

**CONNECTIONS TO DISASTER:  
REBUILDING A CITY WITH ITS OWN DEBRIS**

By

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## ABSTRACT

*Connections to Disaster* investigates the behavior of two competing network typologies (decentralized and distributed), in an effort to remap the relationship between architecture and disaster, specifically the tsunami. Fundamentally, the concept of cloud architecture is one of mobility, and disassembly – qualities which to this point have not been applied in instances of natural disaster relief. Furthermore the discipline of architecture, as applied to disaster relief, serves to benefit firsthand from an exploration in the behavior of networks. Precisely because architecture and the built environment have proven deadly in the event of a tsunami, this thesis proposes a solution to status of architecture as destroyer.

The purpose of this thesis is to apply cloud architectural performance to the real-life aftermath of the 2004 Indian Ocean Tsunami. In addressing the failures of Banda Aceh and Indonesian government to adequately respond to the needs of its citizens in this scenario, this project seeks to enhance the existing relief network. The design proposal situates itself immediately following the tsunami's occurrence, retroactively implementing a new relief network. Additionally, it proposes a system that diminishes the catastrophic effects of future tsunamis. In this way, the system is an active participant in the daily lives of its constituents, providing both awareness and safety.

Banda Aceh, Indonesia was completely obliterated by the 2004 Tsunami, an event that categorically altered the city's economic output, as well as the general psychological well-being of its citizens. Because much of the destruction was caused by the city's architecture, it is imperative for architecture to perform to the extent that lives are saved. This is particularly significant as Banda Aceh sits at the edge of the Sumatran fault, where seismic activity and tsunamis are a constant threat.

It should be understood that even though Banda Aceh, and each tsunami-prone zone, contain unique cultural and social institutions and ways of life – this proposal serves to indicate the potential for a paradigm shift in relief architecture. There is a global need for architecture to serve as a preventative measure, as opposed to a fatal one. The hope is that financial factors which dictate proper tsunami-resistant construction will no longer determine which cities survive, and which succumb to calamity. Instead, architecture will circumvent economics, providing a universal means of livelihood in areas where tsunamis are most foreboding.

## CHAPTER 1: THE COVERAGE CONNECTION

This chapter defines the connection between news event and relief response, such that the chain of relief response depends directly upon the power of its respective news response. Initially based on personal observation, investigation into the relationship between news and disaster relief began to reveal a simple algorithm. Essentially, greater news coverage yields greater relief response.

The aim of this chapter is to establish a preliminary diagram of the assumption, which then becomes the basis for future investigations into the behavior of news networks (both global and independent). This behavior will later serve as model for a mobile and independent architecture. Thus, it is important to understand the root of this independence, and how relief architecture stands to benefit.

### 1.1 Assumption: Media Coverage Enables

It is no surprise that the American public looks to news media as a source for general knowledge. Furthermore, it should be no surprise that news media chooses to cover certain events more than others, especially when the event occurs internationally. What is curious, or perhaps unwarranted, is that for a variety of reasons disasters that occur locally receive more of the precious coverage that incurs relief donations and a greater effort overall.

Thus, there is an especially close relationship between the amount of donations a given disaster receives, and its corresponding media coverage among first-world nations. This equation uses the verb “enables” to describe what a two-way symbiotic relationship is in fact. As perverse as it may sound, corporate media networks look to disaster (natural or otherwise) to generate coverage. Conversely, disaster relief efforts depend on

news media for getting the word out. This is inherently problematic in that the fate of millions of people world-wide depends on a corporate network model that is profit-driven.

What this research attempts to prove and improve upon is that the emerging network structure that is independent web-based media has the potential to level the playing field.

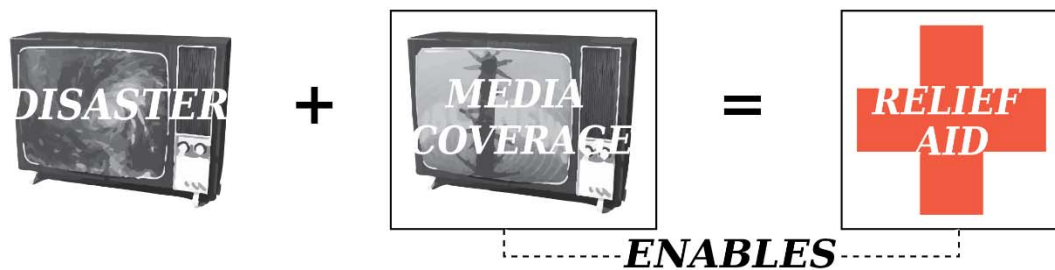


Figure 1.1. Coverage Connection

(Image by author)

## 1.2 Information

Figure 1.2 attempts to trace a path from event to consumer. In a scale-free sense, this diagram is a preliminary effort to understand the hierarchy in the event of a disaster (within the context of media).

Borrowing from Philip Ball, the diagram unpacks the event into a tri-partite system, with two types of parties: activists, and journalists.<sup>1</sup> Activists are marked by red dots, as those who will respond to the news received. Journalists are marked by gray dots and disseminate information. What is worth noting is that the local news media,

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<sup>1</sup> Philip Ball, *Branches*, (Oxford: Oxford Univ., 2009), 150-180.

often the primary source of information for many Americans, is one of the last to receive information, and at that point details may have been compromised.

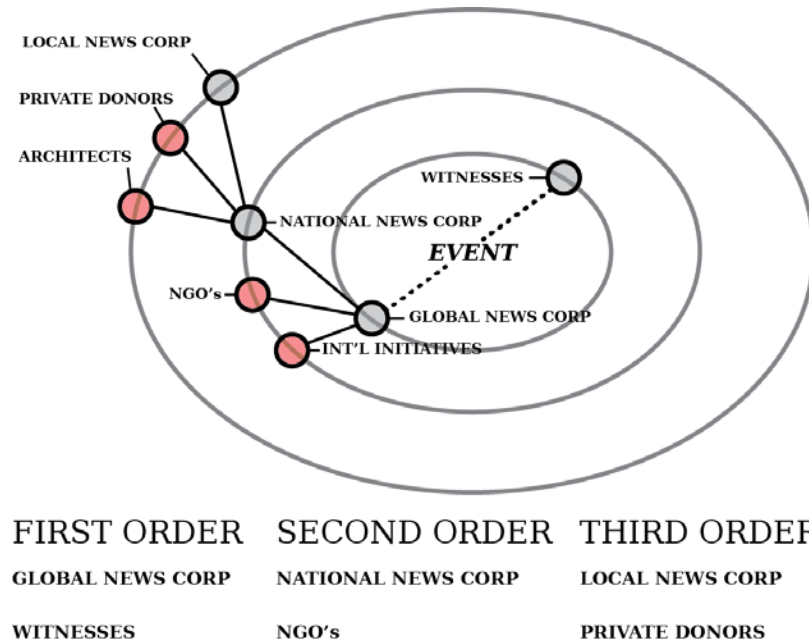


Figure 1.2. Information Path

(Image by author)<sup>2</sup>

### 1.3 Information Flow, Revised

Like the previous information flow diagram 1.3 attempts to document the act of acquiring information on a disaster, followed by its redistribution. 1.3 establishes a chronology, beginning with the event. Both emerging and traditional networks converge on the disaster to collect information. Naturally, there is cross-talk and information is shared between sources (leading to a corruption of accuracy and detail). End-users collect information from both types of media. Users then respond with donations.

<sup>2</sup> Figure generated by author using information gathered from Philip Ball, *Branches*, (Oxford: Oxford Univ., 2009).

What is important is that the emerging network is in fact an endless resource, as information can be collected from any number of blogs, twitter feeds, etc. The importance of this diversity will be explained later on.

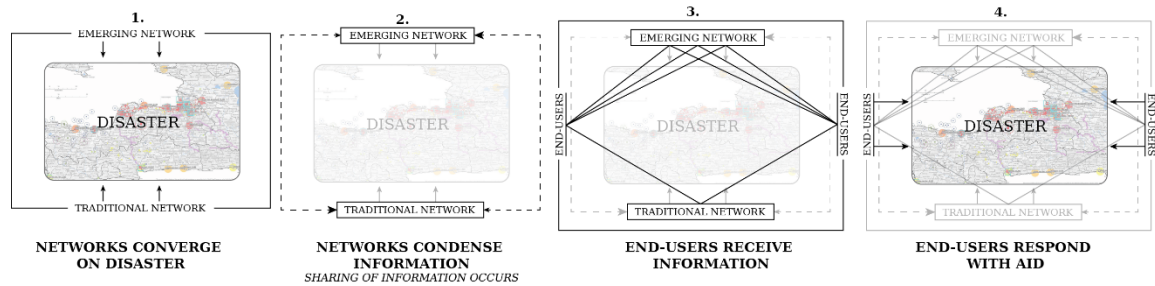


Figure 1.3. Information Path Revised

(Image by author)



## CHAPTER 2: SEARCHING FOR A MEDIA NETWORK MODEL

This chapter builds on the previous chapter's definition of the flow of information, from source to civilian (or volunteer group). Since the inception of network modeling in the Post-war era, there has been extensive research mostly in the fields of mathematics and telecommunications, on the viability of certain types of networks. Furthermore, it is clear that there is no single perfect network model for news and disaster response. Rather, it is a process of finding the best fit.

Additionally, this chapter will expand on the repercussions and causes of specific network models, and how they begin to describe the news. This initial network model research serves as an introduction into the more political implications of certain networks.

### 2.1 Potential Models

Philip Ball addresses a variety of different network models in his article, *Web Worlds*. Beginning with the energy crisis of 2003, where a number of power stations across the northern United States and Canada suffered a breakdown - their connection to the grid was severed. Using this example of a network collapse, Ball's examples of network models offer a number of possible entries into what could be considered a scale-free media network model<sup>3</sup>.

Beginning with concept of scale versus scale-free networks, it is important to understand that real physical networks have scale. That is to say, the telephone network the most common model used for networks until the "digital age") is limited by

---

<sup>3</sup> Philip Ball, *Branches*, (Oxford: Oxford Univ., 2009), 151.

geographic/constraints - wiring and routing stations, etc. An example of a scale-free network would be a network of friends. This implies that linkages between people, though perhaps initiated by proximity, do not depend on actual infrastructure and exist primarily in a psychological capacity.

Figure 2.3 below is a diagram of such a scale-free model. Random rewiring is derived from an experiment where a grid of nodes, is rearranged in a “random” way - meant to mimic a network of friends. This means that while the nodes have a two-dimensional proximity in the diagram, their links do not imply distance necessarily.

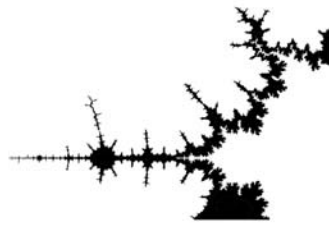


Figure 2.1. Mandelbrot Fractal, 1980  
(Image by Benoit Mandelbrot)<sup>4</sup>



Figure 2.2. DLA, 1991  
(Image by Paul Bourke)<sup>5</sup>

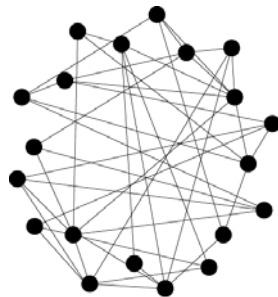


Figure 2.3. Random Rewiring, 2007  
(Image by Aykuyt Firat)<sup>6</sup>



Figure 2.4. Invasion Percolation  
(Image by John Machta)<sup>7</sup>

<sup>4</sup> Benoit Mandelbrot, *Mandelbrot Fractal*, 1980, Wikipedia, accessed March 12, 2013, [http://en.wikipedia.org/wiki/Mandelbrot\\_set](http://en.wikipedia.org/wiki/Mandelbrot_set).

<sup>5</sup> Paul Bourke, *DLA*, Wikipedia, accessed March 12, 2013, [http://en.wikipedia.org/wiki/Diffusion-limited\\_aggregation](http://en.wikipedia.org/wiki/Diffusion-limited_aggregation).

<sup>6</sup> Aykuyt Firat, *Random Rewiring*, 2007, accessed March 12, 2013, <http://www.sciencedirect.com/science/article/pii/S016794730700014X>.

<sup>7</sup> John Machta, *Invasion Percolation*, 2006, accessed March 12, 2013, <http://people.umass.edu/machta/images/invperc5M.jpg>.

Conversely, Ball's other network models are mathematical in their organization (Fig. 2.1). They are not random, they are designed. Media networks, however, are not designed in so much as infrastructure exists to respond to a variety of conditions, and take on a more "organic" structure. DLA and invasion percolation (Figures 2.2 & 2.4) are both organic models but they imply movement from a single source. There is "flow" to the model. It has directionality, which is problematic given the fact that media tends to travel without "directionality". Rather it follows a random path once the network is established.

Pictured below is a diagram of the Paris Metro system (Figure 1.5), a physical network with seemingly "organic" characteristics. Though this is a scale network, with real geographic locations, it nonetheless has distributed qualities that resemble what is found in the random rewiring example.

