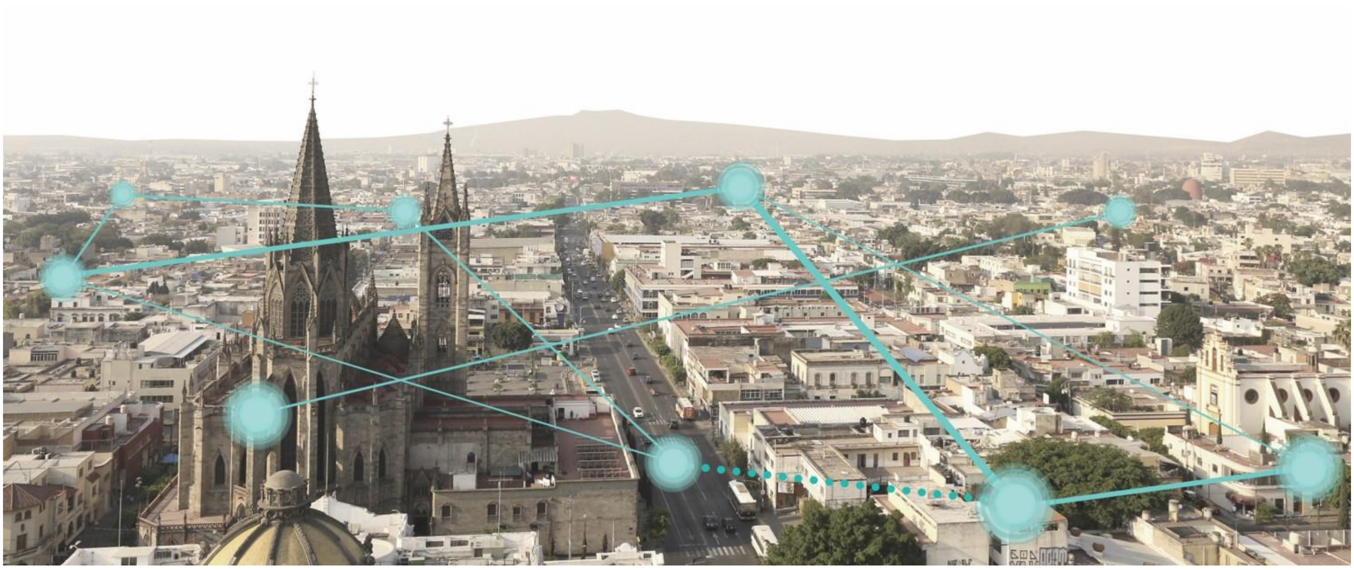
ICT-based Adaptation to Climate Change in Cities: Case Studies

Drawing inspiration from global cases



Implemented by:

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

INTERNATIONAL CLIMATE INITIATIVE (IKI)

of the Federal Republic of Germany

In cooperation with:

Federal Ministry of the Interior, Building and Community

CONTENTS

INTRODUCTION

In the past decades cities have gone through radical changes, from being the motors of economic growth, to becoming the home of 55% of the world's population [1] . In this light, city planning has gained significant importance, as the effective and efficient allocation of resources lies at the intersection of the global challenge that is climate change. The common characteristic of urban agglomerations, a high state of population density, means that well planned interventions can benefit a comparatively large number of individuals. Simultaneously, this characteristic makes cities particularly vulnerable to extreme weather events and other repercussions of climate change. Meanwhile, the worldwide advance of digital technologies have enabled a paradigm shift in urban planning processes from technocratic approaches to citizen-centred solutions. Drivers in this development have been technologies such as social media, smartphone applications, low-cost environmental sensing devices, collaborative mapping techniques and concepts integrating short message service (SMS) technology. Bridging the gap between citizens, urban practitioners, researchers and governments, these platforms incubate potential solutions for the urban challenges of today and tomorrow. The informed and coordinated deployment of information and communication technologies (ICT) can significantly contribute to the adaptation to climate change of urban centres.

Crisis-mapping approaches increase the speed of damage assessment and critical points in the technical infrastructure, such as water drainage and the built environment. Environmental sensors in public spaces, along streets or on the windowsills of private residences highlight areas particularly exposed to pollutants and toxins, such as radiation and fine dust particles. Twitter users report and geotag urban infrastructure destroyed by flooding. Weather data and alerts are reported using WhatsApp to enable better forecasts, and experiences of urban citizens are translated into 'safety data', leading to new ways of assessing the quality of urban environments for its inhabitants. Adapting these technologies for climate-related purposes is proving increasingly popular and leads to the necessity of considering their value and significance for urban practitioners.

Simultaneously, numerous concepts developed in the larger space of ICT-based tools related to climate adaptation follow similar goals, leading to a confusing oversupply. Enthusiastic expectations from the side of creators are not met, when confronted with low user numbers; new digital applications are created, where robust solutions already exist; the sole focus on digital approaches increases energy usage and leads to higher emission. Hence, choosing or adapting the appropriate tools that are most appropriate is key to a successful ICT-based adaptation to climate change in cities as part of integrated urban governance.

INTRODUCTION

This compilation of case studies aims to provide guidance and inspiration to urban practitioners eager to integrate ICT-based approaches to climate change in their work. Those presented examples that are not directly applicable to managing the consequences of climate change, have been included due to their potential in this sector.

The document has a strong focus on open formats and approaches (Open Data , Open Hardware , Free and Open-Source Software , collaborative mapping and crowd-sensing) comprise the majority of this study. The ability to share, modify, use and re-distribute content lies at the heart of constructing useful systems that enable citizens, researchers, governments, and urban practitioners to collaborate towards a more climate resilient future with the use of ICTs. Commercial options are driven by an economically motivated smart-city design. That approach leads to challenges in terms of data ownership, interoperability, transparency and privacy. By contrast, the majority of the presented solutions are free to download, use and run on current Android, iOS smartphones and/or computers.

INTRODUCTION

LIST OF ABBREVIATIONS

API	Application Programming Interface
ACCCRN	Asian Cities Climate Change Resilience Network
CTA	Chicago Transport Agency
DCCMS	Department of Climate Change and Meteorological Services
DIY	Do-It-Yourself
FMS	FIxMyStreet
FOSS	Free and Open Source Software
GPS	Global Positioning System
HOT	Humanitarian OpenStreetMap Team
ICT	Information and Communication Technology
ITU	International Telecommunication Union
LAN	Local Area Network
LED	Light Emitting Diode
LoRa	Long Range Network
MCU	Micro Controller Unit
NGO	Non-Governmental Organisation
OSM	OpenStreetMap
REM	Risk Evaluation Matrix
SDK	Software Development Kit
SPO	Strengthening Participation Organisation
URL	Uniform Resource Allocator
UV	Ultra Violet
GPS	Global Positioning System

01

SOCIAL MEDIA

Social media are digital communication tools through which users create online communities to share information, thoughts, personal messages, and other content. They are popular and widely spread[2] : In the first quarter of 2019, Facebook counted more than 2.3 Billion monthly active users , WhatsApp 1.5 Billion[3] and Twitter 350 Million in the same time frame[4]. According to a study by the Pew Research Center, emerging and developing countries reveal significant growth in smartphone ownership and social media use over the past 5 years[5] .

> “Due to their extensive use, it is indispensable for urban practitioners to consider digital solutions that operate through social media.”

Due to their extensive use, it is indispensable for urban practitioners to consider digital solutions that operate through social media.

Most social media applications allow their users to share text, images, GPS data as well as audio and video recordings in peer to peer or group conversations. “Hashtags” facilitate structuring of user-generated content in the case of Twitter. Rating and voting systems influence the visibility of the (user-generated) content on the platforms. Algorithms based on personal preferences, behaviour and platform dynamics generate a personal feed of information for each user. Social media platforms are typically free of user fees, because their business model is based on user-targeted advertisement. Here, behaviours and user preferences are analysed by algorithms, which show the individual ads for products and services that they are likely to consume. In other words, users ‘pay’ the platform provider with personal data[6] .

Low operational cost and wide proliferation are the biggest advantage of using social media to communicate information. Whereas government and third-party apps face the challenge of attracting the attention and willingness of their prospective users, the large number of existing active users overcomes one of the major challenges in promoting a widespread use of the approach.

With regard to climate adaptation in urban contexts, social media has shown great potential as a means of communication during and after natural catastrophes, tracking developments in real-time, and organising disaster-relief activities. However, the path to integrate social media channels in governmental planning structure is not straightforward. Hurdles begin at the interoperability of the social media with the existing government IT-Structure, questions on data privacy and ownership, as well as challenges within the legal framework. Nonetheless, the case studies below showcase specific contexts, in which social media are a useful and efficient tool to mitigate risks.

1.1 SOCIAL MEDIA-BASED FLOOD-MAPPING: PETABENCANA

INTRODUCTION

PetaBencana (earlier: PetaJakarta) is a free web-based platform that produces city-scale, real time visualisations of water levels during flood events. The maps are created using crowd-sourced

> “Petabencana enables swift and informed decision making by citizens and government in times of crisis”

social media reporting and government agency data. PetaBencana.id thus enables residents, humanitarian agencies and government actors to make more informed decisions in times of crisis.

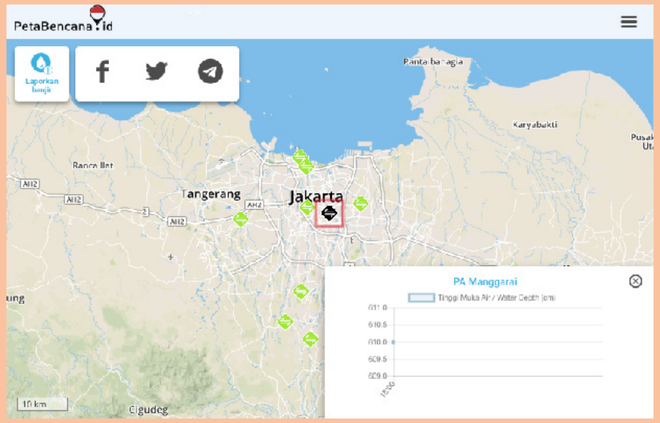
TECHNICAL INFORMATION

On the user side, a smartphone capable of running Twitter, a web browser or Telegram suffices to participate. On the city side, a back-end based on CogniCity, a free and open source software developed to crowdsource and visualize urban data, integrates multiple data sources. The back-end is a part of a software. It is the most remote from the user and often lies on the server that processes data.

