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‘Drought Proofing’ Australian Cities: Implications for Climate Change Adaptation and Sustainability

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***Abstract*—**Urban water management in Australia faces increasing pressure to deal with the challenges of droughts, growing population and the climate change uncertainty. Addressing these challenges is an opportunity to incorporate the parallel goals of sustainable water management and climate change adaptation through holistic, non-technical means. This paper presents case studies from Perth and Sydney which show how despite robust adaptation plans and experience, recent efforts to ‘drought proof’ cities have focused on supply-side measures (i.e. desalination), rather than rethinking how water is used and managing demand. The trend towards desalination as a climate adaptation measure raises questions about the sustainability of urban water futures in Australia.

***Keywords*—**climate change adaptation, desalination, drought management, sustainable urban water management

I. Introduction

AUSTRALIA is often described as the driest inhabited continent, with one of the world’s most variable climates. Historically, periods of low rainfall were labeled as droughts, and considered to be deviant caprices of nature by European settlers accustomed to stable, predictable climates and plentiful rainfall. Dominant discourses of drought construct it as an enemy to be vanquished and misconstrue it as a natural occurrence rather than a socially constructed ‘fact’ [1]. This discourse extends into the of realm water policy, where age-old calls to ‘drought proof’ the continent perpetuated the myth that Australia’s variable climate could be conquered through technology and engineering projects, diminishing the need to adapt water use to natural limits [2]. The specter of drought as an enemy to be fought is further strengthened by the uncertainty of climate change. More frequent and more extreme droughts are predicted to be one of the major effects of climate change in Australia [3], and evidence indicates that climate change has already resulted in permanent alterations to water regimes in south west Western Australia [4]. Clearly, dealing with the uncertain impacts of climate change is a key challenge for policy makers and water managers in Australian cities. Adapting to climate change requires a holistic approach which looks beyond technical and structural means to increase resilience and minimize vulnerability to climate impacts [5]; [6]; [7]. This approach parallels the principles of sustainable/integrated water management, characterized by a shift to a more integrated and adaptive approach including reforms of institutions and integration of the social dimension [8]; [9]; [10]; [11]. These overlapping trends imply that adaptation to climate change could serve as a catalyst toward greater flexibility and innovation in the way we manage our water resources [12] and may speed the transition towards more sustainable urban water systems.

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Recent water management decisions in Australian cities confronting water scarcity and climate change uncertainty call into question the potential for climate change adaptation to leverage a transition to more adaptive and sustainable water management systems . The rush to ‘drought proof’ or ‘climate proof’ cities has resulted in expansion of supply portfolios, with only limited attempts at demand management and integrated urban water management (IUWM). The main innovation has been the introduction of large-scale desalination, valued as a ‘rainfall independent’ source of water. It is an attractive option for Australian cities confronting water scarcity because it easily fits into existing centralized systems and allows water managers to ease up on water restrictions during drought. Since 2005, desalination plants have been constructed in Perth, Sydney, and the Gold Coast and are planned for Melbourne and Adelaide. This paper will explore this phenomenon and its implications for sustainability using case studies of water management decisions in the context of climate-related drying of water sources in Perth and severe drought in Sydney. Water managers in both cities initially developed adaptive, flexible strategies to deal with water scarcity, but when push came to shove, settled on the technical fix of desalination, which was convenient to fit into the existing physical and institutional system and politically more attractive than taking action to reduce water demand.

Sustainable Urban Water Management

Advocates of sustainable water management argue in favor of a paradigm shift away from sole, or even primary reliance on finding new sources of supply to address perceived new demand [13] [8]. A sustainable/integrated water management paradigm focuses on reducing future water demands through more efficient use, considering ecosystem needs in water planning and management, and moving towards participatory, democratic, holistic, and integrated decision making which looks beyond purely technical solutions to reforms of institutions and deeper social and political issues [9-10]. Sustainability depends on the integration of economics, the environment and the social consequences into the planning and implementation cycle. Any transition towards a more sustainable or whole-of cycle approach will be governed by the wider socio-political system in which urban water is currently managed, in particular state government politics and demands [13]. This is a potential barrier to transition towards sustainability since decisions made in the timeframe of the electoral cycle do not sit well within the context of a long-run, sustainable approach to water management which should be based on time horizons of 20, 50 or 100 years.

