NATURAL DISASTERS
HCDE 411 FINAL PROJECT

DORKS
DISASTER OPERATIONS AND RELIEF KNOWLEDGE STUDY

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Table of Contents

1. Abstract

Due to their unpredictability, natural disasters present an ongoing analytical challenge to researchers. In this project, we hoped to assist crisis researchers in exploring the numerous factors associated with natural disasters by creating effective data visualizations. The resources we used included almost 100,000 data points, which would have been difficult to explore in their raw form, but which may have revealed meaningful connections in a visualized form. We approached this problem by combining and cleaning spreadsheets and brainstorming features which could be desired by researchers interested in this field. To ensure that we were on the right path, we consulted potential users for feedback on each iteration of our visualization. Our final visualization was fully interactive and allowed users to see an overview of international disaster consequences on a global level, through time, as well as zoom and filter certain aspects of the data to explore existing relationships. Additionally, a user could make use of a comparison tool, storyboards, and sample user tasks to guide them through the data. Finally, we demonstrated a "stretch" feature which would allow users to select a specific disaster and delve deep into the data on an isolated level, exploring how disasters unfold, relief operations are run, and providing insights for crisis informatics expert to aid in current and future disasters scenarios.

2. Introduction

Natural disasters are a difficult challenge for researchers to address because consequences and relief efforts are highly dependent on uncontrollable forces, such as the severity of the disaster, the type of disaster, and the terrain and locale in which it hits. Furthermore, while infrastructure and technology may play a role in mitigating the negative consequences, such relationships are hard to determine, especially with static data in a spreadsheet.

One of the first concepts we learned in our data visualization class this quarter was that the human brain is built to analyze images rather than text, and visualizations can greatly assist in seeing relationships in data. In Stephen Few's words on the power of perception, "we need a picture of the data" because "when information is presented visually, it is given form, which allows us to easily glean insights that would be difficult or impossible to piece together from the same data presented textually" (Few, 30). We hoped that in an area with so much raw data, visualizations would be especially effective in helping interested parties explore potential relationships in the many factors surrounding a natural disaster.
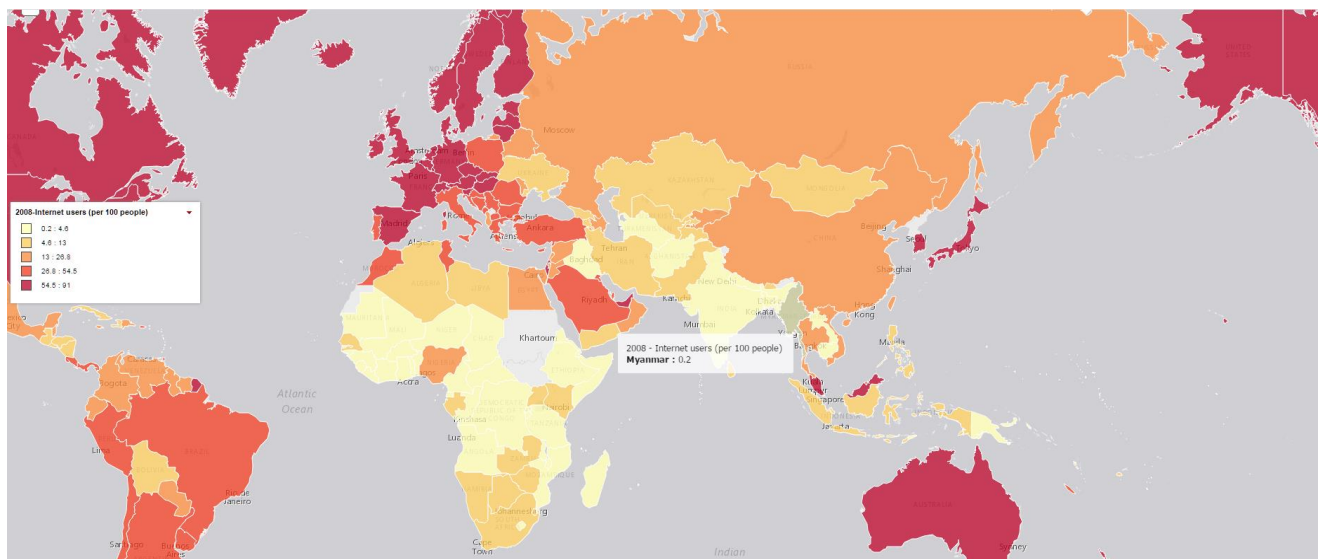
3. Previous Work

Starting this project, we knew that we wanted to work with natural disaster data for several reasons. Although the devastation of natural disasters' impacts can be realized through the photographs that are spread in media, we also saw that there was a huge potential to be able to utilize our design knowledge in a way that could help others learn and explore how natural disasters impact lives all around the world. These datasets have the potential to provide another perspective that photographs may not necessarily be able to, and we were inspired to take on the challenge of creating a visualization from it all.

In our preliminary research, we found that the majority of visualizations were static, limited in scope, and did not encourage either exploration or comparison of data. This, in turn, limits the discovery potential for new knowledge and information. "We can analyze data represented visually on paper to some degree, but we need to interact with the data to get the answers to many important questions", writes Stephen Few in his book, *Now You See It* (Few, 11). Our primary sources were particularly one-dimensional, but we did find inspiring examples of effective visualizations in related areas.

Our primary sources included the World Bank, The Humanitarian Data Exchange (HDX), and the International Disasters Database (EM-DAT) and of those, only the World Bank had an interactive display of data:

World Bank, Internet Users (per 100 people), map view

Source: World Development Indicators. Click on a metadata icon for original source information to be used for citation.
Disclaimer:This map was produced by Staff of the World Bank. The boundaries, colors, denominations and any other information shown on this map do not imply, on the part of The World Bank Group, any judgment on the legal status of any territory, or any endorsement or acceptance of such boundaries.

**World Bank, Internet Users (per 100 people), chart view**

The World Bank's interface allows a user to view their data sets in a spreadsheet, in a chart, or on a map. Filtering is available in chart view, and hovering over countries provided more details on demand.

While The World Bank's interface allows a user to visualize numbers, it does not facilitate exploration and discovery. There is no way to add multiple data types to a single chart, which means a user cannot examine relationships between any given detail from a country and another. Furthermore, we found their tool to be buggy and slow - it usually could only handle one change in data type before crashing.

While there was a lot to be improved from here, visualizations available from HDX and EM-DAT were completely static.

