

## **Modernist Infrastructure and the Vital Systems Security of Water: Singapore's Pluripotent Climate Futures**

*Jerome Whittington*

The anticipation of climate change as matter for urban planning has precipitated a substantial return to large-scale infrastructure development. Major development banks now routinely frame classical development interventions such as roads, dams, or power grids with a climate change rationale, while developing country governments are busy setting up bureaus to access Green Climate Fund monies, which, in the United Nations climate negotiations, have been promised on a par with current development aid spending (on the order of \$100 billion per year by 2020). Urban design has followed suit by taking climate change as a framing logic for frequently large-scale urban infrastructure and construction programs, such as Bangkok's \$12 billion flood control spending package or Jakarta's plans for a vast redesign of its coastal seascape (Whittington 2013; Goh 2014). Built in low-lying floodplains, such postcolonial cities have become paradigmatic of a unique historical conjuncture that brings together global capitalism, localized ecological processes such as land subsidence or urban hydrological transformation, and the longer-term trajectories of a climate changing in unpredictable ways. Singapore likewise has been hailed as a model of urban climate change planning due to its long-standing commitment to detailed urban planning and precise (if sometimes authoritarian) implementation (Chua B. H. 2011). Asian processes of urbanization are constituted by what Aihwa Ong (2011: 10) calls heterogeneous "milieus of intervention" including in Singapore's case a powerful demand for reordering nature and a revitalized modernist vision of infrastructural urbanism. But to what extent can an infrastructure predicated on

## Public Culture

the wholesale reordering of nature adequately grapple with the uncertain possibilities of a planet warming at a historically unprecedented rate?

In this article, I consider the main features of Singapore's urban water infrastructure adaptation to climate change forecasts in order to stress the unique kind of problem climate change represents to cities and their management. Planning discourses in the early 2000s assumed major climate change impacts were to be expected at some point in the relatively distant future. However, a shift in perspective accompanied major climatic events such as the European heat wave of 2003 or Hurricane Katrina in 2005 and was further confirmed by events as diverse as the grain market crisis in 2007–8; historically unprecedented drought and forest fires in Syria, Texas, Russia, Australia, and California; precipitous Arctic ice loss; catastrophic flooding in Thailand in 2011; and “superstorm” cyclones Sandy and Haiyan. Typhoon Haiyan was historically perhaps the largest directly observed storm to make landfall (Daniell et al. 2013). Increasingly, the *de facto* scale for contending with environmental disasters is the urban, and city governments have raced to grapple with the shifting timescales in which climate change runs up against long-term localized ecological changes to multiply existing urban vulnerabilities.

By viewing urbanization processes as emergent within a unique historical conjuncture, this research draws on the concept of vital systems security (Collier and Lakoff 2008, 2014) to foreground the modes of governmental reason, including urban planning, which incorporate specific repertoires of knowledge to anticipate and manage unprecedented futures. Urbanization in Singapore or New York is viewed not simply as an outcome of abstract world-historical processes such as capitalism or climate change. On the contrary, as Bruce Braun (2014: 58) argues, urban resilience infrastructure maintains and expands the apparatus of power through which life is imbricated with state and capital. Cities and their attendant planning practices form a site in which planetary-scale ecology and biopolitical processes of urbanization are dynamically and mutually interrelated.

The sections that follow describe the basic role of Singapore's vital systems security commitments for planning and implementing its climate adaptation agenda for water infrastructure. Situating environmental and climate planning within the country's history of postcolonial urbanism and securitization, I show that the three core adaptation infrastructures for water—water supply, coastal protection, and flood drainage—each can only be understood in terms of the island nation's approach to population security taken broadly. For example, since Singapore imports a large proportion of its drinking water from Malaysia, water supply diversification has the clearest military resonances of the three. But coastal protection and flood drainage also demonstrate key features of Singapore's long-standing

politics of security and emergency. Vital infrastructures and their attendant political logic of security draw into relief the way emerging threats like climate change are constituted by uncertainty (Mayer 2012; Whittington 2013, 2016). Invoking a biomedical metaphor, I introduce the idea of pluripotential climate futures as a critique of Singapore's deterministic engineering for future climate risks and its centralized control approach to adaptation planning. Singapore's planners assume that forecasted climate changes will be limited to small, quantitative increases in set variables (temperature, rainfall, sea level rise) and, by placing too much confidence in deterministic predictions of what climate change will turn out to be, fail to consider the likelihood of potentially nonlinear or chaotic impacts on vital systems security (see NCCS 2012; MEWR 2014). The error is particularly blatant when the government, economically dependent on fossil fuel industries, has plans for a 60 percent increase in national carbon emissions to at least sixty-five metric tons from 2005 to 2020 (NCCS 2012; my calculation).<sup>1</sup> I am not arguing that climate change will turn out to be catastrophic or that we should be convinced *prima facie* of worst-case scenarios. Rather, pluripotentiality describes a situation in which prediction and control *per se* of the burdens of climate change cannot be taken for granted.

### Vital Systems Infrastructures

Stephen J. Collier and Andrew Lakoff (2014) identify vital systems security as a “general diagram” of governmental power that emerged in the context of Cold War planning in the twentieth century. To extend and deepen discussions of risk and complex sociotechnical systems (Beck 1992; Barry 2001), they develop the concept of preparedness (Collier and Lakoff 2008; Collier 2008, following Foucault 2007) as a political rationality in which a conventional understanding of risk as social insurance can no longer provide a guide for the governmentalization of society. Among other things, there is a shift in emphasis from the population as the object or target of power toward what they call vital systems such as food, fuel and water supply, critical industries, transportation and communication, health care, and so forth. As a rationality of governmental preparedness, vital systems security emerged in the context of what they call a period of biopolitical urban-

1. Emissions in 2005 were 41 metric tons; the 2020 business as usual projection is 77.2 metric tons (NCCS 2012: 35, 43). Industry and nonhousehold building emissions account for 74.1 percent of the projected increase; transportation, which includes domestic maritime and commercial travel, accounts for another 14.5 percent. The government of Singapore consistently represents this as an emissions reduction.

## Public Culture

ization (Collier and Lakoff 2014: 21–22; Foucault 2007: 63–65) in which cities' support of biological life increasingly came to be understood as thoroughly dependent on complex webs of industrial production vulnerable to systemic disruption. While drawing on Ulrich Beck's (1992) understanding of risk society, they depart from Beck's arguments about antitechnological or precautionary subpolitics in order to emphasize a biopolitics "designed to assess the vulnerability of vital systems and to ensure their continued functioning" (Collier and Lakoff 2014: 22). Indeed, one early site for development of vital systems security as a mode of operational practice was strategic military planning in the context of World War I. Assessing urban vulnerabilities required an expert rationality of determining which systems were indeed vital—a view of "the national economy as a complex of vital systems" (ibid.: 26) in which specific forms of expertise are developed to determine what infrastructures are critical given extensive systemic interdependency.

The vital infrastructures concept provides a tool for analysis of the political technologies of vulnerability surrounding issues like emerging infectious diseases, climate change, or terrorism (Aradau 2010; Grove 2014; Fearnley 2008). Climate change vulnerabilities, like other hard-to-anticipate emergent threats, can be viewed as a constitutive process of urbanization to the extent that they bear on the built form of the city, whether through direct impacts or strategies of planned preemption. Vital infrastructures, with their clear biopolitical stakes, therefore provide a useful contrast with discussions of vernacular infrastructural materialities (e.g., Graham and McFarlane 2015). Collier and Lakoff would concur with the view of "infrastructure not just as a 'thing,' a 'system,' or an 'output,' but as a complex social and technological *process* that enables—or disables—particular kinds of action in the city" (Graham and McFarlane 2015: 1). However, the issue here is not to describe a "kind of mentality or way of living in the world" (Larkin 2013: 331) in which daily life is structured by built form but rather to describe biopolitical dependency as part of the urbanization process. Major environmental disasters like the Bangkok flooding of 2011 or the devastation of Tacloban, Philippines, by Typhoon Haiyan, demonstrate the "relational infrastructures" described by AbdouMaliq Simone (2015: 20), and their limits, in which people must use "the very bodies of household and kin to hedge against uncertainty." If infrastructure composes a repertoire of possibilities, vital infrastructure is a repertoire for the maintenance of biopolitical life carefully guarded by a security apparatus and yet conspicuously inadequate in certain catastrophic events.

