assuming that the total surface resources available within the constraints of existing technology are $38 \times 10^9 m^3 yr^1$ and the CSIR (2008a) projections are valid, then the future multiplier value of water as a flux will have to be 1.7105 in order to meet the needs for the economic development of the country, either by 2020 if a high developmental trajectory is to be followed, or by 2035 if a low developmental trajectory is to be followed. This can be expressed as follows:

$$(38 \times 10^9 m^3 yr^1) \times 1.7105 = (64.999 \times 10^9 m^3 yr^1)$$

In reality however, this is not happening, because the rapid changes caused by the transition to democracy, have caused a massive deterioration of the water quality in most major reservoirs (Oberholster & Ashton, 2008; Coetzer, 2008; Harding & Paxton, 2001; Turton, 2008), often the result of lost technical capacity caused by aggressive affirmation action policies and the resultant migration of young engineers out of the country (SAICE, 2008; Turton, 2008). While no accurate study has been done to quantify the impact that this deteriorating water quality has on the value of water as a flux, it has been roughly estimated by the author as being in the order of F = 0.8, which means that the value of $Y = (30.4 \times 10^9 m^3 yr^1)$. The source of this deterioration can be generically broken down into three main categories of pollution: radiological, chemical and biological.

Radiological contamination is arising from uncontrolled decant of acid mine drainage from abandoned gold mines (Adler *et al.,* 2007b; CSIR, 2008b; IRIN, 2008; Coetzee, 1995; Coetzee *et al.,* 2002a; 2002b; 2005; 2006; Wade *et al.,* 2002). This is happening because the geology of the gold ore bodies is also closely associated with uranium and other heavy metals, some of which are radioactive (Werdmüller, 1986). The city of Johannesburg has been built on top of a geological feature that now contains a number of hydrogeological compartments that are all filling up with contaminated water, some of which have already started to decant to surface as mines close down (CSIR, 2008b; Hobbs & Cobbing, 2007), but the rest of which are expected to reach decant levels in the next decade. This is a major crisis.

Chemical contamination has a number of sources, including endocrine disrupting chemicals (EDCs) (Aneck-Hahn *et al.,* 2007; Bornman *et al.,* 2005); acid mine drainage from coal mines, mostly manifesting as a heavy sulphate load (Bell *et al.,* 2001; Blignaut & King, 2002; Hobbs *et al.,* 2008; Hodgson & Krantz, 1998); and gold mines, also manifesting as a heavy sulphate load but including a range of heavy metals, some of which are radioactive (CSIR, 2008b; Hobbs & Cobbing, 2007; Naicker *et al.,* 2003; Winde & van der Walt, 2004; Winde, 2005).

Biological contamination is most acutely being expressed as eutrophication, which is a result of dysfunctional sewage treatment plants that are allowing masses of nutrients to enter the major rivers and reservoirs of the country (Harding & Paxton, 2001; Oberholster & Ashton, 2008; SAICE, 2008). The effect of this is to reduce the value of the current stock of water (Q) because it renders that water no longer fit for purpose. Paton (2008) reports that agricultural exports to the European Union currently valued at ZAR 28 billion (US$ 3.5 billion) are under threat, because of high microcystin levels in the irrigation water, to name but one example.