EM-DAT, Total Deaths and Affected 1974 - 2003 (left) and Number Killed in Natural Disasters in 2011 (right)
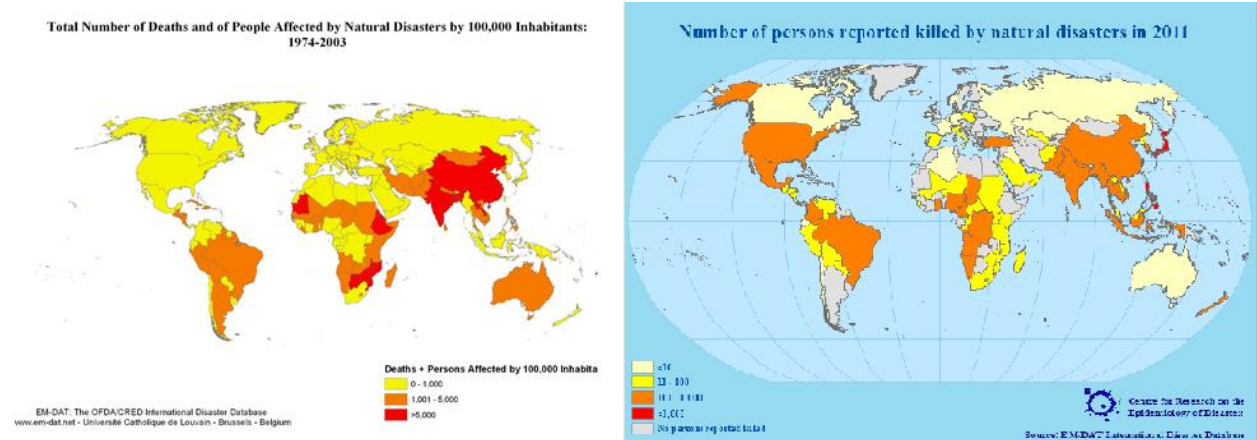
HDX, Nepal Earthquake, Map and Key Figures
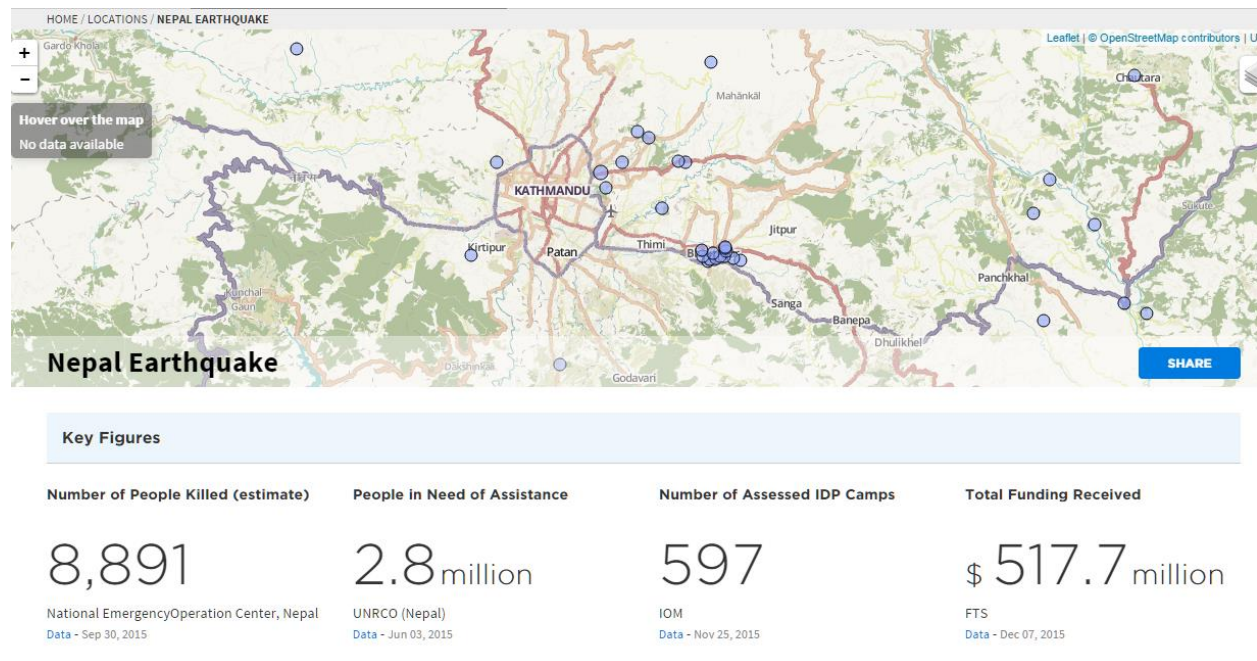
Neither the HDX nor the EM-DAT map views provided a way for the user to zoom, filter, add or compare data, or do anything else a user might be interested in.

We knew we could improve the way researchers can explore the aftermath of natural disasters and we intended to draw upon similar works in related fields to guide us in our design decisions.

Some of the most inspiring examples we drew upon were created by Jennifer Chan, a Crisis Informatics Expert who works for NetHope and has a vast array of experience Tableau.
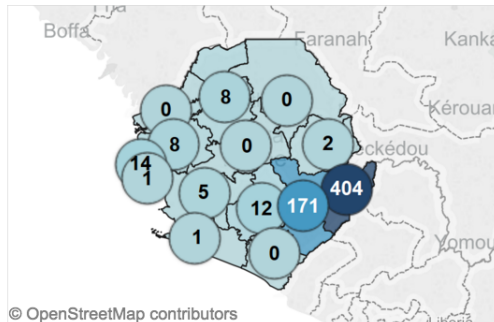

Sierra Leone: Ebola Outbreak
For more information visit the Humanitarian Data Exchange
https://data.hdx.rwlabs.org/ebola

This visualization represent the number of Ebola Cases and Deaths in Sierra Leone provided by WHO Ebola Response Roadmap Situation Report. This data can be downloaded directly via: https://data.hdx.rwlabs.org/dataset/ebola-cases-2014
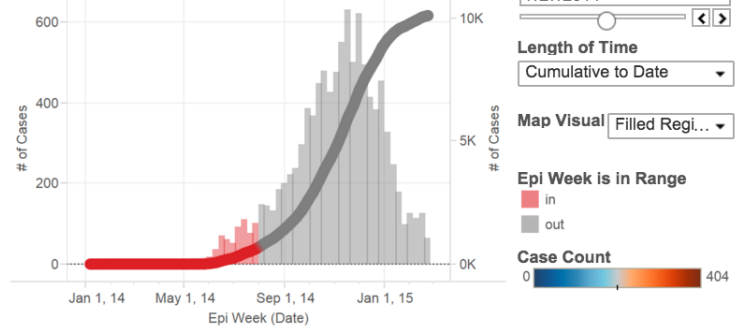
This dashboard is interactive so that the user can visualize the ebola reports data. Please select a week (click the forward/back arrow or by dragging), length of time (choices in lengths of day/sweek) and map visual (see in relation to educational establishments or districts). **Filters located at the right hand side **

Ebola Cases per Distict/Schools & District

Ebola Cases per Time (Jan 2014 - Feb 2015)

Select a Week
7/27/2014

Length of Time
Cumulative to Date

Map Visual Filled Regi...

Epi Week is in Range
- in
- out

Case Count
0 — 404

Ebola Cases by District per Time

Cases by District

Location		
KAILAHUN		404
KENEMA		171
FREETOWN	14	
BO	12	
BOMBALI	8	
PORT LOKO	8	
MOYAMBA	5	
KONO	2	
BONTHE	1	
WESTERN R..	1	
KAMBIA	0	
KOINADUGU	0	
PUJEHUN	0	
TONKOLILI	0	
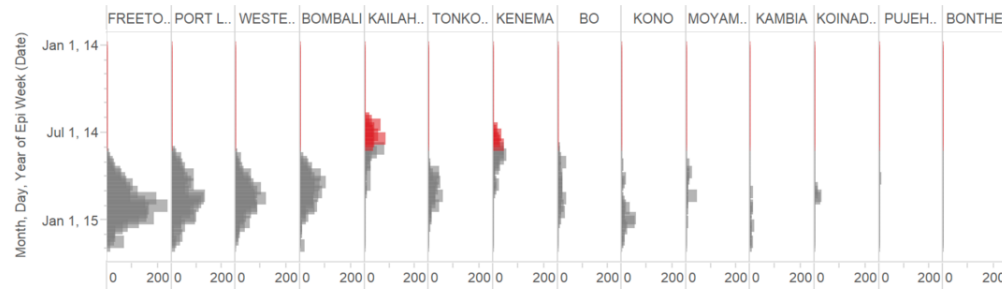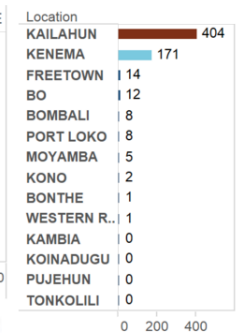
For any questions, comments or concerns please contact:
crisisdata@nethope.org or hdx@un.org

5

Food aid and dispatched supplies during ebola emergency

Based on World Food Program and ebola data from 9 Sep to 12 Feb 2015.
For more ebola data go to Humanitarian Data Exchange: https://data.hdx.rwlabs.org/ebola, for WFP data on HDX go to https://data.hdx.rwlabs.org/dataset/wfp-indicators

| Food aid & total supplies dispatched (cumulative) | Food aid & total supplies dispatched at regular intervals | Number of passengers transported by | Number of passengers transported by | Confirmed ebola cases & deaths (cumulative) | Confirmed ebola cases in Guinea as of 12 Feb 2015 | Confirmed ebola cases in Liberia as of 12 Feb 2015 | C... c... a... |

Measure Names
- Amount (in USD) of t...
- Total number of affe...

