CORRESPONDENCE:

What's family planning got to do with it?

To the Editor — The News Feature 'We are seven billion' in the October 2011 issue of *Nature Climate Change*[1] touches on the important role of family planning programmes in influencing population growth, but neglects to consider the vast unmet need for family planning that exists in developing countries. Addressing this unmet need by increased investment in voluntary family planning programmes that respect and protect rights offers a cost-effective strategy for supporting climate change adaptation[2,3].

According to the United Nations medium variant projection, the world population will have increased from today's seven billion to over nine billion by 2050, surpassing ten billion by the end of the century[4]. The majority of this growth is projected to take place in developing countries: the countries that have contributed the least to climate change, but are the most vulnerable to its impacts. While struggling to adapt to climate change they face the additional burden of feeding and providing for their growing populations. In Africa, one of the continents most vulnerable to climate change[5], the population is expected to more than triple between now and 2100 (ref. 4).

An analysis of the national adaptation programmes of action — in which the 40 least-developed countries set out their most pressing climate adaptation issues and priorities — found that 93% of the countries identify rapid population growth as a factor that either exacerbates the impacts of climate change or impedes their ability to adapt[6]. Climatic impacts identified as being exacerbated by population growth include soil degradation, freshwater scarcity, migration, deforestation and loss of biodiversity[6].

In developing countries, an estimated 215 million women have an unmet need for contraception — that is, they say they do not want to have a child in the next two years, but are not using a modern method of contraception, often because they do not have access to the necessary services[7]. This offers considerable scope to reduce population growth and increase climate resilience, simply by preventing unplanned pregnancies through ensuring that women have access to the family planning services that they want and need. To advance this 'win–win' strategy, rights-based sexual and reproductive health programmes, including family planning services, should be recognized as legitimate components of national climate change adaptation programmes and climate change funding mechanisms. ❐

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COMMENTARY:

The Alberta oil sands and climate

Neil C. Swart and Andrew J. Weaver

The claimed economic benefits of exploiting the vast Alberta oil-sand deposits need to be weighed against the need to limit global warming caused by carbon dioxide emissions.

The US federal government recently rejected approval for TransCanada's proposed Keystone XL pipeline. But TransCanada plans to submit a revised proposal shortly. The proposed pipeline is part of a US$13 billion system aimed at connecting the bituminous oil sands in Alberta, Canada with refining capabilities in the United States, including those as far south as Texas[1]. There has been widespread public interest in, and opposition to the pipeline, primarily owing to environmental concerns (for example, ref. 2). Similar public opposition has arisen towards the proposed Northern Gateway pipeline in British Columbia, which aims to make the oil sands accessible to Asian markets.

The size of the Alberta oil-sand deposits is massive. Estimates for oil-in-place are 1.8 trillion barrels[3], although the economically viable 'proven reserve' is estimated at only around 170 billion barrels with 26 billion barrels under active development[3]. For orientation, Alberta's 1.8 trillion barrels of oil-in-place is roughly seven times the size of Saudi Arabia's proven reserves[4]. It has been suggested that construction of the TransCanada pipeline will encourage an expansion of the area under active development[2]. Indeed, greenhouse-gas emissions resulting from expanding oil-sand production are Canada's fastest-growing emissions source[5], and have the potential to contribute significantly to anthropogenic

climate change. This is accentuated by the fact that the oil sands are more energy intensive to produce than conventional crude oil — and have a greater 'well-to-wheel' carbon footprint[6] (see Supplementary Information).