Climate Change Adaptation in the Water Sector

Increased drought is predicted to be a symptom of one of the most pressing challenges to urban water management in Australia, global climate change. In some areas, a rise in average temperatures is predicted, which could increase evapotranspiration, resulting in greater amounts of moisture in the air and increased rainfall and frequency of heavy rainfall events. But in others, droughts may get longer or more extreme, floods may occur more often, and entire water regimes may shift [3]. The assumption of stationarity – the idea that natural systems fluctuate within an unchanging envelope of variability—has been a foundational concept in water resource engineering, but the impacts of climate change have forced a questioning of this assumption in water planning since observed fluctuations have increasingly deviated from historical ranges [14]. This poses a major challenge to policy makers and water managers to integrate this uncertainty into decision making.

Coping strategies must begin with trying to understand the potential consequences of climate change on water resources and to begin planning for those changes by designing water management systems that are more resilient to increased climate variability, changes in demand and demographic shifts which may result from climate change [5]. Climate adaptation in urban water management systems demands a revision of water infrastructure planning processes, but true adaptation goes beyond structural measures to include forecasting systems, demand management measures and behavioral change as well as economic instruments, legislation, and institutional change [6]. Adaptive capacity in water management has been described as the ability to cope with and adjust to uncertain future developments and potentially catastrophic disturbances like severe droughts [15]. This requires existing social structures – communities, institutions, and policy processes to be able to identify, analyze, prioritize, and treat climate risk [7].

Pahl-Wostl [16] observes that the challenge of dealing with climate change uncertainty is a further push towards an adaptive “management as learning” approach. Iterative learning about the ecosystem and earlier management successes and failures can increase present-day resilience, and can increase the ability to respond to the threats of long-term climate change [17]. However, adaptive management is constrained by institutional barriers to innovation. The dominant resource management paradigm “values activity, control, comfort, and clarity over reflection, learning, and embracing complexity and variability” [18]. While the goal of adaptive management is to maintain resilience (flexibility and ability to withstand change) within ecological and social systems, when institutions themselves are resilient to innovation, the opposite effects can occur. Resilient institutions contribute to the phenomenon known as the “lock-in” situation, in which existing infrastructures, consumer behaviors, and engineering practices and norms serve to stabilize each other, making them interdependent [19]. Lempert’s (2010) case study of climate adaptation in California illustrates the difficulty organizations can have in implementing such adaptive strategies in anything beyond an ad hoc manner [20]. The case studies presented in this paper illustrate these challenges to building adaptive capacity and resilience into Australian urban water systems.

II. BACKGROUND ON AUSTRALIAN WATER SYSTEMS AND INSTITUIONS

Historical Development

Urban water systems in Australia developed in an *ad hoc* manner until the late 19th century, when rapid population increases demanded more centralized planning and infrastructure development. The first site of European settlement at Sydney Cove took its water from the Tank Stream, a small rivulet which served as the settlement's main source of water for nearly 40 years [21]. As population grew, new sources were developed, often in response to periodic droughts which threatened to dry up supplies. Sydney's water use in the 19th century was characterized more by mistakes than lessons learned, but although three vital sources of water were progressively exploited and destroyed, there was always more water to be had farther out [22]. These *ad hoc*, decentralized responses gave way to centralized management in 1888, when the Sydney Board of Water Supply and Sewerage was established to develop, maintain and protect the city’s water supply and sewage system. From this point on, a big-pipe engineering approach became the dominant paradigm and saw the development of the current supply system, a network of dams spread across five catchments. The pattern in Sydney was repeated in Australia’s other major cities, resulting in urban water systems made up of centralized infrastructures designed to serve the aims of providing potable water, sewage disposal, and storm water drainage. This was the best practice of the day, and similar systems were established in Western cities around the world.