METHODOFDATACOLLECTION

The platform uses Twitter during emergency events to gather situational updates: from the street level.

1. An algorithm continuously scans Twitter for the keywords “flood” and “banjir” (Indonesian for flood)
2. Tweets containing these words are subsequently recorded as “unconfirmed reports”
3. The users are then invited to confirm whether flooding is taking place at their location
4. To submit a confirmed report of the situation on the ground, users are simply requested to send a geo-located tweet from their mobile device
5. The data is then displayed alongside further relevant emergency data collected by local



Mapview Petabencana[7]

The map view displaying three social media icons. A click on the corresponding icon opens a Facebook chat, a Twitter tweet composer with a pre-set hash-tag or a Telegram conversation with a chat-bot.

SOURCES

- PetaBencana
- Cognicity
- mapbox
- OpenStreetMap

MORE INFORMATION

- Video explaining CogniCity
- Video explaining how to make a report

INTERESTED IN OTHER DIGITALSOLUTIONSINCASE OF FLODING?

CHECK OUT CHAPTER 1.2

> “A WhatsApp group was created in the aftermath to send out weather information and to request actual observations from members in order to verify forecasts and ultimately improve their reliability.”

DATA INTEGRATION

The PetaBencana platform validates and integrates different data sources into a Risk Evaluation Matrix (REM), which is integrated into the map view. The matrix consists of a reports module, a database module, a server module and a machine interface.

Citizens can provide rainfall data in centimetres via:

- Twitter (using the #banjir hashtag)
- Telegram (via a chatbot)
- PetaBencana.id (direct input)

Several alert apps (Qlue Smart City App, Detik.com App, Z-Alert App)

Other organisations report additional data:

Indonesian state department collecting river gauge data

- Indonesian state department collecting rainfall data
- Indonesian state department collecting data on waterways
- Field data (floodgates, pumps, waterways)

The data is visualised on anThe data is then passed on to a database module using a reports module, and placed on an OpenStreetMap-based map using mapbox, an open source software that allows the creation and customization of maps and layers. Using this map, administrations and public servants can evaluate the risks and make evidence-based decisions more quickly.The resulting risk is then evaluated by operators on the city side.

The risk and map data are publishedmade available to an open API and the following actors and applications:

- Users of Petabencana.id (via map)
- Jakarta Smart City
- InAware
- Pacific Disaster Center (DisasterAware)
- JakSafe
- InaSafe
- Zurich Insurance (Z-Map)

1.2 WEATHER ALERTS AND REPORTS USING WHATSAPP: WEATHER CHASERS MALAWI

INTRODUCTION

The Google Drive Suite contains standard office applications that run in a web browser. Users can create documents, spreadsheets, presentations, questionnaire forms, drawings and maps. All of these applications run simultaneously, as each file has a unique Uniform Resource Locator (URL), which can be shared with others. Creating a file requires registration via a google account.

In the aftermath of a crisis, the document and spreadsheet applications are a quick and easy way of collecting and disseminating information.

> "A WhatsApp group was created in the aftermath to send out weather information and to request actual observations from members in order to verify forecasts and ultimately improve their reliability."

METHOD OF DATA COLLECTION:

The Department of Climate Change and Meteorological Services (DCCMS) in Malawi uses WhatsApp as a two-way communication channel to::

- disseminate 24-hour weather forecasts
- communicate early warnings for storms, floods and lightning
- record observations (rainfall, temperature and more) by its 256 members (meteorologists, farmers, disaster risk monitoring officers)
- Participants are encouraged to provide location and time of the data
- The "spotter reports" provide information to ground truth forecasts to DCCMS.
- offer a platform for discussion related to the proper response to changing climates (e.g. for farmers encountering changing rainfall patterns)

Created by Pause08 from Noun Project

SOURCES

- Article on Weather Chasers Malawi
- Video of Weather Chasers Malawi Meeting (Facebook)
- Presentaion of the Ministry of Natural Resources, Energy and Mining containing further information on the topic

FURTHER EXAMPLES OF WHATSAPP APPLICATIONS

- Restoring connectivity in India using WhatsApp

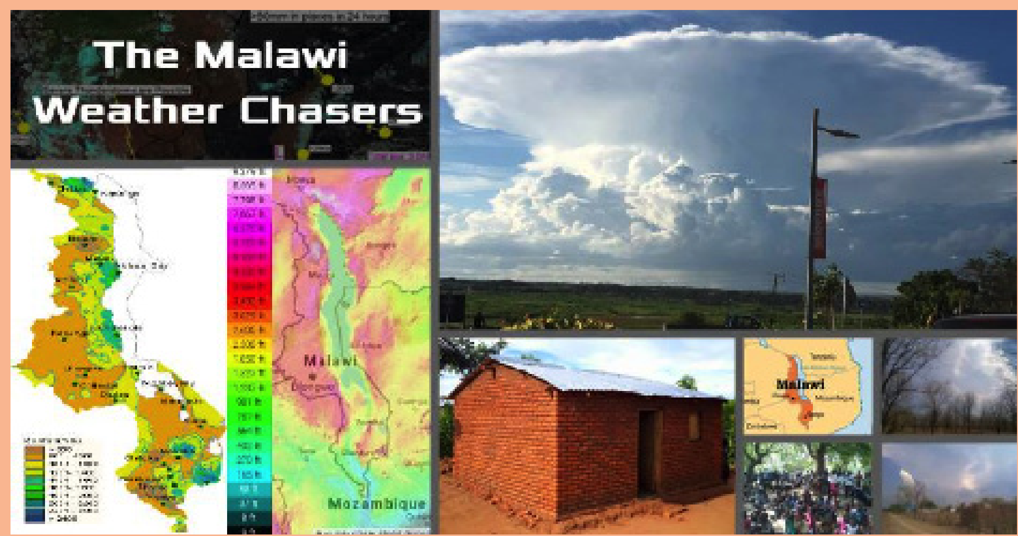
INTERESTEDINOTHERDIGITAL SOLUTIONS IN CASE OF FLODING?

CHECK OUT CHAPTER 1.3

> "When public IT infrastructure is not available, the applications offer a viable means of organising disaster response and relief."

DATA INTEGRATION

Reported observations can confirm hazardous weather detected by satellites, but can also identify where the forecasts are frequently inconsistent. Daily observations recorded by the registered keepers from 21 weather stations are sent through the list. DCCMS is thus able to record data centrally, while interested parties are able to obtain up-to-date information for their areas of intervention. This strengthens the efficiency and distribution of weather forecasts for all parties involved



Weather chasers Malawi

1.3 GOOGLE DRIVE FOR DISASTER RESPONSE: CHENNAI FLOODS

INTRODUCTION

The Google Drive Suite contains standard office applications that run in a web browser. Users can create documents, spreadsheets, presentations, questionnaire forms, drawings and maps. All of these applications run simultaneously, as each file has a unique Uniform Resource Locator (URL), which can be shared with others. Creating a file requires registration via a google account.

In the aftermath of a crisis, the document and spreadsheet applications are a quick and easy way of collecting and disseminating information

> “When public IT infrastructure is not available, the applications provide with viable means of organising disaster response and relief.”

When public IT infrastructure is not available, the applications provide viable means of organising disaster response and relief. The possibility to work on a document collaboratively and real time updating makes it stand out in this regard.

In the case of the Chennai Floods, thousands of people were displaced, mobile towers ran out of inverter battery power and regular media channels did not have access to localized information on the areas most affected. A local lawyer set up a Google Spreadsheet (see above) to consolidate rescue requests and contact details of volunteers. This way, a semi-structured resource was created that allowed coordination of an initially chaotic situation.

> “This way, a semi-structured resource was created that allowed coordination of a complex and chaotic situation.”

As an increasing number of people attempted to edit the spreadsheet, a simple search interface was designed using Github, a platform for source code management, and a submission form was added. The resulting web interface was then hosted on chennairains.org.

METHOD OF DATA COLLECTION

People could tweet aid requests using #chennairains and @chennairains or use the Google Spreadsheet directly.

1. A social media team monitored Twitter for the accountslisted tags and handles
2. An operations team coordinated and matched the aid requests with volunteer offers
3. An on-the-ground team additionally monitored additional specific suburbs in Chennai

Floods in Chennai[8]

Created by Pause08 from Noun Project

SOURCES

- *Project website*
- *Google Docs*
- *Google Spreadsheets*
- *Google Forms*
- *Google Drawings*
- *ICTs and help lines involved in the crisis response*
- *Example of Google Doc use: Nepalquake Google Doc*
- *Google Person Finder*
- *Yoti*

INTERESTEDINOTHERDIGITAL SOLUTIONS IN CASE OF FLODING?

CHECK OUT CHAPTER 2.1

> “The NGO SPO needed a way to receive feedback from flood victims in order to coordinate and to monitor the distribution process of shelter, clothing, medicine and more.”

DATA INTEGRATION

The data recorded through the spreadsheet and social media was used to coordinate disaster relief by matching flooding victims with volunteers. Volunteers could either tweet using the designated hashtag or enter their contact information using the spreadsheet (phone number, Twitter handle, address) together with details such as the number of people that can be accommodated. Flooding victims had the opportunity to use the spreadsheet to find support in their area, enter details on their location and specific emergency situation and find information regarding helplines or doctors.

Alongside its benefits, this process came with an issue labelled ‘social media noise’: Information was circulated through retweets after it had become irrelevant, creating ‘noise’ when looking for actually relevant information. For instance, if a flood victim tweeted a request for help and support/relief was provided, the Tweet (containing the request) continued to be circulated through retweets by other users, who were unaware that it had been resolved.

Another challenge if this method is data privacy ownership. On the Google Drive platforms, the creator of a document can determine among pre-set conditions to grant access:

A document can be made available

- to up to 100 chosen users
- to anyone in possession of the URL
- As a freely accessible published document

Within the setting of co-creation in times of natural disaster, the most effective choice is to make it accessible for anyone in possession of its URL. Since this means open access to private data, its use should be limited to emergencies.