(Left y-axis: Amount (in USD) of total supplies dispatched to the region by UNHRD (cumulative) — 0M, 2M, 4M, 6M, 8M, 10M, 12M, 14M)

(Right y-axis: Total number of affected people receiving food from WFP (cumulat... — 0K, 500K, 1000K, 1500K, 2000K, 2500K, 3000K)

(X-axis: Time — Sep 16, 14; Oct 1, 14; Oct 16, 14; Oct 31, 14; Nov 15, 14; Nov 30, 14; Dec 15, 14; Dec 30, 14; Jan 14, 15; Jan 29, 15; Feb 13, 15)

While the complexity of these two visualizations is vastly different, they are both powerful in their own ways. The first demonstrates that showing multiple views on one screen. Few mentions that by doing so, "we can examine the data in any one of the graphs more easily, and we can compare values and patterns among the graphs with relative ease" (Few, 98). The second image drives home the power of simplicity in revealing relationships between key points. Together, these images remind us that discovery can happen in many ways and a good interactive visualization will allow for both complexity and simplicity as the user desires.
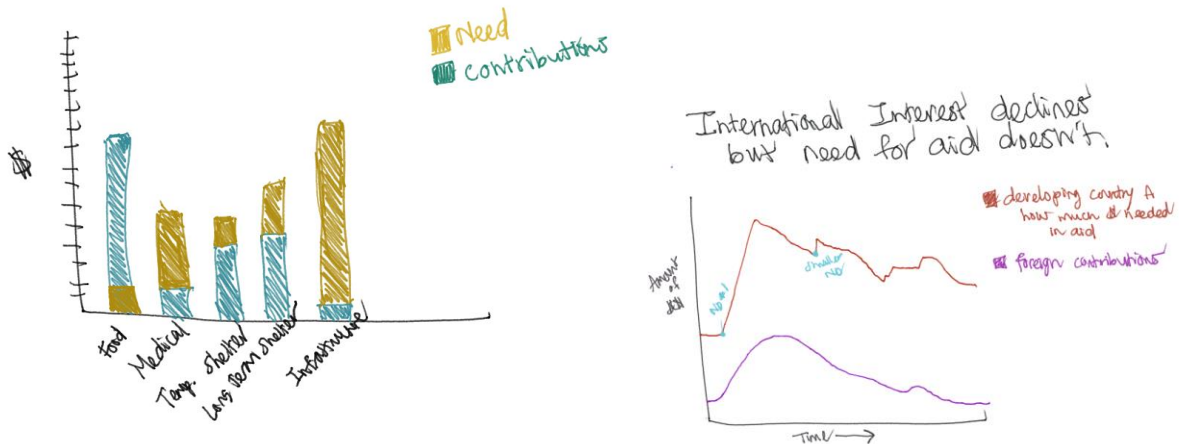
4. Design Process

4.1 Sketches

In the brainstorming process before working with data, we made some conceptual sketches representing the ways in which we might display our data to show interesting results.

Inspired by previous works, we thought that map views, charts, and graphs would all be useful moving forward.

Although we later shifted our focus away from humanitarian aid, these sketches represent certain concepts which carried into our final results.

4.2 Our Datasets

After eliminating humanitarian aid from the scope of this project, we ended up with three primary data sources, for a total of nearly 100,000 data points:

1. *The International Disaster Database*
   From this source, we were able to gather a total of 18,204 data points on natural disasters across the globe that occurred between 1900-2012. Example dimensions included year, type, occurrences, deaths, homeless, and cost of damages.

2. *The World Bank*
   For a total of 51,522 data points, The World Bank provided us with information on what we later defined as "utility" use, including internet users, electricity use, and mobile subscriptions for countries from 1981 to 2015.

3. *The Humanitarian Data Exchange*
   After exploring the many datasets from The Humanitarian Data Exchange, we were able to find 26,014 data points on the Nepal earthquakes that took place earlier this year. This dataset included deaths, injuries, magnitude, demographics, and aid as some of the dimensions, including a survey-response dataset with thousands of unique questions.

With almost 100,000 unique data points, our first challenge was to ensure that all of our data could be combined and put into Tableau without breaking functionality.

We cleaned up our data files, modifying country codes and similarly correlated categories, so that they would merge as intended. In addition, it became apparent during our explorations that certain data sets were incomplete, leaving greyed out areas on our map view to indicate the "holes." While incomplete data is not ideal, we felt those categories were still valuable to explore, so we included a disclaimer on the bottom of our visualization to communicate the limits of our datasets to our user group.

Our last consideration with this many data points was simply how to display this amount of data in a way that would tell a story rather than overwhelm our users. Our next steps in the design process, creating personas and user testing, would be integral to answering this question.

4.3 Personas

Based on the potential users we were in contact with throughout our design process in interviews and usability testing, we created three personas that helped us better understand what goals and motivations we were designing our visualization for. These personas have varying degrees of knowledge and experience with natural disasters, technology, and visualizations.

JULIE WESLEY

"The One-time User"

AGE: 20 years old

OCCUPATION: UCSD Political Science Junior

As a student at the UCSD, Julie only has a general knowledge of natural disasters. She has an interest in becoming more aware of the world around her as it pertains to the political issues that she debates in class.

"I need information on natural disasters quickly for a debate on environmental policies tomorrow!"

DOMAIN KNOWLEDGE:

Natural Disasters ●○○○○

Technology ●●●●●

Visualizations ●●○○○

Julie, a political science major at UC San Diego, has been termed "The One-time User" because she will only use our visualization once to process information quickly for her debate on environmental policies. Although she possess a high amount of experience with technology, she isn't so experienced with natural disasters or visualizations. In fact, she only has a basic understanding of natural disasters and has never created a visualization before, but occasionally sees static ones in *The Economist* magazine she reads

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RYAN STEINBECK

"The Casual User"

AGE: 25 years old

OCCUPATION: Environmental Science Researcher

Ryan Steinbeck graduated from the University of Michigan with a bachelor's degree in Environmental Science. He now works as a researcher at the University of Washington on the Climate Wizard project.

"The environment is so cool! I would love to learn more about it."

DOMAIN KNOWLEDGE:

Natural Disasters ●●●●○

Technology ●○○○○

Visualizations ●●●○○

Ryan attained his bachelor's degree in environmental science and now works as an environmental science researcher at the University of Washington on the Climate Wizard visualization project. He has a solid background with visualizations, and after taking courses specifically on natural disasters during his undergraduate years, he has a lot of knowledge about those as well. He has been dubbed "The Casual User" because he intends to use our visualization every once in a while to learn more about one of his passions, the environment.

