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Title: *Porosity*: Networking Cities for a Changing Climate

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Wreckage from Hurricane Sandy'. Image by Wavlan. 2013

Introduction

On October 28th 2013 Hurricane Sandy hit land on the East Coast of the United States. The deadliest storm to hit the country since 2005 it caused tens of billions of dollars in damage, destroyed thousands of homes, left millions without electric service, and caused 117 deaths in the United States, including 53 in New York, making Sandy the most life costly hurricane to hit the United States mainland since Hurricane Katrina. In all an estimated 186 people were killed across the United States, the Caribbean, and Canada. In the immediate aftermath of the storm not only did the emergency services, state and federal government implement emergency plans of action, including both direct intervention on the ground and massive financial support, so too did a number of charities, community and residents groups across the US.

One of the most surprising of these groups was what became known as Occupy Sandy. As noted by the Homeland Security Studies and Analysis Institute: "Within hours of Sandy's landfall, members from the

Occupy Wall Street movement used social media to tap the wider Occupy network for volunteers and aid. Overnight, a volunteer army of young, educated, tech-savvy individuals with time and a desire to help others emerged. In the days, weeks, and months that followed, "Occupy Sandy" became one of the leading humanitarian groups providing relief to survivors across New York City and New Jersey. At its peak, it had grown to an estimated 60,000 volunteers—more than four times the number deployed by the American Red Cross."[1]

What this phenomenon clearly demonstrates is the potential for digital networking to improve response to catastrophic storm events at a community level. Far from being solely a question of material support and logistics, the response to the disaster was one equally definable as *digital*. Pointing to the possible rethinking of issues around the extreme and localised consequences of climate change and responses to it in purely traditional infrastructural terms, the social media focused organisation of Occupy Sandy potentially offers us a new frame of reference to deal with these, and less catastrophic issues around climate change and our response to it.

This paper provides a discussion of the projected impacts of global environmental change in urban environments in the United States, with a particular focus on their impact on existing storm and sanitary water infrastructure. However, it theorizes a new approach to this archaic system of infrastructure that exploits social networking tools and digital technologies to build greater networks for climate change resilience across the United States and, by extension, elsewhere.

Contradictions in the Contemporary City

At the dawn of the twenty-first century, cities possessed all of the crucial subsystems of living organisms: structural skeletons; input, processing, and waste removal networks for air, water, energy, and other essentials; and multiple layers of protective skin. Even more importantly, the existence of artificial nervous systems was enabling cities to sense changes in their internal and external environments and respond, like organisms, in intelligently coordinated fashion.[2]

The contemporary city is at once old and new; increasingly sophisticated in its integration with novel technologies and yet heavily reliant upon outdated infrastructure. Digitally networked mass-transportation systems, smart phone accessible on-street parking reservation, and the utilization of solar and rain harvesting technologies within complex and constrained urban networks illustrate the new possibilities for creating a more sustainable and livable city. Urban theorist, William Mitchell equates the networked modern city to a cyborg: an extension of the human living system that provides protection, mobility, and the transmittal of resources. This process evolved alongside the technological advances of the city since the mid-nineteenth century and the Industrial Revolution.

More recently, the integration of communication networks has provided the artificial nervous system to complete the urban cyborg metaphor, allowing cities to operate its functions in a sophisticated and coordinated manner.[3] Matthew Gandy reiterates the metaphor of 'cyborg urbanism' with: "The emphasis of the cyborg on the material interface between the body and the city is perhaps most strikingly manifested in the physical infrastructure that links the human body to vast technological networks."[4] This is particularly evident when examining contemporary transportation systems in major cities. Digital applications exist in most metropolitan areas that are able to coordinate transportation routes between multi-modes, factoring traffic, fares, and even arranging parking or ride share possibilities. These innovations have prompted the notable urban think-tank, *CityLab*, to dub the smartphone as the decade's most important transportation innovation – underscoring the role digital networking has played in improving urban mobility.[5]

Yet, other systems of infrastructure are still the remnants of a past century's engineering —even in the most cosmopolitan of cities. This includes outdated systems of storm and sanitary water management. In most cities, stormwater infrastructure is synonymous with roadway infrastructure: crowned streets, gutters, and catch basins serve to transport both rain and vehicles. This system is often overtaxed, and in even minor rain events, failure creates health and sanitation problems, as well as routine flooding. In addition to outdated infrastructure, climate change policy in U.S cities has also lagged in recognizing its immediate impact on essential infrastructure. On a national level, the U.S. has been slow to adopt policy amendments to address climate change mitigation; failure to adopt the United Nations Framework Conventions on Climate Change's benchmarks for reducing greenhouse gas (GHG) emissions in 1997 exemplify the neglect of climate change policy on the national level. Only following the increased occurrence and severity of climate change impacts, including polar vortexes, severe storms, and droughts since 2005's Hurricane Katrina has the U.S. and its cities begun to address efforts at mitigation; however, now the need to address adaptation is paramount. Critical time has been lost.