As populations in urban centers grew throughout the 20th century, water management increasingly relied on measures to increase the availability of fresh water to meet ever-growing demand and support increased economic growth, most often the construction of dams, but also groundwater where it was more convenient to obtain. These water developments were guided by an engineering ethos which prioritized increasing supply and promised technical solutions to all water resource problems. While some reforms have been made in the past two decades, the conventional urban water management scheme of 'big-pipe in, big-pipe out' has continued to serve the basic needs of potable water provision and conveyance of wastewater and has thus largely remained the dominant model for water planning. In the meantime, however, increasing concern about economic efficiency and the environmental impacts of conventional water systems have increased the scope of water management priorities. Although the conventional system was sufficient for much of the country's history, in the past twenty or so years, it has become apparent that current systems cannot cope with both extreme drought conditions and projected increases in urban population [23]. The challenge for water managers is how to guarantee secure water supplies into the future without the option of building new dams, which has been ruled out for environmental reasons and a lack of appropriate sites. The historical approach of supply-side management focusing on big engineering projects has created an unsustainable urban water system which reinforces wasteful practices, thereby driving the demand for increased supply.

Institutional Reforms

Recently changes have been made to Australia's water institutions impacting the way they handle water scarcity, salinity, cost-recovery issues and droughts [24]. The 1980s and 1990s saw the maturing of the water economy as the reality of an inelastic supply of new water and the need to maintain and rehabilitate aging projects set in [25]. The focus of water policy and management shifted away from large-scale infrastructure projects towards economic efficiency and to a lesser extent, ecological sustainability. In 1994, the Council of Australian Governments (COAG), (a policy making body comprised of leaders of all Australian states and territories and the federal government) agreed to a water reform framework aimed at achieving efficient and sustainable urban and rural water industries. The reforms included improved productivity, reduction of state subsidies, user-pays pricing reforms, full cost recovery, separation of policy and provision, use of market and property right mechanisms, promoting community participation and provision of flows to the environment [26]. The COAG reforms drew upon both neoliberal political philosophy and neo-classical economic theory. Water management agencies were now encouraged to think more like private corporations rather than public utilities. In Sydney and Perth, the statutory water management agencies were reorganized as state-owned corporations. Under the new social and institutional logic, economic efficiency became an underlying imperative, citizens became consumers, and previously inflexible and wasteful agencies were made more like the idealized private firm [23].

In the ecological sphere, the COAG reforms included recognition of the environment as a legitimate water user through the introduction of mandatory environmental flows. State/Territory Governments were directed to legislate when necessary and reform institutions to ensure that: water would be allocated to the environment; environmental costs would be included in water pricing; and the guidelines of a National Water Quality Management Strategy could be effectively implemented [27]. The next major reform came in the form of the National Water Initiative (NWI) in 2004. The National Water Initiative is a new philosophical approach to water management [28], with the key imperatives to "increase the productivity and efficiency of Australia's water use, the need to service rural and urban communities, and to ensure the health of river and ground water systems by establishing clear pathways to return all systems to environmentally sustainable levels of extraction" [29]. Although the NWI put environmental sustainability into the guiding framework for all water-related policy and legislation, it also continues the neo-liberal philosophy of reliance on market-based instruments and the imperatives of efficiency, productivity, and a limited role for government [26].

Approaches to Drought

Despite an increased understanding of climatic variability after several hundred years of settlement, the concept of drought is still a potent factor in the water management discourse and the Australian psyche. Historically, drought has been perceived mainly as a "rather tiresome quirk of Australian weather" rather than a permanent feature of the climate [30]. Facing the practical challenges of ensuring water supplies, water authorities have interpreted drought in relation to is impact on inflows to water supplies rather than the exogenous natural occurrence of less than average rainfall. The NSW Government *Metropolitan Water Plan* defines drought as:

> a period of time when the water stored in the reservoirs, plus anticipated or forecast inflows, is considered to be insufficient to meet current or future unrestricted demand (that is, demand that has not been reduced via the imposition of drought restrictions) [31].

