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Urban Digital Divides and Community WiFi: A Case Study of Red Hook, Brooklyn

Keywords: Urban Digital Divide, ICT infrastructure, Wireless Mesh Network, Wireless Community Networks, Broadband Planning, Resiliency.

Abstract:

As a research area, the scholarship on the digital divide has largely focused on the difference in internet access and availability between urban and rural sites. The proposed research endeavor investigates the digital divide within urban areas to understand the linkages between resiliency, information and communication technologies (ICT), and the field of urban planning. Using GIS visualization and a case study approach, this thesis examines internet access and availability within New York City. The GIS visualization draws upon public sources of data to map areas with low internet penetration within the study area. The case study approach involves interviews with members of Red Hook WiFi, an organization in Red Hook, Brooklyn that is working to address the digital divide through training and community outreach. Using this mixed-methods approach, several conclusions came to light: 1) that the urban digital divide aligns with the theoretical understanding of it as “pockets of inclusion and exclusion” with a socio-economic underpinning, as reported in the literature; 2) current and planned initiatives to address this divide are not sufficient; and 3) the community developed and owned WiFi network has enabled key resiliency capacities that need to be built upon. Given these conclusions, this study concludes by discussing the role that urban planning can play in fostering more resilient communities by becoming engaged in broadband planning and also offers recommendations for city agencies, local organizations, and planners themselves.

Urban Digital Divides and Community WiFi: A Case Study of Red Hook, Brooklyn

A Thesis Presented to the Faculty of Architecture and Planning
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by

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Contents

INTRODUCTION

By this point in the 21st century, the notion that information and communication technologies (ICT) form an essential and established part in the lives of many is commonplace and uncontroversial given the extent to which it impacts such a wide range of daily human activity. But when focusing on information technology (IT) and specifically the user's interaction with the internet and its infrastructure, a more complex picture of ICT emerges. For the average user, the internet hovers somewhere within a nebulous cloud— immaterial, virtual, wireless. It is, in the words of Stephen Graham, an "unproblematic and 'closed' socio-technical artifacts" (Graham, 2000, pg. 184). Opening of this conceptualization of ICT reveals a system that is problematic, especially for urban planners. As a first step this can be understood in terms of how ICT infrastructure compares with other infrastructure.

The provision of IT infrastructure in the contemporary city differs from the traditional infrastructure such as electricity, water, and roads in that it dynamically engages with the spatial fabric of the city in two distinct and important ways. Firstly, IT infrastructure is by and large provisioned through private sector operators. Through the liberalization of this sector, IT networks became the domain of a patchwork of various telecommunication firms. The ramifications of this are quite significant. Rather than operating under a unified or central authority with the wherewithal to undertake large-scale (and often times risky) projects, firms parcel off projects into smaller and thus more manageable segments. This leads to the second key difference, which is that private sector actors operating in a market environment naturally choose projects on an individual basis that are high yield and low risk. Of course, such firms are unlikely to be attracted to impoverished geographies, given that the risk/reward balance is generally unfavorable for new and expensive investment. As a result, the landscape of IT infrastructure in cities consists of an uneven topology of connectivity peaks and valleys, often times with the two areas positioned side by side. This urban digital divide has grave implications for equity and access and highlights the gap between the potential of the internet and the reality, between availability and access.

As a field, urban planning has largely shied away from the issue of ICT planning, viz. broadband internet planning. Yet given planners concerns with equity, economic development, infrastructure provision, and resiliency, there is a strong impetus to get involved. This thesis is aimed at understanding the spatial implications of the digital divide within the urban context of New York City. It also seeks to understand how ICT planning overlaps with the larger goals of urban planning. Further, this study will focus specifically on the linked issues of resiliency and

ICT planning/provision in the Red Hook, Brooklyn, given the neighborhoods recent experience with the Hurricane Sandy.

Hurricane Sandy revealed the vulnerability of various facets of the built environment of New York, not the least of which was the internet infrastructure (e.g. the estimated damages to Verizon's wireline infrastructure was estimated to be $1 billion). In the aftermath of Sandy's destruction, the Red Hook Initiative (RHI), a locally based NGO, addressed this vulnerability through the installation of wireless mesh networks (WMN), a system of routing network traffic (both internet and local) across a dispersed network of nodes. In addition, RHI offers a comprehensive program designed to not only provide back-up communications in the event of another Sandy, but also to bring internet connectivity to a disadvantaged community through youth outreach, training and part-time internships.

The provision of WMN can thus be analyzed through the lens of resiliency— not in the voguish meaning of term as a return to a previous or new equilibrium but in the sense of what Davoudi (2012) refers to as "evolutionary resiliency", the ability to reach a new state. This understanding of resiliency is quite apt, as it accepts complexity as an essential characteristic of social systems. Its value is that it rejects the idea that a complex system such as a urban community can be resilient by bouncing back from a disaster to the same place it was beforehand. Evolutionary resiliency emphasizes the importance of overcoming the preexisting vulnerabilities when reaching a new state. Accordingly, this thesis seeks to explore and understand to what extent Red Hook has reached a new state. In summary, this thesis asks the following questions about ICT planning in New York City and in the Red Hook neighborhood:

- How is New York City addressing the digital divide?
- Do the current measures reach areas with the lowest broadband penetration?
- How does the bottom-up initiative of Red Hook WiFi compare: does it offer a better method for addressing the digital divide?
- Specifically, how have the network and its training program contributed to community resiliency?

The next section provides a historical and demographic background on Red Hook in order to provide context for the work that RHI does. The background section is follow by the literature review, which brings together existing work on the urban digital divide, including sociological studies on internet access with insights on the internet as infrastructure from the emerging field of infrastructure studies. The literature review is followed by the methodology and data sources

that have been developed for this study. The results are then presented followed by a discussion of the results.

BACKGROUND

Demographics

The population of Red Hook falls within census tracts 053, 059, and 085 and totals 10,228, of which 82% reside in the Red Hook Houses. As the chart at right depicts, Red Hook has a large Hispanic community (43%) and Black community (36%). According to ACS 2012 5-year estimates, the neighborhood has a median income of $25,000 and a recorded unemployment rate of 19.8%. The entirety of Red Hook is located within the city's hurricane evacuation zone 1, which means that in the event of a hurricane, the neighborhood would be among the first to fall under an evacuation order.

History

Understanding contemporary Red Hook involves understanding the various historical, economic, and social forces that have shaped the evolution of this neighborhood. Its history, from its original ecology and landscape to the succession of major interventions into the built environment, provides a deep insight into the vulnerabilities and resilience of the place and its people. Early Red Hook was a fifty acre marshy island that was separated from the rest of Brooklyn proper. It was settled in 1636 by Dutch colonists who named their village *Roode Hoek*— *roode* for the red soils and *hoek*, meaning point or corner. Early maps reveal an ecologically sensitive area, full of low-lying tidal wetlands, creeks, ponds, and mudflats. This landscape was slowly altered, as a prominent hill on the original island of Red Hook was leveled to provide infill, thus enlarging the neighborhood. By 1835, maps depict a landscape rationalized by man: a meandering road links the neighborhood to Brooklyn, small ponds and creeks have been filled in to leave one large mill pond.

The greatest change to the landscape came between 1825 and 1896, as economic forces and industrialization inexorably reorganized technology, labor, and nature. In 1825, the Erie Canal opened, which allowed goods to be shipped across the Great Lakes and down the Hudson River to New York City. As mid-19th century lower Manhattan was already built out by

public piers and warehouses in various states of disrepair, Red Hook's waterfront location, its large opens spaces, and its proximity to lower Manhattan made it ideal for maritime industries. In addition, the construction of the Atlantic and Erie Basins in 1847 and 1864 respectively fueled Red Hook's boom years as a center for warehousing and maritime trade. By 1896, Red Hook assumed the familiar morphology of present times.

However, the changing nature of technological and economic forces stopped favoring Red Hook as the development of and transportation by rail became far more efficient means than utilizing the barge system of the Erie Canal. Investment slowly began to shift to ports that offered direct rail-to-ship transfers. Such ports were placed in areas where large swaths of land enabled the provisioning of rail infrastructure. Beginning in the 1920's Red Hook began to experience a period of decline. By the 1960's, containerization sounded the death knell of Red Hook's working waterfront, as container ports required large tracts of land. Thus, much as sparsely built Red Hook had drawn investment from crowded piers of Manhattan in the mid-19th century, so too did the New Jersey waterfront draw away investment from Red Hook in the mid-20th century.

For all the investment into the economic development of Red Hook, far less was invested into Red Hook's social infrastructure. In 1880's informal settlements arose the conditions of which shocked New Yorkers of that era. During the Great Depression, a Hooverville rose in the shadow of the Red Hook's imposing waterfront Grain Terminal. In 1939, this Hooverville was replaced by one of New York City's first housing projects— the Red Hook Houses. In 1940, the houses were hailed by Lewis Mumford as "a Versailles for the millions". But despite these high hopes, Red Hook was to suffer a series of setbacks.

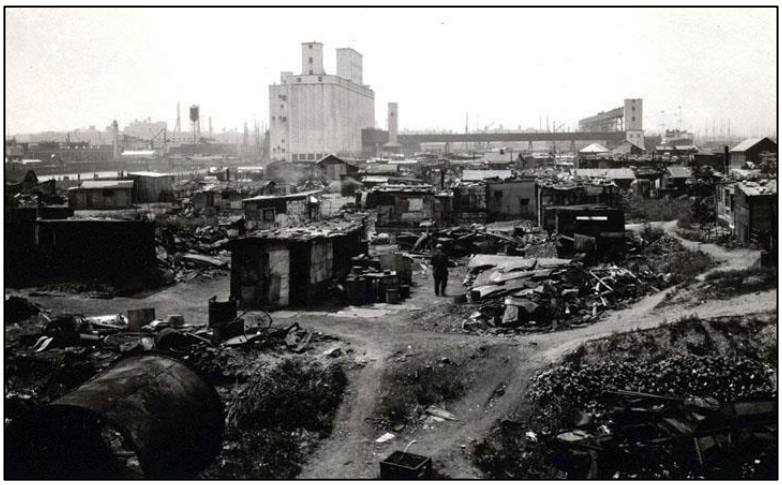


Figure 1: Red Hook's Hooverville (via http://www.theatlantic.com/photo/2012/04/historic-photos-from-the-nyc-municipal-archives/100286/#img25)

In 1964, the Brooklyn-Queens Expressway (BQE) was completed. Originally planned by Robert Moses to cut through the adjacent neighborhood of Brooklyn Heights, the construction was pushed further west into Red Hook after the affluent and well-connected residents of

Brooklyn Heights objected. To mitigate the adverse effects of the portion of the BQE that still cut through Brooklyn Heights, the residents were able to lobby for the creation of manicured parks. For a neighborhood surrounded on three sides by water, the BQE physically severed Red Hook from the rest of the borough of Brooklyn. It also psychologically separated the residents from local government. The confluence of this isolation, as well as declining employment and capital flight led to skyrocketing crimes rates. However, Red Hook's unique economic and social history as well as it's self-perception of pugnaciously opposing outside proposals has fostered a sense of self-reliance among the residents, which in some ways was proven when Hurricane Sandy struck in October of 2012.