As we will see with Ball, and later Baran, the quality 'distributed' is important in understanding the way news media networks work, as well as web-based networks related to media.

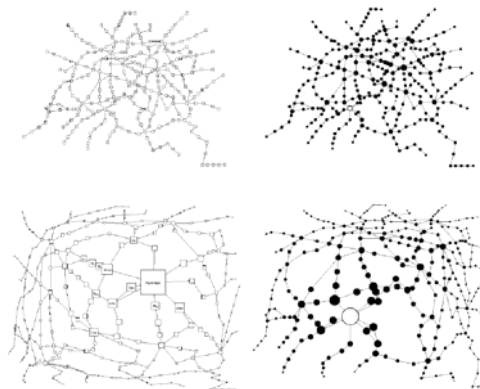


Figure 2.5. Paris Metro  
(Image by Sarkar & Brown)<sup>8</sup>

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<sup>8</sup> Manokit Sarkar and Marc Brown, *Paris Metro*, 1993, accessed March 12, 2013, <http://www.infovis-wiki.net/images/d/do/FisheyeView.png>.

## 2.2 Baran's Distributed Model

Paul Baran's 1964 memorandum entitled *On Distributed Communications* was one of the first articles (government-funded or otherwise) to confront the construction of telephony networks and the future of network technology. Categorically speaking, Baran defines the existing telephone network to be decentralized. It consists of a hierarchy of nodes which then are connected to other smaller, regional nodes. In theory, this diagram in Figure 2.6 could magnify ad infinitum, down to the very compression of data inherent in a telephone system.<sup>9</sup>

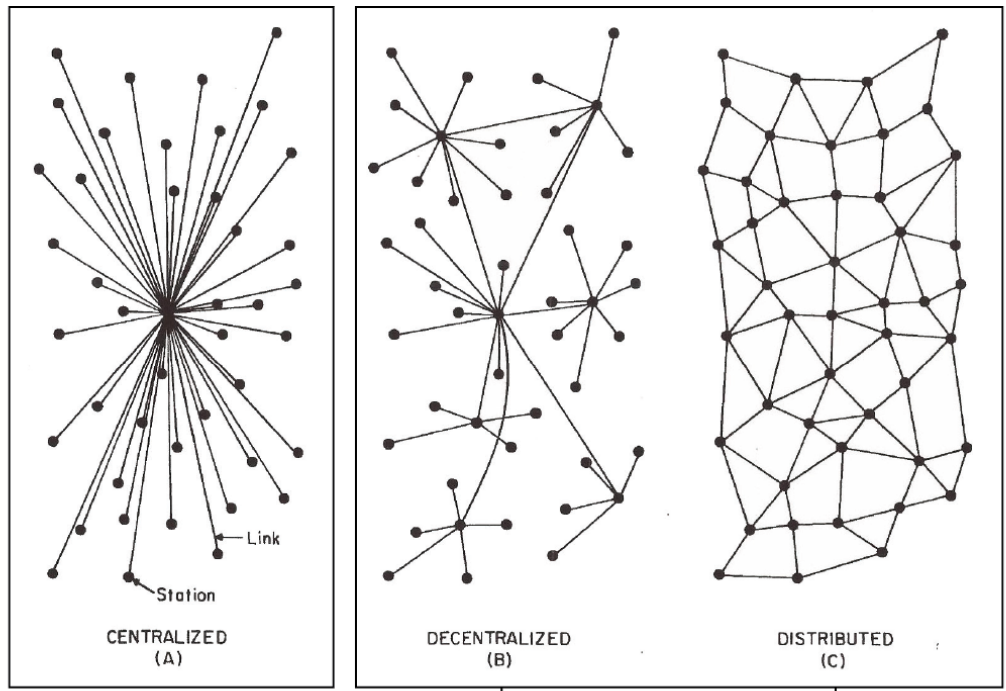
Nonetheless, Baran's point is that such a network, where certain nodes are more important than others, was vulnerable to attack. In context, the mid 1960's being rife with anti-communist fear and rhetoric, Baran's theory is logical in so much as it is superficially meant to protect government interests.

Consequently he proposes the distributed model as a replacement, or rather, a condition meant to be adopted for future techs (yet to be defined). Baran's reasoning being the so-called "resilience" of a distributed network. Figure 2.7 shows that the more "redundant" a node is (the more links it has) the higher the chance it has to survive.<sup>10</sup> The conclusion is then that a decentralized network with nodes with only one or two links is more susceptible to an attack.

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<sup>9</sup> Paul Baran, *On Distributed Communications*, (Santa Monica: RAND Corporation, 1964), 2-10.

<sup>10</sup> Paul Baran, *On Distributed Communications*, (Santa Monica: RAND Corporation, 1964), 11.



DECENTRALIZED NETWORK MODEL  
(TRADITIONAL NEWS MEDIA)

DISTRIBUTED NETWORK MODEL  
(EMERGING NEWS MEDIA)

Figure 2.6. Centralized Model

(Image by Paul Baran)<sup>11</sup>

<sup>11</sup> Paul Baran, *Centralized Model*, 1964, United States Airforce Project RAND, On Distributed Communications, by Paul Baran (Santa Monica: RAND Corporation, 1964) 2.

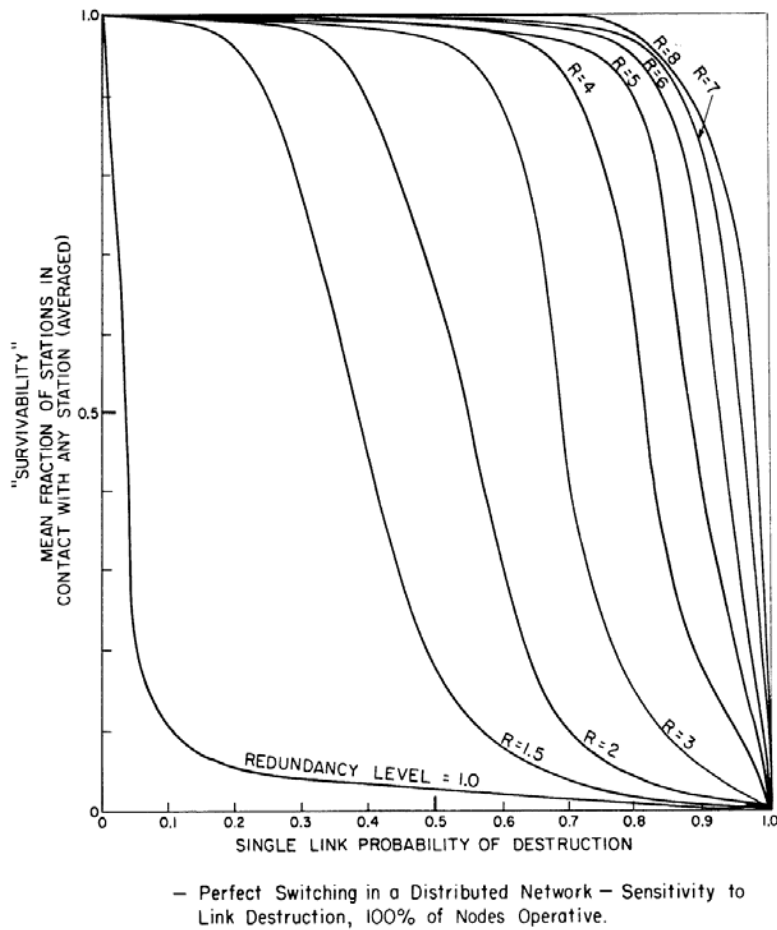


Figure 2.7. Redundancy

(Image by Paul Baran)<sup>12</sup>

### 2.3 Danger: The Power Law

Baran's model and Ball's research make it clear the "Web World" we know of as news media follows two models - decentralized and distributed. Contemporary traditional news media, with its consolidated distribution centers (e.g. Associated Press, Reuters, CNN) falls into the decentralized mode: News is acquired by these corporate

<sup>12</sup> Paul Baran, *Redundancy*, 1964, United States Airforce Project RAND, On Distributed Communications, by Paul Baran (Santa Monica: RAND Corporation, 1964) 10.

bodies and then redistributed back to headquarters, which is then transmitted to local stations, and finally to the network subscribers themselves.

Decentralized networks, on the other hand, are an appropriate model for the emergent media typology. Information is collected by individuals acting independently. It is then distributed across a network via independent users. These end-users do not necessarily act on behalf of a larger entity. As such, information tends to migrate in a more “organic” way, a manner that is decidedly un-designed.

Each model has its benefits and drawbacks. Yochai Benkler goes into great detail in “The Wealth of Networks” about how a decentralized system is preferable in that it allows for greater distribution in both opinion and consumption.

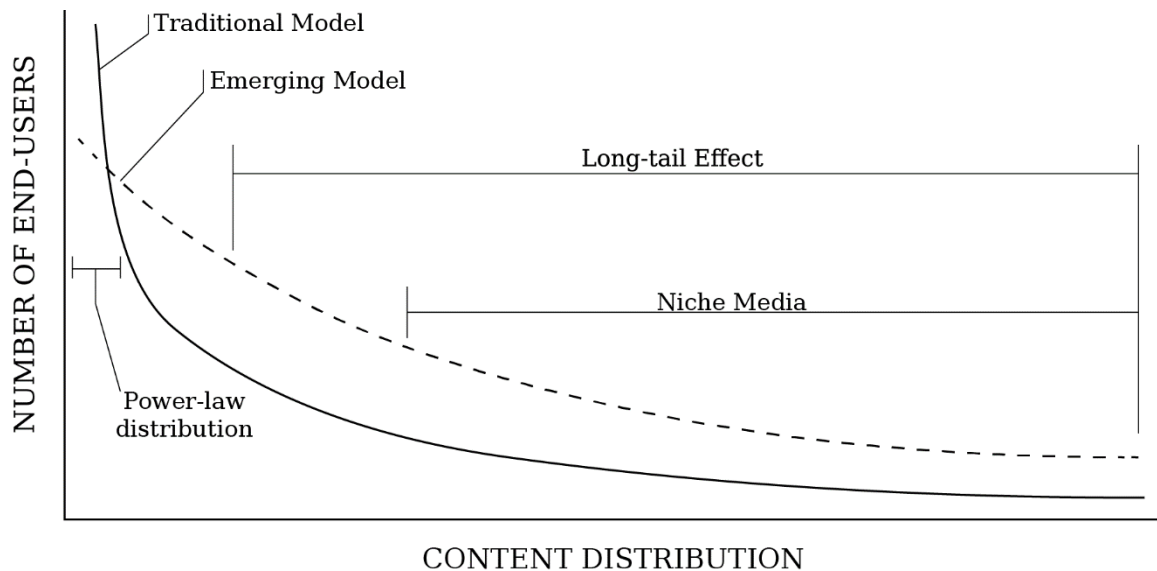


Figure 2.8. The Long Tail

(Image by author)<sup>13</sup>

<sup>13</sup> Image generated by author using theories from, *The Wealth of Networks*, by Yochai Benkler (New Haven, Conn.: Yale University Press, 2006).

Ball describes in network-terms the potential pitfalls in a distributed network - the power-law effect. Currently the strength in the emergent media model is that there is a large range in consumption. That is to say, to a consumer of media and news, there are many options readily available. Balls says however:

Scale-free networks grow according to another rule: the new node connects to an existing node at random, but with a bias: the more links a node already has, the more likely it is to be chosen.<sup>14</sup>

In this scenario users gravitate towards sources that already garner more attention. Blogs, for example, become more popular by already being popular. As Ball says, “the rich get richer.”<sup>15</sup> This is the ultimate danger in emergent media technology - that it will become just as consolidated as existing media. Benkler explains the socio-economic repercussions of such an event, and why it is vital to the news industry to embrace emerging technology in order to properly foster a public discourse.

The long-tail is essentially the inverse of the power-law effect. It explains how when a media transmission is distributed across a vast array of users and distributors, it allows for greater variety in consumption. Figure 2.8 demonstrates (in a scale-free sense) how distribution is affected enabling access to transmission.

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<sup>14</sup> Philip Ball, *Branches*, (Oxford: Oxford Univ., 2009), 178.

<sup>15</sup> Philip Ball, *Branches*, (Oxford: Oxford Univ., 2009), 166.



## CHAPTER 3: THE PUBLIC SPHERE

Having considered the myriad potential models for news networks, this chapter addresses the political ramifications of network behavior, specifically the distributed versus the decentralized. The evolution of these two models marked by a steady increase in output, caused by improvements in technology. It is important, then, to consider the consequences of such technological developments, and how they have been historically manipulated and controlled by various decentralized bodies. Conversely, this chapter will discuss the merits of technology remaining open-source, and how access to technology can shape the news.

