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HOW SHOULD CANADA ADAPT TO CLIMATE CHANGE:
DEBATING THE MERITS OF A TECHNOLOGICAL FIX VERSUS A BEHAVIOURAL APPROACH

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ABSTRACT: This paper is a discussion on whether climate change adaptation should focus on the use of existing, and the development of new, technologies or whether it should focus on the root causes of vulnerability - behavioural change and risk perception. The technological fix argument is that resources should be put into promoting existing technologies that have been shown to be effective but underutilized, and the development of new technologies. The behavioural change argument is that behavioural change is essential, and the notion that one must choose either a technological or a behavioural solution is a false dichotomy. The paper concludes that technology will undoubtedly play a large and important role in climate change adaptation, but by itself is not sufficient to solve the adaptation problem. Behavioural changes are necessary as well - indeed they are likely to be the more crucial factor.

Keywords: climate change, adaptation, technology, behavioural change

1. Introduction

This paper is a discussion on whether adaptation should focus on the use of existing, and the development of new, technologies or whether it should focus on the root causes of vulnerability - behavioural change and risk perception. The authors recognize that any future initiative and policy will include both technology and behaviour, but the issue of emphasis is subject to disagreement and requires further discussion. Brad Bass' recent research has encompassed first hand experience with new technologies, such as green roof infrastructure, simulating the adoption of new energy technologies and simulating the emergence of new strategies. David Etkin's research has included an assessment of natural hazards and disasters across Canada, hail and tornado risk in Canada, impact assessments of catastrophic events such as the 1998 Ice Storm in Quebec and the role of vulnerability in increasing loss and how responses to hazardous events increase vulnerability.

2. The Technological Approach to Adaptation

A technological approach argues that resources should be put into promoting existing technologies that have been shown to be effective but underutilized, the development of new technologies such as nanotechnology and policy, which encourages early adoption of underutilized or new technologies. There are five components to this argument:

1. Behavioural change is difficult to sell, difficult to implement and is not politically popular.
2. We do not have a culture that allows for the emergence, experimentation and discarding of maladaptive behaviours at a rate that is necessary to cope with the rapid onset of new events.
3. Technological change has already worked to reduce environmental impacts.
4. Many of the impacts that we will have to deal with are already present and can be mitigated through existing technologies.
5. There are future impacts that will be larger, but there are existing technologies that can reduce the damage, and we can accelerate the development of new technologies that are already on the horizon.

Although behavioural changes have occurred on a societal level, changing people's behaviour is an extraordinarily difficult task (Beer, 1975; Burton, 1993). This has been recognized for millennia. For example, it is strongly echoed in many of the major world religions, i.e. Judaism and Islam legislate behaviour while Buddhism proscribes a regimented, long-term program of meditation that may take a lifetime. In our modern context, most of us have had to experience the difficulties of change on a personal level, involving weight-loss reduction, ending procrastinating behaviours, learning a new skill, learning how to let go or learning how to slow down.

Similarly, we have failed on a societal level, with the result that some of our personal issues, such as obesity, are now societal issues. Despite our level of education we still prefer the automobile to public transit, cycling or walking even in those areas that are conducive to these alternatives. We still prefer the throw-away and disposable and where we do not prefer this, we have come to expect it (e.g. light bulbs, fashion and cars). People are slow and reluctant to move out of their comfort zones. Thus, behavioural adaptation to risk tends to be incremental and insufficient as a result of cognitive

conservatism (Janoff-Bulman, 1992), which refers to the reluctance of people to accept or reinterpret information that runs contrary to their worldviews.

Two successful changes serve to illustrate this point. As a global society, we agreed to the Montreal Protocol to reduce emissions of clorofluorocarbons (CFCs) to mitigate the destruction of the stratospheric ozone layer. This agreement was lauded as a model for others in that it brought on board governments and industry. However, at the time, one of the major producers of products with CFCs already had the alternative product available and would not suffer an economic loss - thus had no reason to oppose the Protocol. The success of the Montreal Protocol is based on a technological fix, not a behavioural change, i.e. reduce the use, manufacture and sale of air conditioners. In the meantime, industrial sectors that did not oppose the Montreal Protocol are opposing the Kyoto Protocol.

Another lauded change in behaviour was the blue box program in Ontario (household recycling), requiring the separation of waste into different streams. The success of this program is due to the fact that it involved no real change. People were not asked to reduce their amount of waste, only to dispose of it in a different manner. Given the fluctuation in demand for recycled goods, many of them still sit in warehouses, unsold and unused. What recycling has done for many products is transfer the storage from the landfill to above-ground repositories.