Vulnerabilities are built into cities both for how vulnerability planning systematically modifies the urban landscape and for how urban systems render specific

populations vulnerable.<sup>2</sup> Vital systems security involves a different technology of risk analysis than social insurance in the sense of a risk probability distribution. *How* pervasive vulnerabilities are constituted as problems is essential to engaging with those vulnerabilities. Nuclear preparedness was among the first of a series of catastrophe planning situations that required simulation or scenario-based reasoning about potential futures with no analogies in past experience. Emergency preparedness, environmental disaster, critical infrastructure vulnerabilities, and infectious disease preparedness all formed fields of biopolitical power in which “managing uncertain threat[s]” required “the imaginative enactment of a catastrophic future event using scenario-based exercises” (Collier and Lakoff 2014: 26). Put differently, infrastructure design and planning, and its modes of anticipating uncertain futures, provides a diagnosis of the political stakes of climate change itself.

In this article, I place Singapore's climate strategy within the context of the island nation's postcolonial urbanism and its history of perpetual environmental transformation. Singapore's climate policy is orchestrated through the National Climate Change Secretariat and a prominent interministerial committee. The national strategy takes its public form in a comprehensive 2012 document (NCCS 2012) that justifies the limited approach to mitigation combined with interest in high-tech business opportunities and its thoughtful adaptation efforts, including the water infrastructure programs I discuss below. There is, of course, much to be commended in Singapore's typically thorough approach to comprehensive planning, even though its “clean and green” self-image and rhetoric of sustainability is thick and typically subordinate to business interests. The city is also regularly hailed as a model for forward thinking on urban adaptation (e.g., Arnold 2007; Mydans and Arnold 2007), including celebrated comments from the powerful, nationalist leader Lee Kuan Yew on the urgency of urban climate risks. Here I explore the significance of water infrastructure planning through interviews and archival work to assess the extent to which vital systems security provides an adequate framework for understanding the government's continued commitment to modernist infrastructure.<sup>3</sup>

2. On the former, see Grove 2014; Braun 2014; Bulkeley and Broto 2013; Collier 2008. On the latter, see Fjord 2007; Roberts and Parks 2006; Jabareen 2013; Smith 2006; Sims 2009.

3. My analysis is based partly on interviews and discussions with approximately twenty-five people who broadly fall into two groups: those with specific expertise on climate change or environment in Singapore, such as long-term academic observers, biologists, and other environmental scientists, policy experts, and planners, and two prominent diplomats with significant environmental expertise; and those with long-term experience in Singapore and a casual or public nonspecialist

## Public Culture

That commitment rests on a distinctive environmental rationality. Victor Savage (1992) has argued that the governmentality of environment in Singapore depends on an ideology (his term) of *environmental possibilism* comprising two main features. First, it entails that Singapore's strategic geopolitical position can never be taken for granted, and hence basic environmental factors must be constantly guaranteed according to a logic of security—water and food supply, disease control, and urban hygiene are constantly invoked within a security framework. Second, environmental possibilism means that environment is wholly open to design transformation, and spatio-environmental relations are the staging ground for a kind of intensive, anthropogenic nature. If nothing can be taken for granted, the corollary is that Singaporeans are expected to accept perpetual transformation of the urban environment with an unsentimental attitude (certain forms of nostalgia are increasingly permitted). Many commentators have noted Singapore's relatively superficial invocation of the logic of green design in which Singapore is construed as a "city in a garden." What that critique misses is that Singapore is willing to wholly remake spatial and environmental features of the island nation regarding design prerogatives.

Yet Singapore's approach to climate change planning fails to assess what can be understood as a third feature of environmental possibilism, what I call pluripotent climate futures. While predictions for long-term changes at the global scale are relatively stable (but still uncertain), there is an essentially chaotic element in forecasting, especially for such a small area as Singapore. Forecasting cannot take into consideration nonlinear climatic changes or compounded sociopolitical and economic changes. Nonetheless, the Singapore government views the potential threat of climate change in terms of a gradual transformation of base climate variables (temperature, rainfall, etc.), while planning for a large increase in national carbon emissions. In effect, it is far too confident that it knows what climate change holds in store, with the result of limiting its apprehension of the future to a small number of constrained variables. Singapore's approach to climate change planning can be adequately understood in terms of the vital systems security concept. However, its commitment to an artificial remaking of environment through a rationality of control fails to appreciate the pluripotency of climate change futures, evident in its reliance on forecasting rather than a more expansive assessment of climate risk.

---

interest in environmental issues. The research also benefited from site visits and official tours, opportunistic conversations with Singaporeans, and four years teaching climate change to Singaporean undergraduates.

## Terraforming Postcolonial Urbanism

## Singapore's Pluripotent Climate Futures

Singapore's climate change planning can be tied to its long-term commitment to urban planning only in the historical context of decolonization and Cold War militarization. The country is often referred to as a city-state for the fact that its small land area is mostly urbanized, and its form of planned urbanization stretching back to the immediate postwar 1950s has involved envisioning a cityscape that encompasses the whole island (B. Wong 2004). Its geographical status as an island—which in other respects is comparable to, say, Manhattan—is significant primarily because its political independence compounds a sense of national exceptionalism that routinely denies the regional context. Chua Beng Huat (2011) has argued that Singapore should be understood as an island nation rather than a city-state because its urban policy cannot really be separated from national policy and political exigency. A constant refrain in national political address following the separation of Singapore from postcolonial Malaysia in 1965 has been the strict scarcity of territory and economic hinterland and hence the necessity of technologically clever ways of maximizing available territory. Its aggressive social policies were linked to the anticommunist emergency politics of the 1950s and 1960s. Water supply and coastal protection have been at the center of Singapore's security apparatus since the water supply was cut during the Japanese invasion of World War II, leaving a stark memory of the island's vulnerability. This geopolitical dynamism led to postindependence Singapore's aggressive water supply, coastal protection, and flooding drainage policies.

Geographers Rodolphe de Koninck, Juliet Drolet, and Marc Girard (2008) call this unique mode of territoriality Singapore's perpetual territorial transformation. The willingness to manipulate any available spatial option has led to visually spectacular architecture such as the massive enclosed biospheric glass domes and ecologically motivated, apocalyptic "supertrees" that are an iconic signature of Singapore's central downtown waterfront (see Myers 2015). Far more strategically relevant has been the expansion of some 25 percent of the total national land area through infilling of the coastal zones through a bona fide process of geoengineering national territory (Koninck, Drolet, and Girard 2008: plate 4; P. Wong 2005, 2010) (fig. 1). Desalinization, recycling of used water, and the near optimal control of the island's watersheds have come to minimize the need for imported water. To add one last example, the country's use of underground and even underwater space is highly sophisticated (Amir 2015), taking to an extreme what Braun (2000) calls the vertical production of territory. While observers have both lauded and criticized the sustainability effectiveness of Singapore's visually spectacular

## Public Culture



**Figure 1** Infilling of coastal zones. In 1991 the elevation of new land was set to 1.25 meters above the highest-recorded high tide. In 2011 it was raised to 2.25 meters for new construction. Source: Peduzzi, Pascal. 2014 “Sand, Rarer Than One Thinks,” *Environmental Development* 11, 208–218

“green” design features, such debates are overshadowed by the spirit of pervasive manipulation and reconstitution of nature.

In conjunction with terraforming and the production of underground space, Singapore’s commitment to a “clean and green” urban environment since the 1970s cannot be dismissed out of hand. The early impetus to clean up Singapore came directly from colonial-era concerns with hygiene and focused on crowded, dilapidated housing concentrated in the city center, Chinatown, and the shipping quays. Much of the early effort centered on cleaning waterways in part through prohibiting raising of livestock, especially pigs. Cecilia Tortajada, Yugal Joshi, and Asit K. Biswas, among others, have described the process of public health education and enforcement that has been folded into both the formal education system and a form of neighborhood-based environmental governmentality focused on awareness building and community involvement. The Public Utilities Board (2011: 9) discusses “the ongoing Active, Beautiful, Clean Waters (ABC Waters) Programme, which tries to bring water closer to people’s hearts by making water part of their lifestyle.” These programs “covered a wide range of issues including pollution, food hygiene, infectious diseases, waste management, sanitation, anti-spitting, anti-littering, river clean-up, and global environmental issues” (Tortajada, Joshi, and Biswas 2013: 144). Disease vector control is one notable case, since mosquito-borne dengue fever remains a problem on the island and the dengue season is accompanied by mandatory policing by the National Environment Agency



(NEA) including entering people's homes in affected areas. When a dengue outbreak occurred in my neighborhood in 2014, NEA officials politely but firmly entered my apartment to inspect for any possible mosquito habitat and asked me to store upside down an empty vase under my kitchen sink to avoid collecting water.