### 3.1 Danger: A Pattern of Condensing

Yochai Benkler describes a particular pattern that has occurred since the invention of mass media: the newspaper. Beginning with the innovation of the newspaper in the middle of the 18th century, newspapers became a viable amateur and commercial source of information. Transmission was not restricted to the corporate world. However, with the advent of a more mechanized means of production, small newspapers began to fade from view. Instead, larger umbrella news organizations began to pop up around the world - mostly in North America and Europe. With greater capital, and a larger workforce, these corporate news media organizations replaced the private collectives that once stood.<sup>16</sup>

This history is not limited to newspapers; in fact, it is the norm for all developing forms of mass communication. Whether by government or corporate intervention,

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<sup>16</sup> Yochai Benkler, *The Wealth of Networks*, (New Haven: Yale U.P., 2006), 185.

independent media transmissions are gradually pushed out. Often it is legislation on behalf of “capitalist enterprise”. In the case of radio, the United States military co-opted the production in order to streamline broadcasting during the Second World War.

The question is: will the emerging media that exists now, namely the computer and internet, be replaced by a restrictive corporate model. Figure 3.1 demonstrates the perceived effect of media and professionalism - that centralized corporate models lead to an increase in quality

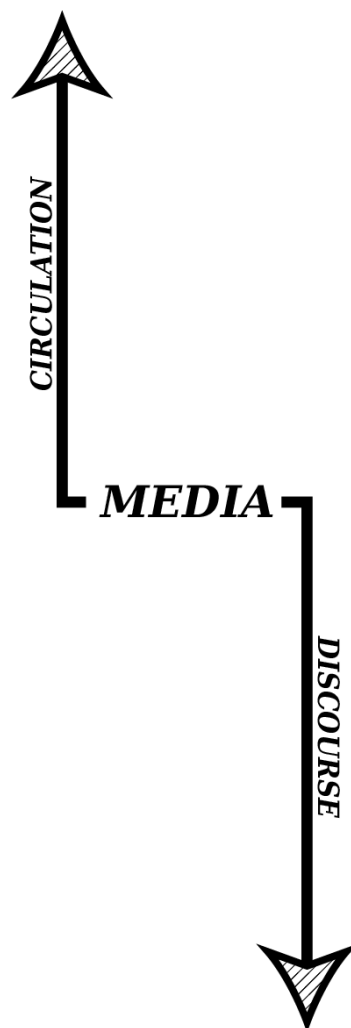


Figure 3.1. Decentralized Media  
(Image by author)

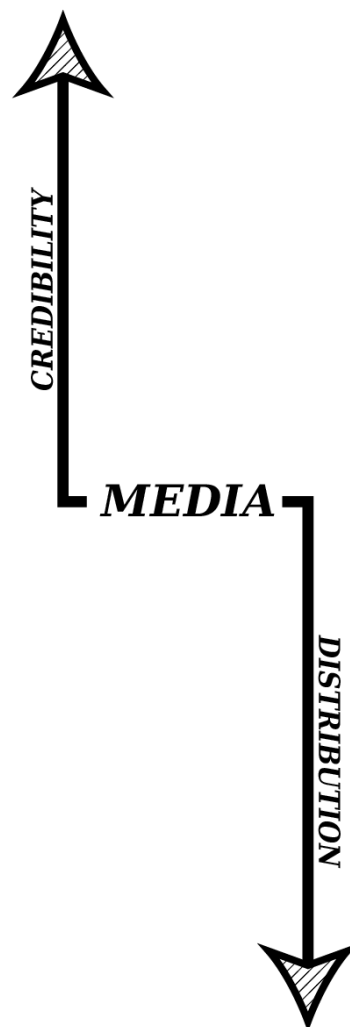


Figure 3.2. Distributed Media  
(Image by author)

### 3.2 A Platform for Public Discourse

In the wake of a model that clearly places more emphasis on number of people reached (for the sake of profit), it is important to understand the effect on discourse in the public sphere. Because amateur transmission is essentially erased over time, the number of opinions experiences a corollary decrease. The effect of this cannot be understated.

It is the relative power of those who manage the mass media when it so dominates public discourse as to shape public perceptions and public debate.<sup>17</sup>

The news, then, is a primary organizing mechanism, and the question of dominance relates directly to the equation of relief response and media coverage. Mass media controls what we, as a society, are aware of. The political implications are that special corporate interests trump those of the consumer. And with respect to disaster relief efforts, corporate interests trump those of the relief itself.

Figure 3.2 demonstrates the actual effects of a centralized media model - where discourse effectively decreases due to its centralization.

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<sup>17</sup> Yoachi Benkler, *The Wealth of Networks*, (New Haven: Yale U.P., 2006), 200.

Keller Easterling identifies an old paradigm, consistent with the characteristics we've come to associate with the citizen-journalist. This person acts on their own behalf, not beholden to a particular hierarchy (corporate or governmental). This person is morally flexible. This person's motivations may vary without warning.<sup>18</sup>

The character Thomas, from Antonioni's film *Blow-Up*<sup>19</sup> is a fair portrait of such a person - a pirate. Definitively amateurish in his investigative techniques, Thomas pursues a story out of obsession and boredom, frankly. While his freedom is admirable, and desirable. His whimsy is also a pitfall described earlier. He pursues on suspicion alone, and his means of interrogation are questionable at best.

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<sup>18</sup> Keller Easterling, *Enduring Innocence*, (Cambridge, MA: MIT Press, 2005), 184-196.

<sup>19</sup> Michaelangelo Antonioni, Director, *Blow-Up*, 1965.

## CHAPTER 4: THE ECONOMICS OF RELIEF

This chapter briefly explains the connection between the rudimentary economic principles of supply and demand, and their effect on volunteer efforts around the world. What is important to understand is the altruistic efforts to relieve those who have suffered catastrophic loss are not immune to the pitfalls of the free market. Similarly, resilient architecture is also a product of financial means and access. While it is ultimately not the role of the architect to realign capitalist systems with altruism, architecture can nonetheless serve to soften the blow of the discrepancy between haves and have-nots.

### 4.1 A Red Cross Donations Case Study

Returning to the theory that media coverage fuels donations toward disaster relief, Figure 4.1 compares two natural disasters that occurred close to one another in terms of time, but received vastly different types of media responses, and consequently amounts of donations.

The earthquake in Haiti, of February 2010 affected about 3 million people, and although the mortality rate was much higher, this is about one tenth the amount of people affected by the monsoon in Pakistan that occurred just 4 months later in the year. There are many reasons to explain this: a simple one being the fact that Haiti, both diplomatically and geographically, is much closer to first-world nations. Another is that

the monsoon took place over the course of about three weeks, making more difficult to track in terms of a before and after effect.<sup>20</sup>

The relative strength of the response to Haiti's disaster can be measured in donation figures provided by the Red Cross - Haiti's effort eclipsed that of Pakistan by nearly 20 percent. Whatever the reason, difference in corporate and public donations is clear. The Red Cross itself is not hesitant to link the discrepancy to media coverage. It is fair to conclude, then, that this is a real-world manifestation of Benkler's theory of dominance.

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<sup>20</sup> International Federation of Red Cross and Red Crescent Societies, *Annual Report 2010*, (Geneva: IFRC, 2010), 9.

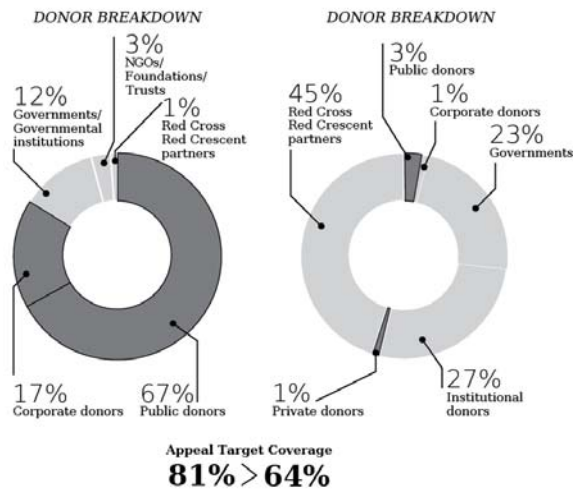
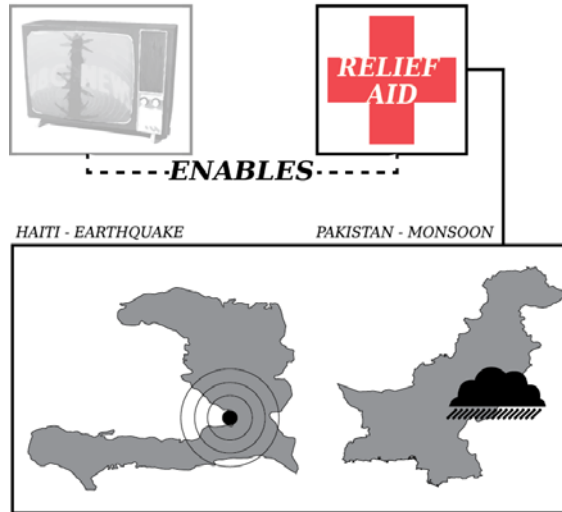


Figure 4.1. Donation Breakdown

(Image by author)<sup>21</sup>

## 4.2 A Danger: Relief Supply and Demand

Howard Sharman, head of humanitarian relief agency *Advance Aid*, identifies a problem in the socio-economic culture surrounding disaster relief. As he puts it:

<sup>21</sup> Image generated by author using data from International Federation of Red Cross and Red Crescent Societies, *Annual Report 2010*, (Geneva: IFRC, 2010), 9.

What happens then is all the NGOs that are responding to the crisis go shopping for the same things in the same places. And what happens in any market when everyone's shopping for the same product? The price goes up.<sup>22</sup>

Figure 4.2 graphs this effect - the relationship between donations and the price of relief materials. It is perhaps strange to consider a situation where there could be *too much* aid. Sharman is clear, however, in explaining that the problem stems from the fact that disaster response depends upon international and corporate products. In essence, nations which are vulnerable to disaster (such as Pakistan) need to stockpile supplies locally so that the supply-demand curve is neutralized.

Competition between NGO's is ineffective in this instance. NGO's with greater means win out, which then condenses the relief. Opinions become more focused, and consequently there is less room for creativity in finding solutions.

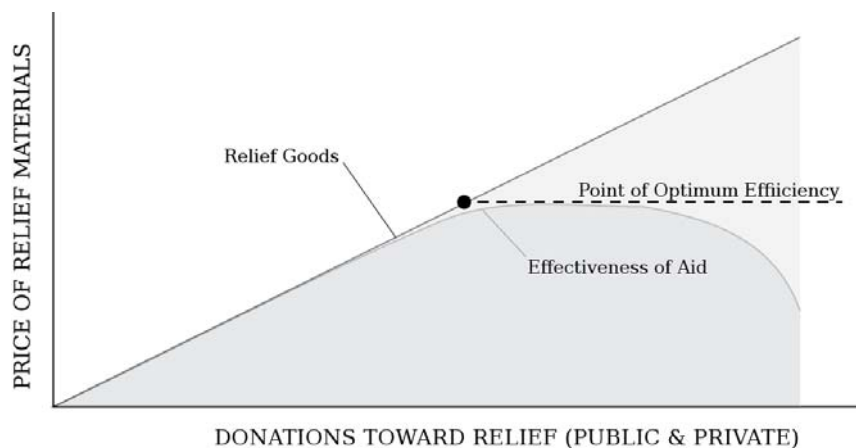


Figure 4.2. Relief Economics Curve

(Image by author)<sup>23</sup>

<sup>22</sup> Rosie Spinks, *Rethinking Humanitarian Relief*, GOOD Magazine, October 2012, accessed March 14, 2013, <http://www.good.is/posts/rethinking-humanitarian-relief-sourcing-locally-before-disaster-strikes>.

<sup>23</sup> Image generated by author using theories from, Rosie Spinks, *Rethinking Humanitarian Relief*, GOOD Magazine, October 2012, accessed March 14, 2013.



## CHAPTER 5: ON THE GROUND LEVEL

Just as news networks suffer pros and cons due to their corporate or independent configuration, so do volunteer networks. This chapter draws a parallel between two instrumental pieces of the initial equation (Figure 1.1) – the conclusion being that the overriding principle which defines the relative success of a volunteer network is where it falls in the distribution spectrum of distribution. The purpose is to illustrate that the great financial means of larger networks and institutions do not necessarily provide the best news content.

Specifically, this chapter comprises a series of case studies that analyze the effectiveness of Baran’s distributed network, as applied to journalism. Beginning with Burmese guerilla journalists, the research will show that distributed news and relief networks experience a much higher degree of mobility, due to their knowledge of locale. Through these case studies the intent is to precisely define the behavior of a distributed network of journalists and volunteers, both technologically and spatially.

### 5.1 Transmission and Documentation

The history of technology in journalism is defined by the separation in function of its technologies. For the most part, landmark innovations in journalism are due to drastic changes in the ability to either transmit or document information. Beginning with Alexander Gardner’s Civil War photography, news was made rapidly available by field photography. Gardner is also a fine example of the citizen-journalist, and potential ‘soldier of fortune.’ Many of his most successful photographs were in fact staged.

Throughout the history of media tech, there has never been a device that was able to both transmit and document. At the end of this timeline, the cell phone marks the

beginning of a new era in journalism where events can be documented and transmitted to the public nearly instantaneously. It is the greatest asset to the emerging distributed media.

