“Collectively Intelligent” Micro-Infrastructure: high and low tech design in climate vulnerable contexts

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Abstract

The notion of collective intelligence has increasingly influenced design methodologies in recent years, especially in the context of new technologies, digital fabrication, and responsive, sensing environments. The authors expand this consideration of collective intelligence to a social, placemaking level to demonstrate its value and potential in developing lasting impact and resilience in post-disaster contexts. At its best, collective intelligence grows locally at the level of community end users as well as globally at the level of transdisciplinary professionals, acting as catalyst for local adoption and replication, while also informing comparable strategies to answer today’s pressing issues in other global contexts. If designed as “collectively intelligent,” smaller, bottom-up projects can effectively build community resiliency while also fulfilling their function as robust infrastructure. There is clearly an opportunity to redefine “infrastructure” in micro-scaled terms. Furthermore, as the power of digital fabrication, “smart” communication and data driven processes, and integrated, interactive sensor components is embraced, designers should not dismiss the equal potential that low-tech, often low-budget, analog-driven projects can have as catalysts for larger systemic impact. High vs. low tech should, therefore, not trigger a dichotomy of choices in disaster response, but rather be seen as coupled strategies to be integrated at once and as appropriate to site. This paper frames side-by-side comparisons of two design responses deployed in similarly vulnerable contexts, New Orleans and Puerto Rico, while discussing the power of applied collective intelligence through simultaneously high and low tech micro-distributed infrastructures.

Collective Intelligence: Constructing Society and Networks

Intelligence refers to the ability to perceive or infer information and to retain it as knowledge to be applied towards adaptive behaviors within an environment or context (Merriam-Webster, 2019). As argued by Pierre Lévy, “Collective intelligence is not purely a cognitive object. Intelligence must be understood here in its etymological sense of joining together (interlegere), as uniting not only ideas but people, constructing society.” (Lévy, 1997). The notion of collective intelligence has increasingly influenced design methodologies in recent years, especially in the context of new technologies, digital fabrication, and responsive, sensing environments. The design profession has responded by questioning traditional, disciplinary boundaries in favor of more open, collective, and networked practices. Those who call themselves “network practices“ take collaboration further, for they combine in joint endeavors of self-styled “networks of network practices.” (Hight, 2005). We are constantly moving towards a society where the individual is part of the collective; where the agency of the singular exists only within the linked-networked system. (Del Signore, 2016).

The authors expand this consideration of collective intelligence to a social, placemaking level to demonstrate its value and potential in developing lasting impact and resilience in post-disaster contexts. As knowledge becomes more networked, fluid, and open, we are continuously witnessing the mixing of sources to produce a "new synthetic whole." As these forms become pervasive in our current culture, how do they affect how we think, produce, and replicate architectural and urban forms? (Del Signore, 2016).

Climate vulnerable contexts, especially post-disaster, are overrun with well-intentioned projects offering emergency services and resiliency measures: some large vs. some small; complex vs. simple; high vs. low cost; global vs. local; high vs low tech; visionary vs. tried-and-true; multi-phased vs. immediate. Given the complex political, socioeconomic, and environmental conditions that exist during emergencies, no single one of these characteristics can sufficiently guarantee success. In fact, when a project can embody characteristics which enable the continued emergence of intelligence from its daily use, this disaster response can act as catalyst for even larger systemic impact. As such, what then makes a project "collectively intelligent" not only through its participatory and/or transdisciplinary design/construction processes, but also as continual through its resultant built form?

Distributed Micro-Infrastructure

As climate related disasters become more prevalent, coastal cities, in particular, are suffering from the catastrophic effects of sea level rise coupled with land subsidence and repeated beatings of storm surge flooding and high winds. As we struggle to make such cities resilient to future climate events, the greatest attention is often given to large-scale, comprehensive strategies to repair and bolster crumbling infrastructures. While the term "infrastructure," has traditionally been applied to large-scale underlying foundations and systems, there is clearly an opportunity now to redefine it in micro-scaled and local terms. Recently, 21st century coastal city challenges have also given rise to smaller-scaled, incremental design strategies driven by grassroots organizations, citizen engagement, and the formation of new forms of public space fostered by placemaking strategies.