Yoti is an app addressing this issue: The app uses information from government-issued identification documents, encrypts them and stores them as a so-called Yoti on the user’s smartphone. The Yoti can then serve as online identificator. This could reduce the amount of sensitive data necessary, when registering to provide or receive help. However, this approach is prone to fail for its necessity of a network effect, meaning a sufficient number of users must register their Yoti.

02

SHORT MESSAGE SERVICE (SMS)

Deemed a revolutionary technological step with its introduction in 1992, the Short Message Service (SMS) has long since lost its status. Regarding technologies enhancing climate adaptation, SMS may be one of the most low-hanging fruit and the most underrated means of communicating data. According to the International Telecommunication Union (ITU), there were more mobile cellular subscriptions than inhabitants worldwide in 2017 , putting SMS in the hands of technically all. Although there are significant discrepancies between developed and developing countries to consider, there seems to be a strong case for the argument that most - if not all - other technologies that are used in climate adaptation require higher levels of technological literacy and equipment than SMS. In times of WhatsApp and other internet messaging services, it may seem technologically obsolete.

> “Nonetheless, in regards to extreme climate events, it might occur that smartphones are only able to send and receive SMS.”

Nonetheless, in regards to extreme climate events, it might occur that smartphones are only able to send and receive SMS.

As a peer-to-peer messaging service, SMS allows groups and communities to coordinate their efforts. That being said, in its traditional form, group messages via SMS are challenging, as not all recipients can see whom the message is addressed to. However, when combined with software an SMS gateway, SMS can be used to request information from a database, and, vice versa, messages can be automated and sent out to individuals or large groups. In this manner, alerts, weather forecasts and more can be sent out to groups of recipients such as farmers. In turn, these individuals can report information, e.g. about pests to coordinate pesticide use, to the centralised service, which is then relayed to the other participants. In cases of catastrophes, warnings and crisis response measures can be communicated to those affected.

The examples below introduce service providers that offer solutions ranging from e-mail, to SMS services, to sophisticated online dashboards. These allow the use of variables to automatically include data such as names, addresses and others, thus enabling automated messaging and managing of thousands of recipients.

2.1 DISASTER RISK MANAGEMENT DURING PAKISTAN FLOODS: FRONTLINESMS

INTRODUCTION

The Pakistani NGO Strengthening Participatory Organization (SPO), implemented a disaster relief project to distribute food items and shelter following the 2011 monsoon flooding in Sindh, which affected an estimated 5.5 million people.

The NGO needed a way to receive feedback from flood victims in order to coordinate and to monitor the distribution process of shelter, clothing, medicine and more.

> "Using FrontlineSMS the project managed to establish an efficient way to communicate with residents."

Using FrontlineSMS in combination with a communication system based on numbers and signs to overcome language barriers, the project managed to establish an efficient way to communicate with residents.

METHOD OF DATA COLLECTION

1. An account with FrontlineSMS is set up by the NGOs.
2. With the account set up, a SMS gateway (point from which the SMS are sent and received) is established. There are commercial providers depending on the region. One can also use a smartphone running Android after installing the FrontlineSMS Cloud App.
3. The NGOs develop a numbering system together with the villagers to categorize the feedback given by the affected. It ranges from 0-9, with each number having a specific meaning:

1 = Food items
2 = Shelter
3 = Conflict
4 = Corruption
5 = Issues with SPO staff
6 = Issues with Partner Organisation staff
7 = Issues with Village Council
8 = Issues affecting women and children
9 = Issues affecting those with disabilities
0 as a means of saying 'thank you'

4. The organisations involved in the process distributed leaflets explaining the use of SMS in pictures and Arabic, the native language. This was done to overcome the language barrier and the fact, that not all phones were able to correctly communicate Unicode characters.
5. Teams went to every village to distribute the printed leaflets, posters and cards, and explained the system to beneficiaries. During this process, field workers documented all beneficiaries' phone numbers, which were then saved to FrontlineSMS. As a result, every message received by FrontlineSMS could be associated with a name and a location. Personalized auto-replies, geographical allocations of help requests and more were thereby enabled.
6. The affected could now send their feedback using the numbering system, allowing the NGOs involved to categorize the prevalent issues and respond accordingly

Created by Pause08 from Noun Project

SOURCES

- FrontlineSMS
- FrontlineSMS Cloud App
- Example of a Free and Open Source SMS gateway

Interested in other digitalsolutionsincase of floding?

Check out chapter 1.1

> "Petabencana enables swift and informed decision making by citizens and government in times of crisis"

DATA INTEGRATION

By managing their contacts in groups through FrontlineSMS, SPO were able to create contact lists for village and Union Council members. With their group contact lists, SPO sent tailored messages before each of their five partner organizations started the aid distribution process in order to alert the beneficiaries. Additionally, the NGO could also solicit feedback via SMS following the distribution. When a complaint was received from a beneficiary, the response manager could call back, ask for more information, and then follow the internal complaints procedure.

The advantage of using SMS to manage incoming complaints was that it was asynchronous – SPO sent automatic replies through FrontlineSMS to acknowledge receipt of messages, and could then call back shortly after. In addition, they had all incoming SMS recorded automatically in FrontlineSMS, which helped them manage and monitor the different types of responses coming in.

TECHNICAL INFORMATION

FrontlineSMS is accessed through an online dashboard that runs in supported browsers regardless of the operating system. The costs to run FrontlineSMS depend on the amount of interactions (sent / received SMS). Additionally, a SMS gateway needs to be established. Its costs vary significantly between commercial providers and regions. Instead, a smartphone running Android can be used to send and receive messages. The costs and amount of SMS that can be sent and received depend on the individual cell phone contract, as does the number of messages that can be sent per second or minute.[10]

2.2 SMS-BASED AUTOMATED DATA MANAGEMENT: BUS TRACKER BY SMS

INTRODUCTION

The Chicago Transport Authority's (CTA) 'Bus Tracker by SMS' can give estimated arrival times of public busses via text message. The user sends a text containing a code identifying the bus stop to a specified number and receives the estimated arrival time in return.

“It demonstrates a simple digital solution using SMS and a Global Positioning System (GPS) based backend.”

It demonstrates a simple digital solution using SMS and a Global Positioning System (GPS) based backend. The same principle could be applied in order to establish automated messaging services allowing users to request data from other remote backends, e.g. to request updates on extreme weather events.

Example image of the user's view[11]

METHOD OF DATA COLLECTION

- A backend of the CTA tracks the GPS coordinates of public busses along their specified routes and continuously calculates the estimated arrival times.
- Users waiting at bus stops can send a message to the system using the syntax 'ctabus [stop ID]'. A message could for instance contain the message: 'ctabus 41411'.
- The system returns the estimated arrival time to the user.

SOURCES

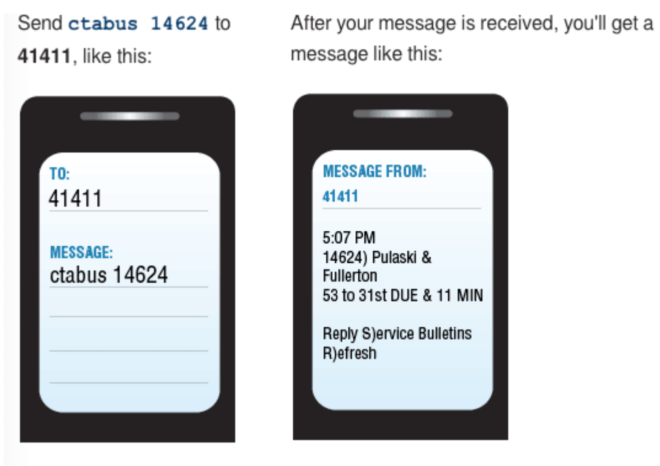
Created by Pause08 from Noun Project

- *Bus Tracker API Documentation*
- *Clever Devices Inc.*

INTERESTED IN OTHER DIGITAL SOLUTIONS FOR TRAFFIC MONITORING?

CHECK OUT CHAPTER 4.4

“The app therefore offers a unique proposition by turning everyday commutes into traffic data, which is specifically relevant for urban and transport planners researching traffic patterns.”



Example image of a bus stop sign[12]

TECHNICAL INFORMATION

Each bus contains a GPS device, which helps the CTA to map buses and improve service and schedules. Additionally, the data can help bus riders make decisions about when to head out to a bus stop. Estimated arrival times and these APIs are provided through a system called “BusTime,” a product made by Clever Devices, Inc.

A Bus of the Chicago transportation system[13]

03

SENSOR-DRIVEN TOOLS

Sensing devices hold a great potential in the field of ICT-based Adaptation to Climate Change in Cities. For one, affordable devices lower access barriers. Simultaneously, an increasing number of service providers such as Arduinos, Raspberry Pis, NodeMCUs allow users to partake in data-driven interventions. The companies listed above provide hardware (for sale) and software (for free), so that users may programme their own prototypes or use programmes that other users of the hardware have previously written.

These sensing devices can collect environmental data such as temperature, humidity, light, and more specific measurements (e.g. fine dust particles, radioactivity). On the lower end, the necessary elements for these devices cost 30€. Web-based services allow the user to upload the collected data to a central server and display it on a map. This Data can then corroborate public debates on specific climate-related events. The projects presented below showcase ways to automatically plot the generated data on interactive online maps, some even offering mobile measurements. However, not all existing projects publish the data on an open basis, thereby reducing their transparency and public utility.

While this section primarily focusses on DIY-sensor kits, pre-configured commercial units exist.

> “DIY-sensor devices require a high degree of technical versatility.”

DIY-sensor devices require a high degree of technical versatility. For eager autodidacts manuals on how to build and program a unit are available. These need to be followed closely to avoid fallible measurements, e.g. by placing a temperature sensor in direct sunlight, producing alleviated temperature readings. In this regard, standardised and tested plug-and-play devices give way to improved measuring precision.