## **5.2 Ground-Level Tech**

### **5.2.1 ENG**

In the world of broadcast journalism, the term ENG (Electronic News Gathering) is used to refer to the technique by which corporate news organizations obtain their news from the field. Typically, this process involves a team of at least three people with several significant (and expensive) pieces of machinery.<sup>24</sup>

Because ENG operates by definition as a team, its mobility is hindered. All three members must be present in order for the team to work successfully, otherwise the effectiveness of ENG is compromised.

The team is comprised of a reporter, a cameraman, and a producer - each with his or her specialty (both in terms of equipment and operation). The reporter and camera both operate one device - the microphone and digital camera respectively. The producer operates and OB (Outside Broadcast) van, as well as news production software. The news is capture by the crew outside the van, then relayed back to the control room by the van.

### **5.2.2 Citizen-Journalist**

The citizen-journalist differs from the ENG model in that it its greatest strength is its mobility. Equipped only with a cell-phone or hand-camera, this model is able to move without having to worry about teammates, or equipment failure. Additionally, the

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<sup>24</sup> Stuart Allen, *Online News*, (Maidenhead, England: Open UP, 2006).

speed with which this model is able to access the network is unparalleled. Both devices have direct network access - news can be documented and published simultaneously.

The inherent problem with this model is its financial incapacibilities. Typically, these journalists are limited to their base city, and are not able to venture outside in order to respond to other news events across the globe. Consequently, they tend to be absolute experts in their locale, precisely because all their time documenting is spent there.

### **5.3 Case Studies: Small-Scale Networks, Large-Scale Events**

In an effort to better understand the real-life examples of individuals acting as journalists, outside the corporate news network, I am examining the following two instances of the previously-discussed emerging model. This is not to say that BBC or CNN did not have roles in the subsequent transmission of this footage. Quite the contrary - large networks were instrumental in disseminating the footage to the world public eye. What I aim to demonstrate, however, is where the emerging model is unique in its ability to capture the events at hand.

It is important, therefore, to acknowledge the limitations of global news networks, and similarly where the citizen-journalist excels. Additionally - where do these two typologies excel, and where do they fail?

To add a bit of background, the events surrounding the Burmese protests of 2007 were a reaction to a rise in oil prices imposed by an extremely oppressive government. Heated tensions between the public and military erupted in proto-military forces

reacting to peaceful protests with violence. In this case, the only journalists who were capable of documenting the events were amateurs, and activists - Burmese citizens.<sup>25</sup>

On the other side of the world, the OPS attempted to document corrupt and inhumane whaling practices in Japan, in an effort to disrupt the industry while exposing it to the world.

Unlike the journalists in Burma, the OPS team was comprised of total outsiders, who were highly specialized, and highly trained.

### **5.3.1 DVB (Democratic Voice of Burma)**

The DVB (Democratic Voice of Burma) is an amateur organization of video-journalists located in the Burmese city of Yangon (Rangoon). In September 2007 they distributed themselves throughout the city in order to document the protests taking place. Events were documented and processed in Yangon, and then sent to a safe site in Norway. Satellites in Norway broadcast the news back into Burma, and eventually all over the world.<sup>26</sup>

Ultimately these video-journalists (VJ's) were the only people able to obtain evidence of the atrocities taking place - Global news journalists were prevented from entering the city.

Because the VJ's were themselves Burmese, and members of Yangon society, they were accepted into more intimate protest settings. These were certainly places normal ENG news crews would not have had access to. In fact because the VJ's were themselves

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<sup>25</sup> Anders Ostergaard, Director, *Burma VJ*, 2008.

<sup>26</sup> Anders Ostergaard, Director, *Burma VJ*, 2008.

working on behalf of the monks' cause, they were not only allowed to march with the monks but were protected by them (from military aggression).

In addition to having access to privileged pieces of the events taking place, the VJ's were able to remain hidden when they needed to. The ability to take shelter in a private residence allowed them to see, and not be seen.

Plain-clothed militarists similarly employed hand-cameras to document the insurgency. The footage would then be used to seek out and capture insurgent journalists. It was essential, then, that the Burmese VJ's be able to remain anonymous in their documentation.

Interestingly, since the primary weapon used against the oppression was network access, this was the most lethal counter-attack the government was able to wage against the journalists - to disable the nation's servers and prevent transmission.

### **5.3.2 Taiji Whaling**

OPS (The Oceanic Protection Society) arrived at the site of the supposed Taiji whale hunts in 2008. Coordinated by Ric O'Barry, a highly trained group of journalists and engineers sought to document the capture and subsequent murder of thousands of dolphins.<sup>27</sup>

Once the footage was acquired it was forwarded to be screened at the IWC (International Whaling Commission) annual conference in Santiago, Chile. The response to the footage came mostly in the form of political denial. Eventually the footage made its way across the globe and back into Japan in the form of a documentary

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<sup>27</sup> Louie Psihoyos, Director, *The Cove*, 2009.

film. It was intended not only to inform the public of the inhumanity of the treatment of dolphins, but also to inform the public of the threat of mercury poisoning.

The OPS team was met with intense resistance primarily from the fisherman themselves, but also with local law enforcement. Because they were not able to collaborate with local personnel, unlike the VJ's in Burma, they were forced to adopt clandestine measures of documentation.

Each member of the team brought a special talent to the project - whether technological or not. Because the effort was collaborative, manned by individuals with great financial means, the dolphin hunt was successfully documented without the knowledge of the fisherman and Taiji locals.

Ultimately this form of journalism represents a sort of hybrid between bottom-up journalism and more coordinated corporate journalism. The individuals at OPS were certainly not part of any larger news organization. Nonetheless they proved to be highly capable in their ability to mobilize quickly. They developed a scheme whereby footage could be acquired and distributed to a larger global network after the fact. The success of their endeavor essentially relied upon the willingness of larger organizations to distribute their footage.

#### **5.4 The Distributed Relief Typology**

This section comprises a series of case studies meant to dissect the behavior of independent (and often spontaneous) volunteer networks, as they compare to independent news networks. Thematically, the volunteer networks here are responding to a specific natural disaster, often in the capacity of lending man-hours over tangible aid

products (such as tents or food kits). In this sense, there is potential for architecture to provide a service as opposed to a good.

#### **5.4.1 Shelter as First Architectural Response**

By and large, and especially in the cases of Pakistan and Haiti, emergency shelters tend to be the first response in the event of a disaster. Dominated by corporate NGO's like the Red Cross, the design of such shelters tends to be top-down – a predetermined kit of parts that is transported to the site. Figure 5.1 indicates the limitations of these shelters, with respect to their performance under the duress of an impending or recent disaster. Clearly, it is problematic that shelters in a monsoon zone perform adequately under the circumstances. The evaluation Figure 5.1 is telling in that the shelter is only so-so according to the evaluation metrics. Similarly, the shelter from Haiti performs poorly in the event of an earthquake.<sup>28</sup>

With the previous research in mind, one might attribute the overall performative shortcomings to the corporate nature of the Red Cross. That is to say, global relief networks suffer the same limitations as global news networks.

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<sup>28</sup> International Federation of Red Cross and Red Crescent Societies, *Transitional Shelters: Eight Designs* (Geneva: IFRC, 2011), 39-59.

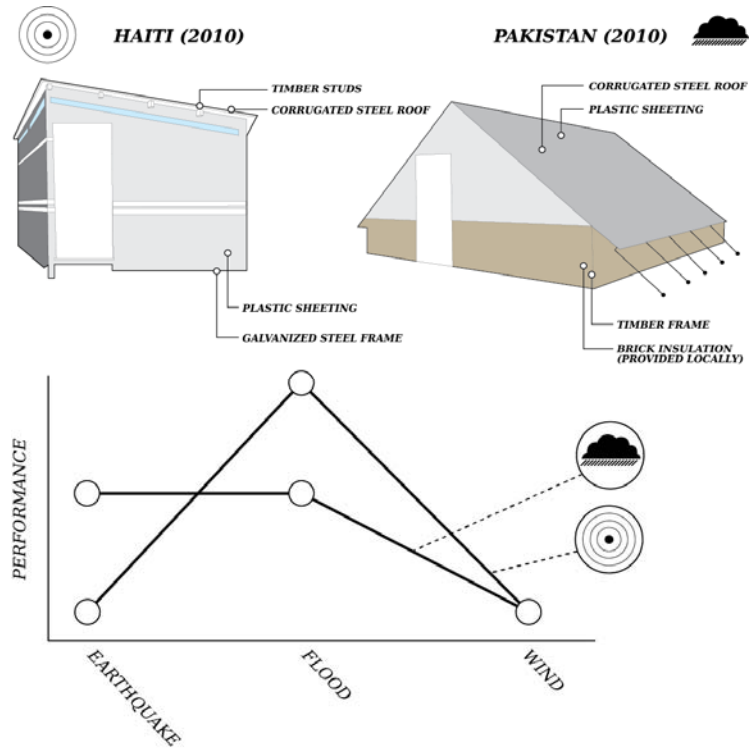


Figure 5.1. Shelter Study  
(Image by author)<sup>29</sup>

#### 5.4.2 Case Study: Niigata Earthquake (2004)

In the case of the 2004 earthquake in Niigata Prefecture, Japan saw an unprecedented surge of volunteerism. The impact of this surge was so strong that “volunteering became a regular occurrence in Japan thereafter”. What is important to note is that the volunteers were not necessarily responsible for the housing or rescue of affected Japanese people. They were more effective in their ability to control effects of PTSD related to the disaster - providing daily assistance in the form of conversation, communication, and general care-taking. Displaced for months, the earthquake affected upwards of 100,000 people. Local support groups formed immediately and organized

<sup>29</sup> Image redrawn from International Federation of Red Cross and Red Crescent Societies, *Transitional Shelters: Eight Designs* (Geneva: IFRC, 2011), 39-59.



relief camps in Niigata, helping people move into temporary housing. One of the largest groups to respond were students from the city of Osaka. Traveling from 400 miles away, these students exhibited a high degree of flexibility.<sup>30</sup>

Organized through a mailing list called *fromHUS*, students began to arrive within a week after the earthquake occurred. Witness accounts describe the students' services as invaluable. They were most effective in exhibiting compassion, relating to the displaced on a personal level. This is especially significant as Japan had up until then not possessed a true culture of volunteering.

Generally speaking, students are a well-suited group to these sorts of volunteer opportunities. Because their work schedules are more flexible, they are more mobile. Additionally because there is a pre-existing community created by the University at Kobe, communication was easily disseminated between organizers and participant.

#### **5.4.3 Case Study: Sri Lanka Tsunami (2004)**

In December of 2004 a massive Tsunami struck the Southern coast of Sri Lanka. The government of Sri Lanka estimates that between 1 and 2 million people were affected. Because the Indian Ocean lacks a seismic warning system, the country was taken by surprise. Galle, the largest city on the Southern coast was devastated. A city of 100,000 people, all of them were displaced. The city's main hospital was inundated with dead bodies, and was eventually forced to shut down. Local religious groups, both Hindu and Muslim, stepped in to create make-shift camps for the refugees. Because the government was slow to mobilize, and international relief could not access the southern half of the country until over a week later, the local efforts were especially important.

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<sup>30</sup> Koichi Suwa, et al., *Waiting as Support, Listening as Aid: A Case Study of Student Volunteering after the 2004 Mid-Niigata Earthquake*, *Journal of Natural Disaster Science* 30, (2009): 106-114, accessed March 21, 2013.

Providing clothing, food, and shelter Temples, Mosques, and Churches “assumed roles in organizing camps for the displaced.”

Eventually NGO and global relief organizations were able to access the needy, and distribute goods. However, it was the local response shortly after the earthquake that proved most critical in preventing further deaths and damage. The threat of dysentery was extraordinary as bodies began to pile up in the streets. The masses were kept away from the dead, until the proper authorities were able to deal with the problem.<sup>31</sup>

#### **5.4.3.1 Sri Lanka Tsunami: Spatial Sequences**

The tsunami hit without warning on the morning of December 26, 2004. The city of Galle, completely taken by surprise, was forced to react without recourse or planning. The community resorted to a reflex response whereby people living in the residential district near the water immediately fled to local religious institutions to seek shelter. It is not that these institutions made themselves known to the public as a place of refuge. Instead, these mosques and temples were sought out precisely because the people of Galle had no prior knowledge of this nor any other tsunami.

The mosque or temple is an important ‘social catalyst’. Providing clean, and climate-appropriate space, these religious remained important shelters long after NGO relief arrived. The tents that were provided were often ill-suited to the hot and humid climate of southern Sri Lanka. It is most important however to note the symbiosis

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<sup>31</sup> Seiji Yamada, et al., *The Sri Lanka Tsunami Experience*, Disaster Management & Response 4, (April-June 2006): 38-48, accessed March 21, 2013.

between the religious center and its constituents. Acting as a single entity, their operation was reflexive - both acting on and receiving input simultaneously.<sup>32</sup>

#### **5.4.3.2 Sri Lanka Tsunami: Device Sequences**

Communication is a seminal point in understanding the relationship between shelter and user. In this case, communication occurred between Galleans primarily by word of mouth. This is not to say that “devices” were absent during the tsunami crisis. Rather, the device is implied in the symbiotic/single-entity relationship. Communication occurred on an intuitive level, circumventing the need for physical devices (although there is no doubt that a physical warning system would have been an effective means of communication).