This definition acknowledges drought as a situation stemming from a mismatch between the amount of water assumed to be available in the future and the amount assumed to be needed. The status of drought relies on the socially determined variable of demand; it is not something that happens independently of anthropogenic use of water. To address this mismatch, drought management strategies thus tend to assume a 'precautionary risk-based' approach in which drought is defined and managed to avoid the risk of water shortage and disruption to public supply [32]. Responding to drought in Australian urban areas has been a necessity since these cities were first settled. Droughts were the impetus which initiated the construction of large storages, with the view to ensure adequate supplies long-term throughout future periods of low rainfall. Water use restrictions in the form of hosepipe bans were first introduced as a drought response measure in Melbourne, Victoria, in the 1860s [33].

Policy makers facing drought and more recently, climate change, have framed their responses as 'drought proofing' or 'climate proofing' strategies which will protect water systems from the potentially disruptive effects of climatic variations (see [34-35]) . These concepts can be problematic because they imply that such a goal is attainable with the availability of new forecasting tools and techniques in the new understanding of the workings of the climate system, In addition, they can raises false hopes which are only squashed by the next surprising climate or weather anomaly [36]. Promises to ‘drought proof’ a city also bring an implied threat that the current system might not be able to withstand a drought, creating an atmosphere of fear and panic among the public and a sense of urgency to do something tangible. Water managers have an imperative to provide a secure water supply for a city’s population, but the concept of drought proofing frames drought as an external enemy to be conquered through technical means, rather than a natural occurrence that may require modification of how water is used.

III. Responses to Drought and Climate Change – Case Studies from Perth and Sydney

Perth – Australia’s Thirstiest City Gets Drier But Stays Green

The first case study focuses on the experience of Perth, Western Australia in adapting to multi-decadal drought which was eventually determined to be caused by climate change. Perth has been described as Australia’s ‘thirstiest’ city and indeed compared to the other capitals it has the highest domestic water use per capita – at 289 litres per person per day, twice that of Brisbane or Melbourne. The city is served by the Integrated Water Supply Scheme (IWSS), which supplies water to 1.6 million of the 2 million people living in Western Australia. The scheme takes water from two major sources: surface water from storage reservoirs on rivers in the Darling Range, and groundwater pumped from natural aquifers. Traditional approaches to drought management have been based on using groundwater resources to substitute for more variable surface water [33].

In Perth, as in most Australian capital cities, most domestic water consumption is used outdoors. Approximately 70 per cent of the water supplied is used domestically and 50 per cent of that is used in household gardens [37]. In addition, about one household in five has a swimming pool, a proportion unlikely to be exceeded in any other capital, except Brisbane [38].

Beginning in the 1970s, water planners in Perth were confronted by an abrupt, ongoing decline in winter rainfall, which led to decreases in inflows to both surface and groundwater sources. Throughout the 1980s, decision-makers responded cautiously to these dry conditions which were viewed as an unfortunate run of dry years. Acting on scenarios which predicted continued declines in rainfall were, water managers adjusted water yield expectations by ‘de-rating’ the supply capacity of the IWSS by 13% [37]. This reduction in estimated long-term mean annual inflow required adjustments to strategic planning criteria leading to earlier development of new water sources and continued promotion of demand management [39]. The late 1970s saw the introduction of user-pays pricing with a fixed service charge and a pay-for use tariff for household consumption above 150 kl per annum, and in 1977-78, Perth was subject to a complete ban on sprinkler irrigation. Both of these reforms had an immediate effect in lowering demand [40]. By the mid-1980s, per capita use had decreased to about 170 kl per year from its peak of 233 kl/year in 1975, and about 30 per cent of domestic customers had installed private wells to irrigate their gardens [40].

Continuation of dry conditions necessitated further incremental downwards adjustments to the assumed yield of the water system between 1987 and 1995. A turning point came in 1996 at a stakeholder workshop on regional climate variability and water resources. The workshop raised the possibility that the drying pattern was the result of non-linear jumps in decadal climate variability, rather than simply an extreme run in a random process. It was not clear when or whether the climate would ever return to ‘normal’. The possibility of a permanent shift meant water supply systems designed to fit previous statistical paradigms, were at risk of falling short and requiring protracted strings of restriction years which were socio-politically unacceptable. To avoid this risk, water managers were forced to adopt the previous 20 years as the new design baseline for surface water sources at a cost of $500 million [7].