SALLY JOHNSON

"The Expert User"

AGE: 38 years old

OCCUPATION: Crisis Informatics Expert at a disaster relief organization

As a crisis informatics expert, Sally works in Tableau to create visualizations based around natural disaster information. Specifically, she has created visualizations on disease correlations and aid. She particularly likes the use of interactivity and dashboards.

"I'd like to see how natural disasters impact the world so I can do my job better"

DOMAIN KNOWLEDGE:

Natural Disasters ●●●●●
Technology ●●●●○
Visualizations ●●●●○

Sally, "The Expert User" is a professional Crisis Informatics Expert at a disaster relief organization and has plenty of experience creating visualizations on natural disasters and exploring how they may correlate with disease and aid. By using our visualization, Sally hopes to better understand the impacts of natural disasters on the world so she can do her job to the best of her ability.

4.4. User Study Results
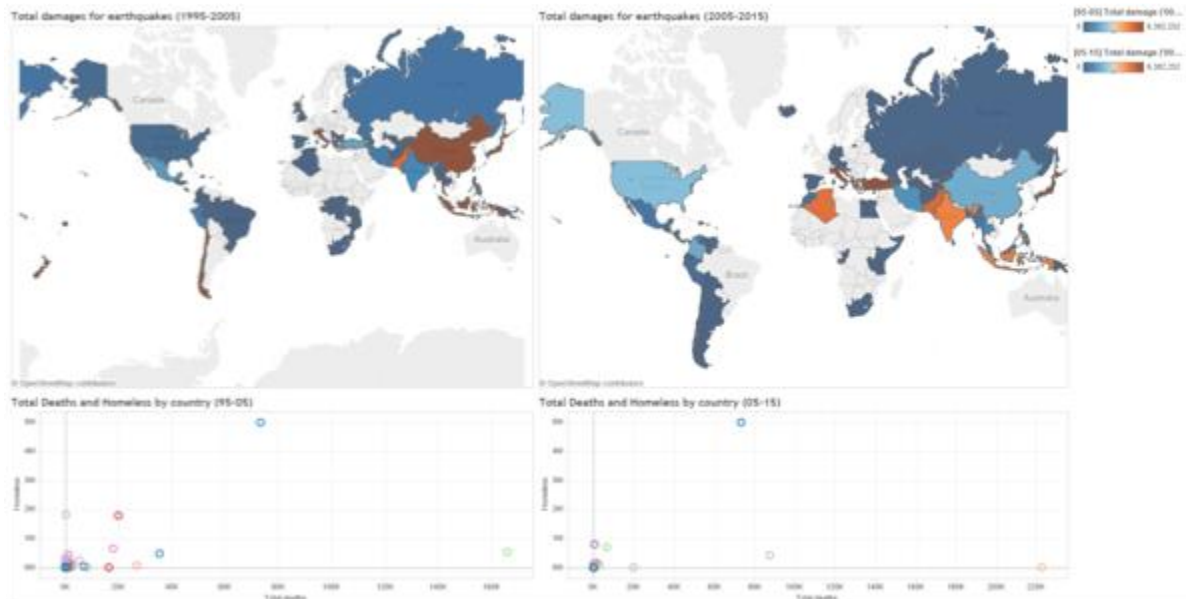
1st Prototype (Earthquake Damages, 1995-2005 vs 2005-2015)

The first prototype we built compares the total amount of damages caused solely by earthquakes from 1995-2005 against 2005-2015. The choropleth's colors correspond to total cost of damages and the scatter plot uses Bertin's visual attribute of position to indicate total deaths and homeless the earthquakes caused by country. In this round of usability testing, we asked the following questions:

1. What are your initial impressions of the visualization?
2. What do you think the colors currently indicate?
3. What information do you think this visualization displays?
4. How would you get the exact cost of damages from earthquakes for the United States?
5. After playing around with this visualization for a while, what confused you about it?
6. What did you like about it?
7. Any other suggestions?

We followed a semi-structured protocol, asking additional questions to dig deeper into the user's thoughts along the way. We were able to recruit a participant that fit "The Casual User" persona to test this prototype and got some useful feedback to move forward in the design process with.

"The Casual User"

- Initial reaction was approval of color choice and the choropleth map
- Correctly identified that colors indicate cost of damages caused by earthquakes
- Graphs at the bottom hard to read
- Logical to hover over country for details
- Felt that users needed to be familiar with Tableau to use
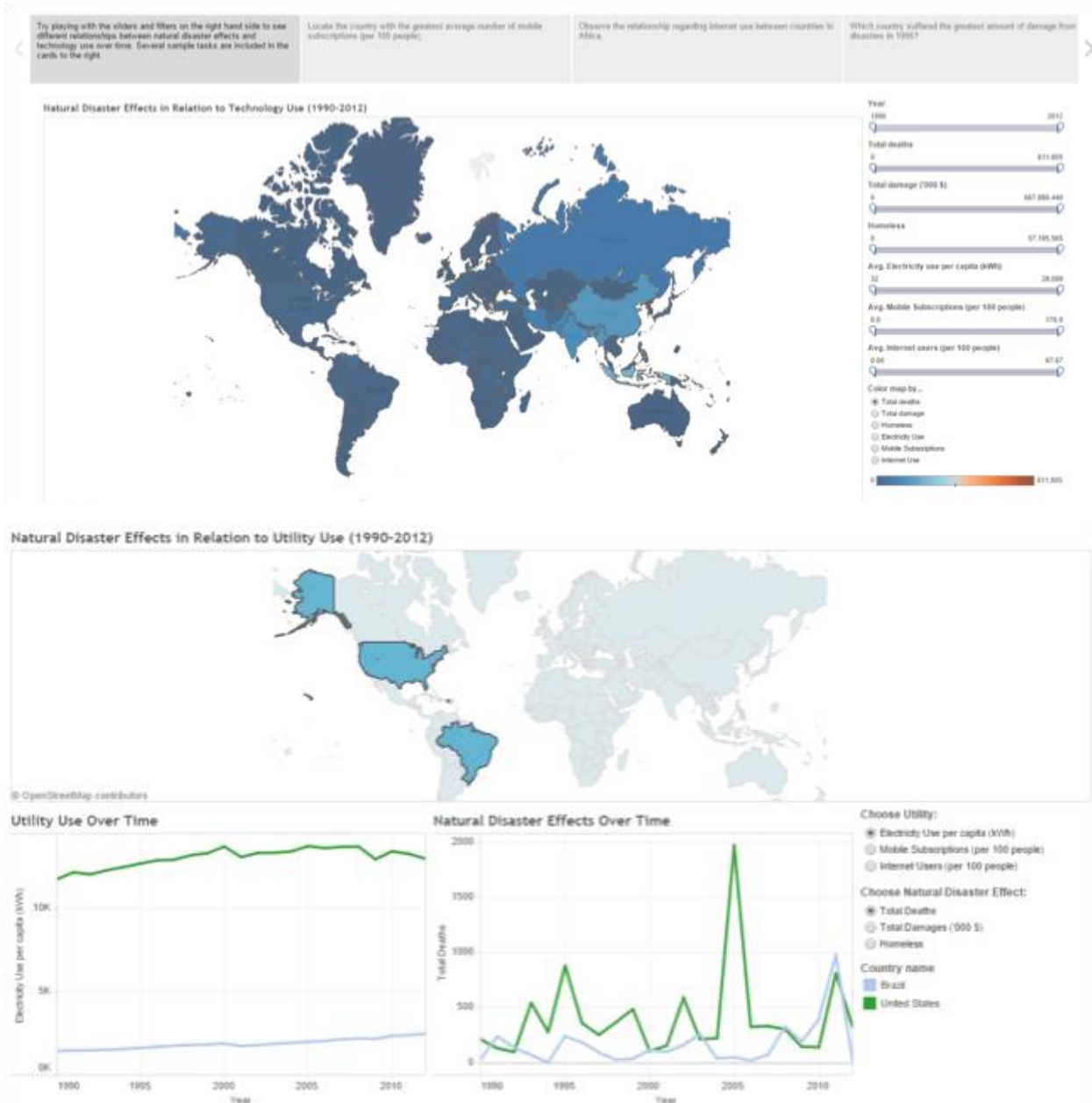
<u>2nd Prototype (Overview map with technology use & Comparison view, utility use vs natural disaster effects)</u>

This prototype brings together an overview of all natural disasters and their effects on the countries in addition to each country's use of different technologies. In this round of usability testing, we replaced the previous user task question (#4) with the following:

1. How would you filter the data to display only the years 2010-2012?
2. Can you please point out a country with more than 60 average Internet users per 100 people? (Estonia is the only one)
3. Can you point out any insights or trends that you notice from the visualization?