In contrast, news media relied exclusively on physical devices for its success in Galle. Arriving by train, networks set up camp where possible in available housing. In order to capture the events, and conduct interviews, they were forced to inhabit the religious shelters to find content (aside from pure photographic footage of the wreckage). Essentially, news media relied on the cooperative effort of Gallean citizens and religious networks. Content was concentrated into a few select spots, further enabling the device-driven method of global news.

#### **5.5 Concluding Remarks on Network Research**

Though Ball and Benkler’s research has proven helpful in defining and understanding news and relief networks, it would be inaccurate to say that there are

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<sup>32</sup> Tetsushi Kurita, et al., *Tsunami Public Awareness and the Disaster Management System of Sri Lanka*, *Disaster Prevention Management* 15, (2006): 92-109, accessed March 21, 2013.

instances of pure decentralization or pure distribution. In actuality, global and amateur networks fall somewhere in between, in a fairly large spectrum of distribution.

What is important is that the benefits surrounding conceptual distributed and decentralized typologies be weighed against their relative drawbacks. That is to say, the shortcomings of global news and relief networks are in many ways due to their lack of knowledge of local conditions. Conversely, amateur networks still possess properties of decentralization, but are much more mobile in general.

Moving into the design phase, I will attempt to carry over the awareness of the potential dangers inherent in either network type. When confronting disaster (natural or otherwise) the opportunity to reduce coverage and relief to numbers like 'lives lost' and 'total donations' is rampant. As such, the design intervention must aim to create a new way of navigating existing news and relief networks. Ideally, the intervention would be as mobile, and locally respected as an amateur network, like the DVB, while possessing the global reach of a decentralized hyper-professional network, like the Red Cross. This hybrid of characteristics – distributed and decentralized, mobile and global – carries the potential for architecture to reach a larger population, unhindered by economic or geographic factors.

## CHAPTER 6: SYMBIOSIS INTERRUPTED

Chapter 6 serves as an introduction to the site for the project proposal, Banda Aceh, Indonesia. As the final iteration in a series of investigations of volunteer relief efforts, Banda Aceh is somewhat unique in that it was almost totally destroyed by its disaster, the 2004 Indian Ocean Tsunami. Because of the intensity of the destruction, this site is rife with opportunity for design, and presents a challenging point for architecture to insert itself.

The chapter will begin with an explanation of the disaster itself, and the seemingly miraculous survival of a single type of building – the mosque. The people who survived the tsunami itself asked not for better architecture, but for better information. Consequently the state sought to affect memory and perception, in addition to slowly restoring the city to its pre-disaster status. The design proposal will build on the constraints established in this chapter, specifically the importance of certain spaces in Sumatran culture, like the mosque and the public market.

### 6.1 Banda Aceh and the Interruption

The city of Banda Aceh felt the earthquake itself, receiving tsunami waves within 15 minutes of the seismic activity. Just 200 kilometers from the plate shifts, Banda Aceh was completely taken by surprise. Without warning, general chaos set in as enormous waves pounded the shores of the Indonesian regional metropolitan center. The total casualty count amounted to an astonishing 170,000 in this area.

Like Galle, the city's primary social catalyst was the mosque. However, because the tsunami's impact was so sudden and devastating, the mosques served as shelter for a

select few. The community-religious network was interrupted and rendered moot. Ultimately the mosque was one of the few buildings left standing in the whole city.

The Grand Mosque at Banda Aceh is perhaps the most important building in the city. As such it was constructed with the utmost care. This is one explanation of its miraculous survival during a period of such intense devastation. Additionally, the single interior space was largely unfurnished, and presented little opportunity for loose debris to destroy the structure.<sup>33</sup>

The image of the solitary surviving mosque in Banda Aceh is startling, to say the least. All infrastructure in the city was destroyed by the tsunami. Consequently, most documentation and relief aid arrived by air.



Figure 6.1. Impact Map  
(Image by author)

<sup>33</sup> Megumi Sumimoto, et al., *Tsunami Height Poles and Disaster Awareness*, *Disaster Prevention and Management* 19, (2010): 527-540, accessed March 21, 2013.



Figure 6.2. Surveying the Damage

(Image by Joel Saget)<sup>34</sup>

## 6.2 Banda Aceh: Aftermath Reporting

Under normal circumstances, the Grand Mosque is bright, spacious, and wide open. However, under duress, the openness and spatial comfort is replaced by crowds and chaos.

Compounding the feelings of stress and displacement, reporters arrive at the scene to gather information. Because this is the only formidable refuge within miles, and the site of most survivors, the mosque becomes the soul information site for global news. As such, it becomes overrun with people, clamoring for information. Though the reporters intend to highlight the disaster's immense impact, there is no doubt that their presence serves to aggravate an already dire situation.<sup>35</sup>

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<sup>34</sup> Joel Saget, *Surveying the Damage*, 2005, Getty Images, accessed March 12, 2013, <http://news.nationalgeographic.com/news/2012/04/pictures/120412-indonesia-tsunami-earthquake-science-world/#/4-helicopter-tsunami-destruction>.

<sup>35</sup> Richard Oloruntoba, *A Wave of Destruction and Waves of Relief*, *Disaster Prevention and Management* 14, (2005): 506-521, accessed March 21, 2013.





Figure 6.3. In Transition  
(Images by Dimas Ardian)<sup>36</sup>

<sup>36</sup> Dimas Ardian, In Transition, 2005, Getty Images, accessed March 12, 2003, [http://www.boston.com/bigpicture/2009/12/five\\_years\\_since\\_the\\_tsunami.html](http://www.boston.com/bigpicture/2009/12/five_years_since_the_tsunami.html).



### **6.3 Banda Aceh: Transitioning and Rebuilding**

Banda Aceh has been rebuilt, but signs of destruction have intentionally been left in place. Serving as both memorial and cautionary reminder, these remnants of disaster are haunting and purposeful.

When surveyed by a group of Japanese disaster management consultants, survivors were asked what the best form of disaster prevention would be. Surprisingly, they preferred lessons in disaster awareness over the implementation of a robust warning system. Psychologically, there is a sense that if people had known of the impending disaster, recourse might have been taken. This, however, would not solve the imminent disaster a tsunami would wreak. Two respondents, out of 46, preferred to build safer houses.<sup>37</sup>

It is important then to recognize that local priorities differ here from outsider logic. At first glance, safer houses seem to be an obvious improvement priority, especially given the task of rebuilding. Why, then, do so many Indonesian survivors prefer to address knowledge, and awareness? These cultural values and practices should inform the executors of the rebuilding effort.

### **6.4 Banda Aceh: Neural Network Mapping**

In recent cases, artificial neural networks are sometimes used to assess the extent of a disaster. Meant to mimic the way the human brain understands and learns patterns of behavior, an artificial neural network is fundamentally a series of inputs with one output. What differentiates this network from a normal feedback loop (where this is

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<sup>37</sup> Hirokazu Iemura, et al., *Earthquake and Tsunami Questionnaires in Banda Aceh and Surrounding Areas*, *Disaster Prevention and Management* 15, (2006): 21-30, accessed March 21, 2013.

feed-forward) is the adaptive nature of the neural network. There is enormous potential in this technology, as evidenced in the following case study, in enabling networks of people to act efficiently during crisis.

The basic behavior of the network is such that a layer of neurons accepts input. Information is processed, and then redistributed to a “hidden” layer of neurons, which then feeds information to a layer of output neurons. The processing is meant to appear automatic - patterns can be recognized, and learned so that new links are created between neurons and output occurs at a near-immediate pace.

Where artificial neural networks fall short is actually learning to create new links that function at a pace even close to human. Human brains are able to recognize people, places, and images with increasing success to the point that response becomes automatic.

The IKONOS images presented here are of before and after satellite scans taken in 2004. It becomes clear that an enormous piece of land and infrastructure was swallowed when the sea overtook the coastal city. It is not clear, however, where exactly roads remain intact, and where they are flooded to the point of inaccessibility.

The Center for Satellite Based Crisis Information (ZKI) ran the images through a neural-network processing code. The computer was able to understand where there had been roads, what those pixels and their neighbors were composed of, and whether or not those pixels existed in the same state after the Tsunami. At an average 94% accuracy, ZKI was able to determine, to the benefit of NGO relief efforts, where road access had been eliminated and where it remained.<sup>38</sup>

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<sup>38</sup> Matthew Aitkenhead, et al., *Remote Sensing-Based Neural Network Mapping of Tsunami Damage in Aceh, Indonesia*, *Disasters* 31 (September 2007): 217-226, accessed March 21, 2013.

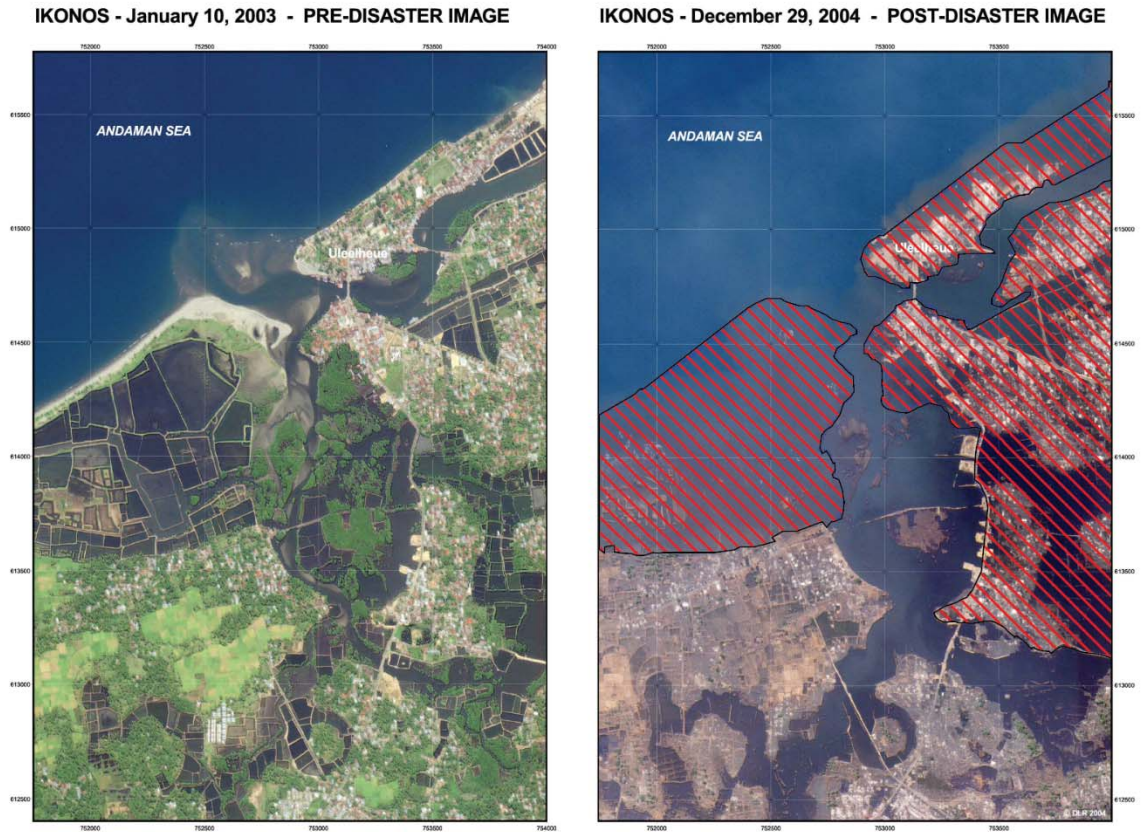


Figure 6.4. Post-Tsunami Images  
(Image by IKONOS)<sup>39</sup>

## 6.5 The Mosque and the Memory Device

When asked about how to prioritize disaster prevention in the event of future mega-tsunamis, the people of Banda Aceh requested education and awareness, ahead of infrastructural improvements. It is fair to infer then that awareness is not only an important cultural value, but also an effective method of casualty prevention (at least in theory).

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<sup>39</sup> International Charter Space and Major Disasters, *Post Tsunami Images*, 2004, accessed March 12, 2003, [http://www.reefbase.org/resource\\_center/photos.aspx?picid=3951](http://www.reefbase.org/resource_center/photos.aspx?picid=3951).