The cityscape is remarkably green, and Singapore is promoted as a city in a garden. Many of the main roads are lined with trees whose broad branches arch over the roadway. Major parts of the island's interior remain forested, and other large areas also remain covered with plants. Whether any of this has any ecological significance is a completely different question. Something like 70 percent of the coastline is artificial—whether infilled land or protected sea barrier—and all the major estuaries have been converted into freshwater reservoirs as part of the water supply infrastructure. Singapore is green in the sense promoted by celebrated Singaporean architect Tay Kheng Soon, whose approach to what has become a dominant theme in large-scale building design incorporates all kinds of green elements. For Tay the tropical city involved an architectural critique of colonial urban forms. According to critic Bobby Wong (2004: 166), Tay's premise was that "when urban schemes or buildings incorporate [his] recommendations—including rainwater collection and recycling, vertical landscaping, aesthetics of shadow rather than platonic volume and plane, connectivity, synergistic mix of uses and social choreography and more—the designs will produce tropicality." Air-conditioning is a powerful metaphor and perhaps the predominant middle-class vernacular relation to climate. Lee Kuan Yew famously articulated a climatological theory of national development in terms of air-conditioning. "Before air-con, mental concentration and with it the quality of work deteriorated as the day got hotter and more humid. . . . Historically, advanced civilisations have flourished in the cooler climates. Now, lifestyles have become comparable to those in temperate zones and civilisation in the tropical zones need no longer lag behind" (Lee quoted in George 2000: 14). In connection to mosquitos and the periodic burning of peat forests for Indonesian palm oil plantations that inundates the city with smoke, it's not uncommon to hear, as in this comment from a young Singaporean, that "Singapore needs to build a huge air-conditioned dome around the country." In Singapore's postcolonial urbanism, Savage (1992) identifies this array of commitments to an artificial nature as an ideology of pragmatic environmental possibilism. This possibilism is double-edged. First, in the broader geopolitical environment, any threat is possible, and the nation and all of its citizens must maintain constant vigilance. Second, no possibilities are foreclosed, and anything remains open, at least hypothetically, so that natural relations become the occasion for futuristic manipulation.

**Vigilance: Public Water Supply**

Large infrastructure dominates the national imagination. As one informant put it, “The Singaporean view of nature is very infrastructural”—by which she meant that natural relations are heavily managed, capital-intensive, and allowed only in controlled spaces. Another, a lifetime environmental educator in the Singapore public school system, called attention to the shift from a technocratic infrastructural approach to a more “human-centered” approach, which, however, “is unable to let go of the engineering fetish” even though there has emerged a host of thin participatory attempts to get citizens involved in conservation efforts. Others routinely brought up the emphasis on “brown” environmental issues—hygiene, pollution, water and air quality—at the expense of “green” ecology or conservation efforts. This highly public emphasis on infrastructure as a practice of state, as Brian Larkin (2013: 336) has argued, forms a powerful critique of the idea that infrastructure only becomes visible when it breaks down. Nowhere is the emphasis on the visibility of vital infrastructures more apparent than in the context of public water supply, which has remained in prominent public view since the island’s political separation from Malaysia in the immediate postcolonial period. “Water security has been a *permanent* consideration of the city-state’s leadership,” argue Tortajada, Joshi, and Biswas (2013: 18; my emphasis). The political narrative of infrastructure has increasingly become linked with climate adaptation.

Currently, seventeen major reservoirs capture runoff from some of the island’s land area. The rapid expansion in water storage capacity since 1965 was the primary development approach to securing relative independence from imported water resources from Malaysia, which continued to be a diplomatic and security concern as late as 2011. “Due to water shortages the government was very nervous about water in the Mahathir years,” one seasoned observer of the country’s environmental politics told me, referring to the sometimes confrontational Malaysian prime minister Mahathir Mohamad. “The reservoirs had nothing to do with climate change.” Most of the reservoirs are dammed former coastal tidal estuaries, which, like the infilled land, essentially eliminate native ecological habitat. One government marine biologist hesitated when I asked him if coastal infilling simply eliminated the existing ecology and replied, carefully, that species colonization of new aquatic habitats was very rapid. Another, also cautious, described the demise of a large mangrove forest when a major brackish estuary was converted to a freshwater reservoir.

Historically, such territorial and littoral appropriation of space provided the main expansion of domestic water supply until technological advances pushed

forward water recycling and desalination in the 2000s. Nonetheless, interest in water recycling and desalination began as early as the 1972 Water Master Plan (Tortajada, Joshi, and Biswas 2013: 20). Of these “four national taps”—imported water, captured local rainfall, desalination, and recycled water—the last two are now described as “climate independent” for adaptation planning purposes. In this context, the security concerns of the independent and vulnerable nation have become translated into the language of resilience, and planners readily acknowledge that the pioneer efforts of the 1970s and 1980s provided continuity of policy focus now reframed as climate resilience.

Efforts to conform water supply technology to the requirements of Singapore's ecological situation have pushed the limits of its territorial and technological imagination, and water recycling efforts must have seemed pretty futuristic when the first pilot plant was built in 1974. Early efforts were curtailed due to cost, although the technologies worked, and were not revitalized until the late 1990s with dual-membrane reverse osmosis and ultraviolet disinfection technologies. Although predominantly used for industrial water demand, branded NEWater has been accepted cautiously by the public and has been the source of major marketing investment. While directly potable if necessary, recycled water is commonly mixed into existing reservoirs and then treated again before entering the domestic water supply. With four processing plants, the country currently has installed capacity of 60 million gallons per day, with plans to meet 55 percent of water demand by the expiration of the country's water treaty with Malaysia in 2061 (Public Utilities Board 2014b). “The political conviction is for water self-sufficiency . . . not strictly for security but also for general diplomacy,” noted one academic observer. That mind-set is very much part of the “common sense,” in Antonio Gramsci's language, of infrastructure in the context of the country's logic of vital systems security.

Desalination of seawater is the other “climate-independent tap.” It provides 25 percent of public water supply and has been the source of government-subsidized, private industry development and test bedding for new technologies. The Singapore Economic Development Board considers the country to be a “global hydro-hub” for major investment partnerships including sustained research centers developed with local universities and a substantial number of corporate partners including Siemens and General Electric (SEDB 2011; NEWRI 2014).<sup>4</sup> Water technology investment has been the basis of the public-private partnership with Hyflux

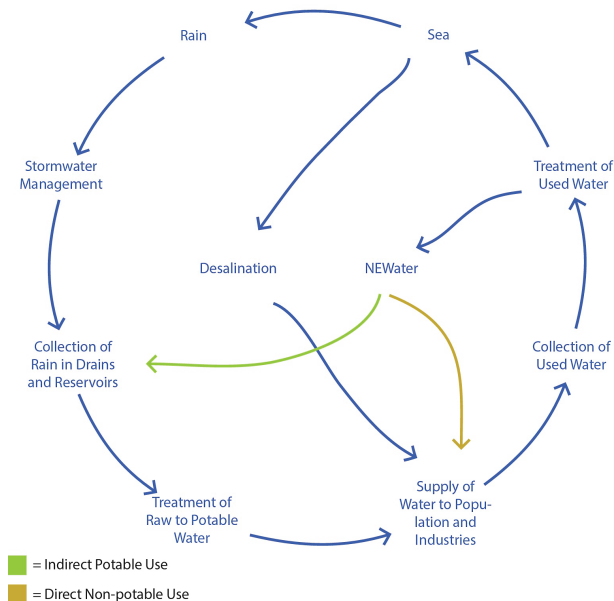
4. Government research and development investment in water technology was some S\$470 million from 2006 to 2012 (Balakrishnan 2012).