We were able to recruit one participant from each persona profile, whose feedback is captured below.

"The One-time User"

● Initial reaction was being overwhelmed by all the sliders on the right
● Unsure why some parts of map were grey and couldn't be clicked
● Happy with filtering capabilities
● No trends were immediately visible
● Decimal numbered people was confusing (i.e. 1.3 people)
● Liked that there was so much data available with so many types of disasters in map view
● Would have liked a reset button to clear all filters

"The Casual User"

● Dull but appropriate colors
● Overwhelmed by right side
● Correctly identified topic of visualization and completed all tasks
● Appreciated story cards

"The Expert User"

● Initial impression: colors were nice, but fade into each other
● Didn't feel the name of the project was as effective as it could be
● Advised not using the word "technology" because it leads to expectations and suggested using "utilities" instead
● Thought layout was nice and clean
● Thought sliders are great and efficient

- Suggested not starting sliders at 0 for all areas to better emphasize the color gradation
- Loved the idea
- Asked if economics should play a factor into the relationship between utilities and natural disasters
- Suggested adding citations

With all of this user feedback in mind, we were able to improve our design through iterations of redesign.

4.5. Redesign

Based on feedback from the first iteration and the midterm presentation, we created a second prototype that removed the scatter plot because it was difficult to identify details for a specific country on it. We also made the decision to move beyond just earthquakes and provide a more general view of all natural disasters across the globe. The lecture on storytelling inspired us to create story cards that guide the user through the visualization because stories package information into a structure that is easily remembered to users. We also thought that story cards would give a user who may have been overwhelmed at first a way to gradually become comfortable with using the visualization.

Based on all the feedback from our users on the second prototype, we decided to reorganize the sliders on the right side for our final visualization. We also numbered the story cards and decided to start using "utility" in place of "technology" for terminology. Although there were several comments on the color choice of the visualization, we ended up keeping the blue and orange. This is because during one of our classes, guest speaker Maureen Stone mentioned that these colors can be distinguished between for those with red-green colorblindness and we wanted to make sure our visualization accounted for accessibility. One change that we did make on the colors is changing the color scale from smooth to stepped to make sure the color differences were more obvious. Additionally, we played around with replacing quick filters with dashboard actions, but realized that this method of filtering the data was more confusing. We added labels to categorize the filters and reordered the entire right side so that the quick filters for the colors were displayed at the top. This was done to ensure it was clear what the colors indicated since the colors were quick to draw in the user's attention.
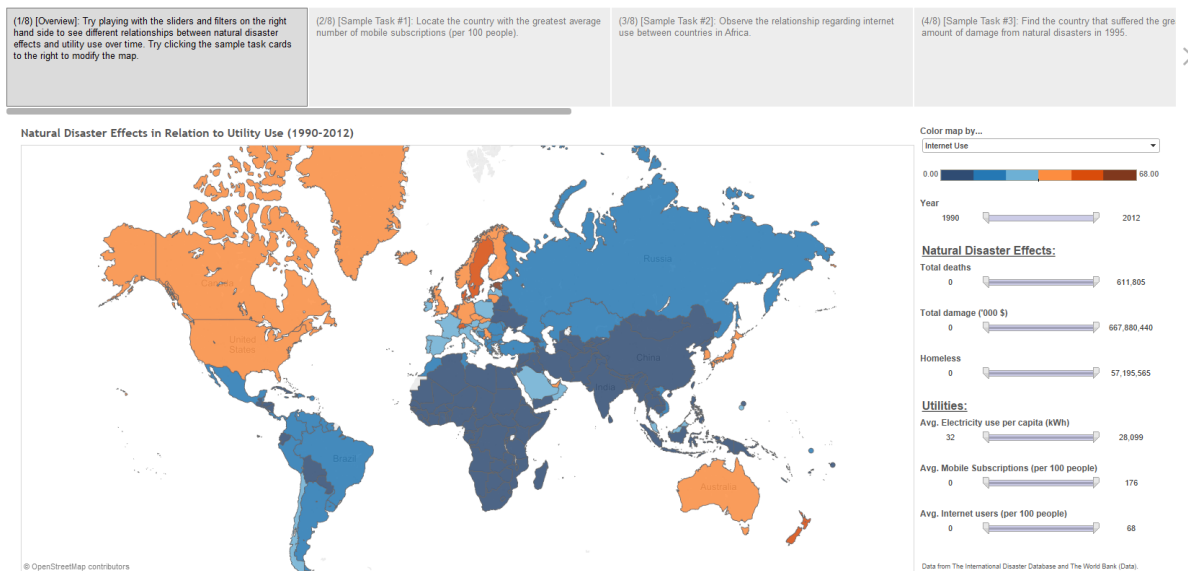
5. Results

5.1 Primary Goal and Visualization

Following our user studies and targeted points for redesign, this was our final visualization presented to the class. The working demo can be found here: https://public.tableau.com/profile/publish/FinalVisualization_3/Visualization#!/publish-confirm along with a downloadable workbook which includes our data.

This world view (shown below) of natural disaster effects related to utility use allows the user to see general values for effects (deaths, damages, homeless) and utilities (mobile subscriptions, internet use, electricity use) using a six-stepped color gradation.

With a filter for each measure included on the right, the user has the freedom to modify the map how they wish. However, through user feedback, we realize that a user landing on this visualization will not know how to proceed and may be overwhelmed with what they're seeing. To address this, we added sample tasks so the user can get an idea of some basic tasks that this visualization can accomplish. In regards to Schneiderman's mantra, this serves as the "Overview" to the visualization, where the user can also "zoom & filter" within this view.

