

Hydro-social Metabolism: Scaling of population growth and water use of nations

*Saket Pande¹

1. Delft University of Technology

Water is important for human life. It is the carrier of nutrients, amongst other things, that control human metabolism. Metabolism, which is a process of transforming energy and materials for work or biomass generation, is one key process that has been hypothesised to control population growth of multiple species as well as flux exchange between species or constituents of an ecosystem. A $-1/3$ power scaling between population growth rates and rates linked to metabolism such as biomass production or rate of energy consumption has been observed spanning >20 orders of magnitude in body size (from zooplanktons to mammals).

Central hypothesis of this paper is that water flux controls the average human metabolism of nations and hence population growth rates. United Nations population statistics and water use of regions (Africa, Asia, North America, Europe, Australia and Latin America) from 1950 to 2000 at irregular 5 years intervals are used to reveal the power scaling between the two. In addition, strikingly similar inter-temporal dynamics in between industrialized regions (North America, Europe, Australia) and in between less developed regions (Africa, Asia) is found. The dynamics across these two clusters of regions is similar in only one respect. The per capita water use and birth rates in both the clusters of regions follows a trajectory that first sees increasing per capita water use with decreasing birth rates followed by decreasing (or constant in case of Africa and Asia) per capita water use with decreasing birth rates. These trajectories demonstrate path dependency of the co-evolution of water use with population growth on the past and corroborate with increased labor participation of women in the industrialized world and perhaps with post-colonial transition in Africa and Asia.

Nonetheless, at any given point in time, all regions appear to always lie on the $-1/3$ power law relationship between human water use and population growth rates. This offers support to the second hypothesis of this paper, that the $-1/3$ power law relationship between nations at any point in time is independent of the temporal co-evolution of water use with population growth.

If the above hypotheses are found to hold valid with finer national scale data at more regular time intervals, this may indicate that humans are no different than non-human primates, other mammals and organisms in being governed by the relationship and that nation states are organisms whose water use and birth rates are constrained by hydro-social metabolism.

Keywords: coupled human-water systems, socio-hydrology, social metabolism, population growth, water use