## Public Culture

to build two desalination plants using “design-build-own-operate” construction and financing arrangements. Hyflux, a major Singaporean water technologies firm, experienced a meteoric annual growth rate of 30 percent from 2001 to 2009, and its CEO was a nominated minister of Parliament during that time (*Wikipedia* 2015; Hyflux 2009). Ong (2005) theorizes this characteristic approach to strategic state investment as the creation of “ecologies of expertise.” It is safe to say that Singapore refuses to take water supply for granted as a matter of public investment and private-sector capabilities development.

The very idea of the island as a sealed system demonstrates why vital systems security can be described as a rationality or logic of rule. Nowhere is that clearer than in the context of national water supply. At the heart of the conceptualization of these “four national taps” is the aspiration that “in Singapore, the complete water cycle is managed” (Symenouh 2013: 15). The idea is that the water system, augmented by recycling, can be understood as a semiclosed loop in which the key variable is the total capacity of the whole system at any given time, rather than simply the availability of stored freshwater (fig. 2). The Public Utilities Board manages freshwater, storm drainage, and used water as an integrated whole. The water in domestic sewage pipes and toilet bowl tanks is effectively part of the usable water capacity of the island. To this end, one of the main achievements of water supply infrastructure is the massive deep tunnel sewage system that supplies the water reclamation plants. The current phase of this project, operational in 2009, comprises forty-eight kilometers of tunnels up to six meters in diameter, thus forming a substantial volume of stored capacity.

Even while recycled water has needed to be supplemented by a major marketing campaign, the express visibility of vital security infrastructure is nowhere more apparent than with the Marina Barrage. The sophisticated tidal gate system forms a



**Figure 2** Singapore’s water system as a semiclosed loop. Note that the two “climate-independent taps” are at the symbolic center of the circle meant to bypass rainfall and storm water management as natural variables. Illustration by the author based on Public Utilities Board 2014a.

reservoir in the heart of the financial district to capture catchment runoff from approximately one-sixth the area of the island; it is routinely mentioned in connection with climate change adaptation. The barrage spans the 350-meter-wide mouth of the Singapore and Kallang Rivers, which were conjoined through land infilling that extended the shoreline several kilometers, to form a 240-hectare (600-acre) bay. The barrage incorporates variable control gates and high-capacity water pumps designed to regulate the balance between storm drainage and tidal inundation. The reservoir level is kept below the regular high tide to allow for more rapid drainage of storm water, which is then pumped into the sea. As the sea level rises over the coming decades, the multifunction design maintains freshwater supply, more rapid drainage for monsoon flooding, and protection from higher sea levels.

The prominent design of the barrage at the heart of the city also integrates urban environmental concerns, in aesthetic, recreational, commercial, and functional registers, that echo the postcolonial emphasis on martial security. Historian Lai Chee Kien has argued that Marina Bay itself mimics the colonial form of the *padang*, which was central to British displays of military power. The *padang* was a flat, open parade ground amid central administrative buildings that served as “an exemplary space for surveillance, military drill display and governance” (Lai quoted in Koh 2014: 166). Lai has argued that Marina Bay, which forms the stage for fighter jet flyovers and military parachute drops for annual displays of national patriotism, now serves as the country’s most prominent “*padang*”—a liquid *padang* that unites Singapore’s monumental prestige architecture, the extensive infilled land surrounding the reservoir, and the deliberate prominence of the country’s water infrastructure (cited in *ibid.*: 183).

The routine invocation of Singapore’s military vulnerability due to constrained water supply demonstrates the subtext of vigilance and emergency central to the country’s modernist infrastructure-oriented urbanization. Whereas the government enjoys effective hegemony regarding security discourses, the emphasis on infrastructure speaks to the heterogeneous, intimately managed sociotechnical processes through which population security is achieved and maintained. However, as the government makes clear, climate change adaptation planning is not the primary motivation for water infrastructure development. Rather, existing postcolonial concern over water security has meant that climate-related vulnerabilities were easily folded into existing water policy when the former were taken into consideration in the late 2000s. Climate change has become an explicit part of vital systems logic of population security.

**Emergency: Coastal Protection**

The clearest specific climate adaptation policy change has been a legal requirement that the platform level of newly infilled land shall be set to a height of 2.25 meters above the highest tide observed before 1991. The requirement is unambiguously due to concern about climate change. It is also costly, since Malaysia and Indonesia have both banned export of sand on the grounds that it is an export of national territory itself (Comaroff 2014). However, most of the coastal areas designated for reclamation have already been developed, and the rule is not retroactive. Beyond the immediate implications of a higher platform level, the new rule calls attention to the vast concentration of shipping, refinery, petrochemical, and luxury development on artificial coastal land. Coastal protection implies a distinction between population vulnerability and the vulnerability of industrial infrastructure, and the radical transformation of much of Singapore's coastal zone has led to a rationalization of space dividing the relatively protected urban population from global economic infrastructure that may or may not remain vulnerable. That historical process of coastal resettlement hinges on the anticommunist emergency of the immediate postwar period.

In the late colonial period, many of the largest of numerous small islands surrounding the southern coast of Singapore were settled by largely Malay-speaking Muslim fishing communities. With a population of over three thousand and a light police presence, the islanders formed a new political constituency when the British decentralized control to the city-state prior to decolonization. There was an active effort to develop the islands with government-sponsored improvements. In a human interest article on government-led development in 1961 a journalist wrote that "the future of the Southern Islands is bright for the government is doing everything possible to eradicate the peoples' problems and make the places productive" (Richards 1961: 6). This effort to improve was made against the backdrop of a socially complex border geography. Mobile fishing communities worked among some fifty-odd offshore islands, while closer to shore extremely busy ports relied on labor-intensive portage. "Floating hawkers" serviced shipping boats with supplies but posed a threat of theft and pilfering. Just across one of the busiest shipping passages in the world, the Riau Islands in Indonesia were considered dangerous sources of piracy, kidnapping, training of armed insurgents, and smuggling.

By the early 1970s, water pollution became a serious concern, and the highly polluted Singapore River was singled out as a target for remaking space. Nearby islands had been slated for acquisition for shipping, oil refining, and petrochemi-

cals, while farther out the military appropriated islands for demolition training and live firing exercises, and specific islands were earmarked for recreation development. Resettlement proceeded apace, including dismantling mosques and schools, while numerous islands were combined or obliterated through land infilling in a process of wholesale rationalization of space. Jack Meng-Tat Chia (2009) shows the cultural history for one of these islands, now owned by Sentosa Resorts and still home to two important temples that receive large numbers of annual pilgrims every October even though the island is basically depopulated. Semakau Island, once home to over eighteen hundred people, was conjoined with Sakeng Island to form Singapore's incinerator waste landfill, while numerous smaller islands became subsumed by the infilling process for shipping, oil refining and petrochemical joint ventures. Once rocky shoals, brackish estuaries, and mangroves, the depopulated military and industrial coastal zone is now some 70 percent artificial coastline.

Depopulation of the coastal landscape occurred within the context of resettlement as perhaps the central feature of Singapore's program for population control and social entitlement. Housing has been the centerpiece of the city's emphasis on total planning, social engineering, and surveillance, with some 80 percent of the population living in government high-rises that also form the backbone of their retirement assets with an ownership ratio of some 94 percent. Gregory Clancey (2004: 38) describes the late colonial anticommunist emergency, which forms a critical part of Singapore's national political imagination, as "one of the greatest forced re-housings in the history of modern colonialism, or for that matter in the history of East and Southeast Asia." He argues that public housing was an essential expression of anticommunist counterinsurgency, which then became a "permanent emergency" for the purpose of population control. For Chua Beng Huat (1991), housing was both a radical reorganization of society and a real enfranchisement of Singaporeans vis-à-vis the state. Resettlement of the coastal population into high-rise government apartments has been part of a larger popular nostalgia and cultural memory of old Singapore. Regardless, it is clear that population vulnerability to climate-related disasters was already sharply reduced through the complete remaking of the island's coastal zones.