Along the fact that plug-and-play devices are commonly more expensive than their DIY-counterparts, intellectual property poses additional problems: Commercial providers are less likely to make the design and software of their solutions openly available, thereby limiting the ways in which they can be audited, re-appropriated and adapted to specific contexts. A major asset of DIY Versions is the sensor assembly according to the identified issue. DIY-devices enable a flexible approach, with the added benefit of being available to larger communities that continuously explore new ways of using the modular design of DIY-devices to re-configure them in order to meet new challenges. Additionally these approaches raise awareness around certain environmental issues such as fine dust particle concentration

3.1 IOTREES IN GUADALAJARA

INTRODUCTION

IoTrees (Árbol IoT in Spanish) is a multi-platform approach to crowdsourcing data on urban trees and monitor the environment by a city's inhabitants. The IoTrees cross-platform gathers information through a mobile and web app, and a network of low-cost DIY sensors that help users monitor air quality, light, weather and noise. It aims to collect data to develop an easy to update Urban Tree Inventory, raise citizen awareness about the eco-benefits of trees and assist in public decision-making based on evidence.

> **"It aims to collect data to develop an easy to update Urban Tree Inventory, raise citizen awareness about the eco-benefits of trees and assist in public decision-making based on evidence."**

Additionally, sensors provide real-time data about environmental conditions that could be crossed with outputted data from trees state on climate change adaptation. In other words, crossing data aims to help developing green infrastructure planning.

METHOD OF DATA COLLECTION

The app contains an existing database of urban trees. Using their smartphones, users can edit these elements of the database or add new ones. In practice, the following steps take place:

• Having approached a tree, an augmented reality function allows users to draw a pattern with their finger based on the tree-type (bush, pine or palm).

• The user then takes a photo to further document the tree.

• The user then chooses whether the chosen tree is part of the already captured database, or if it is a new entry to the database.

• Next, users are asked to provide information on the following variables:

o Location – confirmed on an interactive map (automatically includes latitude and longitude)

o Tree Species (From dropdown list)

o Tree Diameter, circumference and height

• Once the information is uploaded, it must be confirmed by another user. A function in the app named Treender stores all validations. Once the information is confirmed by 50 further users, the data will be tagged as "validated".

SOURCES

- Arbol IoT (android app)
- Arbol IoT (web app)
- ICT-A City of Guadalajara (landing site)
- ICT-A Global (website)

Created by Pause08 from Noun Project

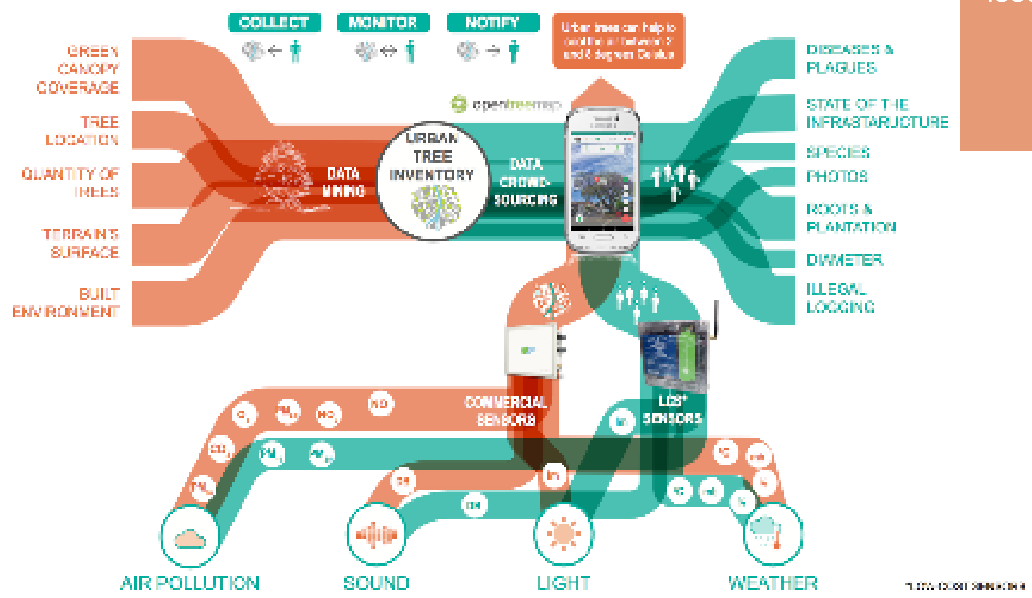
CODE REPOSITORY

- Andropid app
- Sensor
- Backend

INTERESTED IN OTHER APPLICATIONS FOSTERING CITIZEN ENGAGEMENT?

CHECKOUTFIXMYSTREETIN CHAPTER 4.2

> "Users can report issues such as broken lamps, garbage, potholes and others through the app, which matches their geolocation to the correct postcode and the corresponding city department responsible to fix the issue."



Model for data integration in IoT app

DATA INTEGRATION

Preexisting Guadalajara tree database, obtained by Lidar technology feeds 'Arbol IoT'. Guadalajara tree database is hosted in the municipality Open Data Portal "Guadalajara Map":

- https://mapa.guadalajara.gob.mx/
- https://mapa.guadalajara.gob.mx/arbolado/

In the new upscaling phase of 'Arbol Iot', data will be hosted in the planning platform "SIGmetro" which is the official data tool for the planning process for the metropolitan municipalities.

TECHNICAL INFORMATION

As an open source technology, IoTrees is fully replicable in other cities. The programing is interactively documented and made available via web-based hosting services. Interested actors will be able to customize it in line with their local needs and resources.

- Mobile App: The mobile app was programed in 3 versions: Android, Android Lite and iOS.
- Web App: makes use of the open source code of OpenTreeMap
- Sensor: The sensors on the gather measurements on environmental factors such as Temperature, Humidity, Gasses, Fine dust particles PM 2.5 & PM 10, Nitrogen Oxide

3.2 DIY-SENSING OF RADIATION AFTER FUKUSHIMA: SAFECAST

INTRODUCTION

Safecast is a citizen-science-based platform collecting radiation and other environmental data using a mobile, GPS-enabled logging sensor device. It was launched in the aftermath of the 2011 earthquake/tsunami in Japan and the subsequent meltdown of the Fukushima Daiichi Nuclear Power Plant. Safecast quickly began collecting, monitoring, and openly sharing information on environmental radiation, growing quickly in size, scope, and geographic reach.

"Safecast maintains the largest open dataset of background radiation measurements ever collected."

It maintains the largest open dataset of background radiation measurements ever collected. Users have collected over 50 million readings to date.

Created by Pause08 from Noun Project

SOURCES

- Safecast map
- All details (code, files, parts lists etc.) can be found here
- Safecast:Drive app: Apple | Google Play | Amazon Apps

INTERESTED IN PRESET SENSOR TOOLS?

CHECK OUT CHAPTER 3.4

"An interesting aspect of Breeze as compared to the more Do-it-Yourself (DIY) approaches is its self-proclaimed focus on companies as sponsors of the devices, which are then hosted by citizens."

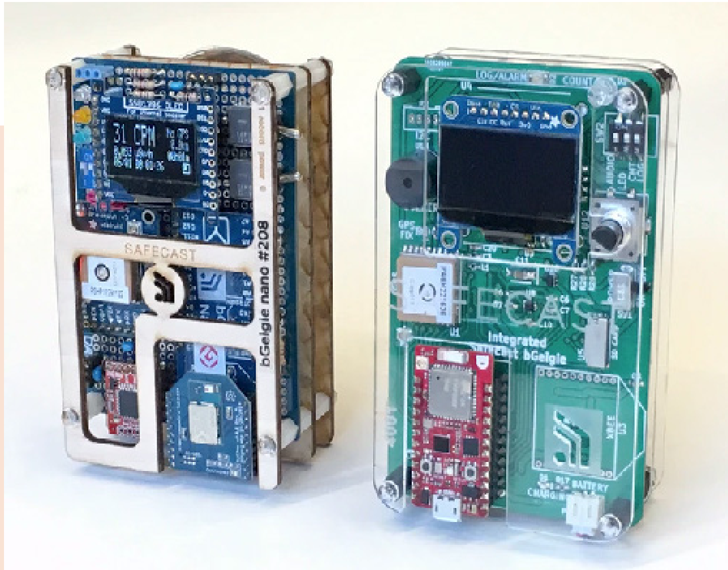
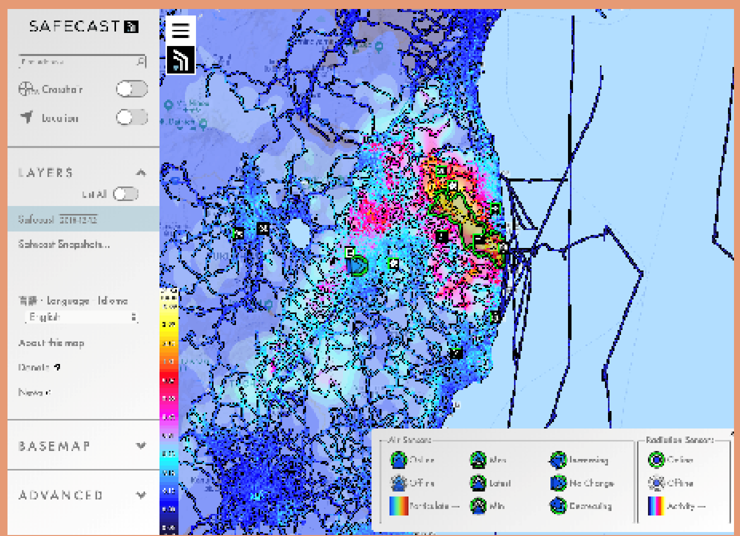


Photo of the bGeige nano[15]



Safecast map displaying radiation measurements made using bGeige[14]

METHOD OF DATA COLLECTION

Safecast has developed a device called bGeige to collect the radiation data. It is based on the Arduino platform and fits into a re-purposed bento box. After several iterations, the bGeige nano is the current variant of the device and can be attached to cars or bicycles, thereby turning it into a mobile measuring station. It is a solid-state, fully digital device. Because of its design, its performance is more consistent than the performance of devices with analogue components, which are more likely to be affected by confounders such as temperature and other external influences. The Safecast bGeige Nano collects a reading every 5 seconds. The data is then uploaded to a central database using a smartphone and Bluetooth connection or via a computer

DATA INTEGRATION

This device is part of a global environmental sensor network enabling people to collect radiation readings to freely use and share the data. Despite the crucial importance, radiation has never been measured on this scale. This precedence case enables authorities to make informed decisions in dealing with the aftermath of the nuclear fallout. Simultaneously, the device improves personal safety of the users, as it alerts in case of increased radiation levels.