Climate research in subsequent years concluded that both the rainfall decrease and warming were likely caused by the anthropogenic greenhouse effect [37]. The overall impact of climate change in southwest Western Australia in the past three decades was a reduction in dam inflows of at least 50% [4]. Perth was one of the first cities in the world to be confronted such a drastic shift in hydrologic regimes, which posed a major challenge for water managers. Through adaptive incrementalism and strategic planning, major crises were successfully avoided without resorting to the politically unattractive measure of severe water restrictions [39].

This experience drove home the need for close coordination between climate scientists and water managers which led to the formation of the Indian Ocean Climate Initiative (IOCI). The IOCI included the CSIRO (Commonwealth Science and Industrial Research Organization) and the Bureau of Meteorology partnering with State agencies to develop effective seasonal forecasts, improved understanding of climate variability. The IOCI became a key vehicle for assisting decision making and adaptation in climate affected sectors of southwest Western Australia [4]. IOCI research provided a strong foundation for policy development and support for actions taken by the Western Australia Water Corporation to adapt to long-term drying of water sources.

In response to IOCI's predictions that even under the best-case emissions scenarios, southwest Western Australia will be drier and warmer, leading to further decreases in system inflows, Water Corporation ultimately decided to build Australia's first desalination plant to increase security of supply. In its 2005 water supply development plan, Water Corporation states that desalination is "the only alternative assured of delivering 45 GL pa to the IWSS by 2009/10" and plans are underway for a second desalination plant. The strategy is clearly a step towards 'climate proofing' the region, using desalination as an essential tool to this end. The report explains that "within the context of a drying climate, the Corporation now considers desalination as the 'yardstick' against which other source options should be evaluated" [41]. Perth's desalination plant began operating in 2006. Located 25 km south of Perth, the reverse osmosis plant produces 140 ML per day, providing 17% of IWSS needs [42]. This makes it the single largest source of water for the city. The Kwinana plant has been touted as a "world-leading model for future sustainable seawater desalination plants globally" [43], since it relies on renewable energy from the newly constructed 82 MW Emu Downs wind farm for all the power needs of the plant, equivalent to the amount consumed by 30,000 homes [44].

The case of Perth demonstrates the complex challenges climate adaptation presents for water managers and the importance of accurate and timely input from climate scientists to inform decision making. For nearly three decades, crisis was successfully avoided through incremental adaptation of the water system and careful strategic planning. However the overall strategy focused on developing new sources of supply, with the constant priority of avoiding politically unpopular water restrictions. This imperative to avoid restricting outdoor water use implies that Perth is truly Australia's thirstiest city from both the supply and demand perspectives. Outdoor water consumption in Perth is approximately 173kl per household compared to 73kl per household in Sydney [38]. Not only do Perth's residents use more water outdoors, they also appear to be especially averse to restrictions on outdoor water use. A recent study found that Perth households are willing to pay 20 per cent more on their water usage bill to be able to use their sprinkler up to three days a week, and would rather pay up to 40 per cent more to finance a new source of supply instead of enduring severe water restrictions [40].

Given this situation it is not surprising that in comparison to other Australian cities, water conservation efforts in Perth appear lax. Despite having the highest per capita water consumption among Australia's capital cities, drought restrictions in Perth are the least severe, permitting sprinkler irrigation and unlimited watering with hoses [45]. Regulations on sprinkler use restricting irrigation to daylight hours only were introduced in 1996, and current water restrictions permit use of sprinklers to two days per week for IWSS customers, although hose watering is allowed at any time [46]. In 2010, in response to water usage figures showing a 9 billion liter increase in water usage, a permanent ban on sprinkler use in winter (when Perth receives most of its rain) was introduced, after a two-month trial ban effectively boosted dam levels and was supported by 93 per cent of the community [47]. While it is encouraging that the wasteful practice of winter sprinkler use has been curtailed, the fact that it took this long to enact such an obvious policy demonstrates the reluctance of water authorities to take on demand management.