Climate change predictions vary throughout the globe, but the need to address their impacts on urban infrastructure is necessary throughout. In coastal cities, the rise of sea levels and increased frequency and severity of storms is anticipated as a result of global environmental change, giving all the more reason for cities to reconsider current systems of stormwater management. In addition to the outdated modes of treating urban stormwater, most cities are also in great need of new infrastructures to prepare for a range of other impacts from global environmental change. Even on the local level, most contemporary cities are only beginning to address adaptation to the predicted impacts of climate change - and typically through policy alone, and not design.

Given that the local and regional planning process can take years (and often decades) to enact and climate change science only recently understanding the full implications of rising GHG, it is not uncommon for current local development strategies to neglect climate change impacts within their plans. Mitigation efforts, which include GHG reduction or carbon sequestration to slow or reduce the current patterns of anthropocentric climate change, represent important opportunities to reduce or slow the current patterns of climate change, and requires global attention.[6] Unfortunately, even if all GHG emissions halted worldwide, the cumulative emissions since the start of the Industrial Revolution would continue to influence global environmental change; as such climate change adaptation must be a critical consideration in the design of cities throughout the globe. While climate change mitigation requires a global effort, climate change adaptation is best tackled on the local level, as many of the impacts are felt at the local scale and depend on local specificities to address.[7] Thus, new infrastructures for adapting to the impacts of climate change must be explored at the city-scale, and designed to keep pace with the increasing severity of storms, droughts, and temperature extremes.

While digital networks have already improved urban mobility and aided in the recovery process of recent extreme storm events, they have yet to be applied to urban stormwater systems or to a process of mitigating the impacts of severe storms. As such, this paper provides a discussion of the projected impacts of global environmental change in urban environments, with a particular focus on their impact on existing storm and sanitary water infrastructure. Whilst transportation systems within many cities gain sophistication through digital networking, systems of storm and sanitary water still operate much as they have for over a century. Thus, the authors theorize a new approach to this archaic system of infrastructure; one that integrates social networking tools with green infrastructure projects at a range of scales to create a comprehensive digital and physical network for urban resilience. This paper proposes that the digital technologies currently employed to improve social connectivity within and beyond urban areas can also build greater networks for climate change resilience, through an improved collective understanding of related impacts and the shared experience of them by community members. Through the combined efforts of concerned citizens, this network within urban communities will not only locate and describe perceived changes to their environments, but also create incentives towards a new patch network of resiliency infrastructure. This paper discusses the specific application of this digital network to address the impacts of climate change on stormwater management, but theorizes its potential to address alternative impacts in cities throughout the United States and beyond.

Climate Change Impacts in Contemporary Cities

Throughout the United States, cities are already experiencing the impacts of climate change; 'Drought,'[8] 'Super Storm,'[9] and 'Polar Vortex'[10] dominated national weather headlines in recent years, all evidence of global environmental change. Sea Level Rise is often touted as a primary concern for coastal cities with developed shorelines, but even inland cities are experiencing dramatic impacts to their existing infrastructures. While these impacts vary throughout the U.S., major cities throughout the country will have to address the impacts of climate change to current modes of stormwater management. New York City and other Eastern seaboard cities in the U.S. must address the new routine of flooding anticipated from the rise of severe storms and hurricanes.[11] While the threat of hurricanes does not exist in Chicago and St. Louis, these and other Midwestern cities will also need to address the management of stormwater not only from severe storms, but from the increased volume of water released during thaws from winter storms as well.[12] Although extreme drought and heat remains one of the region's greatest impacts, even the San Francisco Bay Area has a great need to reconsider its waste-water infrastructure. Rising sea levels within the San Francisco Bay threaten existing treatment systems, as the anticipated 16 inch rise will place many of the catchment systems and outfalls below sea level by 2030.[13] Thus, addressing contemporary stormwater management is critical to achieving resilience to climate change in nearly all contemporary U.S. cities.

Current Urban Stormwater Management

In the United States, sanitary infrastructure systems are oftentimes the product of design from a century prior; in European cities many of these systems are even older. The discovery of links between disease and water in the late-nineteenth century provided the first impetus for large-scale planning and implementation of sewer and water systems in the US. According to historians, Stanley Schultz and Clay McShane, “Water and sewer systems were a city’s lifelines,” and sanitarians, landscape architects, and engineers were employed by cities to develop comprehensive strategies for managing both in the late-nineteenth and early-twentieth centuries.[14] In some cities great engineering feats, including the reversal of river flow and the entire lifting of the city’s finished grade, were required to accomplish the task of removing waste water and providing clean water.[15] The new roadways that lay atop the new sewer systems were also designed to convey stormwater quickly from paved surfaces and into neighboring waterbodies to prevent flooding; these early industrial cities were yet unaware of the environmental impacts of contaminated urban run-off or of any need for treatment. Quick transport of storm and sewer water addressed urban health issues, but it would take another half-century to recognize the lingering environmental issues of waste water disposal and the need for collective treatment.