TECHNICAL INFORMATION

Safecast aims to create an independent, objective database of environmental readings. bGeigie Nano units have periodically been put through calibration tests at QualTek in the US, at the Jülich Research Centre in Germany, and at the IAEA testing laboratory in Seibersdorf, Austria. In all cases the measured accuracy has been shown to be compatible with the Safecast specifications (Accuracy: +/- 10% typical, +/- 15% maximum). +/- 10% is currently considered excellent performance for a Geiger counter. A device costs between $550 USD (self-assembly) and $1,500 USD for the assembled version .

To gather additional readings on air quality, Safecast is currently building a network of sensors to monitor fine particles PM1.0, PM2.5, Carbon Monoxide, Nitrogen Dioxide, Ozone and Methane. All data collected by Safecast is released under a CC0 public domain.

3.3 DIY-SENSOR TO MEASURE ENVIRONMENTAL DATA: SENSEBOX

INTRODUCTION

SenseBox is an environmental data-sensor utilising a micro controller unit (MCU). It can record environmental data (temperature, humidity, air pressure, illuminance, UV radiation, fine dust pollution and more) depending on the chosen setup. The user can upload the data generated by senseBox (and other devices) to a central server, where it is plotted on the openSenseMap and thereby made available, so that anyone can observe, analyse and download the data.

> "The collected data increases the measurement density of various environmental factors and can contribute to more accuracy regarding environmental pollution or traffic."

SenseBoxes measure numerous environmental variables. The collected data increases the measurement density of various environmental factors and can contribute to more accuracy regarding environmental pollution or traffic.

The senseBox comes in two variants: a 'home' edition, which can be freely configured, and an 'edu' edition, which comes as a non-customizable package with a fixed set of sensors included. The home edition also comes with a weather-resistant packaging and a 5m USB cable, allowing the user to install it as a stationary unit, for instance on a balcony. The edu edition on the other hand is meant to be used in schools and other learning environments in order to become acquainted with the MCU platform and to perform research projects.

METHOD OF DATA COLLECTION

When purchasing a senseBox home, the customer chooses a specific loadout. Always included is the MCU, the 'heart' of the device, a temperature and humidity sensor, a radiation protector, weather resistant packaging and a 5m USB cable. The customer needs to choose at least one so-called 'Bee', which represents the type of connection used to transmit data: Wi-Fi, SD-card, LAN or LoRa (Long Range) can be chosen depending on the circumstances. The customer can then pick additional sensors (air pressure, light and UV, fine dust) and items (GPS, LED-display, expander, micro-SD card). The chosen components alongside assembling instructions is then sent to the customer.

Once the customer has assembled the senseBox home, the free and open source Arduino IDE software can be used to set up the senseBox. For less technically versed users, a simplified block-based programming software called senseBox blockly is available online. It enables the user to program his/her device by dragging visual components into jigsaw-like compositions, which are automatically translated into the code that can then be transmitted to the senseBox.

Detailed guidelines on the necessary steps to connect the senseBox:home are available. A guide to publish the data the OpenSenseMap is also available.

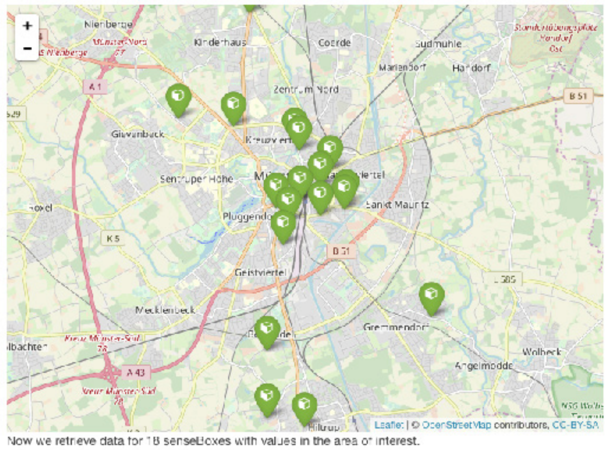
SOURCES

- Website describing the research setup
- Blogpost describing the project
- The data was gathered from the senseBox API (senseBox Github Repo)
- It was then analysed using BinderHub, allowing for a browser-run computational environment that can be reproduced by anyone
- The graphical output was generated using R
- Every step necessary to reproduce the analysis and output can be found here and here

INTERESTED IN DIY SENSOR APPROACHES?

CHECK OUT CHAPTER 3.2

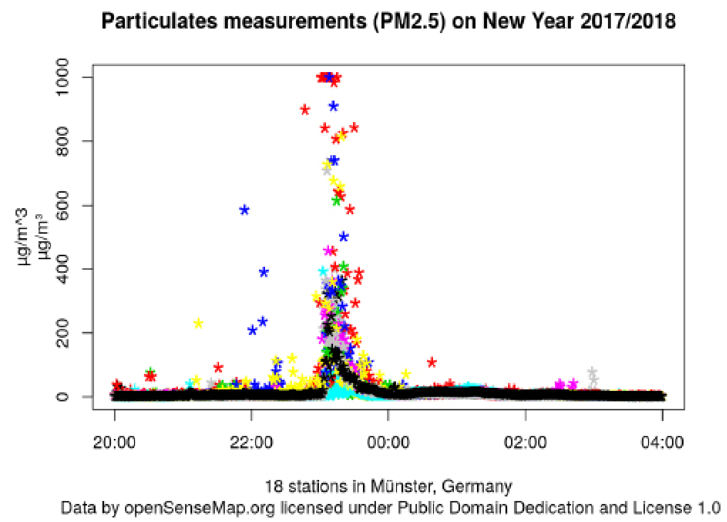
> "Safecast quickly began monitoring, collecting, and openly sharing information on environmental radiation, growing quickly in size, scope, and geographic reach."



Location of the senseBoxes in Münster[17]

DATA INTEGRATION

In the example below, a senseBox user decided to measure the effects of fireworks on the concentration of fine dust particles in the air on New Years Eve 2017 / 2018. Fireworks alone produced 5000 tons of particulate matter in 2016 in Germany, amounting to approximately 17% of yearly emissions by vehicles . The measurements created by the network of senseBoxes can serve as an entry point to the debate on fine dust particles and thereof potential political consequences.



Plotting of the results during NYE 2017 / 2018[16]

3.4 PROPRIETARY SENSOR TOMEASUREENVIRONMENTAL DATA: BREEZE

INTRODUCTION

Breeze is a proprietary out-of-the-box solution to collect and display different environmental data. Whereas other providers of sensory toolkits such as senseBox or Safecast require the user to assemble the sensors, Breeze offers a ready-made design. The start-up sells outdoor and indoor monitoring solutions for municipalities and companies, alongside a publicly accessible map that displays some of the collected data.

Breeze monitors and analyses pollutants in line with the health guidelines of the WHO. Alongside the monitoring of pollutants on the street level, Breeze also offers its monitoring services to private companies. As the air quality of office spaces can have a direct impact on the productivity of staff, Breeze offers the possibility to improve indoor air monitoring for employees and employers.

> "Breeze offers the possibility to improve indoor air monitoring for employees and employers."

METHOD OF DATA COLLECTION

According to Breeze, their software can integrate various types of Open Data. The company states that their "environmental analytics cloud platform gathers real-time data from Breeze air quality sensors as well as external data sources". Furthermore, it utilizes a "proprietary Adaptive Cloud Calibration Engine to increase data reliability and accuracy" by employing "machine learning and big data technologies"[19] . Breeze devices collect Temperature and Humidity, Carbon Monoxide (CO), Carbon Dioxide (CO2), Nitric Oxide (NO), Nitrogen Dioxide (NO2), Fine Particulates (PM10 and PM2.5), Sulphur Dioxide (SO2), Ozone (O3) and Ammonia (NH3). The measurements are made in short intervals (about 30 seconds) and transmitted to a central server owned by Breeze.

As Breeze does not publish their code nor the specific hardware components used, it remains difficult to assess the quality and precision of the measurements. The standardized technical configuration and design nonetheless constitute a major asset.

Air quality in urban spaces can cause irreparable damage[18]

SOURCES

Created by Pause08 from Noun Project

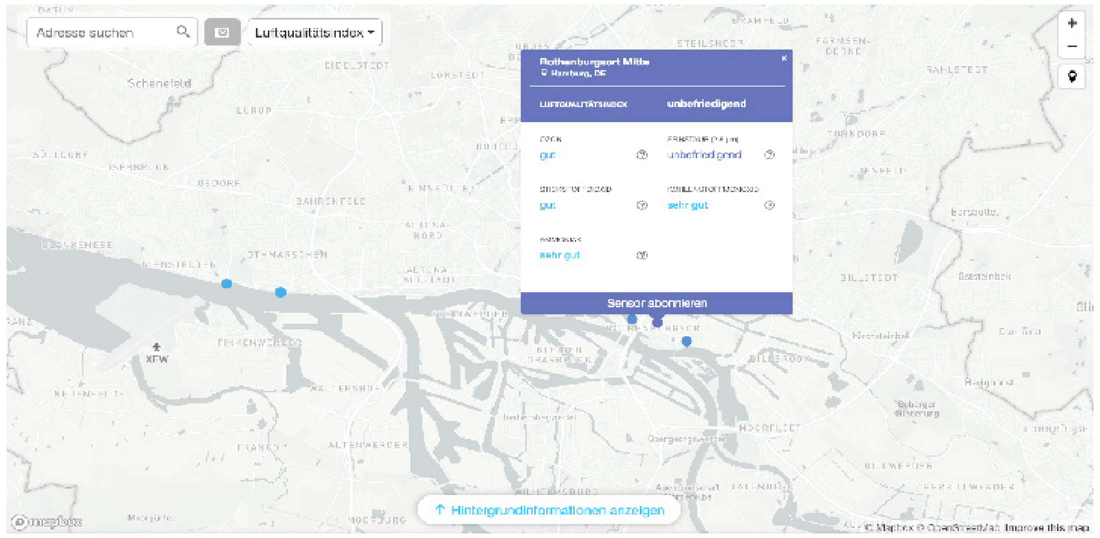
- [Breeze Website]
- [Breeze Map Hamburg]

INTERESTEDINDIYSENSOR APPROACHES?

CHECK OUT CHAPTER 3.2

> "Safecast quickly began monitoring, collecting, and openly sharing information on environmental radiation, growing quickly in size, scope, and geographic reach."

