Cyberseminar on Water and Population Dynamics

Background Paper for a
Population-Environment Research Network (PERN) Cyberseminar
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1. Introduction

Historically population distribution has been fundamentally shaped by access to water resources (de Sherbinin & Dompka 1998; Kummu et al. 2011). Early towns and cities invariably were located near water bodies for water supply and ease of trade, and, at broader scales, population density has historically been highest in humid and sub-humid climate zones (Samson et al. 2011). As civilization progressed, greater efforts were made to create water transport systems (e.g., the aqueducts of ancient Rome) for provisioning of major settlements. While new sources of water have been developed (e.g., pumping deep aquifers and desalination), and agriculture and industry have become more efficient, society's fundamental dependence on water resources has not changed. Recent droughts affecting São Paulo, Brazil, and major urban areas in California, USA, highlight the fragility of major cities to drought, and researchers project further water-related shortages for urban areas in the future (McDonald et al. 2011a). Similarly, Australia's "millennium drought" (stretching through most of the last decade) illustrates the far reaching consequences of extreme water variability on social-ecological systems (van Dijk et al. 2013)

Water scarcity has been identified as the number 1 risk in terms of *impacts* in the *Global Risk Report* – ahead of items such as spread of infectious diseases, weapons of mass destruction, and interstate conflict – while the second risk in terms of *likelihood* is extreme weather events, including flood and drought (WEF 2015). Absolute water scarcity is not the only issue; in some regions, such as China and India, major rivers and lakes have become too polluted to use (UN 2015), and there are also issues related to differential access to water resources. Access to adequate improved waters supplies in informal settlements in many developing countries is particularly challenging, and this has important health and gender dimensions (Crow and Odaba, 2010). At the same time, drought has led to temporary and permanent displacement of farmers and pastoralists in many developed and developing regions, further contributing to urban growth (see for example McLeman et al. 2014 and Guilmoto 1998).

Existing and projected water crises in the future pose threats not only to human wellbeing and environmental sustainability for the planet, but increasingly are perceived by governments as threats to national security (Bakker and Morinville 2013). Growing attention is being paid to the role of governance in mediating human responses to the complexity and uncertainty of future water supply. Yet water governance remains ambiguous in many aspects. This ambiguity is a challenge for researchers and practitioners as it inhibits effective communication and sets participants at cross-purposes.

The purpose of this cyberseminar is to discuss issues around water supply and population dynamics from macro (global and regional) to micro (neighborhood) scales . This cyberseminar aims to contribute to the UN International Decade for Action "Water for Life" (2005-2015) and to discussions around a plan of action for meeting the Sustainable Development Goals (SDGs). We have divided the paper into the following sections: global and regional "hotspots" of water supply and population growth, water supply variability in the context of a changing climate, water supplies for the world's urban areas, and access to water and sanitation in urban and rural areas of low income countries.

2. Sub-topics

2.1 Global and regional present and future water stress

Water availability and water scarcity in relation to population size and growth has been the subject of a number of studies going back more than a decade (Vorosmarty et al. 2000, PAI 1999). In terms of current water stress hotspots, two studies stand out, that of Smakhtin et al. (2004) and Vorosmary et al. (2010). Smakhtin et al. defined the concept of environmental water scarcity as the proportion of the utilizable water in world river basins that is currently withdrawn for direct human use and where this use is in conflict with environmental water requirements (EWR).[1] The result is presented in Figure 1. The map closely largely reflects semi-arid and arid ecosystem, although there are also humid regions such as the southeastern US and northern Europe with large populations that put heavy demands on water resources. More recent updates in WRI's Aqueduct Water Risk Atlas (see http://www.wri.org/our-work/project/aqueduct) finds similar patterns, though larger larger portions of China and Australia are found to be water stressed.