Infrastructure vulnerability in the coastal zones is a more complex matter due to what appears to be a strict separation between publicly accessible civilian urban planning and rigorously maintained secrecy on military matters for these zones. Climate adaptation planning likely incorporates a parallel but invisible military chain of command. Both chairs of the Inter-Ministerial Committee on Climate Change (IMCCC), current deputy prime minister Teo Chee Hean and previous



## Public Culture

deputy prime minister Shunmugam Jayakumar, were concurrently coordinating minister of defense, and Teo was formerly minister of defense. Singapore promotes climate governance through what it calls a “whole of government approach,” but, aside from the position of chair of the IMCCC, there is no public documentation of any military involvement in climate adaptation planning. For the military and industrial coastal zones, one can only speculate on how climate adaptation planning is approached.

More problematically, official technical assessments of Singapore’s climate vulnerability are off-limits, including any discussion of methodologies used. I quickly learned that the Official Secrets Act made inaccessible any more detailed, off-the-record information as contracted researchers and city planners declined requests for interviews. (Even if I accessed such information, I could be prosecuted for making it public.) Disaster response or management is not taken into consideration by the working group on climate change adaptation, confirming a construction of risk that discounts out of hand the possibility of tropical cyclones. It is widely believed that Singapore is not especially exposed to deadly natural disasters (G. Chua 2013). The meteorological argument is that typhoons are unable to form so close to the equator due to the lack of a Coriolis effect. It may be true that the island has never experienced a typhoon in recorded history, but in 2001 Typhoon Vamei made landfall about sixty kilometers north along the Malay Peninsula. Vamei was in fact the first-ever-observed typhoon within 1.5 degrees of the equator and is considered a 1-in-400-year event (Chang and Wong 2008). In Singapore the peak storm surge was approximately twenty centimeters (Tay 2010: 35). Serene Hui Xin Tay further shows that only 13.5 years of extreme wind data were available and demonstrates that storm surges could reach 1.6 meters for a small cyclone (*ibid.*: 69). Kumaran Raju et al. (2012) have shown modest coastal risks due to sea level rise on infilled land. Other potential vulnerabilities like regional migration of climate refugees or political or financial instability are not considered, while food security and infectious disease risks are given brief mention. Any public discussion of Singapore’s risks is filtered through the careful communications mechanism of the National Climate Change Secretariat, which, with minor exceptions, only raises issues related to slow linear changes in rainfall, sea level rise, and temperature. As one interviewee put it, there is no need to press the panic button if climate change is seen as a long-term issue, especially if it risks scaring investors.

Given the importance of shipping, petrochemical, and refinery infrastructure central to Singapore’s status as a global trade hub, it perhaps comes as no surprise that the discursive construction of risk makes it seem like the small island can eas-



ily adapt to modest ecological changes. In the meantime, prominent Singaporean economists argue that based on cost-benefit analysis it makes no sense for Singapore to go to much effort to reduce its emissions. The national policy advertises an 11–16 percent decrease in carbon intensity by 2020, while real greenhouse gas emissions will increase by at least 60 percent, to sixty-five metric tons, by 2020. Given the extreme exposure of regional cities Jakarta, Bangkok, Manila, and Yangon, not to mention smaller centers that make up a highly urbanized region, the biopolitical implication of protecting Singapore's national population at others' expense becomes clear. The historical depopulation of the coast through a process of dispossession was central to the politics of emergency through which the postcolonial city became pivotal to global capital. The apparent split between a biopolitics of population and the preservation of military and industrial interests in the coastal zone draws into relief Singapore's politically conservative approach to emissions reductions and vulnerability assessment.

### **Prediction and Control: Monsoon Flooding**

Monsoon flash flooding has been a constant feature of postcolonial urban management and was routinely at stake in the politics of resettlement during the 1950s–1970s. Flash flooding is the most publicly visible climate change impact and an issue where the government is especially responsive to public opinion. Climatically, the city is subject to intensely focused tropical downpours and, more rarely, extended, multiday rain events that dump a tremendous volume of water in a very short period of time. Concern with drainage goes back to antimalaria campaigns of the 1910s but was especially prominent during resettlement beginning in the 1950s. A prominent flooding event in 2011 captivated the public imagination and is routinely brought up in discussions of climate change. A major downpour swamped the city's most famous shopping district, rapidly flooding malls and carparks and provoking a public outcry over inadequate government control over the situation. It demonstrated that Singapore's technocratic government is not allowed to fail without being subject to intense public criticism—the flip side of which, of course, is that it can't be criticized on more fundamental grounds. Urban monsoon flooding best exemplifies the rationality of obsessive prediction and control in which the only response to a changing nature is more technology.

As with coastal vulnerability and public water supply, adaptation needs for flooding are nonetheless minimal due to long-term investment in public infrastructure. Newspaper archives show that public demand for drainage infrastructure has been high since at least the 1950s, with major investments closely paralleling the

## Public Culture

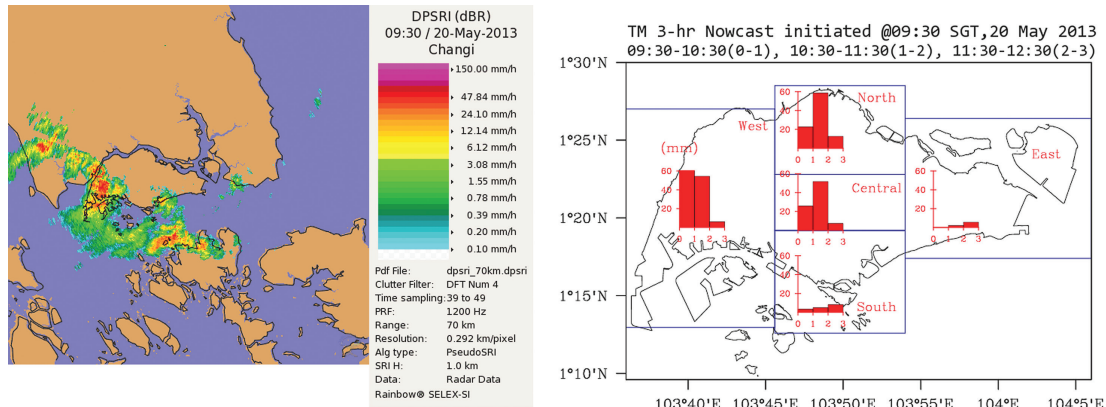
massive push for decentralized public housing. Potong Pasir was one notable area, first home to sand quarrying activities, that became settled by Cantonese farmers before being converted to government-built housing blocks in the early 1980s. Another was Bedok, a major colonial resettlement area that was hit with a series of major floods in 1954, including one that brought almost thirteen inches (thirty-two centimeters) of rain over twenty-four hours. While colonial and postcolonial resettlement proceeded apace, drainage became a key locus of permissible public complaint—effectively a backstory to the social entitlement and population control strategy. After the December 1954 floods, the “Bedok problem” obliged the colonial government to promise rehabilitation while denying any possibility of compensation for flood victims, even while it was acknowledged that they were moved “under protest,” and the colonial secretary promised “vigorous action” on drainage (*Singapore Free Press* 1954; *Straits Times* 1954). Following a major 1978 flood, often hailed as the largest in Singapore’s records at 512 millimeters (20 inches) in twenty-four hours, Potong Pasir was quickly subject to wholesale redevelopment under the directorship of the minister of defense, even while the offending river was subject to millions in investment to dredge and canalize it. But Singapore’s rivers were offending not only for flooding’s financial damages, occasional loss of life, and inconvenience. In news stories from the late 1970s, Singapore’s rivers are the source of tales of crime, pollution, unidentified corpses, waste from pig farms, derelict lighter boats, and industrial debris—already explicitly contrasted with the city’s “clean and green” urban landscape (A. Wong 1979).

Major public debates about drainage have persisted, and there are clearly periodic flooding events that exceed current drainage capacity. The average number of days when rainfall exceeds seventy millimeters per hour has doubled since 1980 (NCCS 2012: 76). The response has been a combination of engineering and sophisticated “nowcasting” of rainfall events with text message and e-mail warnings. In public debates, officials are at pains to show both that they are doing whatever is feasible and that there are limits to what can be done to drain such torrential downpours especially during high-tide events. Drainage canals have been equipped with gates to block the tides, while the Marina Barrage can pump storm water to the sea at a capacity of 280 cubic meters per second (billed as the “world’s largest pumps”; Channel NewsAsia 2007). Singapore’s integrated drainage / water supply system has increasingly relied on innovative mixed-use designs that reconfigure drainage infrastructure as recreational and tourist destinations for enjoying technically enhanced nature. A case in point is the Active, Beautiful, Clean Waters Programme, with a vision of drainage as a site for urban leisure, exercise, and environmental cleanliness—for the same river that, in 1979, was

routinely referred to as heavily polluted and the favored dumping ground for victims of organized crime.