The current struggle to change water use behavior is the result of years of decisions to focus on increasing supplies rather than encourage conservation and water sensitive gardening. This entrenchment of wasteful domestic consumption patterns makes dealing with climate-induced scarcity more difficult and more expensive. One of the major factors in the decision to build the desalination plant was the need to avoid a sprinkler ban. Apparently, questioning the right of Perth residents to have lush, European-style gardens year-round is just too politically risky. Thus, the climate adaptation trajectory in Perth appears to be one of 'climate proofing' through desalination plants, which come at no small cost to society and the environment. Fuelled by a booming economy population growth in Perth is forecast to continue at 1.7 per cent per year, and water demand in the region is expected to double in less than 50 years [40]. In response to these pressures, a second desalination plant is already under construction and scheduled to begin operation in 2011. Some scholars have argued that this second plant may the result of deliberately pessimistic interpretation of future climate to justify larger and earlier investment in desalination technology [48].

Desalination as 'Drought Proofing' in Sydney

Sydney has historically relied on capturing surface runoff in its network of reservoirs to supply its water needs, with 80% of its water needs being met by Warragamba Dam in the Blue Mountains. Rainfall in Sydney's catchments has always been highly variable, with periodic occurrences of severe drought, often followed by flooding rains when the drought breaks. Drought became a major concern once again in 2002, when dam storages began to fall steadily. The perception of drought quickly led to a crisis atmosphere. In 2004, the NSW Government's *Metropolitan Water Plan* examined available supplies and demand projections and estimated that if no actions were taken, Sydney would face a large deficit over the next 30 years. This case study focuses on the NSW Government's decision to build a desalination plant in Sydney during the 2002-2007 drought. The desalination option was initially presented as an emergency drought response, but was then promised "drought or no drought" by the NSW Premier. When this stance proved politically unpopular, desalination once again became a last resort option under a 'readiness' strategy of advanced preparations for desalination while delaying actual implementation until storages hit a trigger point of 30% of capacity. The 2006 Metropolitan Water Plan, which lays out the 'readiness' strategy reflects a mature approach to water management and drought risk designed to minimize vulnerability and improve system resilience without preemptively committing to build expensive supply infrastructure. However, in the run up to the 2007 State election, as storage levels fell below 35%, the NSW Government announced it had called for tenders on the desalination plant project. In the end, despite the well-designed 'readiness' strategy, the rush to 'drought proof' the city saw the desalination plant initiated before the trigger point of 30% of storage had been reached. Immediately after the decision was taken, the rains returned and Sydney was no longer at imminent risk of running out of water.

Sydney's water supply system was designed to respond to extreme climatic variability. The system consists of a network of dams comprising one of the largest domestic water supplies in the world, able to store four times as much per capita as New York's water supplies and nine times as much as London's [49]. Drought was not been a major problem for Sydney since 1960, when Warragamba Dam (which provides 80% of Sydney's water) was completed, until the 1992-1998 drought, which was managed through education, restrictions, and increased supply from transfers from Tallowa Dam in the Shoalhaven catchment. There was also a plan to investigate the option of building a new dam at Welcome Reef to expand the supply network, but this proved politically unpalatable due to the associated environmental impacts. Following this drought, Sydney Water's *Drought Response Management Plan 2002-2012* proposed a series of processes that would be put in place in the next drought, including five restrictions levels, triggers, and targeted demand reductions [33]. Demand management and water conservation have resulted in Sydney using the same amount of water now as in 1974, even though the city's population has grown by one million.

Daily per capita water use in Sydney fell from 506 L in 1990-91 to 342 L in 2004-05. The substantial decrease in demand is primarily due to stronger mandatory water restrictions, but also recycling and education campaigns, as well as a major effort to fix leaking pipes across the metropolitan area.

