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Editorial

Maladaptation

1. Maladaptation

Some degree of climate change is now inevitable, and so therefore is the need for responses to avoid its likely impacts. Yet adaptation to climate change is no easy matter: decisions may fail to meet their objectives, and they may even increase vulnerability. This problem of increasing risks from adaptation is often termed 'maladaptation'. We define and explain five key dimensions of maladaptation, which we then ground with reference to the example of responses to water stress in Melbourne. The five types of maladaptation can be used as criteria for evaluating decisions about adaptation.

1.1. The evolution of 'maladaptation'

Attempts to define and find measures of successful adaptation imply that adaptation can be unsuccessful (Adger et al., 2005; Doria et al., 2009). Indeed, as Adger et al. (2005) argue, given the spatial and temporal complexity of climate change problems and responses, it is likely that actions that are judged by one group to be successful adaptations will be judged by groups in other places and times as being unsuccessful. Yet unsuccessful adaptation need not mean that adaptation has significantly increased vulnerability—it may simply mean an action did not work. There is, however, the possibility that adaptation actions do positively increase the vulnerability of other groups and sectors in the future. Such outcomes have been referred to as 'maladptations'.

The earliest uses of the term maladaptation in the context of climate change include Smit (1993) and Burton (1997). Burton (1997) describes how policies and practices can be maladaptive if they increase vulnerability. Scheraga and Grambsch (1998) describe maladaptation as a situation where the negative impacts caused by adaptation decisions are as serious as the climate impact being avoided. The IPCC Fourth Assessment Report did not define maladaptation, although the earlier Third Assessment report did, defining it as 'an adaptation that does not succeed in reducing vulnerability but increases it instead' (IPCC, 2001, p. 990). The UNFCCC does not define maladaptation.

Descriptions of maladaptation are often accompanied by brief case studies that span a range geographical and temporal scales; ranging from the Sahel (Heyd and Brooks, 2009), to historical Norse settlements (Dugmore et al., 2009). They also cover a range of sectors, including agriculture, infrastructure, water management, and health (Reilly and Schimmelpfennig, 2000; Scheraga and Grambsch, 1998). Few of these examples describe in any detail how maladaptative practices arise.

Agrawal and Perrin (2009) caution that at present there prevails a simplistic view of maladaptation, which can lead to a false classification of actions as maladaptive. They give the example of the frequent classification of pastoralists' migration in response to drought as maladaptive, whereas detailed studies of these responses show that they are time honoured, rational, and routine responses to sustain livelihoods.

1.2. Definition and dimensions

Synthesising and extending insights from these previous definitions and studies, we define maladaptation as:

> *action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, or increases the vulnerability of other systems, sectors or social groups*

There are at least five distinct types or pathways through which maladaptation arises; namely actions that, relative to alternatives: increase emissions of greenhouse gases, disproportionately burden the most vulnerable, have high opportunity costs, reduce incentives to adapt, and set paths that limit the choices available to future generations. In order to show how these are manifest in practice, we explain these with reference to decisions to (mal)adapt to water stress in Melbourne.

1.3. Water management in Melbourne

Melbourne, the capital city of the State of Victoria, Australia, has experienced annual rainfall below the long-term average every year since October 1996. Since March 2008 the average level of storage in the city's reservoirs has been below 30% (Bureau of Meteorology, 2009). This situation is likely to become more acute under climate change, with streamflow and runoff both projected to decrease substantially (IPCC, 2007).

In 2007 the Premier declared that the State had a water crisis, recognising 'that climate change and record low rainfall demands a dramatic new approach to how we plan for Victoria's water needs'. He announced plans for two schemes: the Wonthaggi desalinisation plant with a maximum capacity of 150 GL/annum; and the Sugarloaf Pipeline Project to transport an additional 75GL/annum from the associated Northern Victoria Irrigation Renewal Project to Melbourne (Office of the Premier, 2007).

2. Five types of maladaptation

We define five types of maladaptation to climate change, and explain these with reference to the responses to water stress in Melbourne.

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2.1. Increasing emissions of greenhouse gases

This first type of maladaptation is well known, with the most oft-cited example being the increased use of energy-intensive airconditioners in response to the health impacts of heat-waves (Kovats et al., 2006). The problem with energy-intensive adaptation actions is that while they may address current needs, they create a positive feedback by increasing emissions of greenhouse gases, thereby increasing the likelihood that further adaptation to climate change will be required in the future. In the Melbourne water case, both the desalinisation and cross-basin water transfer scheme projects will consume large amounts of energy. The Wonthaggi Desalination Plant will lead to the emission of over a million tonnes of CO_2 equivalent gases, and its operation will produce over 900,000 tonnes of CO_2 equivalent gases each year (Mitchell et al., 2008). Proponents argue that the desalinisation plant will be carbon neutral because additional renewable energy capacity equivalent to the plant's energy demand will be added. This extra capacity will be equal to between 70 and 90% of existing renewable energy capacity, which could be used to reduce existing emissions if there were alternatives to the desalinisation plant.