Even while planners and experts whom I interviewed remained convinced that engineering solutions were perfectly adequate, they present their own risks. The Marina Barrage project, completed in 2008 at a cost of about US\$150 million, had to be defended against public speculation that it had contributed to the highly visible 2011 flooding—including “technical analysis” by self-styled vernacular experts (e.g., Tan Kok Tim 2011) and awkward claims by the Public Utilities Board that what occurred was not really flooding but simply “ponding.” Whereas flooding presents massive compound problems for Southeast Asian cities like Bangkok or Jakarta, Singapore’s highly engineered concrete waterways are a paradigm of infrastructural modernization. Nonetheless, as Chua Beng Huat (2011: 32) argues, “failure haunts success. . . . Fear of failure keeps the government constantly in search of the next niche for development thrown up by shifts in global capitalism”—and all the more so for potentially chaotic shifts in climate. In a context where much criticism is strictly curtailed, the technocratic imagination can lead to a kind of *reductio ad absurdum* in which the claim to predict and control nature is always already a political vulnerability because it directly relates to authorizing claims of Singapore’s postcolonial rule.

Anticipating erratic, spatially localized tropical downpours demonstrates a kind of Deleuzian intensiveness to the prediction and control approach, especially apparent in the recurring emphasis on information and communication. The Tropical Marine Science Institute, a university research body that contracts for much of the government’s climate change modeling, has developed computation-intensive nowcasting for three-hour periods that show imminent rainfall intensity in different quarters of the island (fig. 3). Using another web-based app, citizens can engage in their own island-wide flood surveillance using government-installed closed-circuit television cameras and flood gauges (excluding military and industrial areas). The Public Utilities Board also documents flooding events on its website with depth and duration data—with the same “finding” repeated for each and every event: “Intense rain caused flooding at this location.” Bobby Wong has argued that Singapore’s urban planning has repeatedly returned to the close-up image of the island completely abstracted from regional neighbors, which establishes a “virtual plane” that, in the country’s independence, constituted the new nation territorially, ecologically, and in its urbanism. For Wong (2004: 173), the repeatedly framed close-up of Singapore—the intensified representation of the island, forty-four by twenty-three kilometers—is akin to Gilles Deleuze’s understanding of the close-up image of a face in cinema: “an intensity ‘that tears the



**Figure 3** Nowcasting provided by the Tropical Marine Science Institute. The radar image on the left shows Singapore in the regional context of the Malay Peninsula (north) and Indonesia's Riau Islands (south). The right-hand image shows expected rainfall intensity in different parts of the city for the subsequent three-hour period.

image away from its spatio-temporal coordinates,' or its historicity." It is also infrastructural rationality that tears Singapore away from its spatiotemporal coordinates. The technopolitics of environmental possibilism demonstrates Singapore's historicity and the limits of its infrastructural reason. For instance, there seems to be little evidence that these high-tech responses to potential flooding are especially used or valued by citizens; they represent the logical conclusion of a process of intensification rather than any practical utility.

### Conclusion: Pluripotent Climate Futures

I have argued that Singapore's approach to climate change adaptation closely tracks long-standing elements of its postcolonial urbanism, namely, its rationality of environmental possibilism and perpetual territorial transformation. Ultimately an approach to population security, water infrastructure as vital systems security bears out Singapore's biopolitics of vigilance, spatial emergency, and intensified prediction and control over nature. But it is precisely the predictability of climate change futures that remains in question. To maintain that adaptation will be possible without mitigation, the island nation must assume that the impacts of climate change will be limited to modest linear changes in base climatic variables. Viewed from a certain perspective, Singapore's climate change policy is comprehensive and duly integrated into many aspects of its economy and society without much of the hand-wringing that frequently accompanies climate-related infrastructure investment. Meanwhile, it has planned for a radical increase in emissions by some 60 percent from 2005 to 2020 and routinely touts the increase as an emissions reduction (e.g., NCCS 2012: 35). In its modest risk assessment and its commitment to increased emissions, Singapore's climate policy seeks to safeguard its

small national population at the expense of regional neighbors while maximizing its position in fossil energy-based accumulation. In a context of increasingly unpredictable, nonlinear climatic changes, Singapore's forecast of modest linear climatic changes amounts to a bold wager that adaptation is possible without substantial global mitigation of greenhouse gas emissions.

Singapore's commitment to the artificial remaking of environment through a rationality of prediction and control fails to appreciate the pluripotency of climate change futures. I use the biomedical metaphor from pluripotent stem cell research, avidly funded in Singapore, to underscore the highly divergent climate change outcomes that may be unpredictably localized in any number of regional contexts. While the government acknowledges scientific uncertainties due to limitations in data and modeling resolution, it nonetheless limits its apprehension of the future to a kind of forecasting. Yet long-term climate modeling is not forecasting, and even less does modeling account for compounded effects through which climate, long taken for granted within the complexity of human sociotechnical systems, permeates manifold future possibilities. Collier and Lakoff argue that vital systems security hinges on a kind of threat analysis that goes beyond probability assessment utilized for social welfare and insurance models of risk assurance. Climate change, like terrorism and emerging infectious diseases, implies an anthropogenic future in which predictability itself is not a realistic assumption.

Climate change adaptation planning fits neatly within Singapore's strategy of environmental possibilism. Savage (1992) describes environmental possibilism as holding, on the one hand, that any threat is possible within the geopolitical and territorial environment of the small, independent island nation and, on the other, that natural relations, including environment and territory, can be wholly remade according to modernist technological aspirations. Futuristic manipulation of the island's natural parameters, which serves to abstract the nation from its regional context, is one signature of Singapore's urbanization strategy. Its infrastructural modernity has been a crucial feature of governmental claims to its uniqueness in the region, and Singaporeans are well aware of their prosperity and ecological security relative to other major Southeast Asian cities. Furthermore, it is a mistake to interpret its approach as a recapitulation of Euro-American urbanism. On the contrary, its urbanization process is distinctive for its perspicuous strategic assessment of the country's geopolitical potential. Singapore's climate adaptation planning fits within this tradition of environmental possibilism.

However, the politically conservative commitment to fossil energy futures and a modest interpretation of climate risk demonstrates an inadequate understanding of the kinds of uncertainty at stake in planning for climate change futures. There is no

## Public Culture

reason to assume that either localized climatic variables or modest linear changes in those variables will be the primary driver of climate change–related threats. Already, in the case of Syria, there is a major demonstrated case of climate change–induced drought helping drive a protracted and bloody civil war and prompting a major regional geopolitical shift (Kelley et al. 2015). Geopolitical militarization in the Arctic has been driven not only by unexpectedly precipitous ice loss but also by the risky, opportunistic exploration of new fossil energy reserves by Russia, Norway, and Canada (Huebert et al. 2012). In Southeast Asia, the large-scale flooding of Thailand’s industrial estates in 2011 demonstrated Singapore’s financial sensitivity to climate impacts happening elsewhere in the world. When adaptation is narrowly construed as a response to variation in temperature, sea level, and rainfall, with some potential for further knock-on effects, it may seem as if modest infrastructural improvements can effectively protect a city from adverse effects of climate change. Singapore views adaptation in such naturalistic terms, and indeed it must if it is to believe in predictability. Yet the problematic of climate change is constituted by uncertainty in such a way that predictability itself cannot be taken for granted. The effects of climate change already permeate complex social and technical arrangements in unpredictable, nonlinear ways, and its chaotic effects are all the more apparent when human anticipation of future climates is part of its present-day impact.