Global warming

Here we quantify the carbon dioxide-induced potential for global warming contained in the Alberta oil sands in the context of global fossil-fuel resources. To estimate the potential for global warming, we exploit the fact that the carbon dioxide-induced global mean temperature change (ΔT) can be inferred directly from cumulative carbon emissions (E_T) by means of the carbon–climate response[7], which is equal to $\Delta T/E_T$. Observational constraints produce a carbon–climate response of 1.5 °C per trillion metric tonnes of carbon emitted (Tt C), with a range of 1.0–2.1 °C per Tt C (5th–95th percentile). The uncertainty range includes uncertainties in climate sensitivity, as well as uncertainties in 'carbon sensitivity' (carbon sinks and carbon–climate feedbacks)[7]. We estimate the carbon available for emissions from the oil sands based on a per-barrel carbon content multiplied by the number of barrels (see Supplementary Information).

If the entire Alberta oil-sand resource (that is, oil-in-place) were to be used, the associated carbon dioxide emissions would induce a global mean temperature change of roughly 0.36 °C (0.24–0.50 °C; Table 1).

This potential warming is almost half of the observed warming seen in the past 100 years (0.76 °C). However, considering only the economically viable reserve of 170 billion barrels reduces this potential for warming by about tenfold (to 0.02–0.05 °C), and if only the reserve currently under active development were combusted, the warming would be almost undetectable at our significance level.

Additional emissions resulting from natural gas, diesel and electricity use during bitumen extraction, upgrading and refining have not been included here, but could increase these numbers (see Supplementary Information). Neither have we considered the potential impact of future carbon capture and storage technologies, which may decrease the stated emissions and warming. It is important to recognize that our estimates do not include greenhouse gases other than carbon dioxide and do not address other potentially deleterious environmental, health and social side effects of oil-sand production (for example, ref. 8) or its potential economic benefits[3].

Table 1 | Oil-sand potential for global warming in the context of global fossil-fuel resources.

Reserve/resource	Amount ($\times 10^{17}$ g C)	ΔT (°C)
Oil		
- Alberta oil sands (OIP)[3]	2.38	0.36 (0.24–0.50)
- Alberta oil sands (proven)[3]	0.22	0.03 (0.02–0.05)
- Alberta oil sands (active)[3]	0.03	0.01 (0.00–0.01)
- Global conventional oil (proven)[4]	1.58	0.24 (0.16–0.33)
- Global conventional oil (TRB)[11]	2.28	0.34 (0.18–0.58)
- Global unconventional (TRB)[11]	3.54	0.53 (0.30–0.86)
Gas		
- Global (proven)[4]	1.07	0.16 (0.11–0.23)
- Global conventional (TRB)[11]	2.16	0.32 (0.19–0.51)
- Global unconventional (TRB)[11]	19.1	2.86 (0.92–6.07)
Coal		
- Global (proven)[4]	6.14	0.92 (0.61–1.29)
- Global (TRB)[11]	98.6	14.79 (7.95–24.71)*
Total (of TRB)	125	18.78 (9.46–32.73)*

OIP, oil-in-place; TRB, total resource base (including reserves)[11]. The figures for proven reserves are from BP[4]. The potential for warming, ΔT, is given for the mean carbon–climate response[7], plus the 5th–95th percentile in brackets. For the TRB figures, the uncertainty includes uncertainty in the resource size, as given in ref. 11. See Supplementary Information for more details. *The carbon–climate response method is not valid for emissions above about 20×10^{17} g C, so these figures are not valid climate change estimates, but are included for comparison.