Today, large coastal cities, including New York City, Chicago, New Orleans, and San Francisco utilize a system of storm and sanitary water infrastructure that combines the treatment of both precipitation and sewage. The U.S. Environmental Protection Agency (EPA) regulates the treatment of stormwater based off a range of variables. As such, cities can be mandated to treat stormwater alongside sewer water, given the presence of heavy metals, fossil fuels, and hydrocarbons can often result in greater toxicity in stormwater than raw sewage.[16] In less populated areas, stormwater is still allowed to flow untreated into existing watersheds. While the combined treatment within larger cities provides important mitigation of toxic urban run-off, in storm events where precipitation rates exceed treatment capacity, a combination of untreated storm and sewer water is released into neighboring water bodies to prevent sanitation back-up within households. The dumping of combined storm and sewer water prevents residential overflows, but can create sanitation problems within flooded urban streets and the watershed as a whole. Annually, it is estimated U.S. cities dump up to eighty-five billion gallons of untreated sewage as a result of perennial storm events.[17] During Hurricane Sandy in 2013, an estimated eleven billion gallons of untreated or partially treated sewage was released into the watershed systems in New York, New Jersey and Connecticut, creating a significant health and environmental concern long after the floodwaters had subsided.[18]

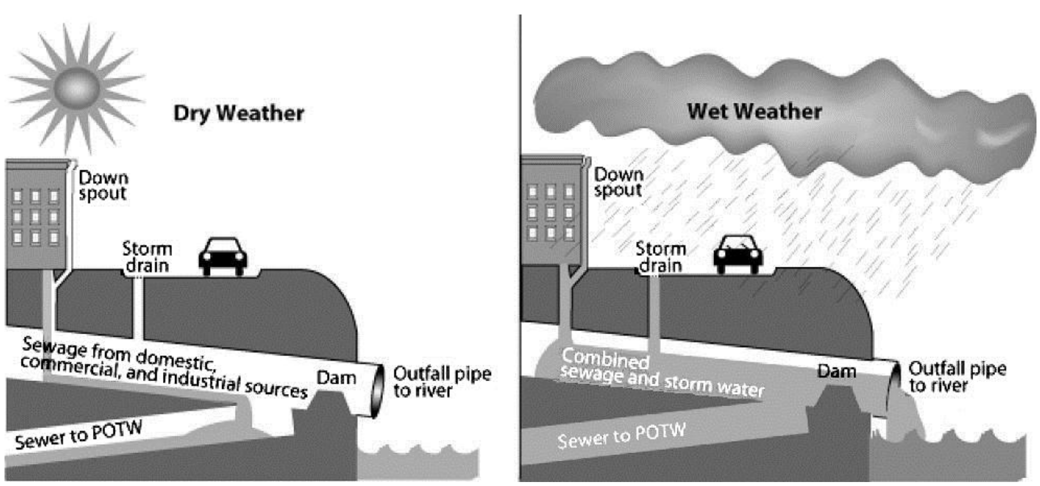

Figure 1. Combined Sewer System

The dumping of untreated urban waste waters resultant from storm events is becoming a common occurrence in the U.S., as the impacts of climate change have increased both the frequency and severity of storm events, particularly on the Eastern Seaboard.[19] The immediate impacts of Hurricane Katrina, Hurricane Irene, and Hurricane Sandy (including power outages, flooding, and property damage) often overshadow the lingering negative impacts to water quality, community health, and biodiversity. Strategies that address the long-term impacts of storm events, as well as the immediate concerns, are needed.

An array of techniques is already being employed in forward thinking U.S. cities such as Portland, San Francisco, Chicago, and New York City. These cities have piloted green infrastructure projects which manage urban rainwater through street swales and planters, permeable paving, rain gardens, green roofs, and improved stormwater performance rules. Policy changes, such as New York City's PlaNYC 2030[20] sustainability initiatives which created a tax on parking lots underscore the societal cost we pay for the swaths of impermeable land in cities. While these techniques speak to physical and policy changes to improve the collection, storage, and filtration of stormwater, the projects resultant from these efforts are typically initiated by individual landowners and rarely coordinated as a network throughout a metropolitan region. As such, these techniques alone are not enough to create fundamentally resilient cities. Instead, a comprehensive inventory of urban landscapes is required, identifying flood-prone areas, opportunities for green infrastructure implementation, and a coordinated effort between projects on both private and public territories. This would allow for an integrated strategy that could employ stormwater collection, source separation, wastewater and graywater recycling, and advanced conservation to address the current issues of urban water management.[21]

Porocity: **Digital & Physical Networks for Improved Stormwater Management**

In response to the outdated infrastructure, this paper theorizes an alternative approach to managing stormwater within the contemporary city, one that capitalizes on emergent technology in both digital media and green infrastructure. Combining digital networks with physical infrastructure, we propose new networks, the *PoroCity* network, which can allow for the distribution of risk, building greater community resilience to climate change. This network represents an example of William Mitchell's cyborg urbanism and more importantly, an alternative to the singular multi-billion, hard-infrastructure project that requires substantial up-front investment. Static engineered solutions often become quickly outdated in light of climate change, and can produce catastrophic consequences when they fail, as was made tragically evident during Hurricane Katrina.[22] In contrast, *PoroCity* takes a 'soft' approach, one that is adaptive, networked, applied strategically over time, and geographically dispersed. Scientist Mark Weiser has theorized on the increased role digital technology and computing will play in all aspects of modern life, including the management of urban infrastructure. He has referred to this integration of digital technology into urban dwelling as 'ubiquitous computing,' and has described the important role technology must play in making cities more intuitive and integrated through 'calming technologies.'[23] *PoroCity* demonstrates this potential for digital integration with stormwater management to address both the short-term and long-term impacts of climate change.