'PPS-Project for Public Spaces' states: "As both an overarching idea and a hands-on approach for improving a neighborhood, city, or region, Placemaking inspires people to collectively reimagine and reinvent public spaces as the heart of every community. Strengthening the connection between people and the places they share, Placemaking refers to a collaborative process by which we can shape our public realm in order to maximize shared value" (PPS, 2017). The development of place is connected to essential elements that bring together physical, relational and symbolic/cultural space as a process that acknowledges the construction of the physical environment.

An individual's quality of life is directly dependent on a city's infrastructure. These "infrastructures" are often only highlighted when adversity hits and we are faced with how well we weather a storm. Post-disaster interventions can rethink infrastructure such that it is better integrated with public space and made more visible in the everyday. Commonplace adoption at its best is exemplified through "parking day" temporary interventions, first installed by Rebar in 2005 in San Francisco, now included as "parklets," a standard street design element in the National Association of City Transportation Officials (NACTO) Urban Street Design Guide.

In Design with Nature, Ian McHarg argues that "nature is a single interacting system and that changes to any part will affect the operation of the whole." Infrastructure, by its very nature, is relational and dynamic and made of smaller, interdependent systems (McHarg, 1969). If designed as replicable prototype, a single instance of a micro-infrastructure node can act in relationship to a larger distributed, networked condition, both to its own multiple instances and/or plugged into other systems. Furthermore, when considered at the small-scale, it can demonstrate the significance of individual contributions as part of a network of systems and thus create an empowered and active citizenship (Laboy, 2016). This meaningful engagement may occur at any stage of a project, from design through construction, but also continued in its use post-build through interactive components that invite participation.

Arguably, the construction of societies and shared networks is as equally important as the built intervention, itself, in building resiliency. At its best, this collective intelligence grows locally at the level of community end users as well as globally at the level of transdisciplinary professionals; acting as catalyst for local adoption and replication, while also informing comparable strategies that can be adapted in other global contexts. While large-scale energy and water projects are critical and not to be dismissed, it is the humanization of the city's infrastructure to visible, interactive place-making that makes resiliency measures able to be understood by the everyday citizen. By making infrastructure [1] visible and adopted as part of everyday public space, [2] micro-scaled and local, [3] replicable, distributed and networked for systemic impact, and [4] interactive with citizen participation, these interventions become "collectively intelligent." These local projects can link populations who have undergone adversity to state and city-wide recovery narratives, necessary for the healing process. When designed as "collectively intelligent," these bottom-up public placemakers effectively build community resiliency while also fulfilling their function as robust climate resilient infrastructure.

High vs. Low-Tech

While "collectively intelligent" design intends to create networked, collective, and distributed responses, it is vital to reflect on how contextual conditions can affect disaster response and deployment. With global challenges that are shared by many territories, population, and natural and man-made ecosystems, we increasingly seek common solutions adaptable to varying contexts. At the same time, however, local conditions can still strongly influence strategies for recovery, especially in terms of cost and technology. In this negotiation of global and local actions, coordinated efforts may rise from a productive overlap of design responses that combine both high and low-tech strategies. Each presents its own challenges and opportunities within specific local contexts. As the power of digital fabrication, "smart" communication and data driven processes, and integrated, interactive sensor components is embraced, designers should not dismiss the equal potential that low-tech, often low-budget, analog-driven projects can have as catalysts for larger systemic impact. High vs. low tech should, therefore, not trigger a dichotomy of choices in disaster response, but rather be seen as coupled strategies to be integrated at once and as appropriate to site.

New Orleans and Puerto Rico

This paper frames side-by-side comparisons of two design responses deployed in similarly vulnerable contexts, New Orleans and Puerto Rico, while discussing the power of applied collective intelligence through simultaneously high and low tech micro-distributed infrastructures.