Later in this book, Bass discusses how important the emergence of new behaviours was in allowing the agents in the COBWEB simulation model to adapt to environmental change. Although this might appear as a contradiction to this stance, it should be noted that the simulations suggested that the speed at which new ideas emerge in that artificial world was also critical to their success and the adaptability of the population. Outside of the realm of culture, where experimentation is constant and rapid, most of our institutions are fairly rigid in how things get done and allow for little experimentation and risk (Holling and Gunderson, 2002; Leadbeater, 1999). This may be due to the bureaucratization that seems to creep into any organization beyond a certain size threshold or the inability to account for the activity of innovation (Leadbeater, 1999). In fact, this rigidity that creeps into many large bureaucracies may be the best argument against a behavioural emphasis on adaptation as large institutions have been the most resistant to

those behavioural changes required to foster the rapid emergence of innovation.

On the other hand, we have had great success with technological change in the environmental area. For example, all of our appliances and furnaces are much more energy efficient than they were ten years ago and this efficiency has been increasing every few years. Houses that are built post-1980 tend to use far less energy per square metre than pre-1980 houses. Our vehicles still pollute, but less so than in the last few years (though there are many more of them). These changes were far more successful than attempts to get consumers to reduce their demand for energy. The imposition of standards forced industry to create more environmentally friendly products. When government has set new standards, industry-wide, they may be opposed, but they are implemented and are effective. It is important to note that these energy saving or emission reduction innovations were not widely adopted until they were legislated. As is evident from other technological realms when an alternative technology is available (beta vs. VHS; MAC OS/Linus/Unix/OS2 vs. Windows; rotary vs. combustion engine) even if it is better in certain areas of performance, it is not necessarily adopted on a widespread scale without external regulation or incentives.

The imposition of new standards was successful because they were incorporated into existing practices without trying to change behaviour. Environmental objectives were achieved through a change in technology enforced by policy.

Two specific impacts of climate change will be used to illustrate this point; the severity of precipitation events and heatwaves. More severe spring and summer storms are expected to lead to increased stormwater runoff which may lead to flooding and more combined sewer overflow events. We may face summers that have more frequent, extreme and/or longer heatwaves. There are several available technologies to reduce stormwater runoff at the source, for example, on the roof, reduce the flow into the drainage system on the road, channel the water and store it (retention ponds, artificial wetlands). These technologies are all currently available, and can be retrofitted into existing buildings and roads and easily adapted to new residential, commercial or industrial developments.

Heatwaves are not just a matter of discomfort, but they can increase mortality, increase air pollution and related illnesses and tax the system, leading to

more brownouts or blackouts. There are two basic technological approaches to cope with more frequent or more extreme heatwaves. One is to reduce the contributions from the city itself, i.e. reduce the heat that is generated by hard surfaces. These surfaces can be cooled by light or reflective surfaces, vegetation with sufficient moisture for evapotranspiration or wetter surfaces. A second approach is to reduce the demand for electricity generated by natural gas, coal, oil and nuclear sources using solar and wind power, technologies that are currently available in today's market. In both of these scenarios, there are no required changes to lifestyle, only to the technology that supports the lifestyle.

There are several barriers to the adoption of new technology, cost being one important factor. Although these technologies have a higher upfront cost, encouraging their adoption could probably best be implemented through legislation. Experiences in other North American cities (Residential Energy Conservation Ordinance in San Francisco, USA; the cool roof policy in Chicago, USA) and countries (German legislation to replace the vegetation removed from new buildings) have been successful in increasing the adoption of current technologies, and have not had a negative economic impact.

Finally, there are extreme events, as indicated by recent flooding in Edmonton, Alberta, Canada and Peterborough, Ontario, Canada, or the ice storm that knocked out the hydro corridors bringing power into Montreal, Quebec, Canada in 1998. If these communities become less vulnerable to these events then technology will probably have played a large role. For example, Quebec could adapt to future ice storms by building infrastructure that is more resistant to ice accretion, building redundancy with alternative power generation and transmission infrastructure or by introducing earlier failsafe thresholds that will allow systems to fail earlier but with less damage.