DORKS (Disaster Operations and Relief Knowledge Study) Visualization

Natural Disaster Effects in Relation to Utility Use (1990-2012)

Following the sample tasks, the user is met with a comparison view, which is a dashboard focusing more on specific country-to-country comparisons. When the user selects a country on the map, that country's data is plotted on two line charts below the map. To view additional countries in the line charts, simply control-click more countries on the map. Users are free to configure which disaster effect and utility they wish to see on the charts with the radio buttons in the lower-right. Ultimately, this view empowers the user to see direct numerical comparisons with natural disaster effects and utility use between countries. In Schneiderman's mantra, this view achieves the "zoom & filter" requirement, where the user can specifically filter to compare countries they are interested in.
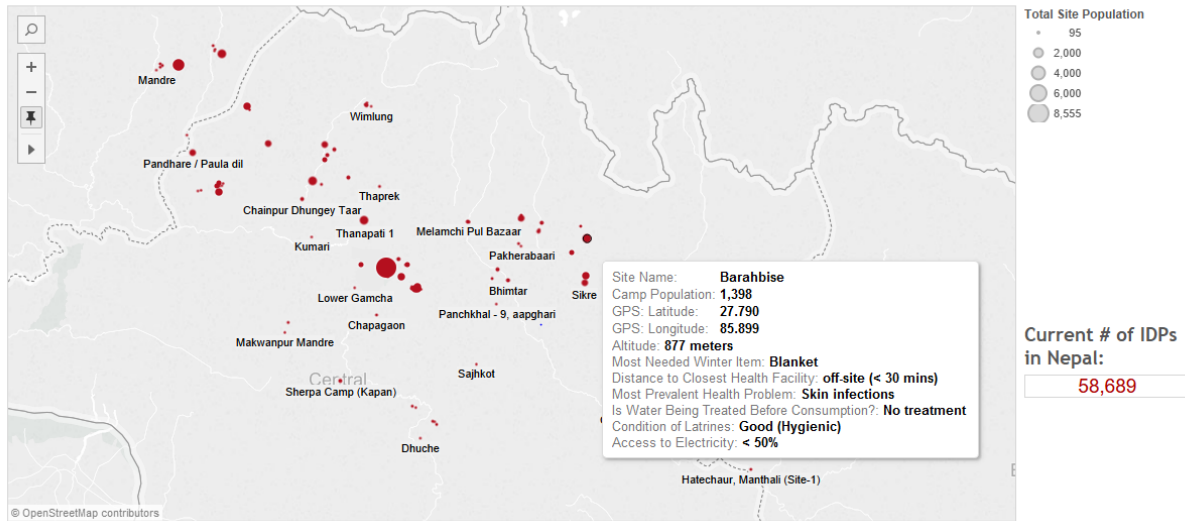
5.2 Stretch Goal and Visualization

In the end, our stretch work culminated in the form of three unique dashboards: the "Magnitude" dashboard, the "IDP" dashboard, and the "Relief" dashboard. These dashboards were targeted exclusively at "The Expert User" -someone who has an intimate knowledge of disaster scenarios and relief operations.
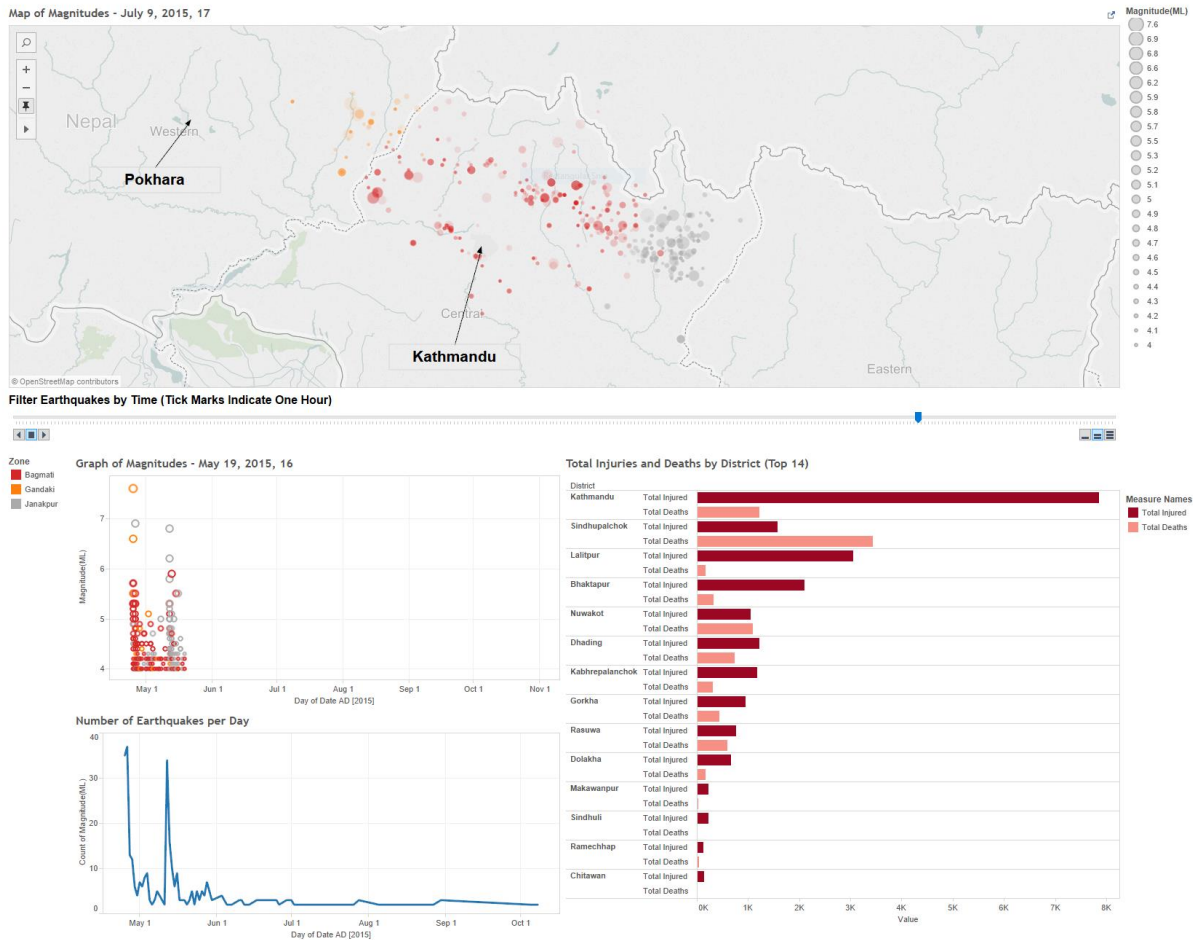
From the reference point of the whole visualization, the Nepal views represent the "details on demand" portion of Schneiderman's mantra. However, taken individually, the "Magnitude Dashboard" can represent the "overview" of the Nepal earthquake. The topmost portion of the dashboard is dominated by a map view zoomed in on the region in Nepal where the earthquakes were recorded. Immediately below is a slider that represents time, starting with the initial 7.6 magnitude earthquake on April 25th 2015, and ending with the last recorded aftershock, which occurred just over 6 months later on October 31st 2015. The user can drag the slider to scrub through time, or hit the small "play" to have it auto play. The data on the graph below the slider and on the map are synchronized, and show the earthquake and all its aftershocks first on an hourly basis, and then by day. The colors represent the three districts in which the earthquakes took place. The blue line graph at the bottom shows the amount of earthquakes per day, graphed over the same timeframe. Finally, the horizontal bar chart on the right shows a breakdown of total injuries and total deaths per district. Based on what we learned in class, we wanted to make sure this information in particular was extremely clear, so we opted for a bar chart so the user would have no problem making comparison based on injuries and deaths throughout the different geographical areas.
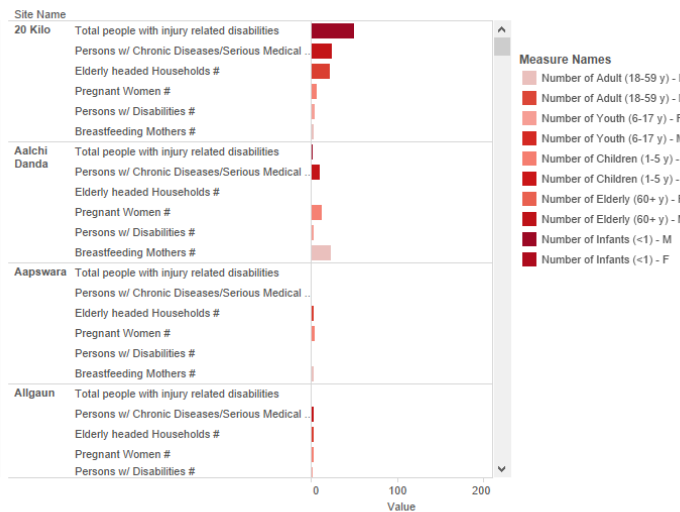
IDP Map (Total Population)