Given Red Hook's vulnerable low-lying ecology and large population of residents in public housing, it should come as no surprise that Hurricane Sandy had a devastating impact. The 14-foot storm surge inundated the entire neighborhood, save for the remainder of the aforementioned hill that was used for infill. In addition to widespread damages to homes and businesses, electricity, water, cell phone, and internet networks went down across the neighborhood. However, the Red Hook Initiative (RHI), a local community organization formed in 2002, was largely spared given its location at the most inland portion of Red Hook. Not only did RHI have electricity, but it also had a basic wireless mesh network (WMN) set up between the center and an apartment that overlooked nearby Coffey Park. RHI soon became a hub for post-Sandy relief efforts, especially once the Federal Emergency Management Agency (FEMA) installed a satellite internet connection. The WMN leveraged this connection to provide internet access across Coffey Park where residents would gather to connect to the outside world.

Since Sandy, RHI has expanded its WMN from two nodes to 15. As part of this wireless network initiative (dubbed Red Hook WiFi), RHI has launched the Digital Stewards program, which employs Red Hook young adults between the ages of 19 and 24 to install, maintain, and promote the mesh network. The stewards are hired for one year and receive training in hardware, software, and community organizing. At the end of their year, stewards are placed in jobs or internships. There are currently four stewards

Figure 2: The Digital Stewards.

in the most recent cohort, with 20 who have gone through the full program. Of these 20, approximately ten of them have leveraged their experience into full-time jobs.

LITERATURE REVIEW

The literature on internet infrastructure and WiFi provision includes both abstract analyses and empirical studies spanning a wide range of disciplines. The authors and ideas discussed in the review that follows hail from fields as diverse as sociology, communications, science and technology studies, and history. However, the topic of internet infrastructure and ICT planning is largely absent from the literature and the agenda of the field of urban planning (Byrum, 2012; McMahon, Thomas, Kaylor, 2012). The approach below will briefly discuss how other forms of infrastructure have been analyzed vis-a-vis the city, before proceeding to theoretical and empirical studies of IT in other fields. It will then review the literature on why ICT planning has been absent from urban planning and then conclude with a review of the literature on ICT and community resiliency.

Numerous authors have analyzed the role of non-IT infrastructure in the development and growth of cities (an illustrative sampling includes Isard, 1942; Olson, 1979; Hughes, 1983; Graham, 2000; Graham and Marvin, 2001; Gullberg and Kaijser, 2004). These studies reveal several key similarities and differences between IT infrastructure and non-IT infrastructure. At the most basic level, the salient characteristic of non-IT infrastructure pertains to their physicality. The manner in which a user interacts with roads, railways, electricity and water is different from how they engage with the internet. In the former, the user is forced to physically interact with the underlying infrastructure, be it by sitting on the train and riding over rails, or by manipulating switches and knobs to provide electricity and water (Star and Bowker, 2010). This latter example highlights the outward terminals of infrastructures that come pre-installed in dwellings.

IT is different. While IT infrastructure obviously has a physical component (towers, communication lines, etc), most users are not required to physically engage with the underlying technology. Once a specialist has installed the outward terminals of an internet connection (i.e. modem, router, cables), the internet remains “on”. Aside from interacting with their devices, their experience is largely immaterial. Further, the language and discourse of the internet only furthers the divide between the two infrastructures. To take but a few examples, “wireless” involves millions of miles of buried wires and anything that considers itself “mobile” is anchored or tethered to real infrastructure such as towers and satellites. "Cloud computing" serves as a

particularly vivid example of the difference between the rhetoric (the "cloud itself") and the reality (massive server farms built where land and energy are cheap).

As discussed above, another key difference is that IT infrastructure is provisioned by a patchwork of private sector actors who are not regulated as a traditional utility is. Traditional utilities such as gas, electric, and water are “natural monopolies”, meaning that only one entity provisions the needed infrastructure and does so at a lower cost as any new entrants would require completely new infrastructure to be built (e.g. think of the cost and impracticality of building numerous gas or water lines on top of each other). In order to ensure that these monopolies do not abuse their position by charging unfair rates or providing substandard service, utilities are regulated with an eye towards the public interest, viz. in the following five ways (from Filipink, 2009): (1) controlling market entry and exit; (2) setting rates; (3) setting standards for quality and safety of service; (4) assuring non-discriminatory service; and (5) preventing undue financial risk.

A significant milestone was reached on February 26, 2015, when the FCC voted to reclassify broadband internet as a utility instead of an information service under the authority of Title II of the Telecommunications Act of 1996. However, as noted in the New York Times article that reported the decision, “the new rules are an à la carte version of Title II, adopting some provisions and shunning others” and that the FCC “will not get involved in pricing decisions or the engineering decisions companies make in managing their networks” (Ruiz and Lohr, 2015). Thus, while this reclassification is a major step forward in that it promotes net neutrality by blocking the practice of paid, prioritized access to telecommunications networks (i.e. the so called “fast lanes” to the internet), the nature of the provision of IT infrastructure is not expected to change.

As a result, the private sector actors that provision IT infrastructure will continue to parcel projects off and focus on high yield/low risk environment. Graham (2000, pg. 190) refers to this process as contributing significantly to “splintered models of infrastructural development”. These splintered models find a ready partner in the spatial inequalities of the city, in that areas with low internet penetration correspond to underserved communities (Odendaal, 2011; OTI 2014; Dailey 2010; Mossberger, Tolbert, Franko, 2012; Njoh, 2012). For instance, in Nancy Odendaal’s 2011 study on ICT infrastructure in Durban, South Africa, she notes that:

> ICT is intrinsically urban. The contemporary city reveals the stark unevenness of the diffusion of ICT, however; concerns over digital divides recognize the spatial and social inequalities that underpin this dynamic. (pg. 2378)

Thus, when it comes to IT and non-IT infrastructure, there are opposing notions of private versus public, fragmented versus unified, and physical verse immaterial. Despite these significant differences, key areas of overlap exist between IT and non-IT infrastructure. For example, both types are considered "unproblematic and 'closed' socio-technical artifacts" or simply a "black box" (Graham, 2000; Forlano, 2008; Star and Bowker, 2010). In other words, the typical user of any infrastructure is largely unaware of it unless it breaks down—e.g. when the water and electricity are cut off or when a road slides into disrepair. Additionally, their historical development share a striking similarity in that both types of infrastructure begin with a disorderly and independently provisioned phase (Sandvig 2006; Sawhney, 2003). As both Sandvig and Sawhney mention, infrastructure such as road, rail, telegraph, and telephone all had initial periods of development whereby each was independently built and operated, without overall coordination. Sawhney (2003, pg. 27) refers to this phase as the " sprouting of infrastructure islands". Ultimately, as a new type of infrastructure takes root and develops, he states that it "does not strike roots and grow on a virgin ground […] it encounters a terrain marked by old technologies" (Sawheny 2003, pg. 25). Most relevant for the current study, Sawhney and Sandvig apply their analyses to the development and provision of WiFi, writing that WiFi has not developed on a blank slate, but has developed on the terrain of wired internet infrastructure. This is a key point to consider when the study considers New York City's plan to upgrade public pay phones into internet and WiFi nodes.

From the discussion above, some areas of potential synthesis can be explored. Firstly, while it is true that IT provision is "splintered" or "fragmented" as Graham and his ilk postulate, it is possible that fragmentation may actually be part of the cycle of developing and deploying new infrastructures. Private sector forces are indeed responsible, but so too are the technology enthusiasts who are rolling out various islands of WiFi without a central coordinating mechanism (enthusiasts who are filled with "libertarian impulses", to borrow from Sawhney (2003)). Second, many of these enthusiasts have also formed alliances and coalitions in order to ensure the more equitable spread of wireless internet. These groups, along with various academics studying infrastructure, and society and technology, aim to problematize IT infrastructure and open the black box (Star 1999; Sandvig, Young, Meinrath, 2004; Star and Bowker, 2010; Forlano, 2008).

Following from this point is the provision of WMNs. WMNs are a system of routing network traffic (both internet and local) across a dispersed network of nodes. It is a non-centralized, nonhierarchical system whereby nodes can remain connected to the network even if the connection is severed between two nodes (Forlano 2008). The rise of mesh networking and its

role in community wireless networks (CWN) has been covered by various authors (Forlano, 2008; Abelaal, 2013; Meinrath 2005; Bar and Galperin, 2005; New America Foundation 2011). However, although these authors and others (including Torrens, 2008; Mossberger, 2012; Hudson, 2014; Bar and Park, 2006; Byrum, Breitbart et al, 2014) highlight the urban nature of WMNs, CWN, and IT provision, little work has been undertaken within the field of urban planning to address this oversight.

The lack of involvement of urban planning in ICT and broadband planning is in some ways perplexing. As noted above, planners consider a wide range of issues— from equity and economic development to infrastructure provision and community resiliency— each of which interfaces with the issue of broadband. Byrum (2012) highlights the key factors that are responsible for this omission as 1) IT and communication infrastructure is not within the purview of planning, 2) the digital divide is a rural not urban issues, 3) telecommunications systems are driven by the private market, 4) lack of funding for planning agencies to undertake IT/telecommunications planning, 5) lack of community and industry group partners, and 6) planners lack of knowledge about technology. Byrum's paper also highlights the absence of telecommunications planning within the curriculum of the top ten graduate planning programs in US universities as well as the lack of literature on this topic (allowing for a few exceptions) within many of the major planning journals. One of the exceptions includes an APA Planning Advisory Service report on broadband planning. This document is an excellent introductory piece for incorporating IT planning concerns into the worldview of planners (McMahon, Thomas, Kaylor, 2012).

In the report, the authors write that "planners are often in positions to advocate for broadband as a vital infrastructure" through numerous avenues. The table below (adapted from McMahon, Thomas, Kaylor, 2012) identifies the point where planners can intervene across the various "layers" of broadband deployment. These layers refer to the discrete steps that data travels through from the human use of application through the transportation of data across the infrastructure of the internet. As the table shows, planners have numerous areas where they can become involved in broadband planning.

Planning Layer	Points of Intervention for Planners	Broadband Planning Component	Technology Functions
Physical Layer	• Inventory • Broadband mapping • Regional telecom plans	• Backbone, middle mile, and last mile infrastructure • Interconnection points on the network	• Manages the exchange of data between a device and the network to which it is attached
Interconnection Layer	• Policies/standards for ROWs, franchise agreements, leasing • Coordinate with other city systems and plans • Incorporate standards into codes	• Coordination among service providers and multiple city systems	• Provides the addressing needed to route packets across multiple networks
Transport Layer	• Aggregate demand • Map anchor institutions • Use public investment as incentive for deployment	• Connect anchor institutions and consumers to the network	• Provides end-to-end connectivity between data sources or destination devices
Application Layer	• GIS • Modeling • Civic Engagement • Collaboration Software • Service Delivery	• Data, video, voice, and mobile applications	• Function required by user programs
Human Layer	• Visioning—participating in broadband planning processes	• Business model and governance	• Organizational model to carry out other layers

Table 1: Broadband intervention points for planners (adapted from McMahon, Thomas, Kaylor, 2012)

The report also addresses some of the factors that Byrum identified as obstacles that limit planners involvement in broadband. For instance, the report identifies resources for planners to learn more about technology and its incorporation in the city. Additionally, although planners cite the private-sector provision of IT infrastructure as a reason to avoid engaging with it, McMahon et al (2012) note that city plans routinely involve or influence the private sector through a mix of financing schemes, partnerships, and public investments in infrastructure. Thus, the private nature of IT provision does not preclude it from falling under the purview of planners.

