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Hydrology and Earth System Sciences Discussions

Interactive comment on "The effects of country-level population policy for enhancing adaptation to climate change" *by* N. K. Gunasekara et al.

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– Population & water: an important issue, but wickedly complex –

The simple approach to this issue is also relatively intuitive – more people means less water per capita, essentially irrespective of climate change impacts. Given the relative uncertainty associated with climate change projections (especially for rainfall and runoff, as well as groundwater recharge), and the comparatively "certain" projections of global population growth, it is clear that the problem of population growth should be considered as a higher priority than water resource impacts due to climate change.

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Interactive Discussion

Discussion Paper

This paper attempts to approach the issue spatially, aimed at informing population and climate policy via regional-scale projections of water stress. Unfortunately, I believe that if one truly wishes to do justice to the problem, it rapidly becomes "wickedly complex" and may prove impossible to solve.

National population growth is a combination of fertility, longevity and net migration. Population growth is intimately linked with demographics, especially the age profile of the population, and the results from fertility reduction policies are slow to appear. Developed countries such as Australia currently have below-replacement fertility, but are still undergoing both natural increase (approx 0.6% p.a.), plus the government maintains a high net migration intake (approx 0.6% p.a.), so that total population growth is relatively high but is dependent on population and economic dynamics in other countries which feed into migration policy. Population changes at the sub-national level are influenced by both national population changes and, particularly in developing countries, the ongoing process of urbanisation (migration from rural areas to urban areas). These factors all serve to complicate the spatial projection of population.

To properly assess water vulnerability we need to know the extent to which people in different locations depend on runoff (surface water resources for urban water supply and crop irrigation), soil infiltration (for rainfed crops) and deep drainage (recharging groundwater for urban use and crop irrigation). Then, we need to know the extent to which these are vulnerable to change under different scenarios of global climate change, and here we encounter both a lack of high-quality historical data and a lack of predictive agreement between contemporary climate / hydrological models. The patchy availability of data and high degree of heterogeneity in water-dependent regions indicates that, whilst a global GIS assessment of water security may seem attractive and "big-hitting", these analyses are probably far more beneficial at the local to regional scale, where the necessary details are available and the corresponding spatial assessments can be performed at a much more useful resolution for policy-makers.

I'm not sure, therefore, whether it is possible to do justice to this issue at the global scale.

– Methodology section lacking –

The authors use an arbitrary threshold population growth rate of 2.5% in 2010 as defining high versus low population growth (and hence defining which countries are assigned the hypothetical fertility policy). To me, 2.5% is actually a very high growth rate (doubling in less than 30 years), although admittedly the authors are probably reflecting public and political opinion by stating that <2.5% is "low growth" (p. 9244, line 11). Perhaps, therefore, the analysis could be used to challenge this widely-held assumption, by investigating different thresholds for policy intervention – especially given the fact that, as the authors point out (p. 9244, line 8), there is not a great deal of difference in resultant global population between their two policy scenarios and the no-policy scenario. The authors should extend their analysis to policy scenarios that could actually make a significant difference – if such policy scenarios are even feasible, that is. (If – for reasons of population "momentum" – we are locked into a world of at least 13 billion by 2100, irrespective of policy, then that is cause for considerable concern and should be reported in the analysis.)

I would like to know whether the fertility-reduction policy scenarios are realistic. That is, are they applied with any consideration of the current age profile in each country, or are they applied macroscopically in the form of a reduced national growth rate? The age profile will dictate the speed with which a change in fertility is reflected in a nation's population – some nations may undergo a relatively fast transition while others may take longer. The authors need to be clear about the method they have used to derive changed population growth rates and justify that these growth trends are realistic from a demographic perspective.

On a technical note, according to the data supplied in the Supplement, numerous countries with average growth rates > 2.5% from 2000-2025 do not appear to have any population policy applied in the analysis. Meanwhile, some countries with average growth

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rates < 2.5% from 2000-2025 appear to have population policies applied. Have the policies been applied correctly?

– Climate scenarios –

This paper draws runoff scenarios from prior work ("TRIP"). Without delving deeply into that work it is not clear how uncertainty in projected changes to rainfall and runoff under climate change have been factored into this analysis. Moreover, there are ongoing debates in the literature about the relevance of GCM-derived data for multi-decadal prediction, especially in terms of precipitation for which there is still substantial disagreement between different models. I am not convinced that simply averaging the results of four models (p. 9244, line 17) is an appropriate technique ("two wrongs do not make a right"), and a more detailed description and justification of this method is required.