Much like a smart energy grid, which uses information networks to more efficiently distribute green energy, *PoroCity* takes advantage of existing physical and digital networks to introduce an adaptable, decentralized, and neighborhood-based strategy for stormwater management. It would employ digital networks to improve communication during storm events, and spatially target opportunities to integrate emergent green technologies with existing stormwater infrastructure. The digital network will be facilitated by online and smart phone applications that allow community members to communicate the real and perceived conditions of storms. At its simplest level, *PoroCity* asks residents to contribute to a publicly accessible mapping of experienced storm events through uploaded digital photos and/or messages. Integrated with geo-spatial referencing, this data will be real-time and place-specific. Municipalities will be able to use this same network to communicate predicted storm data, including precipitation rates, wind force, sea level rise, and evacuation routes, while community members have the ability to share experiences of these conditions, including flooding, power outages, and traffic jams. The *PoroCity* digital network can also be a means of bringing greater awareness of the impacts of climate change, informing a public that can steward greater mitigation and adaptation efforts. Each smart phone exchanging data on climate change impacts represents a point of information interchange between individuals within a community, which collectively, can begin to build a more resilient community.

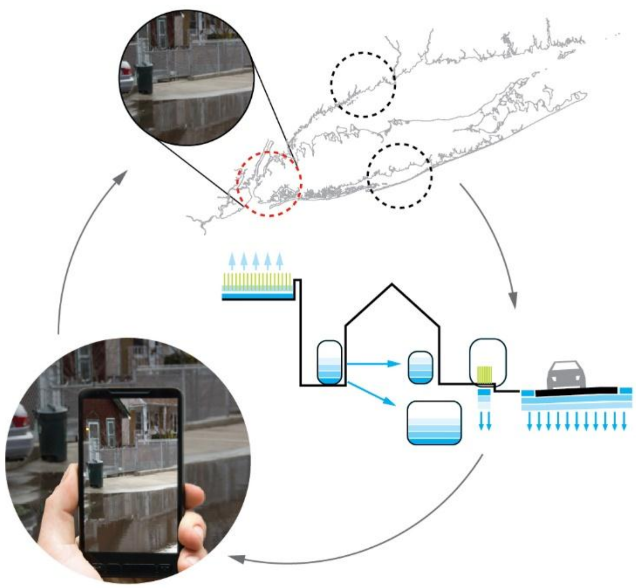

Figure 2. PoroCity Conceptual Diagram

The *PoroCity* digital network also provides communities opportunities to better understand the impacts of smaller storm-events to their personal lives and encourage community stewardship to address these impacts. During smaller rain events, data related to precipitation rates can be accessed by community members and translated to place-specific calculations on water volume based off lot size and pervious surface cover. This will allow individuals to gain greater understanding of the potential of their own properties and patterns towards improving stormwater performance. Morever, the community member water calculations can be shared through the network, allowing for social media sharing on storm-water capacities and encouraging healthy neighborhood competition to transform from 'who has the greenest lawn' to 'who has the greatest stormwater capacity.'

Green infrastructure techniques, including street swales and planters, permeable paving, rain gardens, and green roofs, have proven to be effective solutions in managing stormwater sustainably. An example of the innovative implementation of green infrastructure into constrained urban environments includes the work of Urban Rain|Design, led by landscape architect Kevin Perry.[24] The firm's work includes designs that capitalize on opportunities for increased permeability: ranging from 'accidental permeability' created by cracks in the pavement to larger scale retention and detention basins that improve overall urban stormwater capacity. Most notably, the American Society of Landscape Architects (ASLA) has awarded design excellence awards for the performance of the Portland Green Street sidewalk swale projects that integrate stormwater management with streetscape design. However, the impact of these projects has been limited due to existing policies that separate water management between the private and public entities, and individual green infrastructure projects are rarely coordinated to operate as an integrated system for water management. The collective power of a community's green infrastructure projects is simply not harnessed.

PoroCity proposes to develop connections between existing and new green infrastructure projects and to utilize digital tools to build a fuller narrative of water management that exposes the complete scope of the precipitation process. This includes pioneering efforts to coordinate between public and private water management. Digital communication tools allow crowd-sourced information on blocked drains and flooded lots to combine with municipal data on sub-surface water capacity and quality to target communities with significant perennial infrastructure problems. This information can be utilized to identify existing untapped capacities of urban and suburban development, rather than remaking environments wholesale. The 'left-over' space within existing development patterns provides excellent opportunities for green infrastructure retrofits designed to capture, store, and treat stormwater runoff. Thus *PoroCity*'s network transcends the digital realm to help coordinate physical networking of urban green infrastructure projects.