During the 2004 flood in Peterborough, Ontario, Canada only two small sections of the city were damaged, primarily due to their location. There are a range of technological measures that could be introduced to reduce flood damage. There are a few discussions, such as Mulhall (2002) that indicate the potential for new adaptation technologies that will offer us far higher levels of protection in order to cope with some of these events.

Obviously, just having technology is not a solution. It has to be used. However, experience has shown that new standards for construction, energy

efficiency, emissions and landscape conservation have been very effective at promoting the adoption of these new technologies and have been effective at meeting the environmental and policy targets.

3. The Behavioural Critique

The 'technological fix' argument raises a number of interesting and valid points regarding the balance between technological and behavioural solutions. Arguments in this section are that (1) behavioural change is essential and (2) the notion that one must choose either a technological or a behavioural solution is a false dichotomy – neither one necessarily detracts from the other though the issue is often presented as such.

In this regard, arguments for reliance upon technological solutions are ultimately flawed. They require faith in the idea that all problems can be solved through the use of science and technology. There are, however, classes of problems not subject to such solutions – such as war, poverty and crime. For example, the main difficulty in solving the problem of war is that for many people it is not a problem in need of a solution, but rather a solution to a problem. Problems that are human-centered require human centered solutions, not just more technology. Natural disasters fit into this category.

The argument for an emphasis on behavioural change rests upon the following notions:

1. People have to choose to use technology in order for it to make a difference. This requires a change of behaviour.
2. Vulnerability is not caused by a lack of technology, but social and political factors.
3. The application of technological fixes has often backfired as a result of a lack of consideration of behavioural change. For example, research has shown that changes in risk-taking behaviour tend to accompany and nullify changes in technology that is intended to mae us safer. Changing motivation and risk perception is generally much more effective.
4. Many environmental problems are rooted in our use of technology. The idea that technology can be used to solve problems created by technology is fundamentally flawed. Environmental problems (of which climate change is one example) are deeply rooted in our relationship with the natural world, our values and our worldview. These all lay outside the realm of technology.

5. The tragedy of the commons is, in many ways, being enacted on national and global scales. Many of the behavioural choices people make that emphasize individual gain over social good act ultimately to the detriment of all. Technology cannot solve this problem – a social process is required.
6. Changes in behaviour, though difficult to engender, do occur when sufficient motivation exists. Simply because a solution is difficult to achieve is a poor reason to choose an alternate but seemingly easier approach that will fail.

Natural disasters affect Canadians and people around the world in devastating ways. The knowledge to prevent or greatly mitigate these events exists, but is often not used (White et al., 2001). Thus, we continue to build on flood plains in spite of the knowledge that it will eventually result in a flood disaster. Having knowledge or tools does not mean that they will be used – that can only happen when people make decisions and choose actions that use them. Disasters occur because vulnerable communities exist. This vulnerability is partly a function of the built environment, but also exists because of social and environmental issues. Poverty, access to power, emergency management legislation, disaster financial assistance and many other social and economic factors contribute to disaster occurrence or resilience, depending upon how they are structured. Wisner et al. (2004) discuss the progression of vulnerability to hazards in society, beginning with root causes and then progressing to dynamic pressures and unsafe conditions. Technology addresses the unsafe conditions aspect of vulnerability, but not the root causes or dynamic pressures, and from this point of view is a band-aid solution.

One part of adapting to climate change means dealing with more natural disasters - particularly those related to heat waves, flood and drought. Research has shown that much vulnerability exists not because of a lack of knowledge, but rather through a lack of application of it. The importance of behavioural adaptation has been emphasized many times in the hazards literature, along with the failure of structural mitigation measures that often make the ultimate cost of disasters worse (Mileti, 1999). There are technological approaches to dealing with all of these problems that tend to emphasize supply side economics (e.g. provide more power or water as it is demanded), but behavioural change that addresses demand can also be very effective and provide a series of co-benefits to society and the environment (e.g. conservation).

Perrow (1999) notes that while some technological fixes reduce error, others sometimes create new accidents or are used to justify riskier environments or to compensate for poor organization or system design - and when system failure occurs increased reliance on such support systems (e.g. power, water, air conditioners) can make a disaster all the greater. In fact, one of the driving forces that has been increasing social vulnerability to disasters is increased reliance on technological support systems.