Adopting a memory-awareness device used by Japan in the wake of major tsunamis of the 1930's, the city of Banda Aceh decided to construct poles around the city corresponding to the peak water height in that particular zone. Embedded in the poles is symbolism manifested color and form. The pole acts as more than a simple memorial of those whose lives were lost. It is meant to be a constant reminder of the looming threat of the tsunami. The poles are meant to counteract the fading of memory over time - they are meant to endure, and to enter into the subconscious of the citizen of Banda Aceh.<sup>40</sup>

The debris from the tsunami that remains in the city serves the same purpose, a simple casual reminder of the event, and its raw power. In leaving behind remnants of the tsunami's destruction, powerful visual aids reinforce the purpose of the installed height-poles - a city whose past and future are linked to a single force of nature.

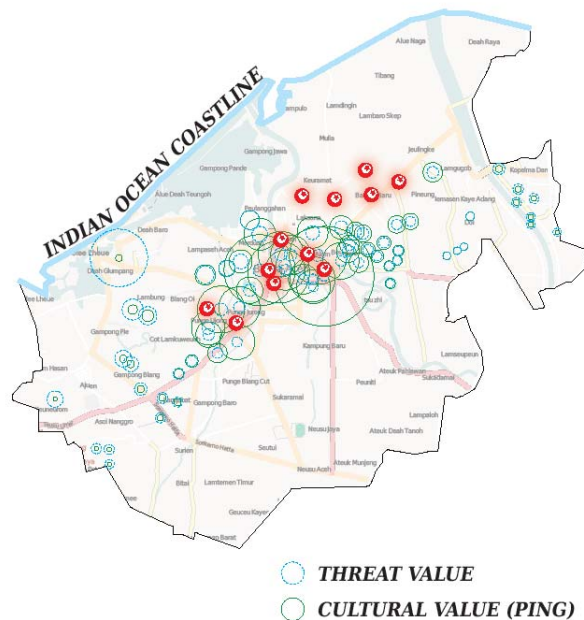


Figure 6.5. Threat Value versus Cultural Value  
(Image by author)

<sup>40</sup> Megumi Sumimoto, et al., *Tsunami Height Poles and Disaster Awareness*, *Disaster Prevention and Management* 19, (2010): 527-540, accessed March 21, 2013.

## 6.6 Landmark and Sorting Mechanism

Serving as a sorting mechanism, the mosques act as attractors in both the placement and importance of the height poles. Since the mosque is the most important landmark in the city, placing disaster-preventive mechanisms near these hubs/points of interest seems logical. Visibility is highest in and around these mosques - the message the poles are meant to convey will reach the most people.

This diagram, then maps, a ‘ping’ value associated with the poles. Poles with larger ping values ostensibly receive greater recognition because of their placement. Mosques control these ping values because of their role in the Sumatran cultural hierarchy. Notice how the largest ping values are clustered around the “religious epicenter”. City planners were right to locate the poles where they are most visible. Additionally, since the poles indicate a physical property of the disaster - water height - they can be assessed according to vulnerability. Poles closest to the coast are the tallest because those areas took on the most water.

This raises the question, should the poles at the center of the city (areas that receive in order to appear most visible to passers-by?

## 6.7 Conclusions on Height Poles

The tsunami height poles are a powerful reminder of the brute force the 2004 tsunami, and its cataclysmic effects on the city of Banda Aceh. In recent news, citizens of that city are said to have responded with a high degree of alarm and comprehension

when notified of seismic activity off the shores of Sumatra.<sup>41</sup> Though that particular earthquake did not itself lead to a tsunami, it is nonetheless noteworthy that people reacted with appropriate alertness. Whether this level of alertness attributable directly to the poles is debatable. As previously stated, the trauma of surviving a tsunami of that magnitude is enough to keep someone alert for the rest of their life. Yet, this is exactly the desired effect of the poles themselves – to remain a constant reminder of traumas passed.

Architecturally speaking, the poles are limited in their capacity to do real good in the event of a future disaster (the occurrence of which is certain). When powerful waves wash ashore, the poles will be destroyed, along with the rest of the city. Hopefully, fewer lives will be lost in that future event, but there is no guarantee. The perils of living close to the shore, in a flood plain remain the most important factors in determining the safety of Banda Aceh's residents. As such, architecture should be more aggressive, and active in its role in preventing loss of life, as well as infrastructure. Additionally, though research indicated potential for intervention with respect to the poles themselves, it became clear that the form and symbolism of the pole should remain. The design proposal will seek to address issues of safety and rebuilding, harnessing memory but engaging the disaster more aggressively and proactively.

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<sup>41</sup> Reza Munawir, *Huge Quakes of Indonesia Stir Panic, but No Tsunami*, Reuters.com, April 2012, accessed March 14, 2013, <http://www.reuters.com/article/2012/04/11/us-indonesia-earthquake-idUSBRE83A0BB20120411>.

## CHAPTER 7: DESIGN PROPOSAL

Although this chapter is the culmination of two semester's worth of research and exploration, the design proposal is very much a reaction to events specific to Banda Aceh, Indonesia and the 2004 Indian Ocean Tsunami. Certain elements, such as news network behavior, have translated more conceptually than literally. However, it should be noted that the design proposal does seek to create a new rebuilding network. In this sense, the distributed network typology is one that is idealized in reality, but manifests itself in the proposal for this thesis. Moreover, all imagined disasters mentioned in this proposal should be considered real and present, as the city itself suffers from a chronic threat. For the purpose of this thesis, the actual intervention occurs in 2004, in the immediate aftermath of the tsunami being addressed. References to future tsunamis are any that occur after 2004.

The proposal, in brief, is a new system by which Banda Aceh, and other tsunami-prone cities, are rebuilt in the event of a disaster. The important question is: how can the built environment transcend simple casualty-prevention, and participate with disaster? To answer this question, the proposal outlines a series of designed measures that ultimately alter the material composition of the city, while enabling it to better perform under the duress of a tsunami, by connecting to specific cultural and economic institutions. Materiality is especially important in this proposal as it addresses a need to conserve building materials which are increasingly rare in Sumatra, as well as a need to enhance properties inherent to existing building typologies.



## **7.1 System Performance**

This proposal repurposes debris left in the wake of a tsunami, and reconfigures buildings across the city to perform at a high-tech level, each typology with its own set of behaviors. The built environment will implement damage mitigation, valuable material preservation, and an escape system for the people of Banda Aceh, escorting them to higher ground.

## **7.2 Sorting Damage to Program**

Figure 7.1 illustrates the extent of damage caused by the tsunami, which spread about 2 kilometers inland from the coast. Damage decreases from the shore in a general inland direction. Areas highlighted in red experienced the most severe damage, while areas highlighted in blue experienced very little damage. Unfortunately, most of the city's infrastructure is concentrated in the red zone. It becomes clear then, that proximity to the shore is cause for concern in the built environment, as well as the social environment.



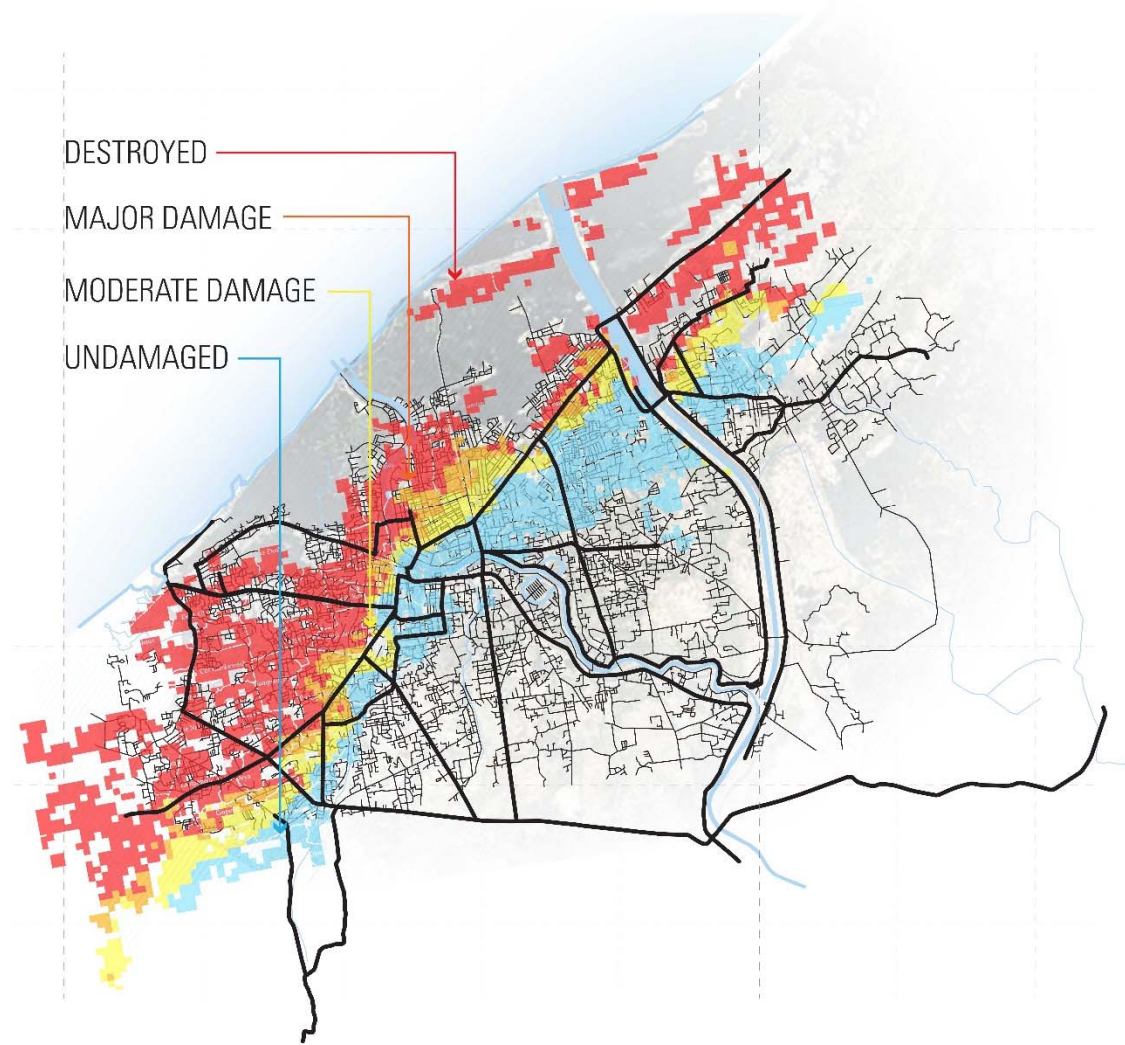


Figure 7.1. Damage Assessment  
(Image by author)<sup>42</sup>

### 7.3 Urban Organization of Program

The majority of Banda Aceh's activity is located close to the shoreline, with the exception of religious structures. This is because the city relies on water in order to

<sup>42</sup> Image redrawn by author, from JICA Study Team, *Tsunami Damage Assessment Map*, accessed March 12, 2013, (Banda Aceh: SK University, 2005).

generate economic output – fishing, brackish water culture, and agriculture all rely to a great extent on proximity to the ocean.<sup>43</sup>

### 7.3.1 Damage to Religious Centers

The large majority of Banda Aceh practices Islam, approximately 98% of the population. It is no surprise then that the city devoted a great deal of attention in the construction of its mosques. The mosques, in turn, serve as gathering centers for the city's activity. Though there are less than 20 mosques in the city, they are of considerable size. The meunasah serves as a sort of community companion to the mosque. Because the mosque is sacred space, it is typically occupied for prayer only. The meunasah, by contrast, takes up the role of meeting place, but maintains a distinctly Muslim affiliation.<sup>44</sup>

Figure 7.2 illustrates the extent to which mosques sustained considerable damage, but remained standing.

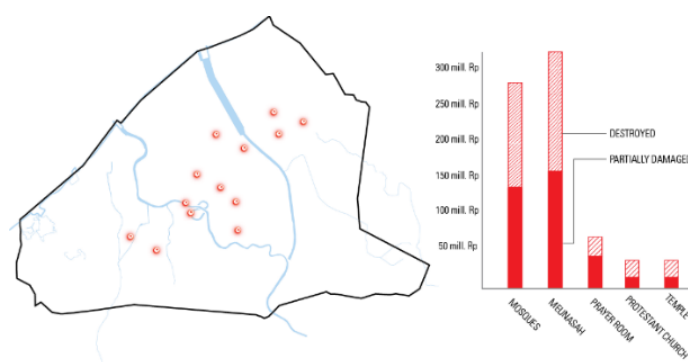


Figure 7.2. Damage Distribution - Religion

(Image by author)<sup>45</sup>

<sup>43</sup> BAPPENAS, *Preliminary Damage and Loss Assessment*, accessed March 12, 2013, (Jakarta: EarthLine, 2005), 32 – 92.

<sup>44</sup> BAPPENAS, *Preliminary Damage and Loss Assessment*, accessed March 12, 2013, (Jakarta: EarthLine, 2005), 32 – 92.

<sup>45</sup> Image drawn by author, with data from BAPPENAS, *Preliminary Damage and Loss Assessment*, accessed March 12, 2013, (Jakarta: EarthLine, 2005), 32 – 92.