Screenshot of Breeze Map[20]



DATA INTEGRATION

Breeze devices hold the potential to complement the existing monitoring solutions employed by municipalities and urban agencies through large numbers of low-cost devices, which increase the resolution of the data points available.

FURTHER INFORMATION

A Breeze device costs between 990€ and 1590€ + an additional 500-600€ per year to operate.

04

WEB APPS

With continuously decreasing prices, smartphones are becoming omnipresent in more and more parts of the world. Equipped with GPS, basic sensors and camera technology, smartphones are an unpreceded tool to collect and share data. In the context of climate adaptation in cities, the inhabitants can participate in environmental mapping, situational reporting, feedback mechanisms and crowd-sensing tools, with no additional costs involved.

The applications presented below, showcase the re-appropriation of the sensors and components integrated in smartphones to generate situational data of urban environments. Firechat establishes a 'mesh network', which functions without Wi-Fi or cellular connection to establish lines of communication by transforming smartphones into network nodes. FixmyStreet uses the camera, GPS module and descriptions to enable citizens to report issues in urban environments to the local administration. Safetipin records subjective impressions of urban environments to assess safety of different areas. Modalyzer records commuting routes and means of transport to make them available for user-chosen research projects. Cyface uses the gyroscopes included in many smartphones to sense damages such as potholes on the travelled road, and Noisetube records noise levels using the microphone integrated in smartphones to create informative maps.

"For urban practitioners, these examples demonstrate the potential of turning the smartphone, into a source of information for a wide field of possible applications."

For urban practitioners, these examples demonstrate the potential of turning one of the most widely distributed and popular devices, the smartphone, into a source of information for a wide field of possible applications. That being said, the efficiency, data-quality and feasibility of integrating the information in specific contexts has to be evaluated for the specific use cases.

4.1 CREATING A MESH NETWORK USING SMARTPHONES: FIRECHAT IN MARIKINA

INTRODUCTION

Firechat is a peer-to-peer encrypted messaging app that uses Bluetooth and Wi-Fi connections to send text and images. It works without access to Internet or cellular data, creating a mesh network (based on the Bluetooth or Wi-Fi technology). Due to the technical limitations of the modules used, users can be a maximum of approximately 80 meters apart for the system to function.

As a mesh network, Firechat has the option to operate in situations where the mobile network is unavailable, given a sufficient user density.

> "Therefore, it develops its full potential when a communication infrastructure needs to be established in densely populated urban areas."

Therefore, it develops its full potential when a communication infrastructure needs to be established in densely populated urban areas. It should be noted, however, that in order for this scenario to function, Firechat needs to be installed on all the devices that intend to use the mesh network prior to internet connections becoming unavailable. Furthermore the range of the network is

METHOD OF DATA COLLECTION

Firechat collates various types of data. Its primary use, however, is the establishment of communication networks in high-density areas with blocked or overstressed mobile connections.

1. The user needs to install the Android or iOS version of the app.
2. The user can then create single or multi-user conversations and chatrooms.
3. Messages are encrypted and transmitted from user to user until they reach their destination.

FireChat LOGO[21]

Created by Pause08 from Noun Project

SOURCES

- Project website
- Article on Firechat (The Verge)
- Article on Firechat (WIRED)

INTERESTEDINALTERNATIVES TOTHEUSEOFSOCIALMEDIA IN SPATIAL PANNING?

CHECK OUT CHAPTER 2

> "Smartphones are able to send and receive SMS even as data intensive and mobile internet-based services (like WhatsApp) are not available due to extreme situations."

DATA INTEGRATION

Open Garden, the Firechat manufacturer, made a Software Development Kit (SDK) called MeshKit available, which allowed local deployment of the software powering the app, e.g. to power city-specific emergency apps. The SDK appears to have been removed since and it remains unclear whether it will return. Other SDKs meeting similar aims, such as the Hypelabs SDK, NewAer and Max-mesh, remain available.

Depending on the App / SDK, different prerequisites need to be fulfilled. A Bluetooth & Wi-Fi connection is always needed on the user side.

Illustration of firechat[22]

4.2 USER-GENERATED REPORTS ON URBAN ISSUES: FIXMYSTREET

INTRODUCTION

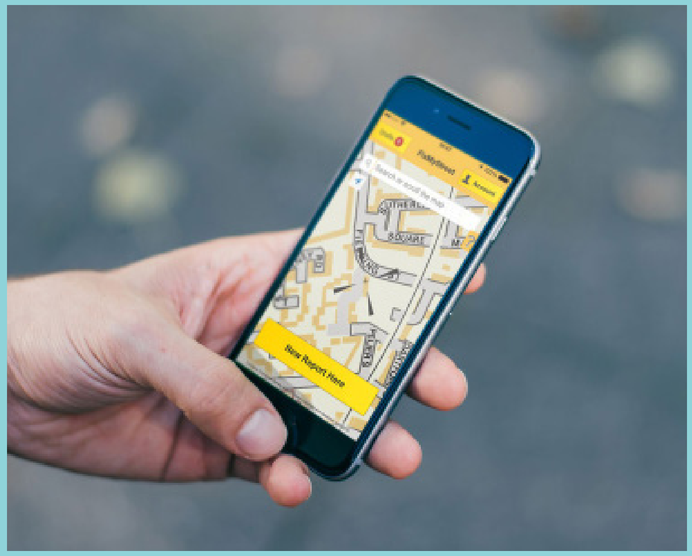
FixMyStreet (FMS) is a popular damage reporting and complaint management app in the UK. For cities, keeping up with damages, vandalism, illegal garbage disposals and more can be a tedious task. Such issues occur on a daily basis and require swift action to maintain urban infrastructures. Users can report issues through the app, which matches their geolocation to the correct postcode and contacts the corresponding city department responsible to fix the damage. This increases the efficiency of the process leading from the occurrence of an issue to the assignment of the responsible department, reducing city bureaucracy. The city administration can plan and react efficiently to coordinate services, and the line of communication between the city and its inhabitants helps to reduce frustration and complications on both sides.

> “The success of that application depends on the users experience with the city services.”

The success of that application depends on the users experience with the city services. It is therefore essential that the reporting app is leading to visible outcomes, performed by the city administration.

METHOD OF DATA COLLECTION

1. The citizens report issues in the urban environment using text descriptions, photographs and GPS tags
2. They post the issue using the website, iOS or Android app
3. The report is forwarded to the council responsible
4. A messaging channel allows the council to respond and update the reporter



Users view of the FixMyStreet App[23]

SOURCES

- FixMyStreet UK
- FixMyStreet Pro
- FixMyStreet Platform

GERMAN EQUIVALENTS:

- Mängelmelder
- Karlsruhe Feedback
- Maerker Brandenburg

INTERESTED IN OTHER PARTICIPATORY DIGITAL SOLUTIONS?

CHECKOUTCHAPTER3.1ON IOTREES

> “It aims to collect data to develop an easy to update Urban Tree Inventory, raise citizen awareness about the eco-benefits of trees and assist in public decision-making based on evidence.”

DATA INTEGRATION

FMS can integrate with existing administrative reporting structures in different ways. In the most basic variant, the reports generated using FixMyStreet are simply sent to the e-mail address of the corresponding council by the software. The email includes the category of the problem and its exact location. The council can then respond to this email normally and the message will be sent to the users' inbox.

A second way to integrate FMS is for councils to use the paid version of the software called FixMyStreet Pro. This option includes the replacement of the internal reporting software used by a council with a customisable version of FMS. Oxfordshire county council is one example that has taken this route.

TECHNICAL INFORMATION

The FixMyStreet platform is an open source software available on Github. Any interested city, council or citizen group can customize their own application of FMS. Examples of this include the City of Zürich and the City of Stockholm

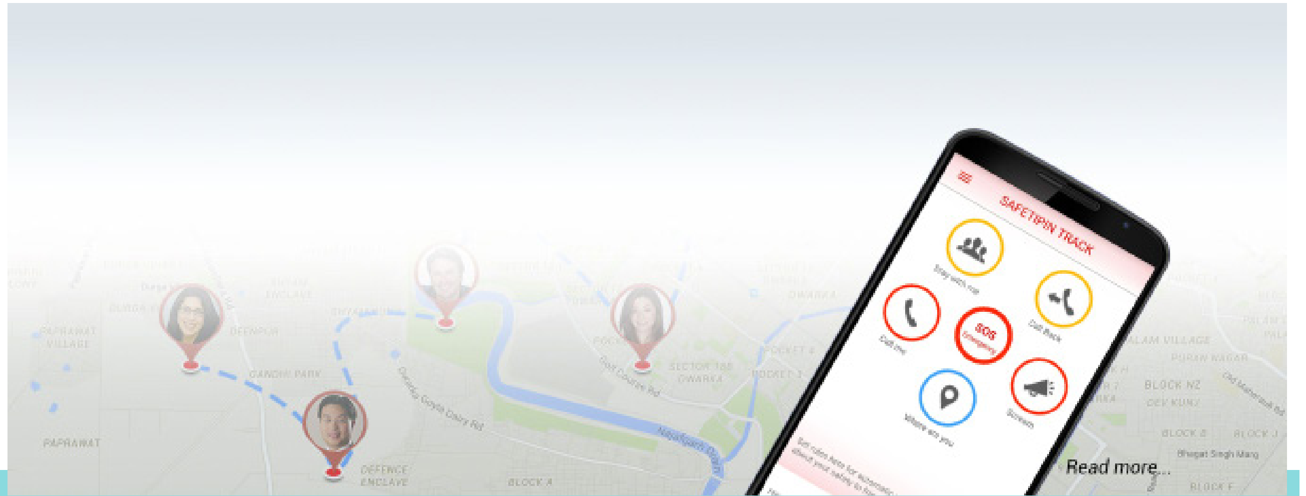
4.3 MEASURING SAFETY IN URBAN SPACES: SAFETIPIN

INTRODUCTION

The ‘MySafetipin’ app is used by citizens to obtain information on the level of safety in a given area based on user reports.

“With MySafetiPin the user can navigate whilst sharing their location via GPS.”