Canada has the knowledge and technology to solve most current environmental problems. Not doing so is primarily a result of an unwillingness to accept the constraints or costs of doing so. It can be argued that better technology will reduce constraints and therefore allow for better adaptation - but the problem with this argument is that many risks associated with technology continue to grow and outstrip benefits (Beck, 1992) and we require increasing amounts of ingenuity to deal with these new hazards (Homer-Dixon, 2000). Thus, from a philosophical perspective reliance upon technology sets up a vicious circle, where new technology creates new risks that then require new technology, and so on. Successful adaptation requires breaking out of this negative cycle.

Albert Einstein said "Today's problems cannot be solved by thinking the way we thought when we created them." The traditional paradigm of technological-fix is not likely to solve problems created by technology, where those problems are human-centered.

Another issue with the techno-fix solution is that it is based upon the idea that the problem is external to people - like the notion that natural disasters are caused by nature. Walt Kelly might have been responding to this concept when he said "We have met the enemy and he is us." Recent thought has moved away from this notion - for example, the paradigm of natural disasters has shifted from one that was largely fatalistic to one that recognizes their occurrence primarily as a result of human activities that create vulnerable communities - putting the locus of control within the human sphere. This shift allows for proactive actions on the part of people to become more resilient. It is a worldview based upon self-empowerment instead of fatalism.

Vanderburg (2000) discusses the effect of technology on society, saying "Here we encounter the fundamental contradiction in technological and economic growth. At the micro level, we find technical and economic rationality; at the

macro level, technical and economic irrationality." The main problem is, he states, that micro decisions in these fields are primarily guided by measurable performance values that are incompatible with human life, society and the biosphere. It is like the tragedy of the commons, where maximizing individual benefits act to the detriment of the collective; thus - a global society that is unsustainable but still growing. What is needed is a shift from an 'economy of technology' to an 'ecology of technology' that "includes the consideration of undesired outputs, and the meaning and value of all inputs and outputs by means of which technology is embedded in, depends on, and interacts with its contexts". This shift requires a different worldview that emphasizes the subjective, environmental values and behavioural change.

Perrow (1999) notes that although technological fixes can be error-reducing they sometimes are used to increase performance values or are excuses for poor organization or poor system design, in which case they can increase risk. For example, Handmar (2000) noted that one of the main purposes of flood warnings in Australia is to justify development in flood-prone areas. This is an example of a problem that is human-centered and not solely addressable by a technological solution. It must be noted that a significant part of the increased vulnerability to extreme weather that has been observed in recent decades is a result of societies increased reliance upon technology and lifelines, and the consequences when complex systems fail in unexpected ways.

4. Synthesis

It was previously argued that choosing either a technological or a behavioural approach is a false dichotomy as adaptation will inevitably involve both to some degree depending on the impact. In fact, a technological approach tends to address supply side economics (e.g. providing more power or water to meet increasing demands that do not affect lifestyle or economic growth) whereas behaviour adaptation tends to address demand side (e.g. conservation), which can have a variety of co-benefits to society and the environment.

One example might be the use of appropriate technology as part of a strategy to address the root causes of vulnerability. As the most vulnerable populations tend to be the most poor, they are least likely to be able to afford a technological approach to adaptation. This argument is very much oriented

to the technological trends in industrial society where new technological innovations have allowed machinery to replace labour in the production process.

A fundamental tenet of microeconomic theory is that there are alternative means to achieve the same output utilizing different mixes of capital and labour. The theory assumes that the mix will be determined by the available budget. As budgets increase, the tendency is to increase the capital-to-labour ratio. At a meeting of geographers in 1984, Bass and Yapa (1984) argued that providing poorer populations with an appropriate level of technology, one that was geared towards local knowledge, needs and geography might provide a means to provide these populations with access to the means of production, thereby increasing their income and perhaps the political power of these populations. Yapa (2002) has shown that technologies that improve standards-of-living are willingly adopted, but their long-term success at reducing poverty will depend on the ability of the local population to purchase, understand and maintain them. Thus the role of technology in reducing poverty, and hence vulnerability is recognized, but this example also recognizes that the technology must be appropriate to the specific geographical context if it is to be adopted by the local population.

5. Conclusion

Immanuel Kant once said that "Science is organized knowledge. Wisdom is organized life." Adapting to a changing environment is not just a problem of science; it is also a problem of how people view their relationship to the natural world and how societies choose to live, the risks they are willing to accept and the actions they are willing to take to deal with those risks. Technology will undoubtedly play a large and important role, but by itself is not sufficient to solve the adaptation problem. Behavioural changes are necessary as well - indeed they are likely to be the more crucial factor.

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