New Orleans is a coastal city located near the Gulf of Mexico, between the Mississippi River and Lake Pontchartrain. Its unique geography makes it a land that lies predominantly under the average water levels of its surrounding river and lake. The draining of wetlands and development in low-lying areas in the early 20th century has made the city continually vulnerable to repeated incidents of flooding (Campanella, 2006). Declared as one of the worst natural disasters in American history, Hurricane Katrina has completely reshaped the city and its form of inhabitation (Del Signore and Roser Gray, 2017). The island of Puerto Rico is no stranger to climate events, lying within an area of the Atlantic Ocean known as "Hurricane Alley." In September 2017, Hurricane Maria hit the island as a category 4 storm with >155 mph winds, partially destroying over 900,000 structures and leaving most of its 3.4 million residents without power, communication, sanitation, and access to food or clean water. Nearly 6 months after the hurricane, 40% remained without electricity, 10% without water, and more than 50% lived under the poverty line (Garcia-Lopez, 2018).

While both contexts continues to face the challenges of establishing a more integrated socio-economic context throughout the different neighborhoods, many platforms exist that can support innovative, multi-scalar, and technology-driven strategies able to be catalysts for current and future urban transformations.

High and low tech design in climate vulnerable contexts: DATAField + Storm Station

DATAField (fig.1) is a project developed in New Orleans that operates as an infrastructural place-maker and a public node that combines

Fig.1: DATAField- View from Broad St. and Lafitte Corridor, New Orleans.

Fig.2: Storm Station in Rio Piedras community garden, Puerto Rico.

citizens' engagement and mediated technologies to catalyze urban responses both from citizens and larger infrastructural systems. Storm Station (fig.2) is a low-tech, off-the-grid, emergency infrastructure set of modules designed for disaster-susceptible Puerto Rico that offers solar powered mobile phone charging, Wi-Fi communications and local sensor-based data collection, and potable water while also acting as a landmark in public space where local residents learn to replicate sustainable solutions and gather together in times of need.

Strategies to Design Micro-Infrastructure as "Collectively Intelligent"

Through a side-by-side comparison of two their own design projects, one high-tech and one low-tech, the authors propose four design strategies as common and necessary in order to instill potential for collective intelligence in built form and to redefine infrastructure as a part of everyday space. "Collectively intelligent" micro-infrastructures are [1] adopted as part of everyday public space and as visible, local nodes of a larger invisible infrastructure; [2] implemented as micro-scaled and local; [3] designed as replicable prototypes to be distributed as a network; [4] interactive with citizen engagement to foster appropriation, participation, feedback, and long-term awareness.

1. Visible, public space nodes:

In New Orleans, a city that continuously faces the challenges of living with water and unstable conditions of soft-land, the DataField project aims at synthesizing strategies for resiliency through the development of a large scale inhabitable urban prototype that acts as public space node. Digital Technologies provide a platform for augmenting the relationship between the localized public space of the New Orleans water canals where the project is deployed and the larger network of water infrastructure in the city, creating an expanded physical and non-physical public platform to enhance communication processes that connect the local with the expanded urban scale. The prototype itself provides a physical node to meet, share and communicate; a place where public interactions can be intensified to foster exchange.

With communication networks down and most other infrastructures crippled after Hurricane Maria, communities across Puerto Rico naturally gathered in major public spaces in search of food, clean drinking water, a cell phone signal and charge, medical aid, and education / information. In times of disaster, Storm Stations act as recognized and networked aid drop sites for relief organizations and vibrant nodes for orchestrated citizen agency, equipped with supporting infrastructure for energy, water, and communications between stations replicated in varying locations. In the every-day scenario, Storm Stations act as flexible, multipurpose social spaces with integrated seating, no different than other placemakers in public space.