In terms of working with communities and industry groups, the report identifies potential partners such as libraries, broadband providers, local government, and economic development

organizations which can be brought together as part of the process of developing a comprehensive plan. The incorporation of broadband planning into comprehensive planning is key: Ziolkowski (2011) notes that most municipalities respond to telecommunication needs in a piecemeal fashion, preferring to act on individual issues rather than plan for broader ones. Provision of this infrastructure thus remains ad hoc, which limits the possibly of "socially optimized outcomes" and results in "profit-maximizing development for discrete market participants" (Ziolkowski, 2011, pg. 27). Thus, the opportunity is there for planners to engage all stakeholders through a visioning process that incorporates these concerns about social equity and the public interest (McMahon, Thomas, Kaylor, 2012).

Since the publication of the APA report in July 2012, there have been signs of growing interest in broadband planning. The APA has created a Smart City Task Force that incorporates broadband planning as a key topic. More planning documents and regional plans are mentioning broadband while a course of "Tech Cities" is being taught on Coursera (Kate McMahon, personal communications, February 4, 2015). That said, there is still much work to be done. In a survey of planners undertaken in February and March of 2013 as a follow-up to the APA report, over 40% of planners were uncertain of what broadband options existed in their communities (aside from DSL and 4G wireless) and less than 15% of communities are addressing this issue in their comprehensive plans (McMahon, 2013). Thus, there is ample room for the current study to investigate key questions regarding the role of planners in promoting resilient communities by means of IT (or ICT/broadband) planning.

Before continuing, it is important to understand what is meant by "resilient" or "resiliency" as multiple definitions exist across numerous disciplines (Norris, 2008). Several authors have commented on the increasing use of the term, while also highlighting the absence of specific definitions (Davoudi, 2012; Rose, 2007; Stumpp, 2013; Funfgeld, McEvoy and Bosomworth, 2013). These authors warn that the term is ambiguous and ubiquitous enough that it risks becoming a buzzword. Given the number of different interpretations of resiliency, this study finds it useful to focus on the notion of evolutionary resiliency (Davoudi, 2012). In this conceptualization, resiliency is seen as the ability of a system to adapt and to transform to a new state in response to stress or disaster. One of the strengths of evolutionary resiliency is its acceptance of complexity, fluidity, chaos, and unpredictability. This stands in contrast to other definitions of resiliency, which involve a system returning to either its pre-existing equilibrium or towards a new, static, equilibrium. Such a distinction is key in that the consequence of a community returning to a state of equilibrium is that it leaves pre-existing vulnerabilities and socio-economic inequities in place.

Pelling (2010) articulates a similar distinction as Davoudi, although his analysis is located not in the field of planning, but rather within the theoretical discussions surrounding social equity and climate change adaptation. In his framework, adaptation operates at three different levels to enable either resilience, transition, or transformation. For Pelling, resilience is understood as non-evolutionary, meaning that the system returns to a state of equilibrium and vulnerabilities remain in place. Transition is more progressive: change happens incrementally as the full potential of system is realized, without changing the overall system. Transformation is the most revolutionary level of adaptation in that the overarching political and/or economic system is reconfigured and power is redistributed across society. Thus, his characterization of the transition and transformation levels of adaptation is most akin to Davoudi's concept of evolutionary resilience. For the purpose of this study, the concept of transition is the most germane as it focuses on change and reform within the existing political regimes.

Both Pelling and Davoudi's arguments are important in framing resiliency vis-à-vis its larger context. However, in order to delve into the constitutive elements of resiliency, it is necessary to consider the model presented by Norris et al. (2008). This model, which appears in Figure 3 below, is regarded as quite influential within the discourse of resiliency (Sherreib, Norris, Galea 2010; Kulig et al. 2013). The strength of the model is its conceptualization of community resilience as a set of four networked "adaptive capacities": information and communication, community competence, social capital, and economic development. Each of these capacities has specific characteristics as well as their own properties such as robustness ("ability to withstand stress without degradation"), redundancy ("extent to which elements are substitutable in the event of disruption"), and rapidity ("capacity to achieve goals in a timely manner") (Norris et al., 2008, pg. 131). These capacities and their characteristics interact dynamically, resulting in a detailed understanding of resilience that underscores the transformational potential of resiliency.

Ospina and Heeks (2010) take Norris et al.'s 2008 analysis one step further by investigating the relationship between information and communication technologies (ICTs) and the elements of resiliency. Over the course of their own literature review, they conclude that ICTs have not been integrated into an understanding of resiliency and that technology has mainly been referenced as a tool to address a specific, as opposed to broader, challenges. Their study then proceeds to explore the linkages between ICT and the properties of resiliency; in addition to the three properties that Norris et al. (2008) identified, they add four more: scale, flexibility, self-organization, and learning. Ospina and Heeks coin the term "e-resilience" to encapsulate their incorporation of ICT into the discourse of resiliency. They conclude by stating

that ICTs as an integrated part of a holistic approach to climate change adaptation can bridge informal and formal actors that operate at various levels, from the micro (or local) up to the macro level.

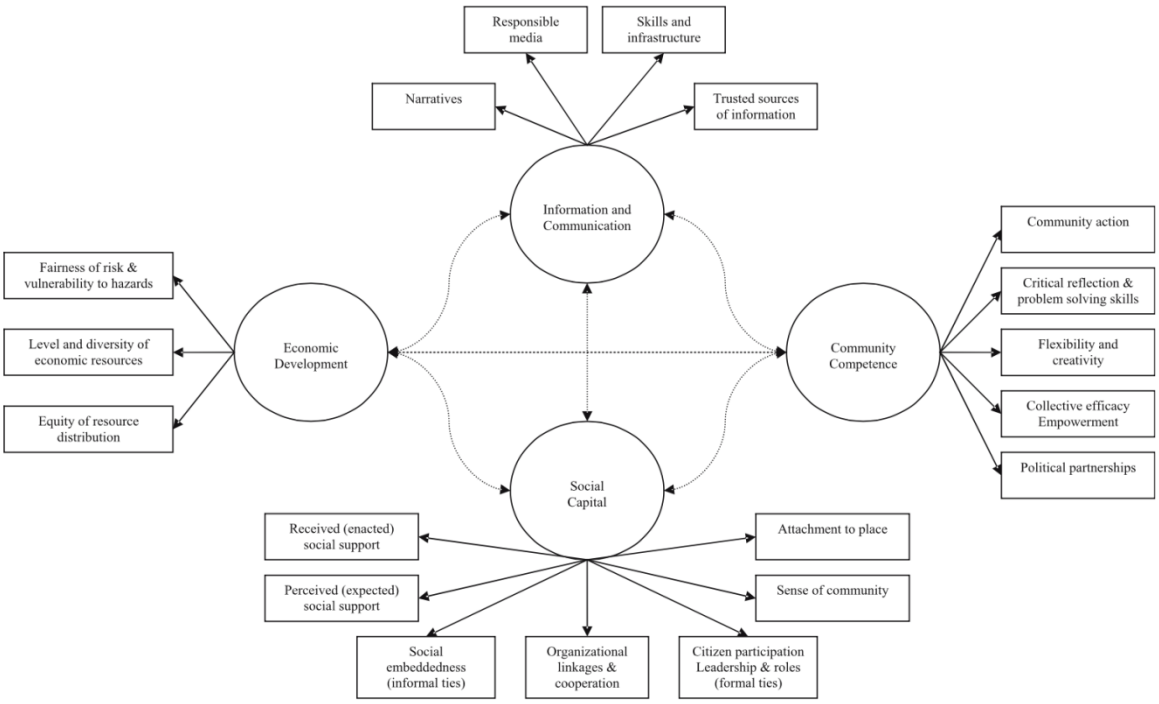


Figure 3: Norris 2008 (pg. 136) model of resiliency as a set of networked adaptive capacities.

METHODOLOGY

The methodology of this study is divided into GIS visualization and a qualitative case study of Red Hook. The purpose of the GIS visualization methodology is to show the extent of the problem of the urban digital divide. It will display where the gaps in internet coverage are. The qualitative portion seeks to determine what the impact RHI's ongoing efforts to address this gap. This proposal underwent IRB review and received approval to move forward on December 10, 2014. The methodology seeks to answer the following questions:

- How is New York City addressing the digital divide?
- Do the current measures reach areas with the lowest broadband penetration?
- How does the bottom-up initiative of Red Hook WiFi compare: does it offer a better method for addressing the digital divide?

- Specifically, how have the network and its training program contributed to community resiliency?

The GIS visualization maps areas within New York with low broadband adoption using publicly available data. The purpose is to provide a macro-level view of the spatial distribution of the digital divide in New York City, specifically the areas with and without access to broadband internet, as well as areas where the New York City Department of Information Technology and Telecommunications (DoITT) has rolled out or is planning to roll out free WiFi. This latter element is important because public WiFi "hotspots" allow users to go online using laptops and smartphones. If hotspots are proximate to living areas, they would obviate or at least mitigate the need for internet access at home.

The qualitative case study seeks to understand how the efforts to roll out mesh wireless networks in the NYC neighborhood of Red Hook have impacted the community. This is key, because Red Hook is the first neighborhood to be rolling out the system in manner that aims to address not only disaster preparedness, but also on community transformation. The Red Hook program is operated by a local NGO, the Red Hook Initiative (RHI), and features two main components. The first component is called Red Hook Wifi and involves partnering with local businesses and residents to provide wireless internet access for the community. The second component is the Digital Stewards program and offers Red Hook youth ages 19 to 24 paid training on the hardware and software of WMN deployment. This program also offers job training and career development and results in an internship or job at the end of the program.

GIS Visualization Methodology

The purpose of the GIS visualization is to depict the geographical extent of the urban digital divide in New York City. It displays gaps in internet coverage using data from the US Census 2013 1-year American Community Survey and the Federal Communications Commission (FCC) form 477. These two data sets display the lack of access to broadband internet at two different scales using two different methods. The ACS data that was released in September 2014 includes for the first time questions on computer ownership and broadband access. The data only exist at the level of the Public Use Microdata Area (PUMA). PUMAs are geographical groupings comprising 100,000 residents; NYC has 55 PUMAs. As a result, the ACS data are best suited to providing a city-wide visualization of the lack of access to broadband. For understanding the lack of access to broadband at a finer resolution, data from

the FCC form 477 is used. The FCC requires all broadband providers to submit on a semi-annual basis the number of residential broadband connections (per 1,000 households) at the census tract level. This information provides a closer look at broadband access at the level of the neighborhood, but is not well suited for city-wide visualizations.