A current example of digital networks employed to improve physical urban landscapes includes the award-winning proposal, *Local Code: Real Estates*, designed by Nicholas De Monchaux.[25] The project addressed underutilized, vacant city-owned parcels within San Francisco by providing comprehensive maps of the social and environmental conditions of these sites to neighbouring communities via digital networks. This digital mapping allows the public to contribute to decision-making regarding site interventions and their potential to address pressing issues experienced by the community. The spaces proposed for *PoroCity* are not unlike those targeted by *Local Code: Real Estate*, and include property easements and setbacks, vacant city-owned parcels, paved lots, open space, and under-utilized roof tops – a range of both public and private landscapes. Combining crowd-sourced information on experienced storm events, municipal infrastructure data, and geographical spatial analysis, existing opportunities to develop an integrated network of green infrastructure can be located. The range of green infrastructure typologies, from small permeable paving applications to large rain gardens, can adjust to the specifics of the context, including property ownership, cost, land-use, and aided by the digital and physical *PoroCity* networks. By re-focusing efforts of stormwater management from large-scale gray infrastructure systems to neighborhood-scaled green infrastructure infill, these networks can also be opportunities for neighborhood re-development, cost efficiencies, and even community job creation.[26]

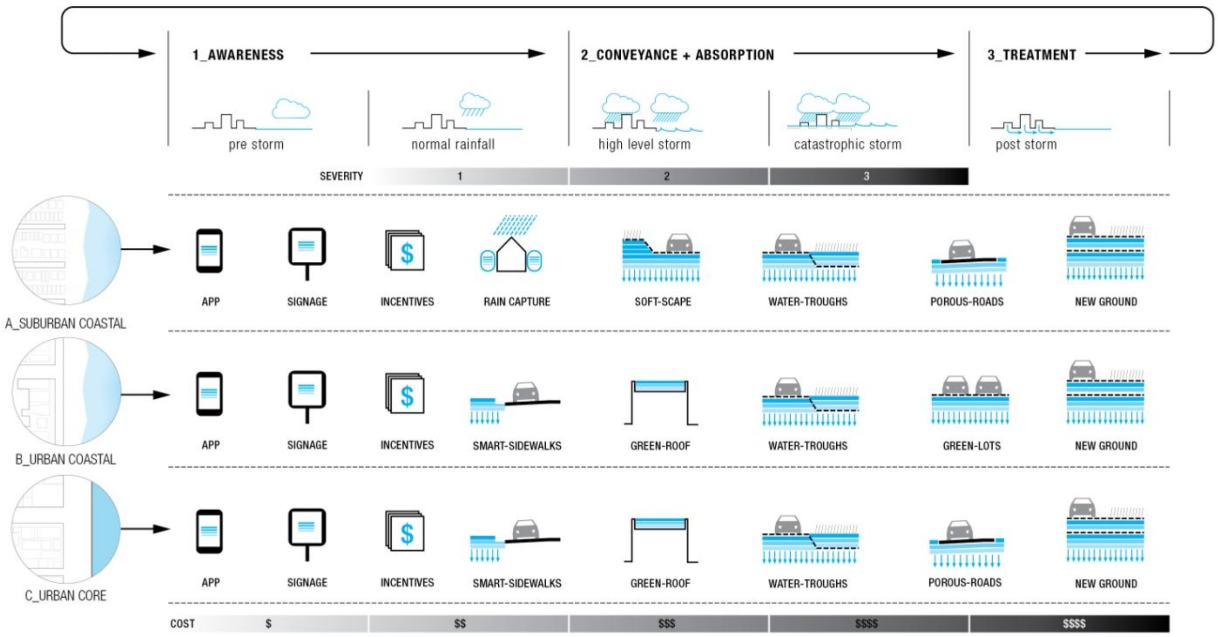

Figure 3. PoroCity Adaptation Strategies

Information connectivity and stormwater connectivity throughout a community builds greater capacity for effective management in storm events at various scales; at the largest scale, when catastrophic storms surpass the ability of networked green infrastructure to manage inundation, digital networks provide means of sharing critical data regarding storm predictions, evacuation routes, and access to emergency services. The potential for digital networking to improve response to catastrophic storm events has already been demonstrated by efforts of the Occupy Wall Street movement's quick response following the impacts of Super Storm Sandy.

Digital networks provide the foundation for this proposal, forming the connective tissue between individuals within a community and projects within a neighborhood; however, physical networking is also an important component of the project. *PoroCity* is applicable in various urban and suburban development patterns, and operates at the individual neighborhood/community scale. Phasing integrates the network with existing communities strategically with the cycle of rain events. By integrating with seasonality of storm events, funding for new green infrastructure projects can be delivered periodically and prevent the need for large, upfront spending for capital improvements. Sociologist, Manuel Castells has theorized the role that knowledge of technology, information, and access to networks will play in the new 'informational economy.'[27] The authors argue that local municipalities and urban infrastructure must also engage in these technologies to remain relevant in the contemporary digital age; an age in which Castells argues will be organized completely around electronic media.