### 7.3.2 Damage to Agricultural Centers

Damage to the agricultural industry was severe, as much of the land used for farming was located near the coast. Because of local farming practices the soil was loose, and tsunami waves transported debris and topsoil more easily across these zones. Additionally, the fisheries located near the coast were completely destroyed, which especially significant considering the important role they play in generating income for those who live in Banda Aceh. Agriculture is important in this sense because its success bleeds over into other sectors, like shipping and the market economy in general. Figure 7.3 indicates the monetary damage to fisheries, while one can only imagine the predicted financial loss the city will suffer due its depleted primary economic resource.

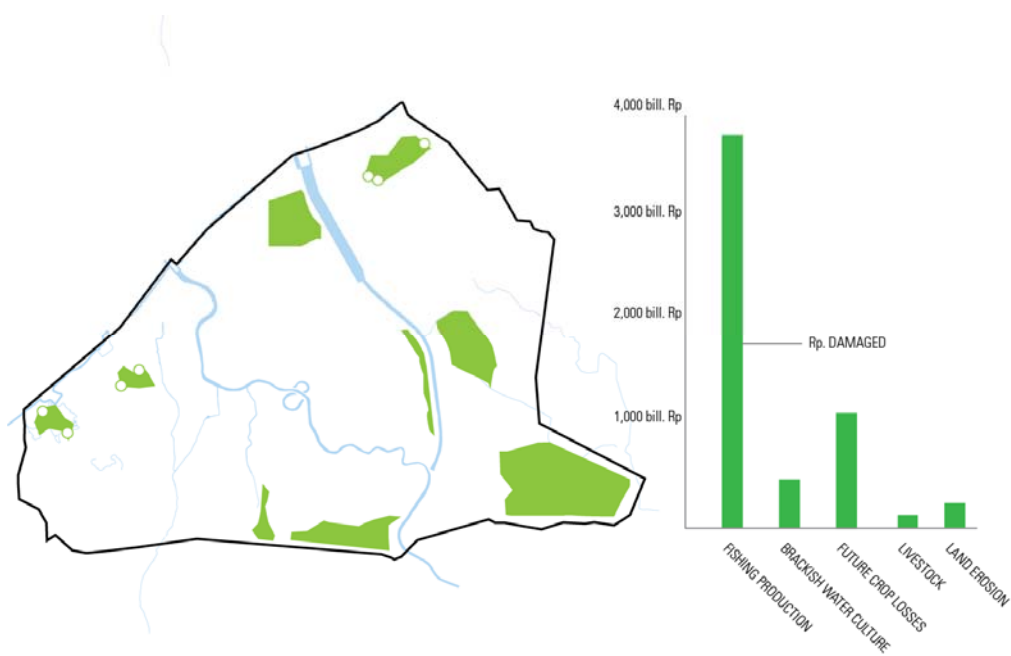


Figure 7.3. Damage Distribution - Agriculture

(Image by author)<sup>46</sup>

<sup>46</sup> Image drawn by author, with data from BAPPENAS, *Preliminary Damage and Loss Assessment*, accessed March 12, 2013, (Jakarta: EarthLine, 2005), 32 – 92.

### 7.3.3 Damage to Ports

Ports in Banda Aceh are located on the shore, with direct access to the Indian Ocean. Consequently they received the most damage. The ports are important to this city because they are the primary means of communication with the rest of Indonesia and Southeast Asia. Products grown and harvested in Banda Aceh are sent through these ports. However, because the port requires a great deal of financial investment for equipment, they suffered an enormous amount of damage, financially speaking.<sup>47</sup>



Figure 7.4. Damage Distribution - Transportation

(Image by author)<sup>48</sup>

### 7.3.4 Damage to Transportation

Road transportation is the principal means of access to various parts of the city. Roadways closer to the shore and point of impact received a greater amount of damage,

<sup>47</sup> BAPPENAS, *Preliminary Damage and Loss Assessment*, accessed March 12, 2013, (Jakarta: EarthLine, 2005), 32 – 92.

<sup>48</sup> Image drawn by author, with data from BAPPENAS, *Preliminary Damage and Loss Assessment*, accessed March 12, 2013, (Jakarta: EarthLine, 2005), 32 – 92.

while those further inland remained largely unscathed. What is important is that without roads connecting emergency shelters, like mosques, to the rest of the city relief efforts were handcuffed in their ability to give aid to refugees. The roads, in this sense, are especially vital in the event of a disaster, because they enable relief to function more capably.<sup>49</sup>

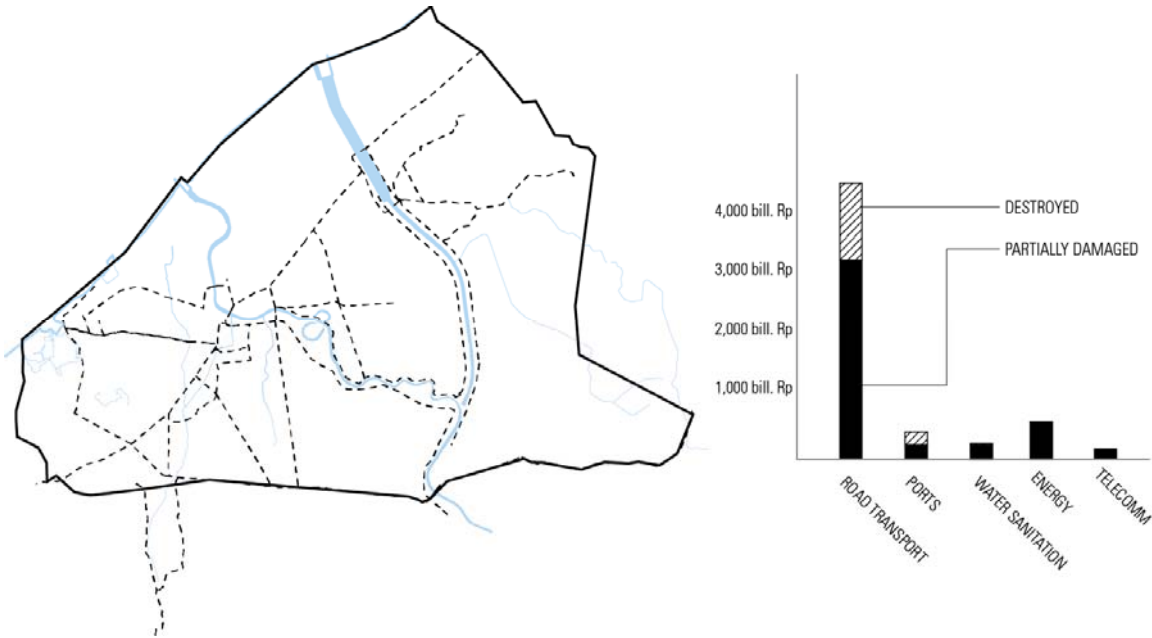


Figure 7.5. Damage Distribution - Infrastructure  
(Image by author)<sup>50</sup>

<sup>49</sup> BAPPENAS, *Preliminary Damage and Loss Assessment*, accessed March 12, 2013, (Jakarta: EarthLine, 2005), 32 – 92.

<sup>50</sup> Image drawn by author, with data from BAPPENAS, *Preliminary Damage and Loss Assessment*, accessed March 12, 2013, (Jakarta: EarthLine, 2005), 32 – 92.

## CHAPTER 8: SORTING MATERIAL

This chapter is the implementation of research derived in the last chapter. Understanding that financial damage to program and damage to culture are distinctly different, this chapter provides an analysis of material damage throughout the city, immediately after the 2004 Tsunami hit. In 2004, the city's topography served as the primary sorting mechanism for debris. The design proposal will use this scattered debris as the point of intervention, beginning what is a complete reshaping of the material composition of the city.

### 8.1 Sorting the City

By examining satellite images, research shows that there are 9 families of materials in Banda Aceh. Depending on the region of the city, and its corresponding program, the material composition varies. For example, agricultural regions have an abundance of topsoil and mud, while areas near the city center have more raw building materials like sheet metal and concrete.

When the tsunami hit Banda Aceh's shores the waves rearranged materials around the city, depending on changes in the topography, but mostly depending on the relative density of the material. Lighter materials, like plastic and timber flow more easily, and so they typically ended up at the bottom of debris piles, covered by denser materials like glass and concrete. These debris piles serve as the primary cleanup site, as well as the entry point of the architectural intervention. Figures 8.1, 8.2, 8.3, 8.4 are simulations of how debris might re-aggregate around the city depending on abundance and density.

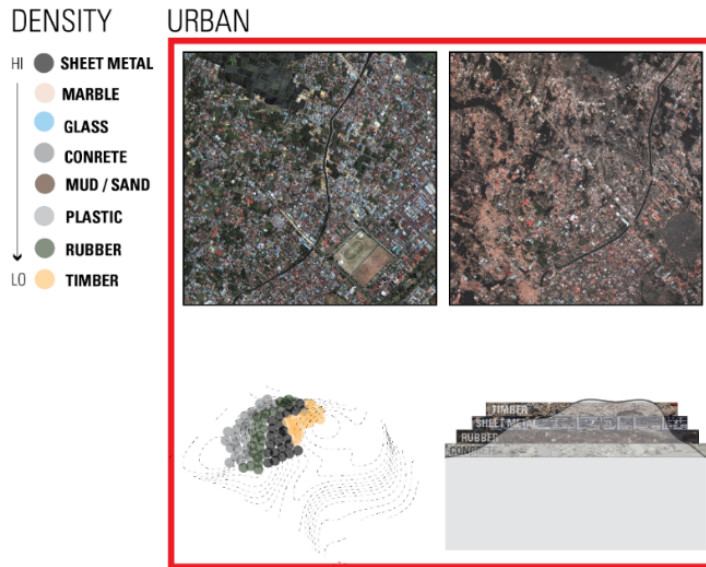


Figure 8.1. Material Sorting - Urban  
 (Image by author)<sup>51</sup>

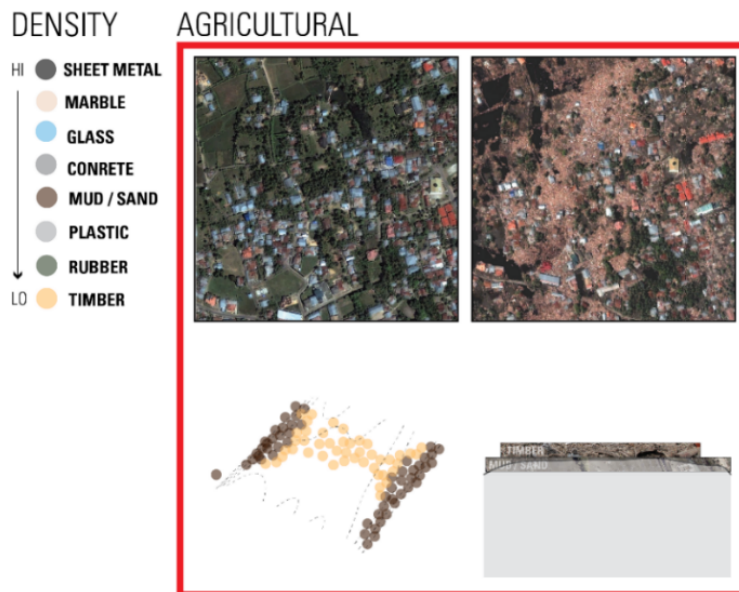


Figure 8.2. Material Sorting - Agricultural  
 (Image by author)<sup>52</sup>

<sup>51</sup> Satellite images from DigitalGlobe, *Banda Aceh City Overview*, 2004, accessed March 13, 2003, [http://www.unep.org/tsunami/photos/banda\\_aceh\\_cityzoom\\_dec28\\_2004\\_dg.jpg](http://www.unep.org/tsunami/photos/banda_aceh_cityzoom_dec28_2004_dg.jpg).

<sup>52</sup> Satellite images from DigitalGlobe, *Banda Aceh Debris Detail*, 2004, accessed March 13, 2003, [http://www.unep.org/tsunami/photos/banda\\_aceh\\_debris\\_dec28\\_2004\\_dg.jpg](http://www.unep.org/tsunami/photos/banda_aceh_debris_dec28_2004_dg.jpg).