Data on existing and future WiFi hotspots are available via New York City's open data website (https://nycopendata.socrata.com/). From this site, the locations of existing WiFi hotspots can be directly downloaded. This includes all hotspots available at libraries, parks, and through public-private partnerships. The future WiFi hotspots can be analyzed by looking at the data on current public pay phones, as the city is planning on upgrading its pay phone infrastructure into internet hotspots with free WiFi through its LinkNYC program.

In addition to the above data, the visualization methodology looks at the GIS data on New York City Housing Authority (NYCHA) developments. This is because Red Hook is home to the second largest public housing development in the city with approximately 8,000 people residing in 2,878 apartments. Further, incorporating NYCHA developments across the city provides insight on to the degree to which public housing residents are affected by the digital divide. In sum, this methodology involves utilizing GIS software and the publicly available data displayed in Table 2 below:

Indicator	**Source**
Residential broadband penetration	2013 American Community Survey (ACS)
Residential broadband penetration (FCC)	Federal Communication Commission (2013)
Existing and future WiFi hotspots	NYC Department of Information Technology and Telecommunications
Percentage of census tract living below poverty level	2013 American Community Survey (ACS)
Median household income	2013 American Community Survey (ACS)
NYCHA housing locations	NYC Department of City Planning

Table 2: Key Indicators.

Altogether, this visualization allows for a spatial investigation of areas with low broadband penetration and their relationship to income and poverty levels, while also determining if existing and future attempts to increase connectivity through the provision of free WiFi hotspots is targeting the areas with the greatest need.

Qualitative Methodology

The purpose of the qualitative approach is to gauge the impact that wireless mesh networks are having in Red Hook. The users of the network were surveyed via the landing page of the Red Hook WiFi network and were asked how many times per week they utilize the network; whether they used the network for fun, local news, or job opportunities, and how important they felt WiFi is for strengthening communities. The full responses are included in Appendix A. The qualitative methodology also involved interviewing the staff and users of the mesh networks in order to answer the larger question of whether the interventions of RHI are enhancing the evolutionary resiliency of Red Hook. Sample questions are included in Appendix B. Additionally a focus group was conducted on March 4th, 2015 with seven past and present members of the Digital Stewards themselves in order to understand how the program has impacted their understanding of: the internet as infrastructure; community resiliency during Hurricane Sandy; their own personal growth and development. The questions listed in Appendix C were used as prompts to encourage the stewards to share their personal experiences and ensure a steady flow of conversation.

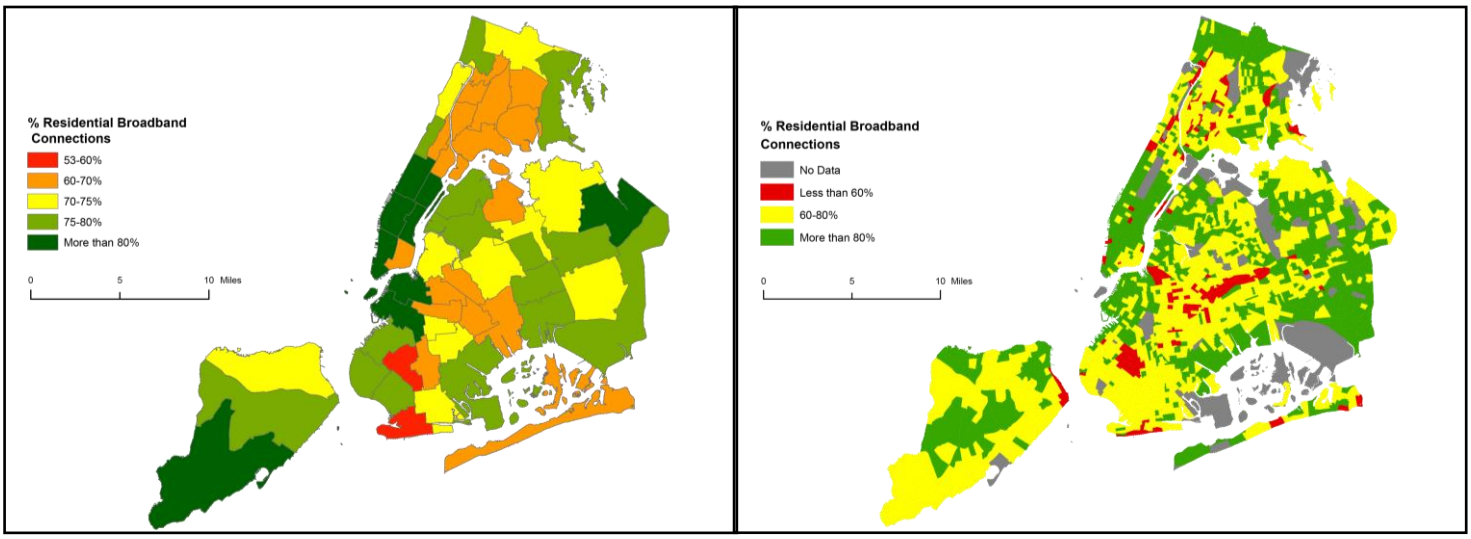
After the responses were collected, they were coded based on Norris's (2008) four adaptive network capacities of: social capital, community competence, information and communication, and economic development. The capacities are then analyzed to see which how Red Hook WiFi have impacted the resiliency of Red Hook. The full responses are included in Appendix D.

RESULTS

Broadband and the City

The Map 1 at bottom left provides a macro-level view of the spatial distribution of the digital divide in New York City using the PUMA level data from the 2013 ACS. Based on the results of this survey, broadband access ranges from 53% of all households to 100%. Unsurprisingly, the areas with the highest level of access are those that tend to be wealthier: e.g. Manhattan up to Harlem, as well as Williamsburg and the neighborhoods of south-west Brooklyn (which includes Red Hook).

While the PUMA-level data are valuable and provides clear evidence that spatial disparities in broadband access exist, it is necessary to consider FCC form 477 data in order to look more closely at broadband access. Map 2 at bottom right uses the most recent FCC data (December 2013) to visualize access at the census tract level. This data present a more complex mosaic of connectivity that occurs at the tract level.



Map 2 (left): Percentage of Residential Broadband Connections by PUMA. (Source: ACS 2013)

Map 1 (right): Percentage of Residential Broadband Connections by Census tract (Sources: FCC 2013; Census 2010)

Looking at the issue at the tract level provides more insight into the number of people affected by the lack of access to broadband. As Table 3 below shows, just over 57% of the population of NYC lives in census tracts with where the residential broadband penetration rate is 61-80%. This affects over 4.7 million New Yorkers. While a larger share of the populace lives in tracts with the highest rates of residential broadband penetration, there are still over half a million people who live in areas with limited broadband penetration.

% Residential Connections	# of Tracts	% of Total Tracts	Population	% Population
Less than 60%	251	11.59	530,008	6.41
61-80%	1338	61.77	4,724,779	57.14
80% +	577	26.64	3,014,212	36.45
Total	**2166**	**100**	**8,268,999**	**100**

Table 3: Broadband connectivity by population and tract. (Sources: FCC 2013; Census 2010)

As mentioned above, the PUMA data show that connectivity tracked with wealth in that more affluent areas tended to live in areas with greater access to broadband. Using the FCC data, this relationship can be explored a bit more. Table 4 at right displays the average percentage of the tract population living under the poverty level in conjunction with the percentage of residential broadband connections. The tracts with the greatest percentage of their population under the poverty level are those with residential broadband penetration ranging from 21% to 60%. The tracts with the lowest poverty level are those with the highest rates of broadband access.

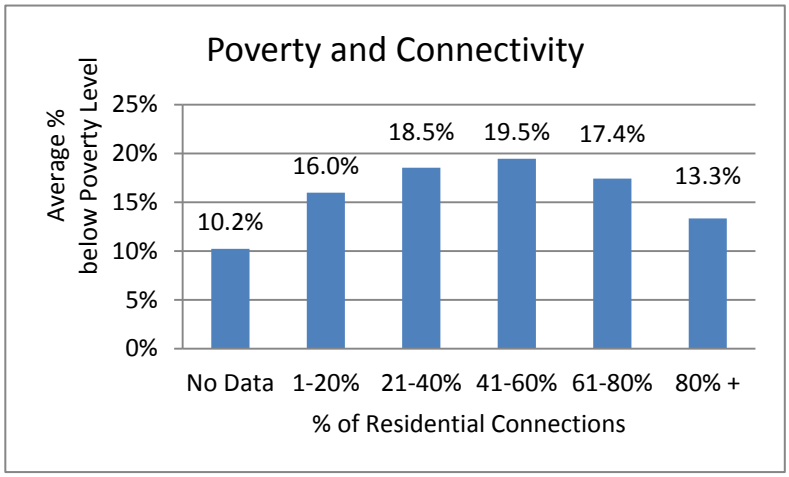


Table 4: Poverty and broadband connectivity by census tract. Sources: FCC 2013; Census 2010)

A similar relationship can be seen when looking at income and connectivity. Table 5 at right displays the average median income and the percentage of residential connections. Similar to the previous chart, the lowest average median income can be found in the tracts with residential broadband penetration rates of 21% to 60%. The highest average median income can be found in the tracts with the highest penetration rates.

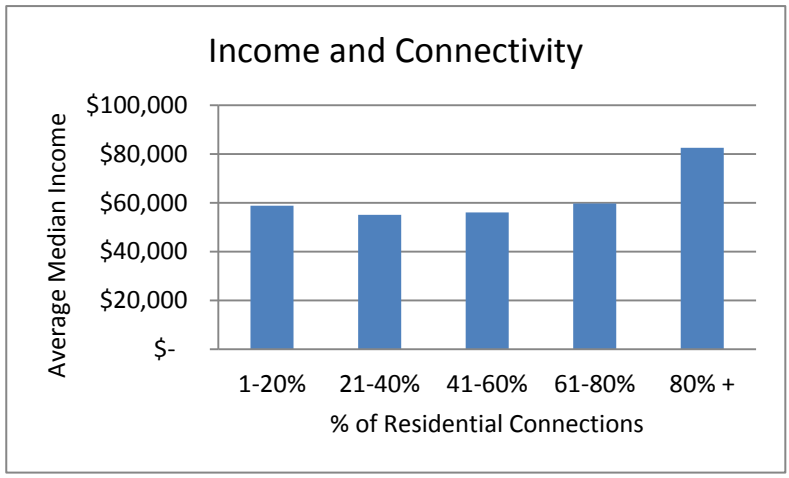
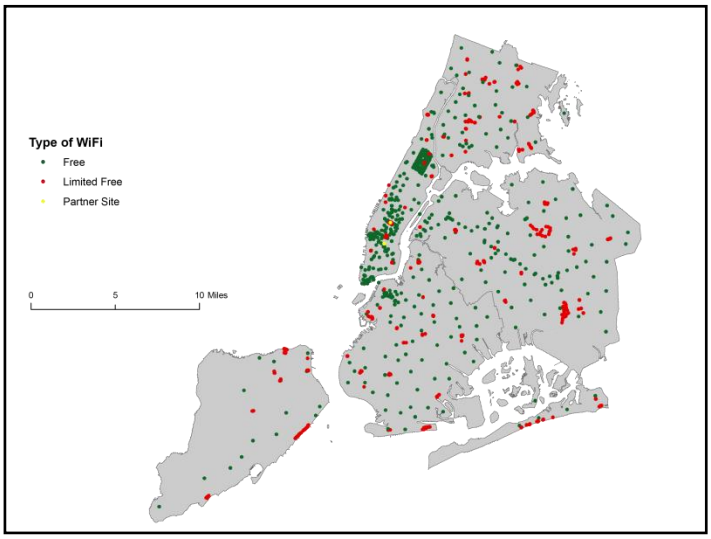


Table 5: Average median income and broadband connectivity by Census tract. Sources: FCC 2013; Census 2010)

The data above demonstrate that digital divides exist within an urban context and that these divides are spatially distributed in an uneven manner across the city. Be it at the PUMA-level or at the census level, it is possible for highly connected areas to exist beside low connectivity areas. Given these disparities, New York City's Department of Information Technology and Telecommunications (DoITT) is "implementing several programs to address the

interrelated aspects of the broadband adoption "gap"[1]. The next section examines two prominent programs that DoITT has in place to mitigate lack of broadband access: free public WiFi and the LinkNYC, the plan to transform public payphones into internet terminal equipped with WiFi.