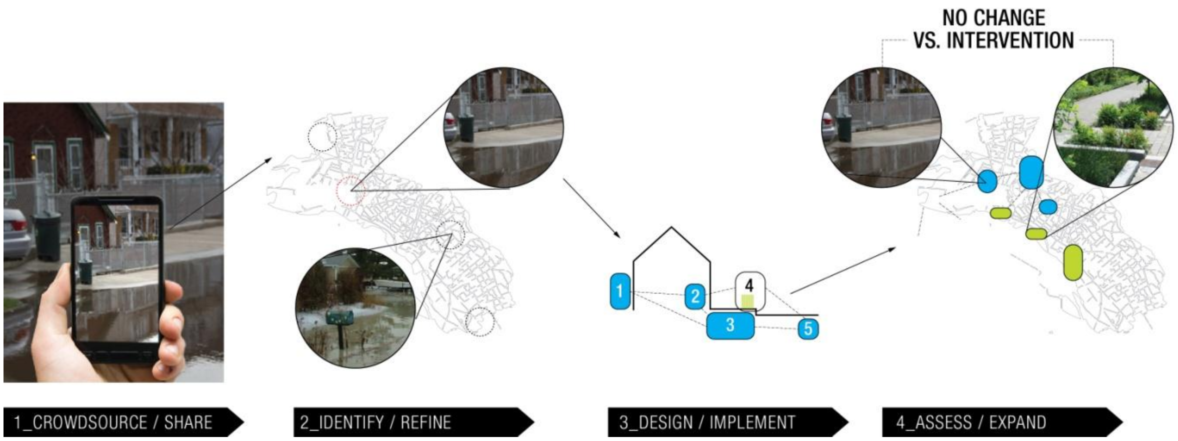

Figure 4. PoroCity Phasing Diagram

Applying the *Porocity* Network

The *PoroCity* network can provide an opportunity for addressing community resilience to alternative environmental and social conditions, beyond merely stormwater management. Funded by the University of California Humanities Research Institute (UCHRI), a current project is being launched to explore the adaptation of the *PoroCity* network towards greater community resilience to climate change in Oakland, California. While stormwater management is still a climate change impact of issue, drought, sea level rise, and extreme heat are also competing concerns within the region. Moreover, the City of Oakland is already host to a range of unique and problematic conditions of social disparity, where the concentration of waterfront industry, transportation, and development contribute to territories of vulnerability exacerbated by environmental concerns associated with climate change. Fifty-seven percent of Oakland's 407,000 residents live in a census track with high social vulnerability to climate change.[28]

Oakland is also a coastal city, and water level in the bay is projected to rise by as much as fifty-five inches or four-and-a-half feet in this area by 2100.[29] Much of the coastal area of Oakland houses important industrial and transportation resources including the Oakland International Airport. While coastal areas in the city are threatened by rising water levels and flooding, inland portions of the city may become more vulnerable to forest fires, extreme heat, and related air quality and health concerns. However, Oakland also has a strong network of community organizations working to engage residents to address the deep need in the city around issues of social, economic, and environmental justice. This includes the community-based, non-profit organization, the Institute for Sustainable Economic, Educational, and Environmental Design (I-SEEED).

Tapping into existing community networks, the *PoroCity* digital network can encourage a greater engagement between vulnerable neighborhoods and the exploration, documentation, and dialogue about the local effects and experiences of climate change. The impacts of climate change are well known to the academics who study them. To the average individual, however, predicted environmental change can be difficult to grasp, [30] especially when they are described through regional and global effects such as species loss, ice cap melts, seasonal temperature and weather changes, and sea level rise. There is a need to better understand the sometime-subtle, local, and everyday ways in which people are experiencing climate change, as these impacts often disproportionately impact socially and economically vulnerable populations. The employment of the *PoroCity* networks in Oakland, California addresses the need for local perspectives by using social network and digital media tools to establish a digital community network to 1. Provide community members with the ability to better visualize the direct impacts of climate change within their immediate surroundings; 2. Create opportunities to contribute images and narratives to community-generated neighborhood resilience mapping; and 3. Encourage communities to participate in on-going local conversations about climate change resilience.

The *PoroCity* network will allow community youth to participate in community site selection, documentation, and analysis based off projected impacts of climate change. These local youths will integrate their site documentation, both imagery and narrative, with existing social media tools, such as Facebook, Instagram, and Twitter to encourage a greater understanding and dialogue regarding anticipated changes to their landscapes. Ultimately, the application of the *PoroCity* network to the communities within Oakland, CA aims to make the impacts of climate change more comprehensible to the average individual at the neighborhood scale. The community partnership, focus on Oakland, and work with youth facilitates the sharing of information with vulnerable communities, who generally have limited access to climate change data. Members of these communities also generally have limited opportunities to engage in the political dialogues regarding climate change mitigation, adaptation, and resilience. This project will support resident dialogue, providing the needed tools and information to envision and advocate for alternatives, and for local action on resilient adaptation in planning and policy.[31]

Figure 5. Alternative visions for a resilient Oakland. Images courtesy of Tyler Van Pelt, UCD BSLA 2013

Conclusion

The digital age is upon us. Urban culture is increasingly inseparably from electronic media and digitally networking. Its impacts on urban infrastructure is already clear, as exemplified by contemporary transportation innovations. However, the potential to expand its presence in addressing climate change impacts is still under-explored in U.S. cities. While 'Occupy Sandy' provides a opportunity to consider a digitally integrated emergency response to climate change impacts, there is also a need to consider opportunities to mitigate these impacts and improve urban infrastructure through digital networking.