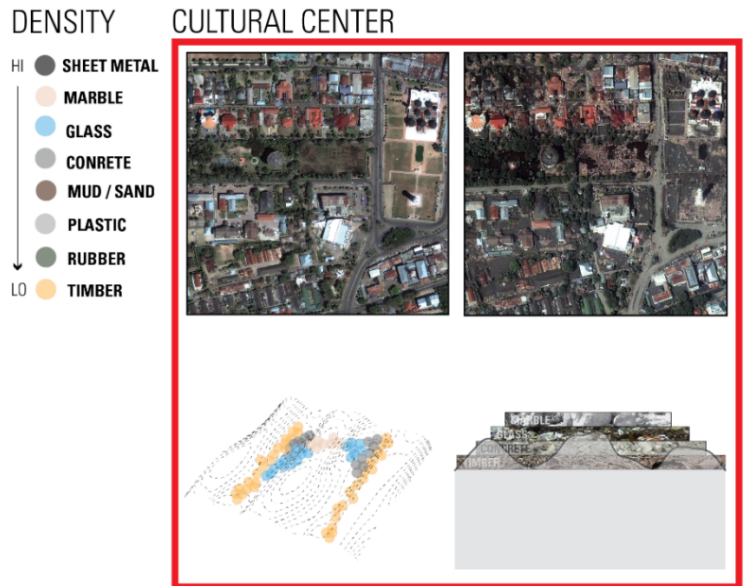


Figure 8.3 Material Sorting - Cultural  
 (Image by author)<sup>53</sup>

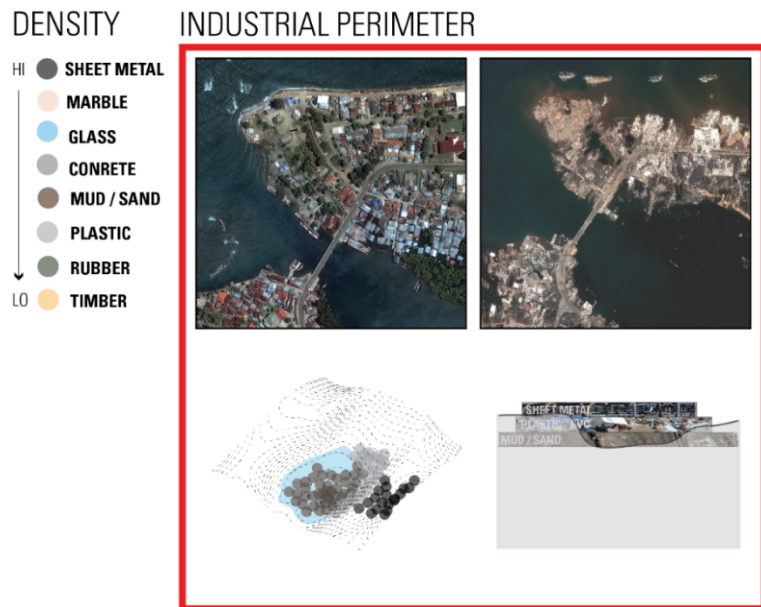


Figure 8.4. Material Sorting - Industrial  
 (Image by author)<sup>54</sup>

<sup>53</sup> Satellite images from DigitalGlobe, *Banda Aceh City Detail*, 2004, accessed March 13, 2003, [http://www.unep.org/tsunami/photos/banda\\_aceh\\_rotatezoom\\_june23\\_2004\\_dg.jpg](http://www.unep.org/tsunami/photos/banda_aceh_rotatezoom_june23_2004_dg.jpg).

<sup>54</sup> Satellite images from DigitalGlobe, *Banda Aceh Northern Shore*, 2004, accessed March 13, 2003, [http://www.unep.org/tsunami/photos/banda\\_aceh\\_northernshore\\_june23\\_2004\\_dg.jpg](http://www.unep.org/tsunami/photos/banda_aceh_northernshore_june23_2004_dg.jpg).



## **8.2 Creation of the Voxel**

There are two main construction tools: the voxel and the drone. The voxel is the building block of the post-disaster city, deployed in areas that were destroyed by the tsunami. It is a new type of brick that can be assembled into a variety of different buildings around city, depending on material composition and need. The drone is the agent of the voxel, that is to say, the drone creates the voxel on its own. Using a series of physical processes, which depend on the material of the debris found at the site, the debris is transformed into new, usable voxels.

### **8.2.1 Drones Converge**

The drones previously described operate in the ocean as an independent network of objects. They are connected wirelessly to the IKONOS Satellite Imaging Center, which scans the earth's surface for compositional changes. Through IKONOS the drones are able to determine when a tsunami has occurred, and immediately attend to the site in need of relief. As they emerge from the ocean, they operate in teams, turning piles of debris into voxels, which then serve as the future city. Figure 8.5 details the processes by which debris is turned into voxels. This depends on the proximity of certain debris types to one another, as well as the physical properties of the debris. Marble and glass, for instance, respond to high pressure, and so the drone would use this technique in order to combine these materials into one new composite.



Figure 8.5. Material Recomposition  
(Image by author)

### 8.2.2 The Voxel's Properties

During the creation of the voxel, the drone applies a coating of sol-gel in order to waterproof the material. The sol-gel requires water as a substrate, which is provided by the water-logged debris. In the process of curing, the gel removes the sea water from the debris, calcifying it. The voxel is now hydrophobic, and impervious to water damage from future tsunamis.<sup>55</sup>

Secondly, the drone coats the newly created voxel with a layer of nano-velcro, which acts as a binding agent on the surface of the voxel. Nano-velcro is a technology

<sup>55</sup> *Sol-gel Treatment*, CentexBel, accessed March 14, 2013, <http://www.centexbel.be/solgel-treatment>.

often used by the United States Department of Environmental Protection, to remove toxic heavy metals from water. In their application, fibers in the Velcro extend and bond with ions in the metal.<sup>56</sup> For the purpose of this thesis, the Velcro fibers are programmed to respond to ions in the sol-gel. In this way, the voxels can be assembled using the velcro as a surrogate mortar.

Finally, the drone embeds a spine in the voxel, which forever links it to the drone-IKONOS network. This new link enables the voxels to be just as aware of impending tsunamis, and allows them to respond accordingly. Later sections in this chapter will go into detail about how exactly voxels will respond to the threat of a tsunami.

### **8.3 The Voxel's Destination**

This thesis will focus on two programmatic elements that will be beneficiaries of new voxel construction: the port, and the public market. Although these three elements are all destined to take on specific behaviors (both during a threat, and not), they should all be understood as being part of a single network. The public market will be designed with the greatest specificity, which should be seen as representative of an overall building tectonic – that of the voxel.

### **8.4 The Dolos**

First designed in the mid 1960's the Dolos is a concrete armor unit manufactured by Sogreah, to prevent coastal erosion. The unit is typically pre-cast concrete, weighing

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<sup>56</sup> *Nano-velcro Clasps Heavy Metal Molecules in its Grips*, EPFL, October 2012, accessed March 14, 2013, <http://actu.epfl.ch/news/nano-velcro-clasps-heavy-metal-molecules-in-its-gr>.

up to 15 tons, and takes the form of a jack, or tetrapod. The units are arrayed so that they overlap and generally interlock once they are deployed on shores or jettys. What makes the Dolos so effective is its mass, combined with the chamfered edges which serve to disrupt wave patterns. Once the units interlock, they function cohesively, resisting powerful wave impact. They essentially become immovable objects because of the interlocking, armoring shores against the heavy force of ocean waves and tidal changes.<sup>57</sup>

Although this technology is rarely used as a measure to mitigate tsunami damage, its potential should not be dismissed. This is primarily due to its brutal appearance, not to mention the high cost of construction. However, the low-tech nature of the Dolos is well-suited for this project, as its geometry could be replicated, and assembled by the drone. Future voxel construction, specifically the port and the market, will make use of the Dolos technology. The new building typologies will be comprised of large-scale building components, and will aggregate in such a way so that although the program and function of each typology differs, the voxelized built environment will use the Dolos as inspiration, an effective measure against wave impact.

#### **8.4.1 The Voxelized Port**

The port, because of its proximity to the point of impact, will use water to its advantage. The primary concern of the voxelized port is one of immediate reconnection to the outside world. In the event of a tsunami ports are most vulnerable due to their proximity to the shore and point of wave impact. In the aftermath, they become especially important pieces in reconstruction, allowing Banda Aceh to communicate with other coastal cities, receiving aid. Though the port is in fact several components – storage sheds, machinery, shipping vessels – the most important is the wharf, which

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<sup>57</sup> Nina Fozein Kwanke, et al., *Concrete Armor Units for Breakwaters*, Concrete International, (2009): 34-40, accessed March 18, 2013.

extends out into the ocean. With the destruction of the wharf, Banda Aceh is most paralyzed, as it loses its ability to receive aid. The voxelized port prioritizes the wharf, so that it is the first component of the port to be rebuilt, and as such becomes the most resilient. The Dolos technology is implemented in such a way so that the wharf superstructure is immovable, and remains functionally intact in the event of a tsunami.

#### **8.4.2 The Voxelized Market**

The final component to be voxelized in detail is the public market. The voxelized market will act as a super-sorting mechanism in the event of a tsunami, in addition to a means of escape. In this typology the Dolos becomes spatial so that it can operate as a market when there is no tsunami threat. When a tsunami does occur, the market is resilient in that it too is an immovable structure, breaking down the waves. In this way, the market acts like a sieve, softening the blow of the tsunami wave, and preventing further damage to the city. In turn, the market collects material by allowing water to pass through it, but not debris. More material accumulates with each tsunami, allowing the market to grow taller. The markets are built up in a series of terraces, allowing people to occupy space above the ground level. With each successive storey, the market becomes a more viable source of high-ground. In this way the market is a continually evolving topography for the city.

The strength of the market typology is dependent in part on its prevalence throughout the city. The more markets there are in Banda Aceh, the more effectively they sort. Generally speaking markets will aggregate close to Banda Aceh's waterways, as this is the primary means by which fisherman bring their catch to the wider public. Over time however, Banda Aceh's coastline will shift inland with each successive tsunami. Markets will therefore be built up gradually inland to adjust for the shift in the location of Banda Aceh's population density.

MARKET - MODULE

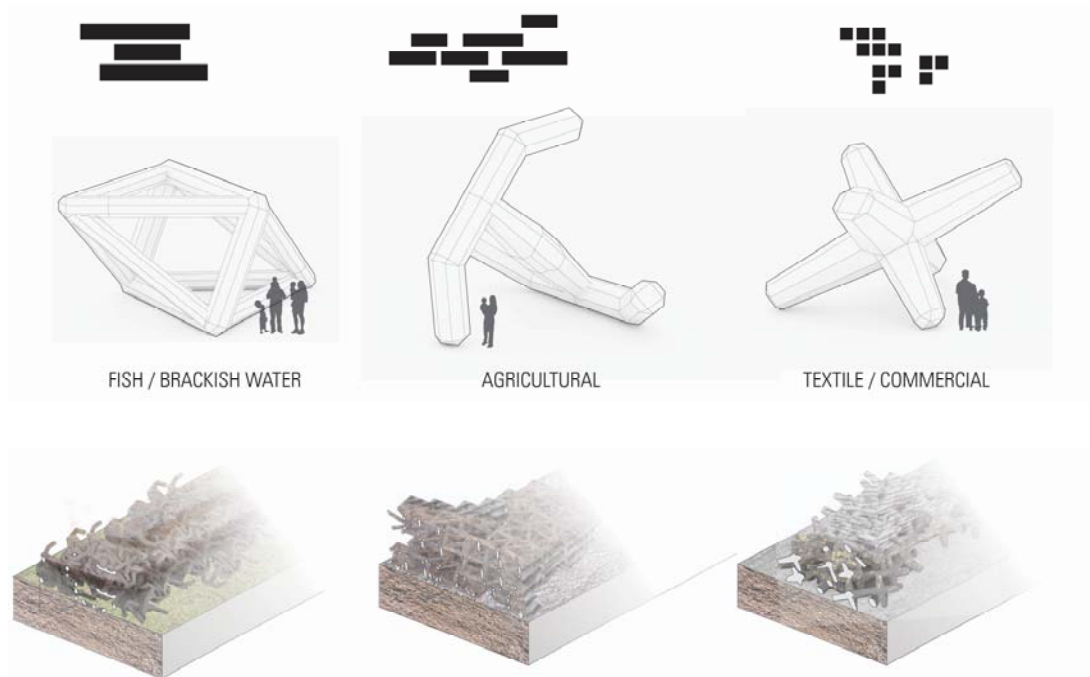


Figure 8.6. Market Module

(Image by author)

## CONCLUSION

The goal of this project is not to find a perfectly engineered solution to preserve life in the event of a tsunami. Instead, the voxelized market should be seen as a step toward architecture as a device to functions on a level which transcends conventional construction. The voxel is a new tectonic which serves the needs to a society, and not necessarily economy. It prioritizes resilience, for the purpose of the architecture of salvation.

Banda Aceh, as city which has endured myriad catastrophes, and which will surely suffer more in future, stands to benefit from an architecture which grows with tsunami, as opposed to its current performance – deterioration or utter destruction. The market is introduced in this thesis as a point of entry for architecture to redefine resilience and program. While the proposal does not necessarily innovate the every-day activity of the market, it does allow it to become a new landmark for the city, affecting memory. Similarly the port responds to disaster not through physical strength necessarily, but through a strategy which achieves resilience over time, and adapts to the changing topographic conditions which are caused by tsunamis.

Perhaps most important is that building material should not be considered expendable, and that there is immense possibility in rebuilding a city from the ground up – Banda Aceh and Indonesia as a whole appears to have made the same mistakes in reconstruction as it did in 2004 leading up to the tsunami. Without an innovative and analytical approach to Sumatran architecture, all tsunami-prone coastal cities remain threatened. Architecture is responsible in this sense, for rescuing cities from the damage the built environment can cause.

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