2. Micro-scaled and local:

DataField is developed as an inhabitable spatial prototype that is plugged-in one of the main water canals. It acts as an urban prototype that operates within the local conditions where is deployed, constructing a narrative with the immediate dynamic water ecosystem. The relationship between its scale and the site enables to establish a connection between users and context, both actively engaged in the making of place.

Storm Stations are freestanding modules, no larger than a bus stop shelter when individually constructed, but jam packed with energy and water infrastructure on a micro-scale. The scale allows for cheap, rapid construction and the ability to scale up with multiple module types linked together and interchangeable with varying uses to suit different budgets and local needs (fig.3).

3. Replicable and networked:

DataField employs parametric modeling software as a means of generating the geometry, a network of macro and micro points is established based on the relationships between pumping stations and their respective capacities (fig.4). The spatial elements are codified within a set of design instructions, allowing for replicability in similar contexts; the embedded responsiveness is supported by sensing and actuating technologies, providing a continuous exchange between the real-time networked data sets and the site.

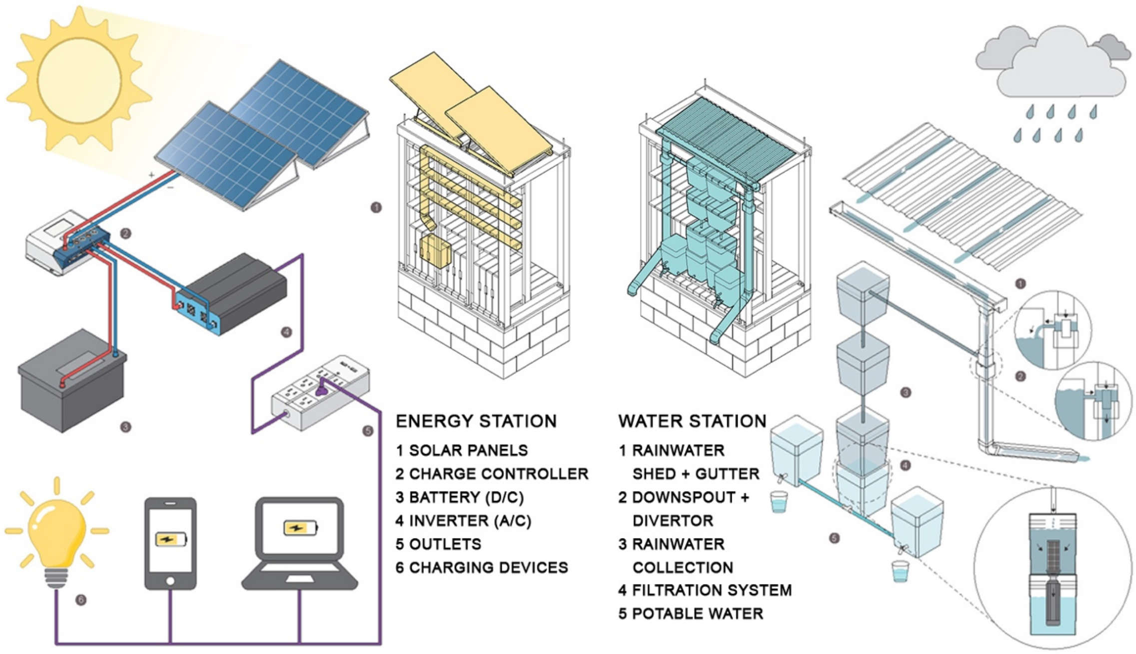

Fig. 3: Storm Station: Energy and Water Modules.