Urbanization and its related planning practices increasingly hinge on a moment in which planetary-scale ecology and the biopolitics of population security are dynamically and mutually interrelated. The shift in perspective in the 2000s, from climate change as a relatively distant future trend to an increasingly complex problem bearing immediately on urban infrastructures, has become part of a situation in which cities are increasingly the *de facto* scale for assessing climate risk. Whether a revitalized modernist trust in infrastructure is up to the task remains to be seen, even while climate change is repeatedly used to justify and legitimate a major shift to large-scale infrastructure investment especially in the global South. Cities are paradigmatic of a unique historical conjuncture that brings together planetary ecology and global capitalism with localized, dramatic urban ecological changes. These localized changes, such as land subsidence in Jakarta or Bangkok, very often constitute the immediate vulnerabilities exacerbated by climate change. In Singapore’s case, it is probably safe to say its long-term investment in water infrastructure has made planners’ jobs incomparably easier. But infrastructure is the built form of its own vulnerabilities—think of the vast areas of the city resting on artificial land just over a meter above sea level—and the government’s deterministic, engineering approach to the prediction and control of nature suggests it hasn’t taken seriously the pluripotency of its climate futures.

## References

- Amir, Sulfikar. 2015. "Manufacturing Space: Hypergrowth and the Underwater City in Singapore." *Cities* 49: 98–105.
- Aradau, Claudia. 2010. "Security That Matters: Critical Infrastructure and Objects of Protection." *Security Dialogue* 41, no. 5: 491–514.
- Arnold, Wayne. 2007. "Vulnerable to Rising Seas, Singapore Envisions a Giant Seawall." *New York Times*, August 29. [www.nytimes.com/2007/08/29/world/asia/29iht-Dikes.2.7301576.html](http://www.nytimes.com/2007/08/29/world/asia/29iht-Dikes.2.7301576.html).
- Balakrishnan, Vivian. 2012. Speech by Minister Vivian Balakrishnan at the opening ceremony of Hyflux Innovation Centre, Singapore, July 3. Ministry of the Environment and Water Resources. [app.mewr.gov.sg/web/contents/contents.aspx?contid=1677](http://app.mewr.gov.sg/web/contents/contents.aspx?contid=1677) (accessed February 5, 2015).
- Barry, Andrew. 2001. *Political Machines: Governing Technological Society*. London: Athlone.
- Beck, Ulrich. 1992. *Risk Society: Towards a New Modernity*. Translated by Mark Ritter. Thousand Oaks, CA: Sage.
- Braun, Bruce. 2000. "Producing Vertical Territory: Geology and Governmentality in Late Victorian Canada." *Cultural Geographies* 7, no. 1: 7–46.
- . 2014. "A New Urban Dispositif? Governing Life in an Age of Climate Change." *Environment and Planning D: Society and Space* 32, no. 1: 49–64.
- Bulkeley, Harriet, and Castán Broto. 2013. "Government by Experiment? Global Cities and the Governing of Climate Change." *Transactions of the Institute of British Geographers* 38, no. 3: 361–75.
- Chang, C.-P., and Teo Suan Wong. 2008. "Rare Typhoon Development near the Equator." In *Recent Progress in Atmospheric Sciences: Application to the Asia-Pacific Region*, edited by Kuo-Nan Liou and Ming-Dah Chou, 172–81. Singapore: World Scientific.
- Channel NewsAsia. 2007. "Marina Barrage Will House World's Largest Water Pumps." August 29.
- Chia, Jack Meng-Tat. 2009. "Managing the Tortoise Island: Tua Pek Kong Temple, Pilgrimage, and Social Change in Pulau Kusu, 1965–2007." *New Zealand Journal of Asian Studies* 11, no. 2: 72–95.
- Chua Beng Huat. 1991. "Not Depoliticized but Ideologically Successful: The Public Housing Programme in Singapore." *International Journal of Urban and Regional Research* 15, no. 1: 24–41.
- . 2011. "Singapore as Model: Planning Innovations, Knowledge Experts." In *Worlding Cities: Asian Experiments and the Art of Being Global*, edited by Ananya Roy and Aihwa Ong, 29–54. Malden, MA: Wiley-Blackwell.



## Public Culture

- Chua, Grace. 2013. "Cyclone Unlikely to Hit Singapore, Experts Say." *Straits Times*, October 22.
- Clancey, Gregory. 2004. "Toward a Spatial History of Emergency: Notes from Singapore." In *Beyond Description: Singapore Space Historicity*, edited by Ryan Bishop, John Phillips, and Wei-Wei Yeo, 30–59. New York: Routledge.
- Collier, Stephen J. 2008. "Enacting Catastrophe: Preparedness, Insurance, Budgetary Rationalization." *Economy and Society* 37, no. 2: 224–50.
- Collier, Stephen J., and Andrew Lakoff. 2008. "Distributed Preparedness: The Spatial Logic of Domestic Security in the United States." *Environment and Planning D: Society and Space* 26, no. 1: 7–28.
- . 2014. "Vital Systems Security: Reflexive Biopolitics and the Government of Emergency." *Theory, Culture and Society* 32, no. 2: 19–51.
- Comaroff, Joshua. 2014. "Built on Sand: Singapore and the New State of Risk." In "Wet Matter," *Harvard Design Magazine*, no. 39. [www.harvarddesignmagazine.org/issues/39/built-on-sand-singapore-and-the-new-state-of-risk](http://www.harvarddesignmagazine.org/issues/39/built-on-sand-singapore-and-the-new-state-of-risk).
- Daniell, James, et al. 2013. "Typhoon Haiyan / Yolanda." Report no. 2, Focus on Philippines. November 13. Potsdam, Germany: Center for Disaster Management and Risk Reduction Technology. [quakesos.sosearthquakesvz.netdna-cdn.com/wp-content/uploads/2013/10/CEDIM\\_FDA\\_Haiyan\\_Rep2.pdf](http://quakesos.sosearthquakesvz.netdna-cdn.com/wp-content/uploads/2013/10/CEDIM_FDA_Haiyan_Rep2.pdf).
- Fearnley, Lyle. 2008. "Signals Come and Go: Syndromic Surveillance and Styles of Biosecurity." *Environment and Planning A* 40, no. 7: 1615–32.
- Fjord, Lakshmi. 2007. "Disasters, Race, and Disability: [Un]seen through the Political Lens on Katrina." *Journal of Race and Policy* 3, no. 1: 46–66.
- Foucault, Michel. 2007. *Security, Territory, Population: Lectures at the Collège de France, 1977–1978*. Edited by Michel Senellart and translated by Graham Burchell. New York: Palgrave Macmillan.
- George, Cherian. 2000. *Singapore: The Air-Conditioned Nation; Essays on the Politics of Comfort and Control, 1990–2000*. Singapore: Landmark Books.
- Goh, Kian. 2014. "Making Room for Water: Urban Adaptation and Uneven Development in Jakarta." Unpublished manuscript, last modified October 24. Microsoft Word file.
- Graham, Stephen, and Colin McFarlane. 2015. Introduction to *Infrastructural Lives: Urban Infrastructure in Context*, edited by Stephen Graham and Colin McFarlane, 1–14. New York: Routledge/Earthscan.
- Grove, Kevin. 2014. "Biopolitics and Adaptation: Governing Socio-ecological Contingency through Climate Change and Disaster Studies." *Geography Compass* 8, no. 3: 198–210. doi:10.1111/gec3.12118.