The user can use the app as a navigation system, which evaluates different routes based on their safety score. The user can also share their location with his contacts via GPS when travelling through unsafe territory.
The app is primarily used in India, Colombia, Kenya, Indonesia and the Philippines and was



Safetypin allows to assess the safety of a district through the users evaluation in predetermined indices[24]

METHOD OF DATA COLLECTION

Any user can publish a post sharing their feeling at a particular place. Users can reinforce posts, put up their own comments, and additionally post it on Facebook and Twitter. While travelling, they can view Safety Audits and plan their routes accordingly. The Safety Audit consists of a set of 9 parameters that make up to the safety score:

- Lighting in the area
- Openness of the area
- Visibility in the area
- Density of people
- Security
- Quality of walk path
- Accessibility of public transport in the area
- Gender diversity in the area

The user evaluates these criteria on a scale from zero to five (0 – 5). Each rating results in a pin on the specific location where the audit was recorded along with the time and date. The colour of the pin is red, orange or green based on the measure of the parameters.

SOURCES

- About the app
- City example (New Delhi)

INTERESTED IN OTHER MAPPING APPLICATIONS?

CHECK OUT CHAPTER 5.1

“HOT provides maps for disaster management, risk reduction and to help disaster responders.”

SAFETIPIN[25]

DATA INTEGRATION

While many urban phenomena can be measured using sensors, the personal perception and “mood” of an area is the result of an interplay of many factors, which can only fully be understood and measured through experience. The app can give urban planners a novel and subjective perspective on the actual perception of a place, enabling them to take steps to improve or change the situation accordingly. Safetipin therefore offers a unique proposition by providing qualitative data that is otherwise difficult – if not impossible – to obtain. For urban planning, implementing the results could lead to new impulses in making cities more liveable. The data generated is particularly relevant for social groups prone to abuse, government service providers, urban planners and non-governmental organizations involved in related social issues.

4.4 TRACKING TRAFFIC PATTERNS USING SMARTPHONES: MODALYZER

INTRODUCTION

Modalyzer is an app that tracks mobility data, with the option to make it available for research or urban planning projects. Users can learn about the CO_2 impact of their own mobility choices. By sharing their data, they can additionally support research projects and help improve existing mobility services. Researchers in need of specific mobility data can post their research project on the website and offer incentives as a reward for data donations.

> "The app therefore offers a unique proposition by turning everyday commutes into traffic data."

The app therefore offers a unique proposition by turning everyday commutes into traffic data, which is specifically relevant for urban and transport planners researching traffic patterns. It furthermore shows the potential of combining the personal utility of an app with incentives to donate data. One key difference to other apps presented here is that the resulting data is not published as Open Data, which on the one hand limits its utility but on the other may help to motivate users to make relatively private data available for specific projects.

METHOD OF DATA COLLECTION

By opening the modalyzer app, location and movement data are gathered. As soon as the smartphone is connected to Internet, the data is transmitted from the app to the modalyzer server, where used modes of transportation, travel durations and distances will be calculated. The software automatically detects the user's means of transportation (car, bus, bicycle, walking, trains), with the option to fill potential gaps by the user (long distance busses, airplanes, motorbikes, water transport) manually.

SOURCES

- Installation instructions for modalyzer
- Example research project
- Envirocar is a similar app that tracks car data (RPM, speed, coolant temperature and more) using a Bluetooth enabled plug. The data is then sent to a central server, where it can be viewed by the user and where it is made available anonymously for research purposes

INTERESTED IN OTHER DIGITAL SOLUTIONS FOR TRAFFIC MONITORING?

CHECK OUT CHAPTER 4.5

> "With the Cyface App and the Cyface Sensorbox, GPS data and road quality data can be captured."

Modalyzer allows tracking routes via mobile devices[26]

DATA INTEGRATION

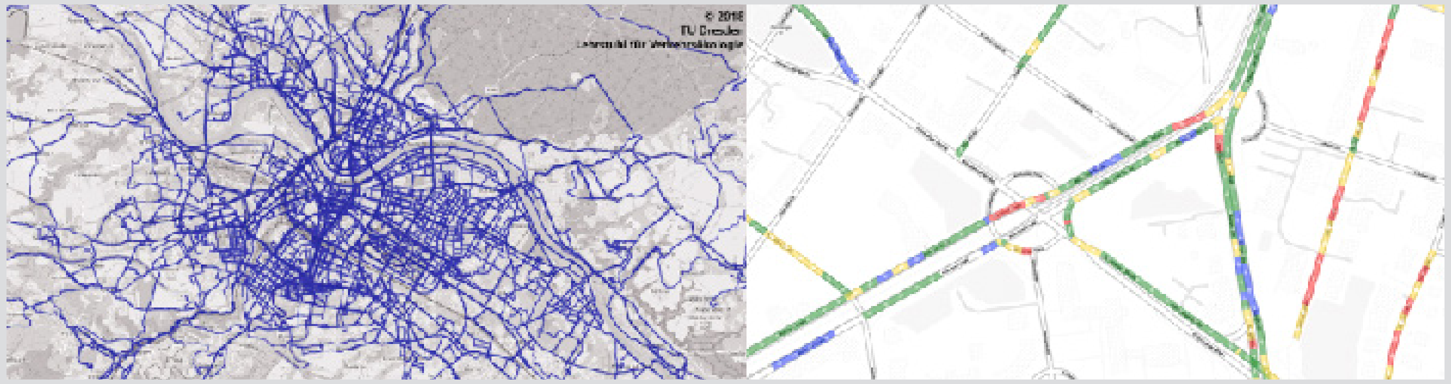
The data collected is used in different research projects with different goals. One current example ('Mobility Patterns in Maastricht and Berlin') wants to illustrate the status quo of the traffic behaviour in Maastricht and Berlin, detect social hotspots and analyse these in terms of infrastructure, leisure facilities etc. and gain insights into the multimodality in the two cities.

As traffic in cities poses major challenges, informed planning is crucial[27]

4.5 MEASURING ROAD QUALITY AND TRAFFIC DATA: CYFACE

INTRODUCTION

With the Cyface App and the Cyface Sensorbox, GPS and road quality data can be captured. Potholes that are more than 1 cm deep will be registered alongside GPS-based traffic data in both variants.



Screenshot of road data maps made using cyface[28]

METHOD OF DATA COLLCETION

The Sensorbox is built on the Raspberry Pi platform and is meant to be installed permanently in vehicles. It runs on the electricity of the host vehicle and starts up as soon as the vehicle is turned on. Both the Sensorbox and the smartphone app use an accelerometer, gyroscope and GPS sensor, to collect a wide range of data. During the ride, vibrations are recorded autonomously (sampling rate of 50-200 Hz.), stored and transmitted to previously defined servers when a WLAN connection is established. While the app needs to be engaged before every trip, the Sensorbox records data continuously. Both options can be used with cars and bicycles.

SOURCES

- cyface Sensorbox
- Project website

INTERESTEDINOTHERDIGITAL SOLUTIONS FOR TRAFFIC MONITORING?

CHECK OUT CHAPTER 4.6

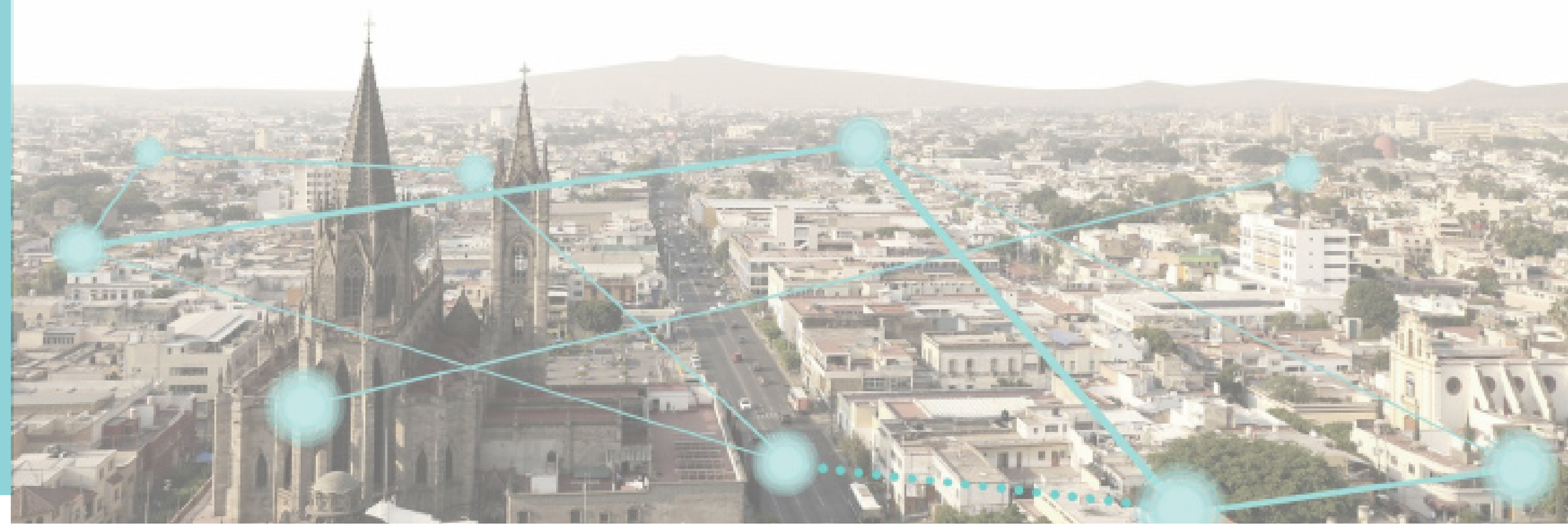
“Noise pollution in cities is proving detrimental to our health: According to the World Health Organisation (WHO), one in five Europeans is regularly exposed to sound levels at night that could significantly damage their health , leading to cardiovascular diseases, sleep disturbance and stress.”

DATA INTEGRATION

The data generated can support urban planning, give automated feedback on damages to roads, provide councils insights in the popularity and quality of tourist travel routes, generate data for researchers and help road engineers to lower costs. The Cyface Sensorbox can also be used as an alternative measuring instrument e.g. in vehicles of public waste collection

Correspondingly Cyface offers three use cases and related pricing structures:

- Cities / communes: record street quality fast and cheap
- Research: transform vehicles into data generation machines (Example 1, 2, 3)
- Engineering: record and evaluate road surface data less costly



4.6 SENSING NOISE USING SMARTPHONES: NOISETUBE

INTRODUCTION

The NoiseTube research project proposes a participative approach for monitoring noise pollution by involving the general public. The NoiseTube app uses the microphone of mobile phones to turn them into noise sensors, thereby enabling citizens to measure the sound exposure in their everyday environment. Furthermore, each user can participate in creating a collective map of noise pollution by sharing geotagged measurement data with the NoiseTube community.