Currently, the city has 1,050 WiFi hotspots distributed across the city as shown in Map 3 at right. These hotspots are deployed in a variety of areas: parks and public libraries, MTA stations, and in various neighborhood or business districts (e.g. Harlem WiFi, Downtown Brooklyn). Of these 1,050 hotspots, 609 (58%) are classified as free, while 439 (42%) are classified as "limited free". Unsurprisingly, the use of the term "limited" in "limited free" is significant: according to the DoITT, limited free is defined as "3 free 10 minute sessions every 30 days or purchase a 99 cent day pass through midnight". In other words, 42% of WiFi hotspots in New York City limit the user to accessing the internet for three ten-minute blocks, totaling 30 minutes of free WiFi per month. Otherwise, they can purchase passes that would total $30 a month, which is the same price as Time Warner's basic internet plan, or twice the cost of their "Everyday Low Price" plan.



Map 3: Free WiFi hotspots. (Sources: NYC DoITT 2014)

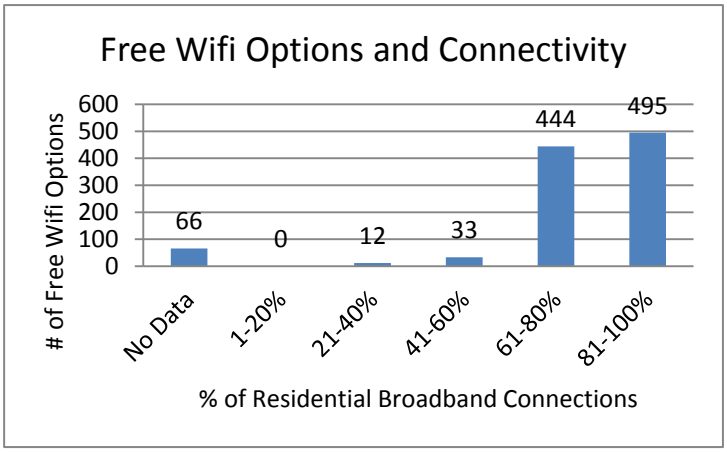


Table 6: Free WiFi and broadband connectivity by Census tract. (Sources: NYC DoITT 2014, ACS 2013)

Further, as the Table 6 makes clear, the spatial distribution of WiFi hotspots is skewed towards tracts where residential broadband penetration is already high. 42% of hotspots are located in tracts with broadband penetration of 61-80% while 47% are located in tracts with 81-100% penetration. This leaves a little over 10% of WiFi hotspots for the remaining tracts. Finally,

[1] http://www.nyc.gov/html/doitt/html/open/broadband.shtml

as Table 7 shows, the greatest amount of WiFi hotspots exists in census tracts with the lowest proportion of the population under the poverty level. As this proportion increases, the amount of hotspots decreases. These results indicate that a spatial reconfiguration is necessary in order for NYC's array of free/semi-free hotspots to address any gaps in residential broadband penetration.

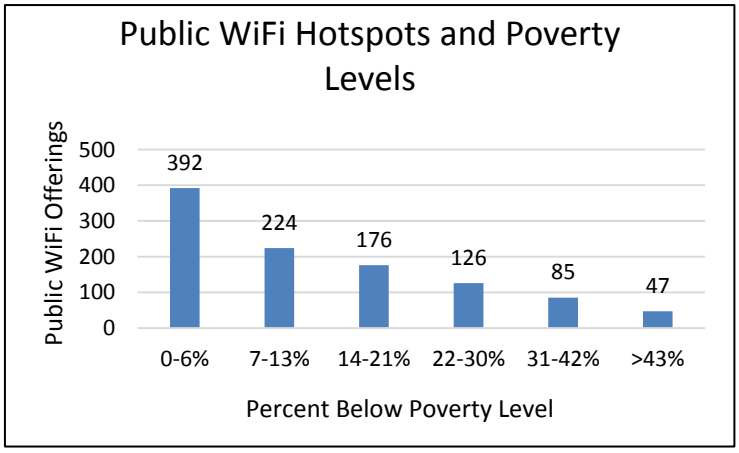
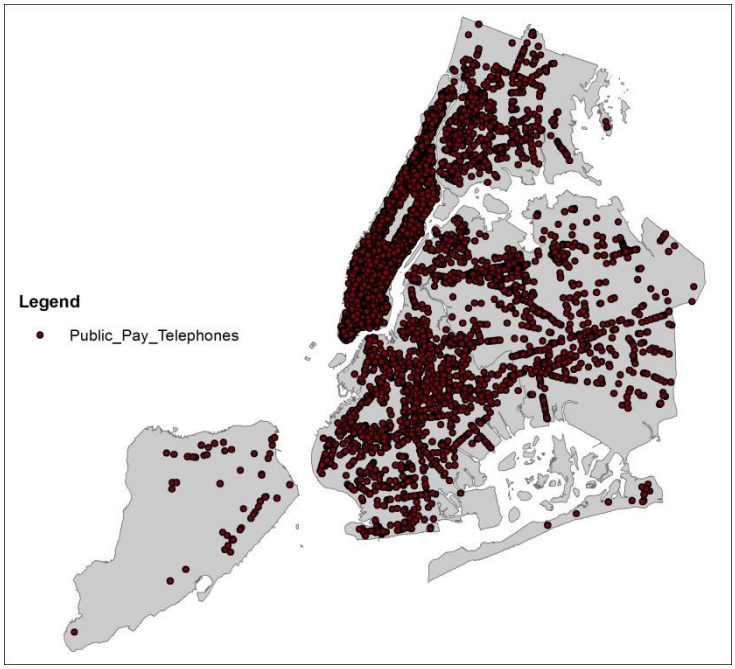


Table 7: WiFi hotspots and poverty levels. (Sources: NYC DoITT 2014, ACS 2013)

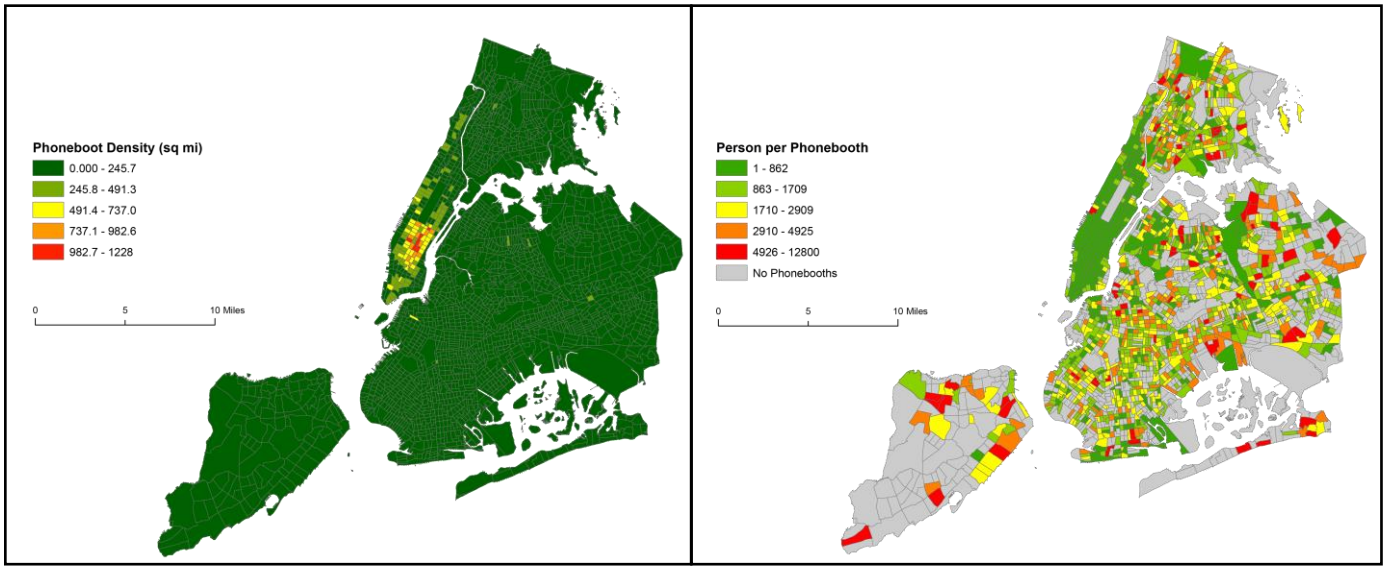
Another option that is garnering attention and excitement is LinkNYC, the city's initiative to transform the existing network of public payphones into next generation internet enabled kiosks that include free WiFi within a 150 foot radius. While this is certainly a valuable initiative, it is worth examining the spatial distribution of the future kiosks in order to see how effectively they can be used as a tool to address the gap in access.



Map 4: Public payphones in New York City. (Source: NYC DoITT 2014)

The Map 4 at right displays the sites of future kiosks by examining the location of current public payphones. It uses the most recent data (December 2014) from DoITT via NYC's Open Data page. Upon first glance, the map shows a preponderance of phone booths in Manhattan, with the Bronx and Brooklyn as fairly well-provisioned. However, when normalizing the count and distribution of payphones by population and area, a different picture emerges.

The two maps in Map 5 below highlight the problems of relying on the kiosks to address the gap in broadband coverage. The map at left normalizes the payphone count by area and displays the number of booth per square mile. It is clearly evident that the heaviest concentration of phone booths is located in Manhattan, specifically in the Midtown area. This map can be contrasted with the map at bottom right, which maps the population of each census tract against the number of phone booths in each tract. It essentially displays the inverse of the preceding: areas with the highest population or lowest number of payphones are all in the outer



Map 5: Comparison of phone booth density and person per phone booth. (Sources: NYC DoITT 2014, ACS 2013)

boroughs. Note that the census tracts that are in grey are those with no phone booths at all. Taken together, these two maps demonstrate that the existing payphone infrastrucuture is concentrated in areas that have a relatively lower population demand for it. In short, the transformation of payphones into kiosks will not go too far in addressing the gap in broadband coverage. Finally, a caveat on this dataset: although listed as having been updated recently, a user's comment on the website notes that upon canvassing Western Queens, 30% of the payphones depicted were no longer present. Thus, the maps below are likely over-representing both the scale and impact of the future kiosks.