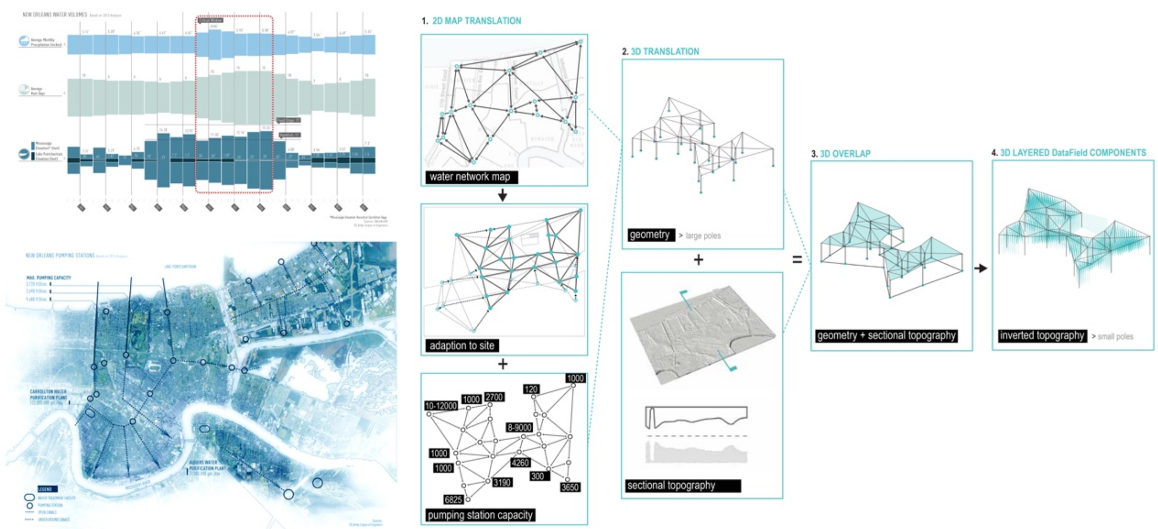

Fig. 4: New Orleans Water Volumes, Pumping Stations and generative mapping process.

Fig.5: Media Concept and Narrative (Input - Processing - Output).

Without the kind of widespread tech support platforms and industry/academic units available in New Orleans, the Storm Station depends on local communities for its ultimate success as a widely replicated project dispersed across the island and as an established network of off-the-grid service nodes. The low-tech design features all off-the-shelf materials available with major local suppliers and easy do-it-yourself (D.I.Y.) construction with simple tools.

4. Citizen engagement:

DataField aims at providing the user with a dynamic multi-loop method for experiencing spatial conditions. The project organizes different invisible water-related data streams through sensing technology and light responsive systems; simultaneously real time messages sent from APPs via smart devices communicate awareness and concern about infrastructural challenges at the local scale (fig.5). Citizens have the opportunity to connect with each other at crucial times, exchanging information and drawing attention to extreme local conditions at the micro scale.

The design of Storm Station and its uses was directly informed by traveling to Puerto Rico to witness the damage firsthand and by engaging with local residents to understand post-disaster challenges. Stations are built in collaboration with local community organizations and citizen volunteers with the aid of D.I.Y. step-by-step manuals for construction and replication. Real-time data of rainwater and solar energy collection and consumption is collected through local sensors and programmed for educational display with raspberry pis.

Conclusion

This paper aims to set up an operative framework by comparing two projects that share design strategies as well as a set of contextual conditions. While deployed in two different geographic contexts, New Orleans and Puerto Rico, both engage and reinterpret infrastructures as networked conditions to generate large scale impact from small scale interventions. The potential of integrating low and high tech within a cohesive design strategy allows for setting up platforms for design responses that are both flexible and highly adaptable. On the one hand, low tech strategies foster quick and cheap implementation of models that can be prototyped, tested and implemented with a limited amount of resources while providing a high level of impact; on the other, high tech and digital technologies implemented through systemic approaches can be a powerful tool to design in vulnerable ecosystems and support resiliency through the fostering of data harnessing, sensing technologies, and citizens' tech engagement. High vs. low tech should, therefore, not trigger a dichotomy of choices in disaster response, but rather be seen as coupled strategies to be integrated simultaneously in the context of global and local responses. The emerging scenarios, especially at the community level that this coupled integration will bring is yet to be defined and has the potential to be rooted in a continuous production of collective intelligence and mutual stewardship between communities and place.

Endnotes

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