PoroCity presents an opportunity to reconsider the outdated systems of urban infrastructure through systematic integration with new digital technologies and social networking tools. While improving infrastructure networks are an important goal towards urban resilience, building communities' capacities to manage their experience of climate change could have far greater impacts. Digital networks allow for communities to become more involved in the evaluation and decision-making processes of their urban experiences. This includes addressing urban landscapes and infrastructure, and participating in the dialogue towards improving their performance. While the conditions vary from city to city, the *PoroCity* network can universally help communities gain greater capacity to manage the multiple impacts of a changing climate.

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[1] This report determined the key success as such: 1. The horizontal structure of Occupy Sandy enabled the response functionality to be agile; 2. Occupy Sandy used social media as the primary means to attract and mobilize a large volunteer corps, identify real-time community needs, and share information. Open-source software tools were used to coordinate rapid relief services; 3. Occupy Sandy leveraged the Occupy Wall Street infrastructure to emerge within days of the storm; 4. Occupy Sandy leveraged existing community infrastructure to address needs, establish trust relationships, and build local capacity; and 5. Transparent practices increased trust among Occupy Sandy members and the general public. From Eric Ambinder and David M. Jennings. "The Resilient Social Network." A Report from the Homeland Security Studies and Analysis Institute (2013): 4.

[2] William Mitchell, "Intelligent Cities," *Inaugural Lecture of the UOC 2007-2008 Academic Year* (2007): 5.

[3] William Mitchell. *Me++: The Cyborg Self and the Networked City*. Cambridge: MIT Press (2003).

[4] Matthew Gandy, "Cyborg Urbanization: Complexity and Monstrosity in the Contemporary City," from *International Journal of Urban and Regional Research*. 29.1:26-49, (2005).

[5] Eric Goldwin, "The Most Important Transportation Innovation of the Decade is the Smartphone," from *The Atlantic's CityLab*. Accessed September 4, 2014 from http://www.citylab.com/commute/2014/09/the-most-important-transportation-innovation-of-this-decade-is-the-smartphone/379525/?utm_source=Urbanful+Primary+List&utm_campaign=690ecc1b30-September_4_Test_Group_I&utm_medium=email&utm_term=0_fdf64fbc84-690ecc1b30-197316741.

[6] The 2010 United Nations summit addressed the need for climate change mitigation to require global efforts to have impact on the pattern of fossil fuel usage and greenhouse gas production since the start of

the Industrial Revolution. United Nations Environmental Programme (UNEP). 2010. UNEP Year Book: New Science and Developments in our Changing Environment. Published by the United Nations.

[7] Climate change impacts vary regionally, as do the political structures that govern cities and regions throughout the U.S. As such, planning efforts to address adaptation will require a local response. Stephane, Hallegatte, Fanny Henriet, and Jan Corfee-Morlot. 2011. "The economics of climate change impacts and policy benefits at city scale: a conceptual framework." Climactic Change, 104:51-87.

[8] Examples given of regional and national headlines: "Drought Emergency Declared in California," by Michael Short. *San Francisco Chronicle*, January 17, 2014. "Severe Drought Grows Worse in California," by Norimitsu Onishi and Malia Wollan, *The New York Times*, January 17, 2014. "Drought not just a California problem," *USA Today*, September 4, 2014.

[9] Examples given of regional and national headlines: "Learning From the Superstorm," by Judith Rodin, *The New York Times*, November 2, 2012. "New York Ignored reports warning of superstorm," from *USA Today*, December 8, 2012.

[10] Examples given of regional and national headlines: "Polar Vortex: Temperatures Fall Far, Fast," by James Barron and Henry Fountain. *The New York Times*, January 6, 2014. "Polar vortex: America in deep freeze." From *The Boston Globe*, January 9, 2014. "Wintry week looms as polar vortex returns," by Doyle Rice, *USA Today*, February 24, 2014.

[11] The impacts of global environmental change include a projected increase in the severity and frequency of hurricane and severe storm activity on the Atlantic Coast. Geophysical Fluid Dynamics Laboratory/NOAA. "Global Warming and Hurricanes: Has Global Warming Affected Atlantic Hurricane Activity?" December 30, 2013. Accessed September 22, 2014 from http://www.gfdl.noaa.gov/global-warming-and-hurricanes.

[12] The occurrence of winter 2014's polar vortex has been directly linked to anthropocentric driven climate change, and the upcoming 2015 winter is anticipated to experience similar patterns of severe cold and precipitation. Eric Holthaus. "New Study Links Polar Vortex to Climate Change." From *Slate's Future Tense*. September 3, 2014. Accessed on September 22, 2014 from http://www.slate.com/blogs/future_tense/2014/09/03/new_study_links_polar_vortex_to_climate_change.html.