- Huebert, Rob, et al. 2012. *Climate Change and International Security: The Arctic as Bellwether*. Arlington, VA: Center for Climate and Energy Solutions.
- Hyflux. 2009. "Hyflux Still Expanding." Press release. *Asia Biotech* 13, no. 2: 57. [www.asiabiotech.com/publication/apbn/13/english/preserved-docs/1303/0057\\_0057.pdf](http://www.asiabiotech.com/publication/apbn/13/english/preserved-docs/1303/0057_0057.pdf).
- Jabareen, Yosef. 2013. "Planning the Resilient City: Concepts and Strategies for Coping with Climate Change and Environmental Risk." *Cities* 31: 220–29.
- Kelley, Colin, et al. 2015. "Climate Change in the Fertile Crescent and Implications of the Recent Syrian Drought." *Proceedings of the National Academy of Sciences* 112, no. 11: 3241–46.
- Koh, Hong Teng. 2014. *Last Train from Tanjong Pagar*. Singapore: Epigram Books.
- Koninck, Rodolphe de, Julie Drolet, and Marc Girard. 2008. *Singapore: An Atlas of Perpetual Territorial Transformation*. Singapore: NUS Press.
- Larkin, Brian. 2013. "The Politics and Poetics of Infrastructure." *Annual Review of Anthropology* 42: 327–43.
- Mayer, Maximillian. 2012. "Chaotic Climate Change and Security." *International Political Sociology* 6, no. 2: 165–85.
- MEWR (Ministry of the Environment and Water Resources). 2014. "Factsheet: Study of Long Term Impact of Climate Change on Singapore." Singapore: MEWR. [app.mewr.gov.sg/data/ImgCont/1386/6.%20Factsheet%20-%20Climate%20Change%20Study%20%5Bweb%5D.pdf](http://app.mewr.gov.sg/data/ImgCont/1386/6.%20Factsheet%20-%20Climate%20Change%20Study%20%5Bweb%5D.pdf) (accessed August 26, 2014).
- Mydans, Seth, and Wayne Arnold. 2007. "Lee Kuan Yew, Founder of Singapore, Changing with the Times." *New York Times*, August 29. [www.nytimes.com/2007/08/29/world/asia/29iht-lee.1.7301669.html](http://www.nytimes.com/2007/08/29/world/asia/29iht-lee.1.7301669.html).
- Myers, Natasha. 2015. "Edenic Apocalypse: Singapore's End-of-Time Botanical Tourism." In *Art in the Anthropocene: Encounters among Aesthetics, Politics, Environments, and Epistemologies*, edited by Heather Davis and Etienne Turpin. London: Open Humanities Press.
- NCCS (National Climate Change Secretariat). 2012. *National Climate Change Strategy*. Singapore: NCCS.
- NEWRI (Nanyang Environment and Water Research Institute). 2014. *The Power of Water*. June. Singapore: NEWRI. [newri.ntu.edu.sg/aboutus/Documents/NEWRI%20Brochure\\_June%202014.pdf](http://newri.ntu.edu.sg/aboutus/Documents/NEWRI%20Brochure_June%202014.pdf).
- Ong, Aihwa. 2005. "Ecologies of Expertise: Assembling Flows, Managing Citizenship." In *Global Assemblages: Technology, Politics, and Ethics as Anthropological Problems*, edited by Aihwa Ong and Stephen J. Collier, 337–53. Malden, MA: Wiley-Blackwell.

## Public Culture

- . 2011. "Introduction: Worlding Cities, or the Art of Being Global." In *Worlding Cities: Asian Experiments and the Art of Being Global*, edited by Ananya Roy and Aihwa Ong, 1–26. Malden, MA: Wiley-Blackwell.
- Peduzzi, Pascal. 2014. "Sand: Rarer Than One Thinks." *UNEP Global Environmental Alert Services* (March): 1–15.
- Public Utilities Board. 2011. *Water: Vital, Valued, Vibrant*. Annual Report 2010–2011. Singapore: Public Utilities Board. [www.pub.gov.sg/mpublications/Lists/AnnualReport/Attachments/16/PUB\\_AR2011.pdf](http://www.pub.gov.sg/mpublications/Lists/AnnualReport/Attachments/16/PUB_AR2011.pdf) (accessed November 18, 2015).
- . 2014a. "Closing the Water Loop." August 29. [www.pub.gov.sg/about/p.s/default.aspx#ctw](http://www.pub.gov.sg/about/p.s/default.aspx#ctw).
- . 2014b. "NEWater." May 30. [www.pub.gov.sg/about/historyfuture/Pages/NEWater.aspx](http://www.pub.gov.sg/about/historyfuture/Pages/NEWater.aspx).
- Raju, Kumaran, et al. 2012. "Future Sea Level Rise Implications on Development of Lazarus Island, Singapore Southern Islands." *Contributions to Marine Science*, edited by K. S. Tan, 23–31. Singapore: Tropical Marine Science Institute, National University of Singapore.
- Richards, Arthur. 1961. "Our Island Neighbours." *Singapore Free Press*, November 10.
- Roberts, J. Timmons, and Bradley Parks. 2006. *A Climate of Injustice: Global Inequality, North-South Politics, and Climate Policy*. Cambridge, MA: MIT Press.
- Savage, Victor. 1992. "Human-Environment Relations: Singapore's Environmental Ideology." In *Imagining Singapore*, edited by Ban Kah Choon, Anne Pakir, and Tong Chee Kiong, 210–39. Singapore: Times Academic Press.
- SEDB (Singapore Economic Development Board). 2011. "Tap into Singapore's Pool of Resources." Singapore: SEDB. [www.edb.gov.sg/content/dam/edb/en/resources/brochuresnew/Global-Hydrohub-Brochure.pdf](http://www.edb.gov.sg/content/dam/edb/en/resources/brochuresnew/Global-Hydrohub-Brochure.pdf).
- Simone, AbdouMaliq. 2015. "Relational Infrastructures in Postcolonial Urban Worlds." In *Infrastructural Lives: Urban Infrastructure in Context*, edited by Stephen Graham and Colin McFarlane, 17–28. New York: Routledge/Earthscan.
- Sims, Benjamin. 2009. "Disoriented City: Infrastructure, Social Order, and the Police Response to Hurricane Katrina." In *Disrupted Cities: When Infrastructure Fails*, edited by Stephen Graham, 41–53. New York: Routledge.
- Singapore Free Press*. 1954. "The Bedok Problem." December 23.
- Smith, Neil. 2006. "There's No Such Thing as a Natural Disaster." In *Understanding Katrina: Perspectives from the Social Sciences*, by the Social Science Research Council (SSRC). New York: SSRC. [understandingkatrina.ssrc.org/Smith](http://understandingkatrina.ssrc.org/Smith).

- Straits Times*. 1954. "Vigorous Action on Drainage: Goode." December 15.
- Symenouh, Ginette. 2013. International Enterprise Singapore. November 22. Unpublished document in author's possession.
- Tan Kok Tim, 2011. "Technical Analysis of Why the Marina Barrage Is the Cause of Recent Floods." *Temesak Review*, June 15. [www.temasekreview.com/2011/06/15/technical-analysis-of-why-the-marina-barrage-is-the-cause-of-recent-floods/](http://www.temasekreview.com/2011/06/15/technical-analysis-of-why-the-marina-barrage-is-the-cause-of-recent-floods/).
- Tay, Serene Hui Xin. 2010. "Typhoon-Induced Extreme Water Levels near Singapore: A Numerical Model Investigation." MSc thesis, Delft University of Technology.
- Tortajada, Cecilia, Yugal Joshi, and Asit K. Biswas. 2013. *The Singapore Water Story: Sustainable Development in an Urban City-State*. New York: Routledge.
- Whittington, Jerome. 2013. "Fingerprint, Bellwether, Model Event: Climate Change as Speculative Anthropology." *Anthropological Theory* 13, no. 4: 308–28.
- . 2016. "Carbon as a Metric of the Human." *Political and Legal Anthropology Review* 39, no. 1.
- Wikipedia. 2015. "Hyflux." [en.wikipedia.org/wiki/Hyflux](http://en.wikipedia.org/wiki/Hyflux) (accessed February 5, 2015).
- Wong, Alice. 1979. "Taking a Slow Boat up the Singapore River." *Straits Times*, November 27.
- Wong, Bobby [Wong Chong Thai Bobby]. 2004. "The Tropical City: Slippages in the Midst of Ideological Construction." In *Beyond Description: Singapore Space Historicity*, edited by Ryan Bishop, John Phillips, and Wei-Wei Yeo, 165–75. New York: Routledge.
- Wong, Poh Poh. 2005. "Reclamation." In *Encyclopedia of Coastal Science*, edited by Maurice L. Schwartz, 791–94. Dordrecht: Springer.
- . 2010. "Singapore." In *Encyclopedia of the World's Coastal Landforms*, edited by Eric C. F. Bird, 1129–34. Dordrecht: Springer. doi:10.1007/978-1-4020-8639-7\_19.3.

.....

**Jerome Whittington** is an anthropologist whose research focuses on anthropogenic climate change and its constitutive uncertainties as a generative impulse for emerging sociocultural practices. His recent works include "Carbon as a Metric of the Human" (*Political and Legal Anthropology Review*, forthcoming); "The Terrestrial Envelope: Fourier's Geological Speculation" (in *A Cultural History of Climate Change*, edited by Tom Bristow and Thomas H. Ford, forthcoming); and "Fingerprint, Bellwether, Model Event: Climate Change as Speculative Anthropology" (*Anthropological Theory*, 2013). He is based at the National University of Singapore.