2.2. Disproportionately burdening the most vulnerable

Adaptation actions are maladaptive if, in meeting the needs of one sector or group, they increase the vulnerability of those most at risk, such as minority groups or low-income households. For example, the Wonthaggi desalinisation plant will be located on thirteen sites significant to the Bunurong Aboriginal community, who vehemently oppose the development. Both it and the Sugarloaf pipeline project will impact disproportionally on poorer households in the form of higher water costs. The combined cost of both projects will be at least AU$4.25 billion, with the costs to be recovered through an estimated 11% annual increase in the cost of water delivered to users over the period 2009–2013 (Melbourne Water, 2009). These costs will impact disproportionately on poorer households, who pay a higher share of their incomes on water and power, and who do not have the same opportunities to reduce water use that wealthier households have for reasons of income and land tenure (Lee, 2007).

2.3. High opportunity costs

Approaches may be maladaptive if their economic, social, or environmental costs are high relative to alternatives. Both the Wonthaggi desalinisation plant and the Sugarloaf pipeline will have high social costs (described above), and environmental costs, for example the Sugarloaf Pipeline Project will lead to reduced flows in the already critically stressed Murray River (Davidson, 2009), and the desalinisation plant will adversely affect the local benthic marine environment (Mitchell et al., 2008).

A range of recent studies suggests that a combination of strategies can deliver large volumes of water and reduce demand at lower cost than the desalinisation and pipeline projects. Two of the most significant strategies are pumping wastewater treated to the highest standards in treatment plants into reservoirs, which would supply 42% more water than the desalinisation and pipeline projects combined at 60% of the cost (DSE, 2003); and increased use of rainwater tanks to supply water for gardens and toilets, which when installed in houses with large roof collection areas delivers water for less capital and operating costs than the planned alternatives (MJA, 2007). These, in combination with other policy measures, seem likely to be able to solve Melbourne's water problems for less money, and fewer environmental and social costs than the planned pipeline and desalinisation projects (Commonwealth of Australia, 2002; DSE, 2003).

2.4. Reduce incentive to adapt

If adaptation actions reduce incentives to adapt, for example by encouraging unnecessary dependence on others, stimulating rent-seeking behaviour, or penalising early actors, then such actions are maladaptive. Many households in Melbourne have taken action to adjust to water scarcity: some have invested in simple technologies and practices to recycle grey water and to capture rainfall, and many have changed their behaviours, for example by taking shorter showers, or by replacing non-indigenous plant species with natives better acclimatised to long dry periods. This suggests that there has been a distinct change in the social norms around water use—away from an excessive 'consumption' norm, to one focussed on responsible water conservation.

These changes have been achieved with simple and cheap policy instruments such as rebates on the purchase of rainwater water tanks and public education. The potential further effectiveness of such instruments, which encourages millions of water users to take responsibility for action, saves water users money, and creates powerful new norms, will be undermined by the desalinisation and pipeline projects, which transfer responsibility for responses to government, and will stifle the water conservation norm.

2.5. Path dependency

A major issue with large infrastructural developments is the way they commit capital and institutions to trajectories that are difficult to change in the future. Whilst in the past large infrastructure projects may have had some success, in the future such path dependent responses may lead to decreased flexibility to respond to unforeseen changes in climatic, environmental, economic and social conditions. In other words, expensive engineering responses such as are being implemented in Melbourne reduce the portfolio of adaptation options in the future. Of note here is the US$34 million desalinisation plant built in Santa Barbara in 1990, which has never been used due to ample rainfall since its construction. It is still maintained ostensibly as an 'insurance policy' (City of Santa Barbara, 2009), but more likely because it is a sunk cost.

3. Conclusions

Adaptation strategies may increase the vulnerability of other systems, sectors, or groups if they increase emissions of greenhouse gases, disproportionately burden the most vulnerable, have high opportunity costs, reduce incentives to adapt, or set paths that limit the choices available to future generations. These five pathways to maladaptation offer a basis by which adaptation decisions can be screened for their possible adverse effects. Each implies a question and a line of investigation that diligent policy makers could ask and seek answers to before committing resources to adaptation decisions.

The desalinisation and pipeline projects that Melbourne has committed to in response to water stress exhibit all five types of maladaptation. These projects might have been avoided were the five criteria for identifying maladaptations applied. A key lesson from this case is that maladaptation is likely given the time lag between changes in climate and changes in institutions.

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