This section on broadband and the city concludes by looking at the relationship between the distribution of broadband and New York City Housing Authority (NYCHA) developments. Table 8 below categorizes the number of NYCHA developments and residents by their census tract's level of broadband penetration. A majority of development and residents fall into the 61-80% penetration range. While this might seem positive, it is worth noting that while the FCC

data offers data at a finer geographic resolution, the broad range of 61-80% reduces some of the clarity. Thus while it might be positive that over 330,000 public housing residents live in tracts with 80% broadband penetration, the other side of the issue is that they are also living in tracts with 61% penetration, which is far from salutary. Thus, the picture is unclear when peering beyond the tract into the level of the building lot. Exceptions to this are those public housing developments which constitute their own census tract. The Red Hook houses are one such example and those will be discussed in the following section.

Residential Broadband Connectivity	# of Developments	% of Developments	# of Residents	% of Residents
Less than 60%	62	12.55	76,471	14.08
61-80%	293	59.31	337,481	62.10
80% +	139	28.14	129,510	23.83
Total	**494**	**100**	**543,462**	**100**

Table 6: Residential broadband connectivity and NYCHA housing.

Broadband and Red Hook

The results section on the digital divide in New York City concludes by looking at broadband penetration and NYCHA housing and by noting that due to the fact that the spatial resolution of the FCC data is at the tract level, it is difficult to draw conclusions about individual housing developments. However, an exception to this is those developments that fall into their own census tract, such as Red Hook Houses. As the map at right shows, the Houses are the only part of Red Hook that has residential broadband

Map 6: Residential broadband connectivity in Red Hook.

penetration rates of 60-80%. The rest of the neighborhood is at 80-100% penetration. Moreover, there is only one truly free option for connecting to the internet which is the public library. As the focus group with the Digital Stewards below makes clear, the library is hindered by poor quality equipment and is not a viable option.

Survey of Red Hook WiFi Users

The users of the Red Hook WiFi network were surveyed using an online survey that displayed once users logged on to the network. The survey ran from March 3, 2015 until April 4, 2015 and garnered 27 responses to the following three questions:

1) How many times per week do you use Red Hook WiFi?
2) Do you use Red Hook WiFi mostly to: browse the web for fun, see what's going on in Red Hook, browse the web for job opportunities or schoolwork?
3) On a scale of 1-5 (1 being the lowest, 5 being the highest), how important do you think WiFi is to strengthening communities?

As Figure 4 below shows, 13 of 27 respondents utilize the free network for fun, while 10 use the network for job opportunities and schoolwork. Only four users logged on to the WiFi network to learn more about local events. However, the most frequent users were those who were those who utilized the network to search for job opportunities or schoolwork. Finally, the average response to the question of the importance of WiFi to strengthening communities was 4.66 out of five.

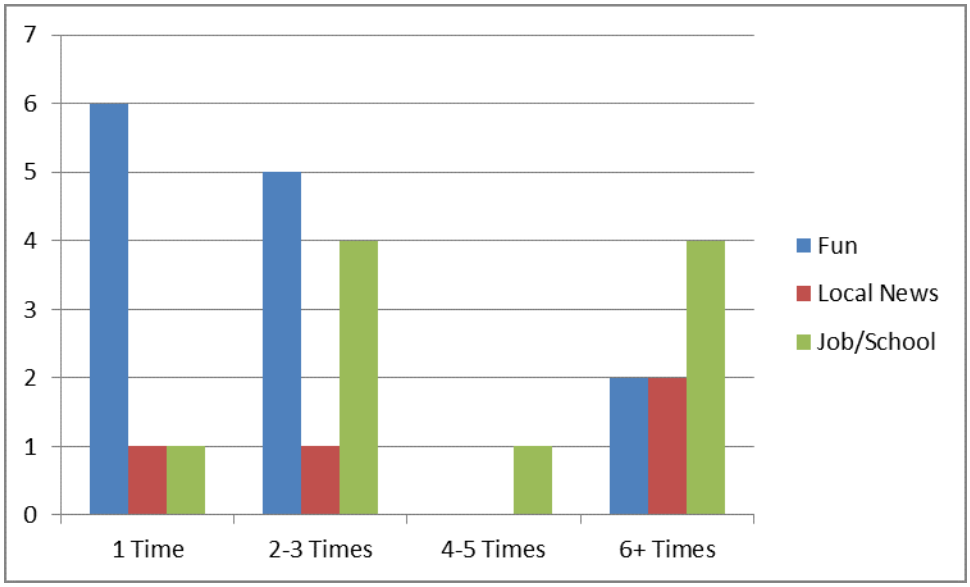


Figure 4: Frequency and usage of Red Hook WiFi.

Survey of WMN Organization

The other part of understanding the overlap between WiFi and community resiliency in Red Hook involves an interview with the head of the Red Hook WiFi program, a survey of the members of the Digital Stewards program, and a follow-up case study with the stewards. The first part of this survey was an interview with Anthony Schloss, Director of Community Initiatives at the Red Hook Initiative and head of the Red Hook Wifi and Digital Stewards program. Mr. Schloss provided insights into how the WiFi system in Red Hook developed and the challenges encountered. He also spoke about the various groups Red Hook WiFi partnered with and where he would like it to go in the future.

The process of setting of Red Hook WiFi began in the months before Hurricane Sandy hit. During that time, Mr. Schloss was working with a technician to set up a preliminary network of two nodes centered on Coffey Park as a small project aiming at reducing the digital divide in Red Hook. Soon after establishing this basic mesh network, Hurricane Sandy hit, FEMA responded by increasing Red Hook's access to the internet by installing a satellite dish on top of the RHI's headquarters in order to provide a much needed communication system to the outside world. Interest in the work of Red Hook WiFi grew as funding for reconstruction became available from various organizations, including the NYC Economic Development Corporation. As RHI began to establish a network of WiFi nodes post-Sandy, one of the key bottlenecks that emerged was access to private rooftops. Out of a concern for liability, many buildings owners were concerned about the prospect of young individuals clambering over their rooftops and installing WiFi nodes at the very edge of the roof. However, by early 2015, Red Hook WiFi was successful in persuading enough building owners to establish a network of 15 nodes (see Map 7 above).

Map 7: Red Hook WiFi nodes in Red Hook.

Another challenge that remains for the organization is evaluating the success of their efforts. For instance, the organization does not have a system in place for assessing how much time users are spending on their splash page (the page that automatically appears when users log on to Red Hook Wifi). Thus while it is unclear whether users spend time exploring the splash page and the local information posted on it, anecdotally it is thought that most users leave the splash immediately in order to browse the web or access social media sites. Given the absence of evaluation tools, it is also unclear if using Red Hook WiFi has increased users' awareness of the importance of IT infrastructure, although the focus group with the Digital Stewards provided additional insight into this question.

Finally, with respect to future steps, Red Hook WiFi is looking to expand coverage to include the residents of NYCHA housing. Currently the program's WiFi encircles the Red Hook Houses but does not enter their premises. The organization is discussing with the NYCHA authorities to expand coverage to include the houses and is hopeful that it will be able to expand. Red Hook WiFi is also looking to generate locally generated content that can draw people to the local, rather than global, aspects of the internet. Part of this would entail transforming the Digital Stewards program into a local workforce that can sell its services to local businesses for web, audio, and video services. This particular goals has especial promise given the results of the survey and focus group with the stewards themselves.

Survey of the Digital Stewards

Ten Digital Stewards responded to an online survey that included seven questions that were based on a Likert scale of 1-5, as well as six open ended questions. The first six questions on the Likert scale sought to ascertain their comfort level with using the internet in general, as well as with using internet connectivity software and hardware. These questions were paired in order understand what their comfort levels were before and after joining the Digital Stewards program. The final question asked the degree to which they felt that WiFi was important for strengthening communities. The table below displays the average responses, as well as the difference, in order to understand the change the Digital Stewards experienced since joining the program.

Question	**High**	**Low**	**Average Response (n=10)**	**Difference (Before-After)**
On a scale of 1-5, (1 lowest, 5 highest), what was your comfort level using the internet before the Digital	5	3	3.8	0.9

Stewards Program?				
On a scale of 1-5, (1 lowest, 5 highest), what is your level of comfort now?	5	4	4.7	
On a scale of 1-5, (1 lowest, 5 highest), what was your level of expertise with the internet connectivity hardware before the Digital Stewards Program?	4	1	2.5	1.6
On a scale of 1-5, (1 lowest, 5 highest), what is your level of expertise now?	5	3	4.1	
On a scale of 1-5, (1 lowest, 5 highest), what was your level of expertise with the internet connectivity software before the Digital Stewards Program?	4	1	2.5	1.5
On a scale of 1-5, (1 lowest, 5 highest), what is your level of expertise now?	5	3	4	
On a scale of 1-5 (1 lowest, 5 highest), how important do you think WiFi is for strengthening communities?	5	3	4.5	N/A

In each of the three sets of questions that asked about perceived strengths since joining the program, the stewards reported net increases in terms of comfort level with the internet, and internet hardware and software expertise. Before joining the program, the average level of comfort with using the internet was 3.8, which increased by 0.9 to a post-program level of 4.7. The pre/post-program responses were the highest of the three sets of questions, and the difference was the lowest amount, which confirms the unsurprising result that the Digital Stewards self-select to join this organization— in other words those who join are those are already adept at using the internet. What the subsequent two sets of questions reveal is that their knowledge of connectivity hardware and software is less proficient, resulting in a larger perceived gain in skills. Finally, with an average response of 4.5, the stewards strongly agreed that WiFi is a tool for strengthening communities.

Their responses to these quantitative questions were given some context through the open ended questions. The questions are reproduced below along with summaries of responses and/or specific quotes:

- Since Sandy, have you observed other (non-internet/WiFi) improvements to your area? If yes, what are they?

  Overall, the stewards did not see many other improvements to Red Hook since Hurricane Sandy: five responded no and three responded yes (two responses were invalid).

- What effects have WMNs had on you as a community member?

The responses to this question mostly pertained to increased personal communication (four responses). Two responses stand out as they invoked the communal aspects of WMNs: one respondent stated that the Red Hook WMN "shows we can work together", while another stated that these networks increase the communication levels of the community.

- Do you feel that other members of the Red Hook community are aware of Red Hook WiFi?

  Five responded "Yes", four "No", and one "Maybe". One respondent highlighted the issue of age, writing that mostly younger residents know about the network— this is a topic that came up again in the focus group. Another wrote that while he felt that many are aware of the network, they "haven't felt the need to take a risk and come join" as a Digital Steward. This too was a topic that was discussed in more detail in the focus group.

- Do you think that other members of the Red Hook community think of WiFi and internet connectivity as an important tool for strengthening the community?

  The majority of the stewards felt that the community regarded WiFi and internet connectivity as an important tool: seven responded "Yes", one "No", and two were unsure. Age came again by a different respondent, who stated that the "younger generation of the community see it as an important tool" but not so much the older generation. Another who responded affirmatively wrote that the community considered the internet an important tool only because it was provided to them for free. One of the unsure respondents highlighted that he felt that "most people don't really think about it often", a response that parallels the idea that infrastructure is a black box (an earlier response actually seconded this notion by stating that people complain about disconnections/diminished service).