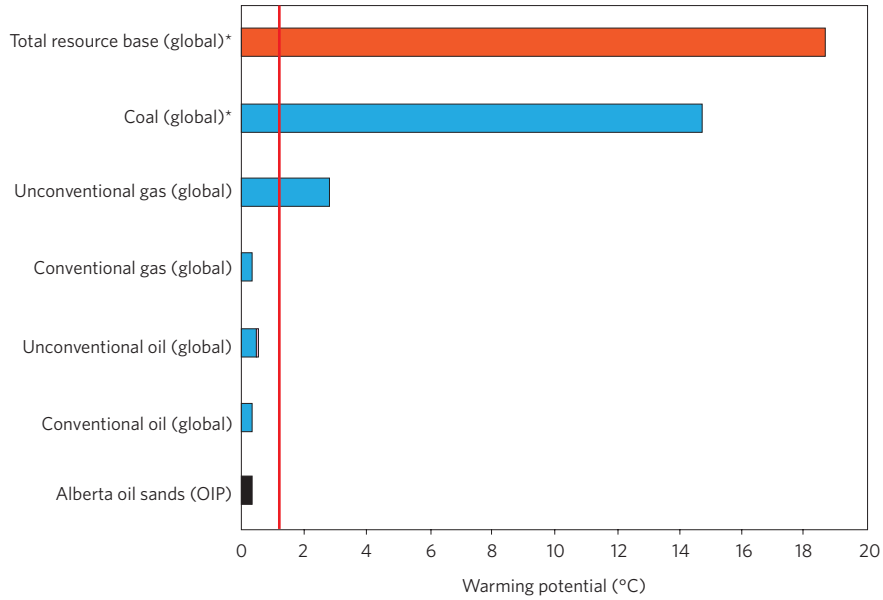

Figure 1 | Central estimate of the potential for warming of the different fossil-fuel resources in Table 1. The red line indicates the limit of 2.0 °C warming from pre-industrial times agreed to under the Copenhagen Accord. Note, that here we only consider the effects of anthropogenic carbon dioxide. The potential for warming associated with proven Alberta oil-sand reserves is indicated as a barely visible sub-component (shown in pink) of unconventional oil (global). The potential warming of the total Alberta oil-sands oil-in-place (OIP) is shown in black. *The carbon–climate response method is not valid for emissions above about 20×10^{17} g C, so these figures are not valid climate change estimates, but are included for comparison.

Carbon footprints

To have a 66% chance of limiting warming to less than the 2 °C limit put forth in the 2009 Copenhagen Accord, one carbon–climate modelling study estimated that total future global carbon emissions should be limited to less than 5.9×10^{17} g C (ref. 9). If this amount were to be distributed equally among the current global population, the resulting allowable per capita cumulative carbon footprint would be 85 tonnes of carbon. The eventual construction of the Keystone XL pipeline would signify a North American

commitment to using the Alberta oil-sand reserve, which carries with it a corresponding carbon footprint. For comparison, by fully using only the proven reserves of the Alberta oil sands, the current populations of the United States and Canada would achieve a per capita cumulative carbon footprint of 64 tonnes of carbon.

The Government of Canada has recently announced its intent also to secure the Chinese market for oil-sand products[10], indicating the potential exploitation of this resource regardless of the ultimate fate of the Keystone XL pipeline. If distributed over the current population of China, the proven Alberta oil-sand reserves would lead to a per capita cumulative carbon footprint of 16 tonnes of carbon. However, many other sources of fossil fuels will also be needed if growing Chinese, and indeed worldwide, energy demand is to be met through the exploitation of fossil fuels.

Recent estimates show that an enormous global fossil-fuel total resource base is available to meet this growing demand[11] (Table 1). Resources here are defined as those fossil fuels in the Earth's crust for which "economic extraction is potentially feasible"[11] — an upper limit of nature's bounty and human techno-economic ability. Coal resources have the largest potential for global carbon emissions (79% of the total), followed by unconventional gas (15%) and only then the unconventional oil of which the Alberta oil sands form a part (3%; Fig. 1). Coal's significance is due to the large tonnage available, together with its high carbon content. It is clear that the total global fossil-fuel resource base could easily yield over 2 °C of warming given sufficient global demand and a lack of international regulation.

If North American and international policymakers wish to limit global warming to less than 2 °C they will clearly need to put in place measures that ensure a rapid transition of global energy systems to non-greenhouse-gas-emitting sources, while avoiding commitments to new infrastructure supporting dependence on fossil fuels[12]. ❐

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Additional information

Supplementary information accompanies this paper on www.nature.com/natureclimatechange.

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