Total Site Population
- · 95
- ◦ 2,000
- ◦ 4,000
- ◦ 6,000
- ◦ 8,555

Mandre
Wimlung
Pandhare / Paula dil
Thaprek
Chainpur Dhungey Taar
Thanapati 1
Melamchi Pul Bazaar
Kumari
Pakherabaari
Lower Gamcha
Bhimtar
Sikre
Panchkhal - 9, aapghari
Chapagaon
Makwanpur Mandre
Central
Sajhkot
Sherpa Camp (Kapan)
Dhuche
Hatechaur, Manthali (Site-1)
© OpenStreetMap contributors

Site Name: **Barahbise**
Camp Population: **1,398**
GPS: Latitude: **27.790**
GPS: Longitude: **85.899**
Altitude: **877 meters**
Most Needed Winter Item: **Blanket**
Distance to Closest Health Facility: **off-site (< 30 mins)**
Most Prevalent Health Problem: **Skin infections**
Is Water Being Treated Before Consumption?: **No treatment**
Condition of Latrines: **Good (Hygienic)**
Access to Electricity: **< 50%**

Current # of IDPs in Nepal:
58,689

Site Demographics

Site Name
20 Kilo
- Number of Adult (18-59 y) - F
- Number of Adult (18-59 y) - M
- Number of Youth (6-17 y) - F
- Number of Youth (6-17 y) - M
- Number of Children (1-5 y) - F
- Number of Children (1-5 y) - M
- Number of Elderly (60+ y) - F
- Number of Elderly (60+ y) - M
- Number of Infants (<1) - M
- Number of Infants (<1) - F

Aalchi Danda
- Number of Adult (18-59 y) - F
- Number of Adult (18-59 y) - M
- Number of Youth (6-17 y) - F
- Number of Youth (6-17 y) - M
- Number of Children (1-5 y) - F
- Number of Children (1-5 y) - M
- Number of Elderly (60+ y) - F
- Number of Elderly (60+ y) - M
- Number of Infants (<1) - M
- Number of Infants (<1) - F

Aapswara
- Number of Adult (18-59 y) - F
- Number of Adult (18-59 y) - M
- Number of Youth (6-17 y) - F

0K 1K 2K 3K
Value

Site Elderly & Disabled

Site Name
20 Kilo
- Total people with injury related disabilities
- Persons w/ Chronic Diseases/Serious Medical ..
- Elderly headed Households #
- Pregnant Women #
- Persons w/ Disabilities #
- Breastfeeding Mothers #

Aalchi Danda
- Total people with injury related disabilities
- Persons w/ Chronic Diseases/Serious Medical ..
- Elderly headed Households #
- Pregnant Women #
- Persons w/ Disabilities #
- Breastfeeding Mothers #

Aapswara
- Total people with injury related disabilities
- Persons w/ Chronic Diseases/Serious Medical ..
- Elderly headed Households #
- Pregnant Women #
- Persons w/ Disabilities #
- Breastfeeding Mothers #

Allgaun
- Total people with injury related disabilities
- Persons w/ Chronic Diseases/Serious Medical ..
- Elderly headed Households #
- Pregnant Women #
- Persons w/ Disabilities #

0 100 200
Value

Measure Names
- Number of Adult (18-59 y) - F
- Number of Adult (18-59 y) - M
- Number of Youth (6-17 y) - F
- Number of Youth (6-17 y) - M
- Number of Children (1-5 y) - F
- Number of Children (1-5 y) - M
- Number of Elderly (60+ y) - F
- Number of Elderly (60+ y) - M
- Number of Infants (<1) - M
- Number of Infants (<1) - F

With the Magnitude dashboard giving us an "overview" of the Nepal earthquake, the second dashboard we created represented the secondary portion, "zoom and filter". This IDP dashboard switches from looking at the higher level details of the earthquake itself, and focuses in on the human aspect of this disaster. IDPs, or Internally Displaced People, are locals who have been forced from their homes as a result of the earthquake, but are still within their country's borders. The map shows the geographical location of all currently known IDP "camps", with the size of the dots corresponding to the total IDP camp population. The map shows 121 IDP camps that contain a total of 58,689 people. After clicking on a specific camp, the two bar charts below the map will filter to that camp only. The chart on the left gives you a detailed demographic breakdown of the camp's population, in terms of number of Adults, Children, Infants, and Elderly, broken into respective age groups and separated by gender. The chart on the right highlights demographics of those who might need or require special care, such

as those with injury related disabilities, chronic diseases, pregnant women, disabled persons, elderly, or breastfeeding women, with the color representing the associated age demographic.

Using "details-on-demand", when the user hovers over a specific camp, you're given a breakdown of key information, found in the tooltip on the image above. The altitude has been an especially important figure for relief efforts in Nepal, as a great of amount of the destruction and deaths are actually a result of landslides triggered by the earthquake, and those at higher altitudes are at a higher risk of being in landslide danger zones.
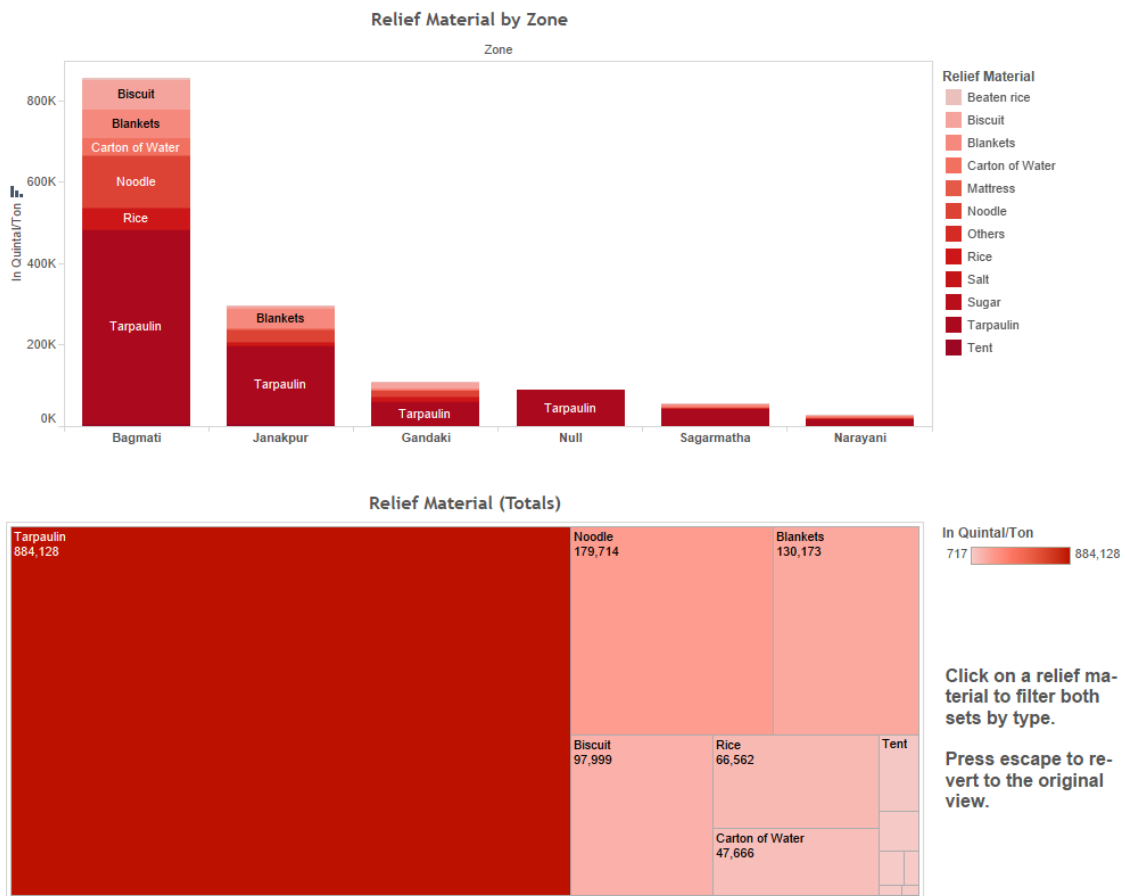
The last dashboard extends the, "zoom and filter" and, "details-on-demand" mantra one step further, and examines only the high-level relief materials that have been distributed into Nepal since the first Earthquake in April. You're given two views, one stacked bar chart to see distribution per zone, and a squarified tree map to compare totals against. The user can also select a specific material to focus on if they wanted to examine only type at a time, and assess how and where it has been distributed.