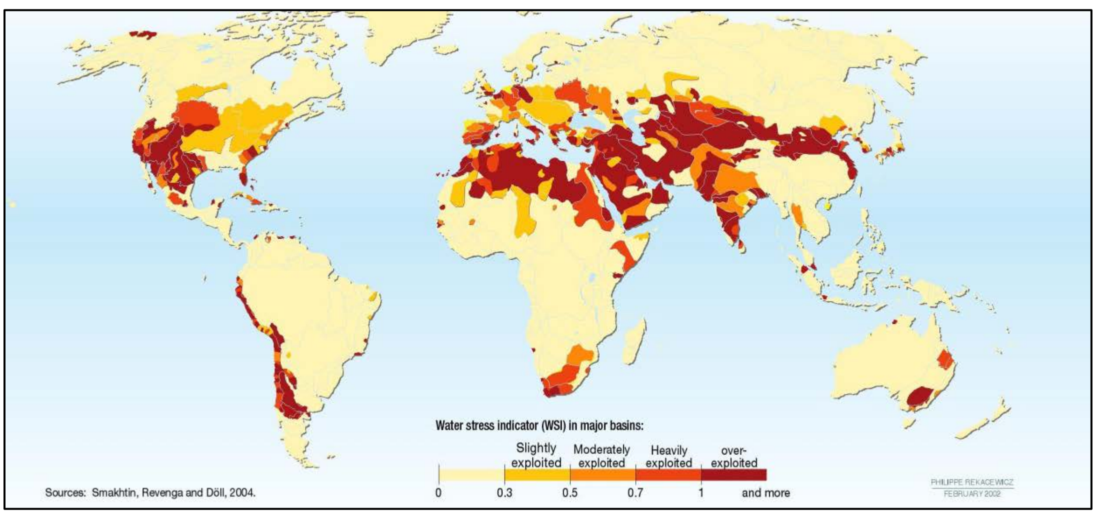

***Figure 1: Basins that are water stressed based on environmental water requirements** [Source: Smakhtin et al. 2004 courtesy of UNEP-GRIDA]*

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[1] EWR required to maintain a fair condition of freshwater ecosystems range globally from 20 to 50 percent of the mean annual river flow in a basin.

Vorosmarty et al. employed a GIS overlay analysis to generate a map of global threats to water security. Figure 2 shows the human water security threat, which is a function of large populations with intense water demands in relation to available freshwater resources. Several regions stand out, including the US mid-West (where agricultural demands predominate), to Europe, India, and Northeast China (where domestic, industrial and agricultural water demands all play a role). Similarly to Smakhtin et al. they also mapped areas where water use by humans represented a threat to biodiversity. They find that nearly 80% (4.8 billion) of the circa 2000 world population lived in areas where either incident human water security or biodiversity threat exceeded the 75th percentile.

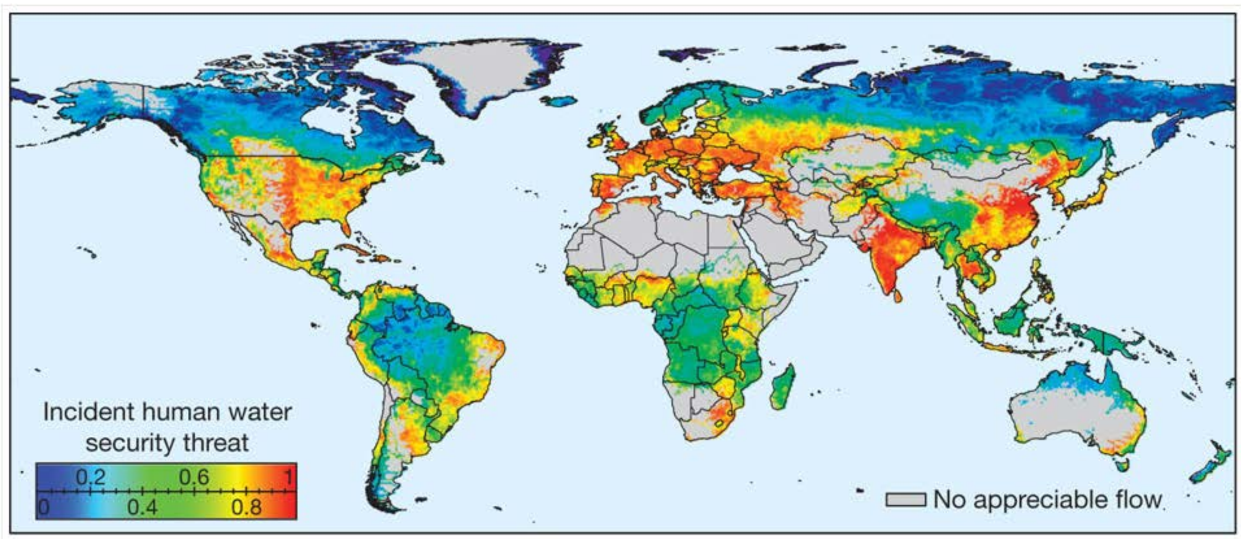

Figure 2: Global geography of incident threat to human water security *[Source: Vorosmarty et al. 2010]*