Desalination was first proposed as a potential drought management measure in the first *Metropolitan Water Plan (MWP)*, which replaced the *Drought Response Management Plan* in 2004. This document laid out a new strategy to deal with the drought and a long-term strategic plan for Sydney's water management in compliance with National Water Initiative reforms. The 2004 MWP announced a commitment of $4 million for planning and design of a desalination plant "to ensure that, if the drought continues beyond another two years, a desalination plant for Sydney could be constructed relatively quickly and efficiently" [50]. As the drought continued and mandatory restrictions were increased, the NSW Government came under increasing pressure to do something in response.

The conventional option of building a new dam at Welcome Reef in the Shoalhaven Catchment had already been deferred indefinitely by the Carr Government, and the proposed site turned into a nature reserve [51]. In any case, a dam would take too long to construct and fill in order to be of much use during an extreme drought. Transfers from the Shoalhaven Catchment began in 2003, and increased as the drought continued, supplying up to 600 GL to Sydney as an emergency boost to water supplies. In July 2005, Premier Bob Carr announced that a plan for a $2 billion desalination project which would be located at Kurnell, south of Sydney. However the project would only proceed if dam levels continued to fall for another two years.

At the time this announcement was made, storage levels in Sydney's dams (including Shoalhaven transfers) were holding steady at 41% of capacity [52]. Sydney had been in drought since 2002, and dam levels had been falling slowly but steadily since then. However, because Warragamba Dam is such a large storage and the other smaller dams receive more rain, even with only 41% of total system capacity, Sydney had at least two years of supply left, in a worst-case scenario of no rain. Water restrictions up to Level 2 had successfully reduced demand – with an average 12 per cent reduction since 2003 [53]. The introduction of Level 3 mandatory water restrictions in mid-2005 promised to reduce demand even further and allow Sydney to ride out the drought, at least in the meantime.

In August 2005, Morris Iemma took over as Premier of New South Wales and announced that "Sydney needs a new source of clean drinking water, drought or no drought" [54]. This was a clear shift from Carr's promise to build a desalination plant only if the drought continued and worsened. Iemma's promise to build the desalination plant regardless of drought conditions appears to have been a political move to garner support and assert his decisiveness as a new and untested Premier. However, the NSW Government's commitment to desalination regardless of drought conditions proved unpopular with the public. A 2005 Newspoll survey found that 60 per cent of Sydney residents opposed the decision to build a desalination plant and would rather see investments in water recycling and reuse [55]. This attitude was shared by former head of Sydney Water, Bob Wilson, who observed that the desalination plant was addressing the shortage with "a big engineering solution" when a host of small initiatives - such as expanding Sydney's level of recycling - would be more logical [54].

Perhaps in response to public dissatisfaction, in February 2006 the NSW Government announced a new approach to drought management in the *Metropolitan Water Plan Progress Report*, ahead of the 2006 *Metropolitan Water Plan*, which was released in May of that year. This report introduced a new strategy to "drought proof" Sydney using newly-discovered groundwater resources as well as a new approach to desalination. Rather than committing to the project 'drought or no drought', the new 'desalination readiness' strategy was to maintain the capacity to construct the desalination plant only when it is actually needed, rather than building it pre-emptively. The report explains that if preparations are made so that construction can be initiated at a trigger point of 30% of storage capacity, only 26 months will be required to complete a desalination plant [34]. This allows for more flexible management of existing sources under uncertain climatic conditions and greatly reduces the risk of pre-emptively investing billions of dollars on an infrastructure which may prove to be unnecessary.

The 2006 MWP included this strategy as part of an "adaptive" plan to meet supply-demand balance with a diverse portfolio of supply and demand measures [31]. This approach would re-evaluate the question of how best to meet the supply-demand balance every five years, giving water managers the capacity to respond to circumstances as they change, take advantage of new information and technologies as they emerge, and avoid costs by deferring investment until it is needed [31]. The 2006 *Metropolitan Water Plan* represented an innovative strategy of drought management which sought to increase resilience in the system while pursuing increased demand management and avoiding unnecessary construction of big infrastructure projects. Although preparations for building the desalination plant continued in 2006, official policy was to initiate implementation (by calling for tenders) only when storage levels hit the trigger of 30%.