[13] Current outfalls for San Francisco's combined sewer system are located at an elevation only several feet below existing high tide levels. Sixteen inch projected mean sea level rise for 2030 will inundate existing stormwater catchment systems with sea water. San Francisco Planning and Urban Research (SPUR). 2011. "Climate Change Hits Home." Urbanist, Issue 503.

[14] Stanley K. Schultz and Clay McShane, "To Engineer the Metropolis: Sewers, Sanitation, and City Planning in the Late-Nineteenth Century America," The Journal of American History (1978): 389 - 411.

[15] The city of Chicago, Illinois was lifted an entire finished floor grade to provide clearance for the city's sewer system. "Reversal of Fortune - 99% Invisible," 99% Invisible, accessed December 17, 2013 from http://this-episode.net/2013/08/reversal-of-fortune-99-invisible/.

[16] U.S. EPA mandates stormwater treatment based off a municipality's population density and impervious pavement cover within metropolitan regions "Stormwater Program," United States Environmental Protection Agency, accessed on December 17, 2013 from http://cfpub.epa.gov/npdes/home.cfm?program_id=6.

[17] Michael Schwirtz. “Report Cites Large Release of Sewage from Hurricane Sandy,” *The New York Times*, 30 April 2013, http://www.nytimes.com/2013/05/01/nyregion/hurricane-sandy-sent-billions-of-gallons-of-sewage-into-waterways.html.

[18] Ibid.

[19] Stephanie Hallegatte and Jan Corfee-Morlot, “Understanding climate change impacts, vulnerability and adaptation at the city scale: an introduction.” *Climactic Change*, (2011): 104-1-12.

[20] PlaNYC includes a $0.05/square foot tax on stand-alone parking lots within the city. New York City Office of the Mayor, “PlaNYC 2030: A Greener, Greater New York,” New York City: Office of the Mayor (2007).

[21] Stormwater collection, source separation, wastewater and graywater recycling, and advanced conservation techniques are three critical ways in which cities areas can improve major urban watershed concerns. David Del Porto, "Urban and industrial watersheds and ecological sanitation: two sustainable strategies for on-site urban water management." *Water Crisis: Myth or Reality?* (2010): 285.

[22] Levee failures in New Orleans, Louisiana resultant from Hurricane Katrina in 2005 resulted in nearly 2,000 deaths and over $100 billion in property damage. Louise K. Comfort, “Cities at Risk: Hurricane Katrina and the Drowning of New Orleans,” *Urban Affairs Review* (2006): 501 - 516.

[23] Mark Weiser. "Open House,” from *Review*, the web magazine of the Interactive Telecommunications Program of New York University. March 1996, ITP Review 2.0.

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[25] *Local Code: Real Estates* was a finalist for the 2010 national competition, entitled WPA2.0 and hosted by UCLA’s cityLAB. University of California Los Angeles Department of Architecture and Urban Design. “WPA2.0, The Projects: Local Code: Real Estates,” accessed September 10, 14 from http://wpa2.aud.ucla.edu/info/index.php?/theprojects/local-code/.

[26] In Buffalo, New York, local green infrastructure projects are being studied as opportunities to create community-based organization in stormwater management. Sam Magavern, Tina Meyers, Jen Kaminsky, and Sarah Maurer. “Building the Blue Economy: Opportunities for Community-Based Organizations in Stormwater Management.” A Report from PUSH Buffalo and The Partnership for the Public Good (2014): 3.

[27] Manuel Castells. *The Rise of the Network Society, The Information Age: Economy, Society, and Culture, Vol. 1., Second Edition.* (2000): Oxford Press: Cambridge, MA.

[28] Catalina Garzon, Heather Cooley, Matthew Heberger, Eli Moore, Lucy Allen, Eyal Matalon, Anna Doty, and the Oakland Climate Action Coalition. (Pacific Institute). *Community- Based Climate Adaptation Planning: Case Study of Oakland, California*. California Energy Commission. (2012): Publication number: CEC-500-2012-038.

[29] Noah Knowles. “Potential Inundation Due to Rising Sea Levels in the San Francisco Bay Region.” San Francisco Estuary and Watershed Science, (2010): 8: 1-19.

[30] It is difficult to fully understand the detailed causes of migration and economic and political instability, but the growing evidence of links between these issues, climate change, and political conflicts are alarming. Michael Werz and Laura Conley. “Climate Change, Migration, and Conflict: Addressing complex crisis

scenarios in the 21st Century." *Center for American Progress*, January 2012. Accessed September 22, 2014 from http://www.americanprogress.org/issues/security/report/2012/01/03/10857/climate-change-migration-and-conflict/.

[31] Led by N. Claire Napawan and Sheryl-Ann Simpson, University of California Davis, Department of Human Ecology, and with collaboration with the Davis Humanities Institute and other members of the University of California, the application of the *PoroCity* network to Oakland, California has been initiated as of September 2014 with an anticipated launch in June 2015.

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