Parish et al. (2012) projected future water stress based on SRES climate and population scenarios. Figure 3 shows projections for the SRES A2 (business as usual) and A1F1 scenarios to the year 2100. Red colors indicate areas of increasing water stress and blue colors indicate areas of decreasing water stress (Figure 3). The authors found that only in the A2 scenario, which is based on higher population growth projections, did eastern Asia have increasing stress. By contrast, the WRI Aqueduct projections show much larger portions of the world in 2040 experiencing increased water stress (Figure 4).

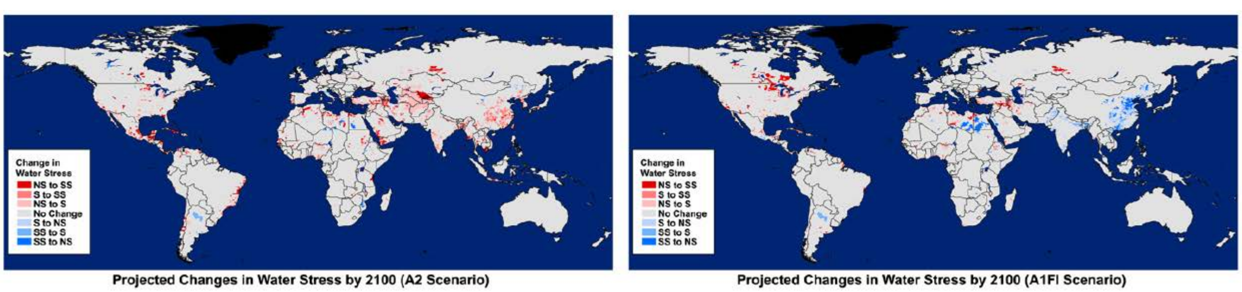

Figure 3: Projected ''Hotspots'' of water stress change to 2100: A2 (left) and and A1F1 (right). *[Source: Parish et al. 2012]*