- Has installing/accessing mesh networks changed your perception of the infrastructure of the internet?

  Nine of the ten responded affirmatively, with one writing that he had not had the opportunity to install a node yet. Two responded that the experience has increased their knowledge, one responded that he actually understood the infrastructure of the internet, and another wrote that installing/accessing mesh networks changed his

perception in a “drastic way [because] it inspired me become a network system admin(istrator)”.

Focus Group with the Digital Stewards

Seven Digital Stewards participated with the interviewer in a focus group was held at the Red Hook WiFi office on March 4, 2015. In order to encourage them to speak freely, none of the organizations leaders were present. The focus group began with a discussion of how the Digital Stewards joined the program and what types of skills they were seeking. The conversation then shifted to questions about what they learned during the program and then transitioned to how they have engaged with the community after finishing the program. The conversation then concluded with a discussion about Hurricane Sandy and WMNs. Overall, the conversation was notable for the themes of personal and community resiliency, in addition to references about the tight community bonds in Red Hook. Also of note is that Norris’s (2008) four networked adaptive capacities of economic development, information and communication, community competence, and social capital are applicable to many of points raised by the Digital Stewards.

The stewards spoke about wanting to learn more about technology and the internet in general, and software coding, networking, music and video production specifically. Two of the stewards spoke specifically about wanting to learn new skills in order to rely on themselves and not be forced to pay others. For instance, one steward spoke of being interested in video production, while another mentioned his dream of learning how to code in order to make online games. Both of those stewards (though this is true of the others) were unsure of how to get started on this path until they learned of the Digital Stewards through word of mouth.

When asked how it is that some joined the stewards while some did not, the stewards grew animated as they discussed their insights into Red Hook and the psyche of the community. Describing Red Hook as having a strong “work and hustle culture”, the stewards noted that people were ready to work at all costs “to put food on the table”. In fact, some community members who had heard about the Digital Stewards program, would show up at the Red Hook WiFi offices and ask what work needed to be done. When informed that the “work” that was offered was actually part of an internship that taught a wide range of skills (ICT/video/audio production skills, leadership and community organizing skills), these individuals balked. The stewards agreed that these types of individuals were unable or unwilling to change. As one steward put it: “You can’t tell a hustler that you’re in an internship making $8.75, they’ll be like “I make that outside”.” The same steward continued by saying, “We live in the projects. The

projects is kind of based on two things: you either want to get out or stay in”— in other words, some Red Hook residents were ready to embrace change and learn new things, while others were not. Altogether, the participants were unanimous that the program presented “the idea of a job in tech”, requiring training and preparation that requires a desire to learn more and acquire knowledge.

Desire is one thing, but drive is another. Joining the program required taking a test on the basics of technology. One steward was open about failing it on a few occasions and studying hard to pass. Another spoke of the program being the first thing he did without quitting. They all spoke with confidence about the new skills they learned or were currently learning. They spoke of learning technology inside and out— from physical hardware, to network topologies, to video and audio production. The latter was a keen interest for several of the stewards, as they either had an interest in creating or producing music and film. Some were amazed at the complexity of making a film, which they did through an assignment which required them to interview local community members. Others spoke of learning to access knowledge through Google and YouTube, something they had not done before. The access to free tutorials expanded their horizons at all they could learn. They felt empowered by the skills that they learned at Red Hook WiFi, a program which taught them that “there is a spot for you in the technology field”.

Figure 5: Images from the Digital Stewards' office on network topologies and community WiFi mapping.

When asked where they would go for information or training before Red Hook WiFi, they mentioned the Red Hook Initiative office, but they also spoke of learning from their neighbors. This comment segued into another brief discussion about how unified Red Hook is; how everyone in the community knows each other. One spoke of “seeing stuff in other communities”, but that such problems “[do not] wash over into Red Hook”. On the topic of what surprised them about learning about the internet, they mentioned the notion of a mesh network, that one can communicate without an actual internet connection was a surprising. One mentioned being surprised about learning that a main connection point for fiber optic networks was located in Manhattan, while another spoke abstractly about how the internet is a physical internet and an underlying technology that can be used to broadcast the internet. He went on to note that “people think that the internet is just social media, that there is no physical network”.

That last point led the conversation to a discussion how they interact with their community after completing the program. Asked if and how they explain their work to the community, they explained that people are supportive of what they do, especially younger individuals. However, they felt as if most members of the community did not consider the internet as a tool to gain knowledge; most people, they felt, do not realize that there is simply so much information on the internet. For the youth, the internet is primarily social media. When asked if they felt that the community also used the WiFi network for local information, the steward responded that most people do not access the information on the splash page, which includes local information. (NB: This seems to be true as one of the community surveys for this study involved posting questions to the survey. Over the course of two weeks, there were only three responses.) That said, the local content that is placed on the splash page is the work of the Digital Stewards themselves, who use their production skills to create videos for local businesses. In terms of other activities, the steward who spoke of having an interest in learning how to code in order to create games is now developing a lesson plan for teaching his own coding course at the library. The stewards did note that not many people go to the library as there are limited books and only eight outdated computers. However, they spoke about learning the process of participatory budgeting and developing a $50,000 grant application to create a multimedia room at the library. Their proposal is currently pending and they are anticipating a positive response.

The focus group concluded with a discussion of Hurricane Sandy. With no cell phone reception, the only option that existed was through social media and the internet provided by Red Hook WiFi at Coffey Park. As noted earlier, this basic mesh network covered a large part of the park and soon became a central gathering point for people trying to reach the outside world. One steward noted with a degree of incredulousness that while he could not telephone his

mother to assure her that he was ok, he was able to use the FaceTime feature of his iPhone to video chat with her. Overall, the stewards felt as if Sandy had changed the way they thought about community, connectivity, and the internet. The network helped bring people together and tightened community bonds, especially given the length of time it took for the federal government to respond. Until FEMA arrived, it was just the community groups who came together to organize relief efforts as well as people simply relying on each other. The stewards highlighted the fact that before efforts were organized, the only place one could receive supplies was from their neighbors. They described the RHI offices as the "Mecca of communications in Red Hook". Hurricane Sandy was a catalyzed the need for an expanded community communication system.

Post-Sandy, the stewards feel as if the community is more unified. Asked if they felt that the unity was still present over two years after the storm, they felt that while things are back to normal, people feel as if they can rely on each other to a greater degree and feel safer knowing that they have a mesh network that will help them reach the outside world in the event of a future disaster. They expressed pride that as Digital Stewards, it was their job to keep the WiFi going.

DISCUSSION

Urban digital divide: New York City

Graham (2000) refers to the private provision of ICT infrastructure as contributing significantly to "splintered models" of development as private firms seek to maximize profit by investing in high-yield low risk environments. Graham (2002, pg. 37) smartly summarizes the effect of ICT's uneven diffusion when he writes that "urban societies [have] become separated into the 'on-line' and the 'off-line' in complex tapestries of inclusion and exclusion which work simultaneously at multiple geographical scales". Using the most recent data from FCC, the maps in the Results section above confirm this idea of a complex tapestry: census tracts with the highest rates of residential broadband penetration adjacent to those tracts with the lowest rates of penetration. This map stands in sharp relief to claims of ubiquitous cities for it depicts what Odendaal (2011, pg. 2377) described as "the stark unevenness of the diffusion of ICT".

Odendaal continues by writing that "concerns over digital divides recognize the spatial and social inequalities that underpin this dynamic" (ibid). The results illustrated this connection between uneven access and socio-economic inequalities in several ways. Firstly, a connection

was made between residential broadband penetration levels and poverty levels. The census tracts with the highest level of broadband access were those with the lowest percentage of residents living under the poverty level (13.3%), while those tracts with lower levels of broadband penetration had the highest levels of poverty, peaking at 19.5% in tracts where the penetration levels are between 41-60%. Secondly, a link was made between income levels and connectivity. The tracts with the highest level of broadband access had an average median income of $82,531. This figure drops to $59,758 for tracts with 61-80% penetration and $55,061 for tracts with 21-40%. It is interesting that tracts at the lowest level of penetration (1-20%), had an average median income of $58,808. This might be explained by extenuating circumstances such as land use. For instance, the FCC map of New York displays a cluster of lowest connectivity (red tracts) just above a cluster of highest connectivity (green tracts) located to the northwest of Central Park. This cluster represents the Manhattanville expansion of Columbia University, an area where there are many large unoccupied buildings due to construction (thus low penetration), but where there are still residents (thus explaining why the income there is slightly higher than in other areas of the city).

The patterns described above extend to the free WiFi options as well. Excluding 66 tracts where there was no FCC data, a full 50% of free WiFi hotspots (or 495 of 984) were located in tracts with the highest levels of broadband penetration. When including the band of tracts with 61-80% penetration rates that number shoots to 95% (or 939 of 984 hotspots). These hotspots were predominately distributed in areas of New York City with the lowest levels of poverty—37% of hotspots are located in the tracts where the poverty level is under 6%. From this, it can be concluded that the efforts of NYC's Department of Information Technology and Telecommunications (DoITT) to reduce the digital divide through the provision of WiFi hotspots is not distributed in a manner that seriously contends with their stated goal of addressing the gap in broadband adoption.

As noted above, another option that the city is moving forward with is LinkNYC, the initiative to upgrade the existing network of public pay phones into a internet hubs, complete with touchscreen internet access, phone charging ports, and WiFi up to a range of 150 feet. This is an interesting development in and of itself as it supports Sawheny's analysis that a novel form of infrastructure "does not strike roots and grow on a virgin ground […] it encounters a terrain marked by old technologies" (Sawheny 2003, pg. 25). On WiFi, he notes that it is not growing in isolation, but has developed on the terrain of wired internet infrastructure. And as the wired infrastructure of pay phones is heavily concentrated in Midtown Manhattan and not in the surrounding boroughs where there is a higher per person demand, LinkNYC is perpetuating the

fragmented nature of ICT provision and falls short of addressing the broadband gap. Ultimately, while these DoITT initiatives are a useful step to reducing the digital divide, they do not reach the areas with the lowest levels of broadband penetration

Digital Divide in Red Hook: Making the connection between ICT and resiliency

Looking at Red Hook's location and demographics, it is easy to identify its vulnerabilities. The entirety of the neighborhood lies in a Zone 1 hurricane evacuation zone, while just over 80% of its population resides in public housing. Yet the history of this Brooklyn neighborhood shows that its residents are accustomed to facing adversity. The construction of the BQE isolated Red Hook both physically from Brooklyn and psychologically from its local government. Consequently, the residents of Red Hook developed a strong sense of community that has helped it overcome the myriad challenges that have come up over time.

The work of Red Hook WiFi and the Digital Stewards program is a manifestation of this community solidarity. When analyzing the responses from the Digital Steward focus group according to Norris's (2008) framework of resiliency many of the comments that the stewards expressed were linked to one of the four networked adaptive capacities; viz. social capital, community competence, information and communication, and economic development. Appendix A lists each response under the relevant capacity.