6. Discussion of Process

6.1 Tableau

Working with Tableau for this project was an educational experience, but the learning curve and limitations of the program added some unexpected challenges to our design process.

While Tableau was still functional after adding most of our data, the performance and speed of operations plummeted compared to early exploration with just a fraction of the data. We found that performing a table join, which brings separate sheets in excel together into one table before loading them into Tableau, helped improve the load times. This ensured that Tableau only traversed a single table to perform an operation instead of five. Additional performance suggestions from Tableau's Amanda Pype included using separate sheets in the dashboard as smaller visual filters, modifying parameter syntax and hiding unused fields while aggregating visible dimensions in the data extract. Through experimentation, only the third suggestion proved useful. Maintaining a high level of efficiency became an ongoing consideration for the rest of our design process.

Another unexpected effect we saw from merging so many data sets was that some data was being cut during the joining. Our solution was to manually add null value rows so that important data was not excluded based on just a few missing fields.

6.2 User Feedback

One of the greatest challenges with getting user feedback was having readily available access to study participants. Although we would have liked to test each prototype with each of the different types of participants from the personas, many of the people we reached out to were slow to respond and had busy schedules. This translated into difficulty getting prompt user feedback for us and we had to do our best to coordinate schedules and schedule testing sessions far in advance.

Although there were several points from the user feedback that we ended up incorporating in our final visualization, there were also several points that we considered but never ended up in the visualization. This may have been due to considering the tradeoffs and deciding that changes wouldn't contribute value to the visualization or due to limitations with the tools and resources at hand. For more on what we would've liked to do with our visualization, please reference the "Further Work" section below.

6.3 Collaboration

Although this project undoubtedly benefitted from a collaborative approach, and we utilized a number of tools to facilitate communication and coordination of schedules, we found that there was no easy way to collaborate on the creation of the visualizations.

We tried a number of ways to split up our data visualization, including meeting up in person, uploading all of our currently-used data files to Google Drive, e-mailing one another our latest Tableau files, and chatting through online programs to discuss our progress.

Unfortunately, in-person collaboration is not ideal with complex imagery on small laptop screens, schedule conflicts, and only having one file editor at a time. We felt that a collocated collaborative approach was detrimental to our progress and moved on to remote collaboration, which provided its own set of challenges.

While the inability to simultaneously manipulate an image was a drawback of in-person collaboration, the ability to do this remotely meant that we had two divergent versions of a visualization after hours of work. There was no way around this, even if we kept an open dialogue each step of the way.

In the end, rather than forcing it, two of our group members took the lead with creating our visualizations in Tableau, while others put extra hours into aspects like analysis, user studies, and creating personas.

Outside of Tableau, our group felt that a collaborative approach was hugely beneficial in ideating, analyzing, and choosing a direction for our project. Our primary tools, Google Drive, Slack, and When2Meet.com were essential in keeping our group running smoothly. Respectively, these tools granted us synchronous access to the same files, allowed us to communicate, and made meeting times easy to determine.

6.4 Stretch Goals

When we revised our goals, we created one "stretch" goal for us to work on, if we had satisfactorily met the criteria for our primary goal already. As our primary goal constituted examining natural disasters at a high level and global scale, using Schneiderman's Mantra of overview first, zoom and filter, then details-on-demand, we identified our stretch goal as:

On a specific disaster level, how can we create visualizations targeted at crisis researchers to aid them in disaster scenarios as they unfold, and allow them to study and gain knowledge for future relief operations?

About three quarters of the way through the project, we realized that we were on track to satisfactorily meet our primary goal, so we began looking into pursuing our stretch

goal as well. The 2015 Nepal Earthquake was one of the most data-driven disasters in recent years, and one of our initial motivational factors for this topic, so we elected to use that event as the focal point of our stretch goal.

It should be noted that our stretch goal was purposefully not included in our previous usability studies, and our final deliverable is only representative of one "iteration" of work. As a result, we have intentionally not included this work in our design section. The reasoning behind this is twofold:

1. We wanted to ensure that work and energy and was focused on completing our primary goal first
2. We did not have direct access to an active crisis researcher, who would have been the necessary user for targeted feedback and usability testing

With these two factors in mind, we treated this as an opportunity to explore the data without specific bounds or restrictions.

7. Evaluation of Results

To evaluate our final result, we examined our final product in comparison to our revised goals, our user feedback, and the principles of visualization we learned of in class.

Overall, our evaluative studies showed us that we were successful in meeting our primary goal. Maintaining a cyclical design process of ideation, exploration, testing throughout the project, we corrected our most common criticisms as we added functionality. Some of these corrections included adding citations to the visualization, modifying the ways in which our users could filter data, and transitioning from what was described as an "overwhelming" amount of data up front to a guided exploration through use of story cards.

We were also able to get an evaluation of our final visualization by bringing this final visualization to users. These users were impressed with how much data we could display in one page while retaining a clean interface. They were able to find and follow the story cards, which allowed them to understand possible tasks that could be completed with our visualization. There were still concerns over the loading times when playing around with the filters and having to reset them all one-by-one manually instead of having a single button, but as mentioned before, these were all limitations when working with Tableau.

Our stretch goal was not evaluated for success or failure, as without the appropriate user to test against, this would have been an unfounded and purely subjective statement. We were able to apply the same principles to this portion of our project, but it is a section that would need much attention in future work.

8. Further Work

Although we had time to explore some of our stretch goals toward the end of our project, there are still several attributes of this project that we would have enjoyed exploring further.

The first aspect would be expanding the visualization beyond the Nepal earthquakes, adding localized data for other parts of the world. At the time of this writing, Tableau does not natively support visual geographical elements such as district and zone markings. As a result, we had to use key coordinates to place localized statistics and figures, which isn't representative of the geographical area affected. In some cases this was a better solution, but in others we found that it caused problems with occlusion. Our contacts at Tableau suggested that support for this feature could come in a future release, and if so, that is something we could modify in the future for more visual clarity.

Additionally, we would have liked to standardize the disaster metrics per capita and GDP. This was a limitation of our dataset and it caused us some difficulty in the process of creating our visualization by taking data out of context, causing unfair comparisons between countries. By standardizing these measures, the data could be displayed with less distortion. After all, one of Tufte's principles of graphical integrity is to provide sufficient context in regards to the data at hand.

8. Acknowledgements

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