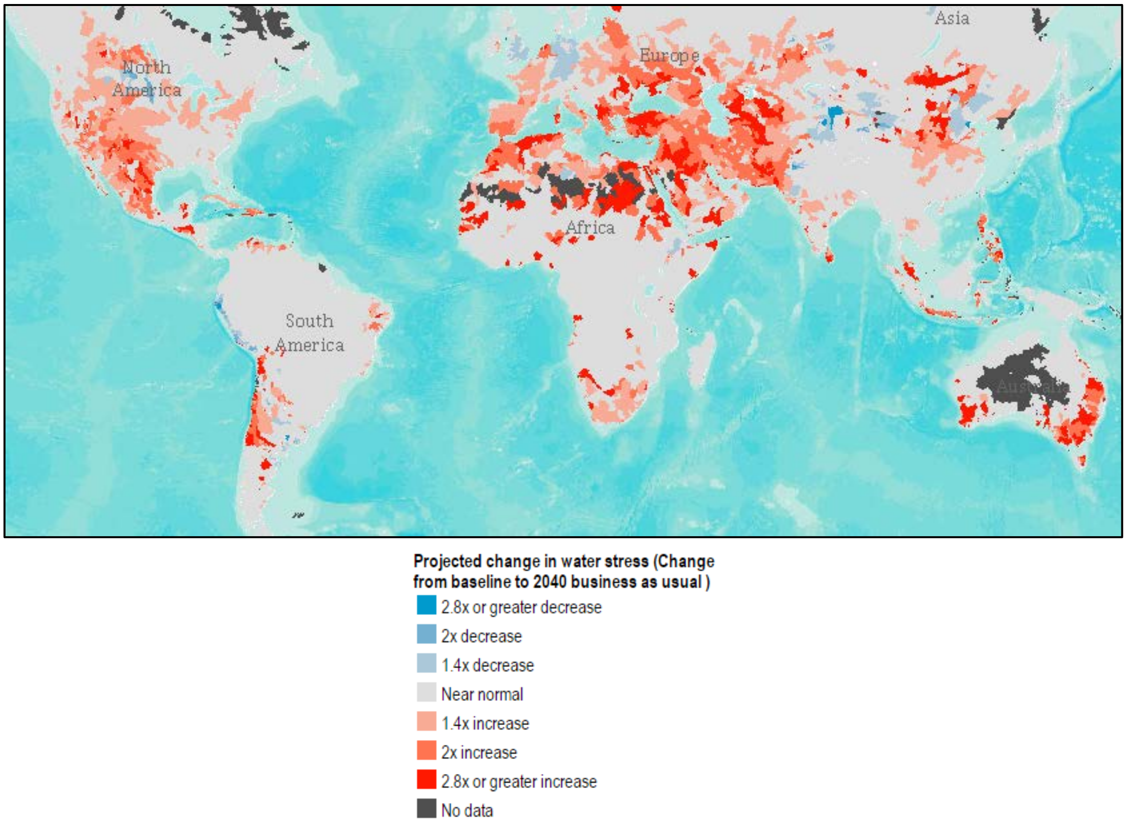

Figure 4: Projected areas of water stress change to 2040 *[Source: Luck et al. 2015, WRI Aqueduct Water Risk Atlas]*

While projections retain a certain amount of uncertainty, what is clear is that there are large populations *today* residing in regions with significant water stress. And as Vorosmarty et al. (2000) found, in the short- to medium-term it is population growth that will in many instances contribute most to future water stress in many of the world's regions. As we will explore below, even (or especially) in stressed regions there is ample room for improved water management and more equitable distribution of water resources.

Discussion questions:

- *What are the population dynamics in the current hotspots of water scarcity?*
- *Population used to be seen as a direct driver of water consumption; increasingly policies, institutions, and technologies mediate that demand for water and decouple the relationship? In what regions has there been greatest success in decoupling, and what can we learn from them?*
- *What are some of the intervening/mediating/contextual factors linking water supply/access and population dynamics globally?*

2.2. Water supply variability in the context of a changing climate

Almost 90% of the most disastrous events across the globe between 1900 and 2006 were caused by hydrometeorological phenomena, principally floods, droughts and windstorms (Adikari and Yoshitani

2009). Floods and droughts alone have been responsible for 45% of the total fatalities, 30% of the total economic damage caused, and over 84% of the total number of people affected by *all* recorded natural disasters (Güneralp *et al.* 2015). With increasing climate variability and shifting population demographics, the consequences of these events will become more severe and far-reaching.

Güneralp *et al*. (2015) identified that approximately 30% of global urban land in 2000 was located in what are called high-frequency flood zones and, rather alarmingly, almost half of the global urban expansion by 2030 will have taken place *within* these vulnerable areas. For regions which are already considered flooding 'hotspots' such as India, Southern Asia, and Southeastern Asia, it is anticipated that this development could result in as much as three-quarters of the urban land falling under high-frequency flood risk (Güneralp *et al.* 2015). In fact, the growth of coastal urban settlements and the concomitant rise in flooding exposure between 2000 and 2030 will generally be greater throughout Africa and Asia than anywhere in North America and Western Europe (Güneralp *et al.* 2015). At the other extreme, drylands currently comprise about 40% of the global land surface (Güneralp *et al.* 2015, de Sherbinin et al. 2014) and are home to about 35% of the world's population (UNEMG 2011), but the African continent's population and livelihoods are particularly susceptible to drought and desertification across the Sahelian region, the Horn of Africa and south to the Kalahari (UN 2007a, UNEMG 2011). Owing to their marginality and the frequency of climate shocks, these regions have been the locus of high out-migration in recent decades (de Sherbinin et al. 2012)

Projected climate change generally signifies an intensification of present climatic variability, however such forecasts remain somewhat equivocal and are seldom universally agreed upon due to the extent of current variability (Calow *et al.* 2011). It is anticipated that rainfall will become more seasonal and intense, but with prolonged intervening dry periods (Kundewicz *et al.* 2007). Current water supply infrastructure for human settlements is built to store water reliably based on past climate variability (e.g. to supply water consistently for up to a 100 or 500-year drought). As witnessed in Sao Paulo in 2014/15 and much of California in 2014/2015, the water supply systems have often strained to keep pace with demand from rapid population growth in the face of persistent drought (a subject we return to in Section 2.3).