The use of low, medium and high emissions scenarios from SRES is a common approach to climate change impact modelling. However, the high emissions scenarios (and to some extent, also the medium emissions scenarios) are coming under increasing scrutiny and criticism in light of apparent fossil fuel scarcity in the 12 years since SRES was published. It now appears plausible that a chronic lack of energy resources (and the resultant constraint on economic growth) will define the foreseeable future. This may be a moot point in the context of the current paper, because the low and high emissions scenarios did not differ greatly in terms of water stress; population growth (not climate change) was found to dominate future water stress. However, the nexus between declining energy availability and rising population is probably at least as important as climate change discussions.

– "Water stress" indicator is overly simplistic –

The stress classifications come from Arnell (2004), who applied earlier classifications from Falkenmark (1989). It seems timely to challenge these water stress indicators. I accept that if one's aim is to conduct global spatial assessments, then mathematically simple indicators are helpful – especially if they can be constructed out of simple spatially-gridded data such as the population and runoff occurring in a given grid cell. The water stress indicator used in this paper implicitly assumes that the water used by the population in a given grid cell (a) comes entirely from runoff, and (b) is entirely sourced from within that grid cell. However, the water required for human wellbeing is far more complex than simply the runoff available per capita in a given geographic cell. Surely, actual water stress depends on consumption relative to availability, and the various aspects of water consumption warrant at least some discussion in the context of future drivers of water-related stress. Consumption involves direct (household) plus indirect (industrial and agricultural) water use. The most basic direct water consumption requirements (for drinking, cooking and cleaning) are some 20-50x smaller than even the 500 m3/capita/yr that characterises nations under "extreme water stress" (the highest-stress category). Indeed, as Arnell (2004) states, "In practice, the thresholds are arbitrary, and all are well above minimum physiological requirements." The fact that "extreme water stress" occurs in nations with 20-50x the basic water requirement indicates that there may be more significant factors influencing water stress than simply the quantity of runoff available per person within a given area. These may include:

1. Political, economic and social factors / conflicts preventing the development and maintenance of water storage, treatment and distribution infrastructure 2. Local heterogeneity of both water resources and population (i.e. variations at a smaller scale than the regional scale at which the per-capita runoff was assessed – perhaps most of the water falls on the wrong side of the mountain range and flows out to sea, and most of the population occurs on the other side) 3. Lack of accuracy in the runoff data itself 4. Populations' reliance on water resources other than runoff, such as groundwater, which may be depleting faster than the recharge rate, and/or may be declining in quality (e.g. saltwater intrusion)

The above factors could at least be explored qualitatively in the paper, although the complexity they would introduce to any spatial / quantitative / predictive analysis is probably overwhelming (see my initial comments). However, several case studies looking at “extreme water stress” countries could help illustrate what water stress actually looks like.

It is also likely that countries or regions apparently undergoing water-related stress are undergoing interrelated water / food security problems. After all, food production strongly dominates the “water footprint” of virtually all nations, and everybody needs food. Importantly, however, the location at which the majority of water is consumed for food production is not co-located with the main population of food consumers. To make matters worse (from a spatial assessment perspective), depending on a variety of factors, some crops are irrigated using surface water (runoff), some are irrigated using groundwater, and many are rain-fed. This calls into question the usefulness of a water stress indicator based on runoff per population within a specific geographic grid cell, and suggests that such an indicator may give highly misleading predictions of water-related vulnerability in the future.

By way of an example, the per-capita water available in an agricultural irrigation district may appear to be vastly more than in a city, but this does not mean that the farmers are less vulnerable to reductions in water availability than the urban population, because irrigated farming depends on using large amounts of water. Moreover, the city population may in fact be extremely vulnerable to any future reduction in their per-capita food supply, driven by changes to the city population, despite the fact that the food is derived from water resources in the rural region.

The import/export balance of “virtual water” is critical to the question of population dynamics and water resources management, but it becomes very complex – perhaps impossibly complex – to quantify and predict. One can imagine a plethora of different scenarios involving future changes to population (and affluence/diet) in the food-importing and/or food-exporting regions, superimposed upon changes to land use (e.g. urban encroachment), soil fertility, technology, energy and fertiliser prices (not to mention food prices), as well as aspects of climate change that are not limited to only runoff.

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Interactive Comment

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