Political factors ultimately pushed forward the implementation of the MWP's adaptive 'readiness' strategy. In early February 2007, two months out from the NSW State election, Premier Morris Iemma vowed that he would "not let Sydney run out of water" and revealed that tenders had been called for the desalination plant project [56]. At this juncture, dam levels were approaching the 30% trigger point of the desalination readiness strategy, dipping to a low of 33.9% on February 8th, 2007 [57]. The announcement was clearly meant to garner support among voters seeking certainty and action in the face of the most severe drought experienced in the past century.

This decision abandoned the adaptive 'readiness' strategy – the desalination project would go ahead even though storage levels had not hit the trigger of 30%. In fact, after hitting the low point of 33.8% in early February, system storage levels began to rise, reaching 57% by mid-July, when the contracts for the desalination plant project were executed between Sydney Water and the winning consortium [58];[59]. In an apparent moment of panic, the NSW Government committed to a $2 billion Sydney desalination project, to deal with a drought that ended long before the plant began operation in 2010. At 250 ML/day (90 GL per year), the Sydney desalination plant is nearly twice the size of the one in Perth, and like Perth's its energy use is offset by renewable power generated by a wind farm. The project resulted in a $110/year increase in domestic water bills for Sydney residents [60].

This case study shows how political expediency and institutional inertia can lead to an inefficient decision to building an expensive infrastructure before it was actually needed. In its headlong rush to 'drought proof' the city and solve the perceived water crisis, the NSW Government ignored expert advice and its own adaptive plan to deal with drought and the uncertain future posed by climate change. For the NSW Government the quick-fix of desalination provided a simple response to Sydney's water shortage – not only as a campaign platform but also in terms of implementation. Constructing a 'water factory' pre-emptively was costly, but apparently preferable to closely adapting to changing climatic conditions by investing more in demand management, increasing recycling, and occasionally enacting high-level water restrictions.

IV. Discussion – Desalination, Climate Adaptation and Sustainability

These two case studies demonstrate the importance of socio-political factors in shaping climate adaptation and drought management policies. In Perth, the reluctance (or inability) of decision makers to restrict outdoor water use behaviors constrained the adaptive response to increasing supply through desalination. In Sydney, the NSW Government abandoned its own adaptive and robust drought management plan due to political considerations. The risk of appearing to be doing nothing (by following the 'readiness' strategy and waiting until it was absolutely necessary to build a desalination plant) outweighed the risk of pre-emptively investing $2 billion in a potentially unnecessary infrastructure project. In both these cases, extreme water scarcity presented an opportunity to re-evaluate existing water systems in the context of sustainability and adaptive capacity, and efforts were made in this direction. However, the perceived socio-political challenges of selling adaptation the public and enacting behavioral change led policy makers back to the conventional path of augmenting centralized supplies. The examples presented from Sydney and Perth illustrate the limitations of 'drought proofing' and 'climate proofing' concepts in water planning. Not only do these concepts support a narrow problem definition of absolute water scarcity, they portray elimination of climate risk as an attainable goal (through technical means) rather than an ongoing process of adaptation of both technical and social systems.

This study concludes that desalination does not further true climate adaptation or sustainable urban water management. Although independence from rainfall makes it a 'climate proof' water supply solution, it reinforces the institutional tendency towards reliance on supply-side solutions. Desalination distracts from the need to address the demand side of the equation and the need to build adaptive capacity and resilience into urban water systems through an integrated, whole-of cycle approach. The high level of certainty it provides to policy makers confronting uncertainty implies that it will remain an attractive option for climate adaptation. It also caters to the edifice complex of institutions and politicians and provides opportunities for a new stream of contracts to the infrastructure industry, which only adds to its appeal [44]. Desalination plants are being rapidly adopted as a 'drought proofing' measure not only in Australia but throughout the world, and it is worth questioning whether they may doing more harm than good by locking in unsustainable patterns of water management and narrow climate adaptation trajectories.

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