As a result of shifting extremes, the quantity and quality of water will be negatively impacted, with more being lost as runoff or through organic and pathogenic contamination during rainfall and flooding events, while surface storage systems will become increasingly vulnerable and water supply technologies tested during extended dry stretches (Calow *et al.* 2011). These climatic shifts may also stimulate significant population migrations, particularly from dry agricultural regions perhaps to the very cities that experience the converse challenge of flooding due to sea level rise as well as increasing water supply pressures (de Sherbinin *et al.* 2007, Warn and Adamo 2014). In truth, the worsening of such events is expected to affect living conditions along multiple dimensions, including health (both disease and mortality), economic hardship, food insecurity, conflict, and basic quality of life.

Discussion questions:

- *What are some of the current 'hotspots' of flooding and drought, and what are the population dynamics in those hotspots?*
- *How might population distribution change in the future as a result of declines or increases in water availability owing to climate change? What could be the consequences of these changes?*

2.3 Water supplies for the world's urban areas

Population growth and climate change together present a significant challenge for urban water authorities. Total urban populations are expected to increase from 3.3 billion in 2007 to 6.4 billion by 2050 (WaterAid 2011), and most of these inhabitants will have little choice but to reside in unplanned informal settlements (UN 2007b). McDonald *et al*. (2011a) estimate that the total number of people living in urban areas with a perennial water shortage will increase from 24 million in 2000 to 162 million by 2050 as a result.

These statistics begin to introduce the pervasive deficiencies of formal water systems across the globe and subsequent challenges facing urban water managers. Urban service networks have quite simply not been able to keep pace with the rate of global urbanization even with the significant increase in private sector participation since the 1990s, a shift that was widely perceived as a solution at the time (Bakker 2010). It is thought that as much as 75% of basic services – including water – are provided to the consumer through 'informal' channels in African cities under *current* global demographics (Simone 2005), so the severity of the situation is clearly set to intensify.

The three main factors that dictate water provision in a city are availability (or the absolute amount that can be sustainably appropriated from surface or groundwater stores), delivery (usually associated with infrastructural issues) and quality (that is the treatment and suitability of water for urban domestic use) (McDonald *et al.* 2011b). For resource managers the exacting task is to sustainably – or at least equitably in the case of a deficit – balance water demand for domestic consumption with industrial and agricultural needs. Water is, after all, central to all forms of socio-economic development. However, as Figure 5 below highlights, the demands from agricultural and industrial sectors are reaching unprecedented levels. The challenge for urban water management bodies is to ascertain how to utilise and distribute this increasingly limited resource both fairly and without compromising the basic needs of each individual domain.

Discussion questions:

- *Are supply systems for major cities in most regions adequate to supply domestic and industrial needs?*
- *How and where do agricultural water demands constitute competition for urban water use, and how have those conflicts been resolved?*

