We have more to worry about than climate change

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Climate change and the associated issues of fossil fuels understandably dominate the debate about sustainability in Australia and globally. Indeed for many, it is the only issue on the radar. However humanity will have to deal with many other threats in the twenty-first century as population and economic growth places greater strains on the flow of the natural resources that underpin our society.

Rockstrom, Steffen et al warn us that in addition to climate change there are eight other planetary boundaries that define a "safe operating space for humanity". Of the identified "boundaries", genetic diversity and nutrient flows (phosphorus and nitrogen) are listed as high risk, i.e. "beyond the zone of uncertainty").

Other warnings come from the most recent Ecological Footprint data which identifies a 2011 global footprint of 1.5, meaning that humans are using ecological resources 150% faster than they are being replenished by natural processes. This "overshoot" is possible while the stock of resources is sufficiently large to supply the resources, but cannot continue indefinitely. How long can it go on?

In an article recently published in the Journal of Natural Resources Policy Research I report on various future global scenarios using a population-economy-resources model developed using the technique of System Dynamics. Although the model is inspired by the famous Limits to Growth studies, its configuration is simpler and focusses specifically on the limits imposed by resource availability. The model tracks the likely future consumption of renewable resources, fossil fuels and non-renewable materials and is calibrated against real word data from 1960-2010. This calibration process establishes the current pattern of resource intensity for those resources, i.e. the rate of their consumption per unit of GDP.

The initial run of the model assumes that resources are unlimited, and global economic growth continues until GDP per capita and living standards approach that of OECD countries now, resulting in population stabilising at around 10 billion during the next century. This 'smooth landing' for humanity (if it were possible) would result in global GDP around 9 times greater than the current. To realise this level of economic activity (based on current patterns of production and consumption) would require three to four times as much energy (mostly derived from fossil fuels), and raise the ecological footprint from 1.5 to over 4. However the largest increases in resource flows by far in this scenario are metal ores and industry / construction materials. The consumption rate of these materials grew sixfold between 1980 and 2010, driven significantly by China, who by 2010 consumed nearly half of these materials annually. If current global consumption patterns continue, flows of these materials would grow by a further nine times! The key question is: are these future materials flows possible? What are the consequences if they are not?

The subsequent round of modelling explores these questions by placing limits one at a time on the stocks of ecological capacity, fossil fuels and metal ores / construction materials. The ecological footprint is the ratio of renewable resource consumption to regeneration (referred to as 'Biocapacity'). These are flows into and out of a notional stock which I have called ecosystem capacity. For the purposes of modelling I have assumed that the initial stock is equivalent to around 500 years of the 1980 net depletion rate. The model suggests that current consumption patterns overlaid on future economic growth will result in constraints becoming evident around the end of the century, with severe depletion of renewable resources in the middle of the next century. Doubling the initial stock of resources delays this process considerably (by around 150 years) while halving it brings depletion forward by half a century.

What about fossil fuels? The ultimate realisable stocks of oil, gas and coal were conservatively derived from the recent literature on that well researched topic. This data infers that the ultimate resource is equivalent to around 110 years of production at 2012 rates. While this sounds like a large stock, it is rapidly depleted by exponential economic growth after 2010, leading to constraints in resource availability around 2050 and exhaustion by the end of the century. Doubling the initial stock delays the process by around 40 years.

A similar process for establishing the available stocks of other non-renewable materials (metal ores and industrial / construction materials) suggests resource constraints will start to bite around the end of this century followed rapidly by severe depletion.

In each of these cases the scarcity of resources acts as a brake on economic production, impacting adversely on GDP per capita and hence living standards. As living standards drop and resources diminish, population growth plateaus, and then reduces rapidly over the simulation period (to 2350). These results are very similar to those of the Limits to Growth studies that have caused so much controversy over the years. While many have dismissed these studies as unrealistic (including the newsworthy Bjorn Lomborg), and there are credible criticisms of the model's limitations, there has been no serious work that undermines the core contentions (see Turner and Alexander). Like that and all System Dynamics studies, the timing and exact numeric values in this study are the combined effects of initial conditions, posited causal relationships, and in particular, the equations and graphical functions that regulate them. Therefore, the timing and values predicted by the simulations are not to be taken as accurate. However the basic behaviour of the system is predictable from our understanding of the dynamics of growth-limited systems, that is, that depleting resources at a faster rate than their regeneration or substitution must eventually lead to their exhaustion, giving rise to overshoot and decline or collapse.

The model was then modified to introduce 'voluntary measures' that could potentially avoid resource scarcity and associated impacts on the economy and living standards. This process identifies that very significant changes to the global economy will be required to avoid the present overshoot conditions leading to the decline and / or collapse of living standards and population during this or the next century:

- increasing the fraction of renewable energy rapidly from the present level to 100%;

- reducing demand for other non-renewable materials by 75% (per unit of GDP) as their stocks decline; and
- simultaneously increasing the fraction of materials recovered and reused from 10 to 70% as stocks decline.

These voluntary measures only achieve global stability if both of the following conditions apply:

- continuing improvements in living standards in the developing world deliver the demographic transition (and thereby constrain net global population / resource consumption); and
- all measures occur simultaneously and without delay.

Absent these conditions, the model produces overshoot and collapse behaviour during the simulation period. Although easy to configure in a mathematical model, the implementation of these or similar voluntary measures at anywhere near the scale and timeframe required, appears presently infeasible. Although some action is being taken with respect to greenhouse gas emissions and recovery or recycling of materials, the scale of these actions does not reflect the urgency of the task. Almost no action is being taken on reducing the economic demand for other non-renewable materials, and it is highly questionable whether it is even possible to reduce demand per unit of GDP for such materials by 75%, let alone in the timeframe identified.

With present policy settings the market will not deliver these transitions. The conventional wisdom (enunciated by Lomborg and others) is that scarcity will induce a price signal that incentivizes technology improvements that in turn lead to reductions in resource use or substitution. The problem with this argument is that resource constraints take effect well after depletion of the resource stocks begin. By the time that scarcity reduces GDP and, thus, resource demand – it is too late to avoid overshoot and decline.

In order for people everywhere to attain and / or retain a reasonable quality of life, human society must learn to live within the limits imposed by the bio-physical world. The pursuit of economic growth without a plan to transition to a sustainable future only brings forward in time the risks identified in this work. Although climate change is properly the present focus of our attention, these associated but broader resource issues cannot be ignored for much longer.

The full article is available at www.sustainableplaces.com.au