As the results in the appendix show, the majority of responses can be categorized under the social capital category, with information/communication and community competence following. The impact on economic development had the fewest responses. Looking at the social capital category closer reveals that most of the responses about the strength of Red Hooks' community bonds describe factors that were already in place pre-Sandy and pre-Red Hook WiFi. The area with the greatest change was the information and communication capacity, which reflects the positive effects catalyzed by the efforts of Red Hook WiFi. This technology of wireless mesh networks was a key enabler of community resiliency, providing a link out of Red Hook during Sandy and providing a locally developed network that enhanced access to the internet post-Sandy.

Despite these positive effects, more work needs to be done in order for the network to reach its full potential. First, more community outreach is needed in order to promote Red Hook WiFi and the important role it can play in empowering Red Hook. Although the BQE and the Hudson River will continue to separate Red Hook from the rest of the city, Red Hook WiFi can act as the missing infrastructure to overcome these barriers. Second, the potential for

strengthening the economic development of Red Hook is needs to be more fully exploited. Although economic development was outside of the purview of this thesis, it was mentioned in the interview with the head of Red Hook WiFi as well as in the focus group with the Digital Stewards. Both confirmed that this is an area with the potential to enhance Red Hook's resiliency in one of Norris's adaptive capacities. Finally, city agencies such as DoITT the Department of City Planning, or the New York City Economic Development Corporation should view Red Hook as an incubator or pilot study for encouraging similar locally developed and owned network in other New York City neighborhoods and/or other cities. If the cycle of infrastructure development and deployment covered in the literature review at all augurs the future, then efforts to hasten the transition of broadband and WiFi from the splintered model of today into the integrated network of tomorrow must be encouraged. Given the linkages between ICT and resiliency, urban planners must engage more forcefully on this topic.

CONCLUSION AND RECOMMENDATIONS

Despite broadband being the pre-eminent infrastructure of the current era, the topic of broadband planning is currently not well discussed within the field of urban planning. But broadband access touches upon issues of equity, economic development, infrastructure provision, and resiliency, all of which are near and dear to urban planners. This thesis mapped the digital divide in New York City and analyzed the efforts of the Department of Information Technology and Telecommunications to bridge that divide, concluding that the efforts were important but stopped short of spreading broadband access. It also showed that the positive effects of a community-owned WiFi network span numerous several different areas, such as increased inter/intra-community linkages, increased community competencies, and enhanced resiliency. When the WiFi network is combined with a job training and skills development program as with Red Hook WiFi, the positive effects are multiplied to include personal resiliency through increased skills, leadership skills, and community organizing skills. However, these efforts would greatly benefit from additional emphasis on program evaluation as well as community outreach about the program.

With the positive outcomes so clear, the bigger question that remains is why planning still does not involve itself more robustly in the issue of broadband planning. In order to encourage planners to get involved in reducing the digital divide, this thesis offers the following recommendations:

- For city agencies, ICT issues should not be the domain of IT specialists or the private sector alone. Planners are well-positioned to engage in the digital divide, bringing spatial analysis skills; community and economic development tools; visioning and participatory planning skills; and cross-disciplinary understanding that bridges the private and public realms.
- These planning skills can help agencies such as DoITT rely less on retail solutions (e.g. individual WiFi zones) and focus more on wholesale solutions (partnering with local organizations and providing funding and training).
- Local organizations can achieve much success on their own, as the case of Red Hook WiFi demonstrated. Yet these organizations will need support in areas such as program evaluation and outreach. Planners, with the skills described above, can act in a support role to help organizations overcome these barriers to program growth.
- Further, planners outside city government or within it can enable the placement of WiFi nodes, by working with local organizations and city agencies such as the Department of City Planning or NYCHA to expedite and facilitate the approval to install nodes on certain rooftops (e.g. public housing) or infrastructure.

As the importance of broadband and WiFi continues to grow exponentially, planners should engage as outlined in the recommendations so as to ensure that the values such as equity and resiliency have a voice at the table.

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APPENDIX

Appendix A: Full Responses to User Surveys

How many times per week do you use Red Hook WiFi?	Do you use Red Hook WiFi mostly to:	On a scale of 1-5 (1 being the lowest, 5 being the highest), how important do you think WiFi is to strengthening communities?
2-3 times	Browse the web for fun	3
2-3 times	See what's going on in Red Hook	5
1 time	See what's going on in Red Hook	2
6+ times	Browse the web for job opportunities or schoolwork	5
1 time	Browse the web for fun	5
6+ times	See what's going on in Red Hook	5
2-3 times	Browse the web for job opportunities or schoolwork	5
6+ times	See what's going on in Red Hook	5
2-3 times	Browse the web for fun	5
6+ times	Browse the web for job opportunities or schoolwork	5
6+ times	Browse the web for job opportunities or schoolwork	5
2-3 times	Browse the web for job opportunities or schoolwork	5
2-3 times	Browse the web for fun	5
1 time	Browse the web for job opportunities or schoolwork	4
1 time	Browse the web for fun	5
6+ times	Browse the web for fun	5
6+ times	Browse the web for fun	5
1 time	Browse the web for fun	5
1 time	Browse the web for fun	5

6+ times	Browse the web for job opportunities or schoolwork	3
2-3 times	Browse the web for job opportunities or schoolwork	4
1 time	Browse the web for fun	5
1 time	Browse the web for fun	5
2-3 times	Browse the web for fun	5
2-3 times	Browse the web for fun	5
4-5 times	Browse the web for job opportunities or schoolwork	5

Appendix B: Questions for Staff/Leaders of WMN Program

1. What has been the greatest bottleneck in rolling out WMNs from your side?
2. What has been the greatest bottleneck in rolling out WMNs from the perspective of the community?
3. Did you interaction with city planning agencies or community boards? If so, can you please describe the process of working with these organizations? Did any pledge support?
4. People tend not to focus on the importance of infrastructure until it breaks—e.g. a water main or an electrical line. Do you feel that your organization has increased awareness about the importance of infrastructure—in this case, of IT infrastructure?
5. Part of this study seeks to understand whether increased access to the internet in Sandy-affected communities has resulted in the community feeling as if they emerged stronger after the hurricane than before, i.e. did not simply return to the status quo. With this in mind, do you feel that the community views your work through the lens of a strengthened community post-Sandy, or are do they mostly view WMNs as simply a way to get internet?
6. What sort of monitoring and evaluation do you do to measure the success of your program?
7. What is the next step once you reach your goals for internet coverage? Do you plan to begin working on skills for searching and applying for jobs online, or working with the elderly or non-native English speakers?

Questions for individuals:

1. On a scale of 1-5, (1 lowest, 5 highest), what was your comfort level using the internet before the Digital Stewards Program?
2. On a scale of 1-5, (1 lowest, 5 highest), what is your level of comfort now?
3. On a scale of 1-5, (1 lowest, 5 highest), what was your level of expertise with the internet connectivity hardware before the Digital Stewards Program?
4. On a scale of 1-5, (1 lowest, 5 highest), what is your level of expertise now?
5. On a scale of 1-5, (1 lowest, 5 highest), what was your level of expertise with the internet connectivity software before the Digital Stewards Program?
6. On a scale of 1-5, (1 lowest, 5 highest), what is your level of expertise now?
7. On a scale of 1-5 (1 lowest, 5 highest), how important do you think WiFi is for strengthening communities?
8. Since Sandy, have you observed other (non-internet/WiFi) improvements to your area? If yes, what are they?
9. Has the distribution of wireless mesh networks changed your sense of safety in case of emergency? If so, how?
10. What effects have WMNs had on you as a community member?
11. Do you feel that other members of the Red Hook community are aware of Red Hook WiFi?
12. Do you think that other members of the Red Hook community think of WiFi and internet connectivity as an important tool for strengthening the community?
13. Has installing/accessing mesh networks changed your perception of the infrastructure of the internet?

Appendix C: Focus Group Questions

BEFORE BECOMING A DIGITAL STEWARD:

What led you to become a Digital Steward?

What were your network skills beforehand?

What network skills did you learn?

Did you learn how the internet works?

How else do you think you could have gotten these skills?

Do you think these skills are important?

Do you think most people feel this way?

Do you feel empowered to change the community?

How much did you think about how the internet works before becoming a Digital Steward?

Where did you go for WiFi internet before?

BECOMING A DIGITAL STEWARD:

As you became a digital steward, what surprised you about learning about the internet?

What surprised you about yourself?

What skills have you developed?

AFTER BECOMING A DIGITAL STEWARD:

How local is Red Hook WiFi?

How much content is locally produced?

Are there local bulletin boards?

Do you ever use RH WiFi to learn about what's happening in RH?

Do you think other community members do as well?

Do you spend much time talking to others about RH WiFi?

Do you talk to others about community WiFi?

SANDY:

How did you interact with RH WiFi during Sandy?

Did you use it in Coffey Park?

Did Sandy change the way you thought about connectivity, community and the internet?

Do you think that now post Sandy, RH is a tighter community?

Do you think having a mesh network contributes to that? If not, what is needed?

Appendix D: Coded Focus Group Discussion

ECONOMIC DEVELOPMENT:

- Local content: blog, videos. Businesses have videos on the webpage that were produced by

INFORMATION AND COMMUNICATION:

- What surprised you about learning about the internet? Mesh itself.
- Do you ever explain how internet or WiFi functions to community? Told people what job is about, people are supportive of what we do. People curious about DS, then realize it involves setting up WiFi, think it's cool.
- No cell phone reception at all. The only way out was through social media and the internet.

- WiFi up during hurricane
- Storm pushed need for community system for communication.
- Contribution of mesh network, people feel safer? People will be more calm knowing they can keep in contact.
- RHI was mecca of communications.
- DS here to keep WiFi going.

SOCIAL CAPITAL:

- RH WiFi trying to attack a bunch of different issues that faces red hook.
- RH has developed a strong independent culture.
- People in RH know people in RH.
- RH has this strong work and hustle population.
- Knew how to work with programs, but coding and video production is new.
- Takes it to the next level. Research everything. Google.
- YouTube tutorials— opens your world. Started watching YouTube, it should be its own school
- RH is so unified.
- Everyone in community knows each other, knows their face.
- Seen stuff in other communities, but it doesn't wash over into RH.
- If I didn't know something would ask next door neighborhood.
- FEMA and government weren't in RH for at least a week or two. Mainly community centers that did work, community came together.
- People know more people now. Only place you could get supplies was from your neighbor.
- Post Sandy: People know more people now. Only place you could get supplies was from your neighbor. Felt like more unity in the community.
- Is unity still there? Things back to normal, but people know that they can rely on other people.

COMMUNITY COMPETENCE:

- Increased skills
- Teaching a coding class at the local library, planning out lectures
- DS is preparation, gaining knowledge, when it comes to explanation, learning about technologies,
- What surprised them about themselves? Program is the first I did without quitting. Public speaking, explaining things to people. Pre-test at RHI on technology, failed it horribly. Studied hard to succeed.
- Some people don't recognize the importance of knowledge. Don't consider that it takes knowledge to develop tools to advance.
- Do you think most people recognize technology is a tool to move forward? Young people: social media.
- Learning participatory budgeting