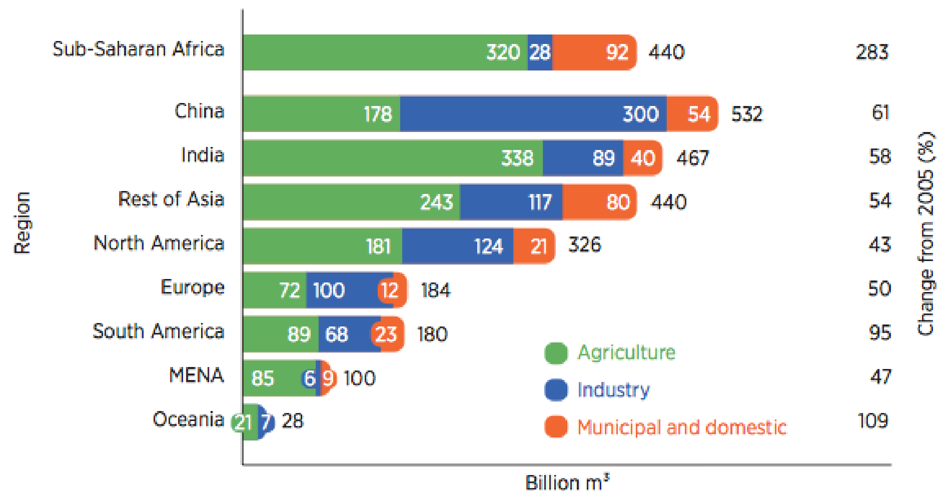

Figure 5: Increase in annual water demand (2005 to 2030) [Source: World Bank 2013; 24]

2.4 Access to water and sanitation in urban and rural areas of low income countries.

Approximately 663 million people are officially recognized as currently being without access to an improved water source across the globe (WHO/UNICEF Joint Monitoring Programme 2015). Meanwhile, 2.4 billion people still lack access to improved sanitation facilities (WHO/UNICEF Joint Monitoring Programme 2015). These statistics are widely employed and undeniably alarming, however given the difficulties and shortcomings associated with measuring the percentage of the population with access to improved services, it is unfortunately probable that they are also grossly underestimated (Nganyanyuka et al. 2014). They meanwhile do not provide an immediate insight into the issues of differential access and health that are such pressing concerns within the sector.

Measuring the percentage of the global population with 'access to improved water and sanitation facilities' sounds like a complicated task to put it lightly. Indeed, even if the absolute number of those potentially able to utilize an improved source (a technological intervention to either protect water from contaminants or safely store/transport faecal matter) was measured accurately, the continued monitoring of all facilities for issues such as their cost, quality, functionality and sustainability becomes unfeasible. The result is that many urban or rural residents classed as having 'access' are either unable to utilise affordable facilities and obtain sufficient volumes of potable water, or simply have no access to these services at all in reality (WaterAid 2011).

Access is also highly inequitable. Generally it is only high- and middle-income households that have access to a piped water supply and an even smaller percentage have access to sewerage systems (WaterAid 2011). It is often the responsibility of women and girls to oversee all things water-related in the household. This includes utilizing water to complete domestic tasks and travelling long distances or over dangerous terrain to collect water, either on a daily basis or when a local source becomes non-functional (Water and Sanitation Program 2010). Arising from such differentials is the idea that adopting holistic, multi-stakeholder approaches to water management that cut across these and other power relations such as race and age will help to improve service efficiency and instigate far-reaching benefits. The most important benefit is health. While it is difficult to determine exactly how many of the 1.5 million deaths from diarrhea in 2012 were directly attributable to inadequate water, sanitation and hygiene (WASH) facilities, it is reasonable to deduce that a significant majority were WASH-related based on the rates of differential and inequitable access (WHO 2014).

Discussion questions:

- *What demographic characteristics are most often associated with problems of water access?*
- *What are some of the intervening/mediating/contextual factors linking water supply/access and population dynamics locally?*
- *How can water supply and sanitation systems be bolstered, especially in informal settlements of developing country cities, and issues such as the gender dimension of water access be best addressed?*
- *What strategies can be deployed for increasing wastewater treatment covering greater proportions of the world's urban population?*

3. Conclusion

The future of global water security in the context of climate change and rapidly shifting demographics is a grave concern, but a concern in which optimism and opportunity should also feature heavily. Ethiopia is a useful case example of the global water distribution dilemma. While Ethiopia is consistently ranked in the lowest echelons of population-water access rates, the nation actually boasts an abundance of natural water resources that could more than serve its inhabitants. Like many other countries, Ethiopia needs an effective and sustainable management to oversee equitable resource reallocation – a large but not insurmountable task. Ethiopia's problem reflects broader global issues: while there are regions with absolute water scarcity, in most regions water stress is largely a man-made phenomenon rather than a natural obstacle, and the overarching question that follows from this is what governance approaches and management strategies will protect, and more importantly improve, water security for today's 7.2 billion inhabitants and tomorrow's 10 billion?

Discussion question:

- *What are the existing/emerging efforts to create governance institutions (at multiple levels) for a more sustainable future of water supply vis a vis demographic and environmental change?*

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