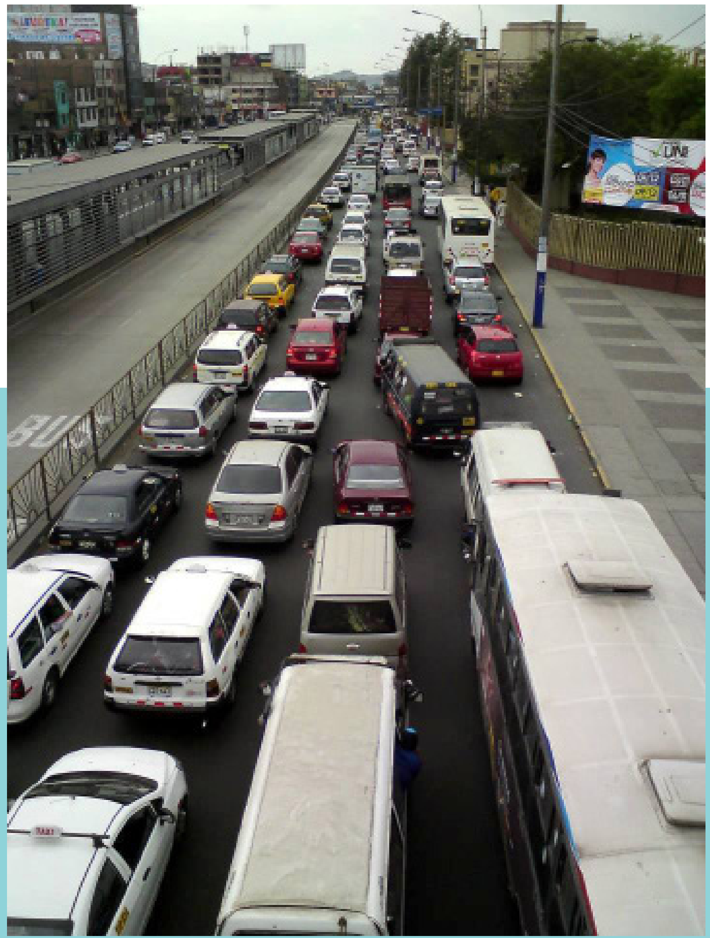
Noise pollution in cities is proving detrimental to our health: According to the World Health Organisation (WHO), one in five Europeans is regularly exposed to sound levels at night that could significantly damage their health[29] , leading to cardiovascular diseases and sleep disturbance. Monitoring these noise levels is commonly attributed local councils, which may not be able to generate sufficient data on noise pollution to assess and react to the levels in their jurisdiction.

> “Noise pollution in cities is proving detrimental to our health: According to the World Health Organisation (WHO), one in five Europeans is regularly exposed to sound levels at night that could significantly damage their health , leading to cardiovascular diseases, sleep disturbance and stress.”

METHOD OF DATA COLLECTION

The noise data is collected via the microphone of smartphones that have the app installed. It measures the decibel (dB(A)) levels, records the GPS coordinates and offers the ability to tag the measurements with specific information, for instance to note a sound source such as trains or planes.

The data is made available in a map view and via an API.



Automobiles cause noise pollution[30]

SOURCES

- Noisetube API
- Noisetube App Android

INTERESTEDINOTHERDIGITAL SOLUTIONS FOR TRAFFIC MONITORING?

CHECK OUT CHAPTER 2.2

> “Bus Tracker SMS demonstrates a simple digital solution using SMS and a Global Positioning System (GPS) based backend.”

DATA INTEGRATION

Local governments can improve decision-making by understanding noise pollution in their city using maps and statistics based on NoiseTube. They can receive feedback and opinions from citizens and give them feedback in return. Nuisance sources can be identified and strategies to reduce their impact developed. Researchers can use the data to analyse specific noise patterns and sources. A series of publications have integrated NoiseTube data, available under the open GNU LGPL v2.1 license. Campaigns targeting noise-related issues could use the data to generate specific visualizations.

The app is free to download and runs on Android smartphones.

> “Sources of noise can be identified and strategies to reduce their impact can be developed on the basis of the data. Researchers can use the data to analyse specific noise patterns and sources.”

Noisetube

05

MAPPING

Crowd-based mapping initiatives are amongst the most popular approaches in the field of climate adaptation. Describing geospatial contexts, in order to visualize structures and circumstances or to find new ways of describing the world, is a challenge central to many climate-related issues. OpenStreetMap (OSM) as the largest project in this domain with over 4.3 million users, 4.1 billion nodes, 3 millions changes/day and 1 million contributors[31] . It has been the foundation of countless mapping efforts around the world. Several projects build on OSM technology to engage citizens in the process of filling data gaps such as information about infrastructure and areas impacted by natural in cities.

> “Maps are important tools to coordinate humanitarian efforts, research geospatial phenomena, display environmental data and plan urban strategies of disaster risk reduction and resilience building.”

Maps are important tools to coordinate humanitarian efforts, research geospatial phenomena, display environmental data and plan urban strategies of disaster risk reduction and resilience building. In developing countries, geospatial data is not always available and is subject to change once climate catastrophes have occurred. Refugee displacement and outbreaks of diseases are potential consequences, which are difficult to understand without geospatial data. Similarly, maps can be used to reduce disaster risk and increase resilience by exploring and analysing potential issues with given infrastructures.

As data repositories, maps can benefit from many sources of knowledge which may be technical (satellite images), local (on-the-ground reports and local knowledge), or even personal (see Safetipin above). As a vessel of knowledge, maps can integrate a wide and diverse variety of information, which is why many of the featured projects above plot the recorded data onto maps at some point.

5.1 OPENSTREETMAP

INTRODUCTION

OpenStreetMap (OSM) is a collaborative project to create a free editable map of the world under an open license. More than the map itself, the data generated by the project is considered its primary output. The growth of OSM has been fuelled its role as foundation to develop geospatial tools and services through additional layers. Embodying the principles of Free and Open Source Software, OSM is a primary example for the collaborative use of technology . It serves as the backbone of countless mapping-related projects around the globe.

Anyone is free to use the Open Data provided by OSM for any purpose as long as they credit OpenStreetMap and its contributors.

> "As the 'Wikipedia of cities', OSM is one the most crucial tools for urban practitioners encountering data gaps in their work."

As the 'Wikipedia of cities', OSM is one the most crucial tools for urban practitioners encountering data gaps in their work. Comprehensive tutorials provide with guidance on the design and execution of collaborative mapping efforts using OSM. Prominent cases such as HOT and OpenDRI showcase the power of OSM in the context of climate adaptation.

Open street map is an Open Source Software[32]

METHOD OF DATA COLLECTION

OpenStreetMap emphasizes local knowledge. Users can tag places and add attributes about roads, buildings, addresses, shops and businesses, points of interest, railways, trails, transit, land use and natural features, and more. This leads to unique descriptions of urban environments: for instance, wheelmap.org provides a layer on OSM that shows whether a place is accessible for wheelchairs, and a user created a tag to designate LGBTQ-friendly places. Contributors use aerial imagery, GPS devices, and low-tech field maps to verify that OSM is accurate and up to date.

Depending on the project using OSM, the process of entering new data can vary. To edit the actual OpenStreetMap, a user needs to::

1. Create an account: https://www.openstreetmap.org/user/new
2. Visit https://www.openstreetmap.org/ and login
3. Enter the editing mode by clicking the 'edit' button
4. Make changes to information on the map
5. Submit the changes for review or upload them to the map

SOURCES

- Introduction into OSM (OSM)
- OSM help
- Learn how to map (Missing Maps)
- Extensive resources on how to map (Missing Maps)
- Overview of OSM editing apps and tools (OSM)

INTERESTED IN OTHER MAPPING APPLICATIONS?

CHECK OUT CHAPTER 5.2

> "Open Cities is a project of OpenDRI that is carried out in 11 cities in Sub-Saharan Africa to engage local government, civil society, and the private sector to develop the information infrastructures necessary to meet 21st century urban resilience challenges."

Related projects

Missing Maps

DATA INTEGRATION

OpenStreetMap is the groundwork that many collaborative mapping initiatives are built on. Its openness and flexibility allows stakeholders with diverse approaches to adapt it to their purposes. Apart from HOT, OpenDRI and Missing Maps, the major humanitarian efforts integrating the OSM scheme are:

- Map of nuclear sectors around the world: http://www.leretourdelautruche.com/map/nuke/
- Mobile offline maps: https://maps.me/
- Print-map style map of Europe: http://map1.eu
- Rating service of urban criteria (transport, schools, etc.): https://www.onedome.com/locality-reality/explore

A large list of more OSM-based services is available here.

5.2 OPENDRI: OPEN CITIES

INTRODUCTION

The Open Data for Resilience Initiative (OpenDRI) is a World Bank project that combines the practice of the Open Data movement to solve the challenges of resilient building to natural hazards with a climate adaptation strategy.

“Open Cities is carried out in 11 cities in Sub-Saharan Africa to engage local government, civil society, and the private sector.”

Open Cities is a project of OpenDRI that is carried out in 11 cities in Sub-Saharan Africa to engage local government, civil society, and the private sector to develop the information infrastructures, essential to meet 21st century urban resilience challenges. Since its launch in 2011, OpenDRI has worked to implement these ideas in projects in over 25 countries around the world.

METHOD OF DATA COLLECTION

A transdisciplinary team of experts receive funding and targeted training, to perform following tasks throughout a year in the selected cities:

- create and compile open spatial data on buidings, critical infrastructure, and natural risks
- develop targeted tools to assist decision making of key stakeholders
- support local capacity-building and institutional development necessary for designing and implementing urban resilience interventions

DATA INTEGRATION

In the final phase of the project, teams develop their products and share results. Once the final product is shared, a sustainability and dissemination strategy is developed in cooperation with project mentors.

The openly shared Data can be utilised for other applications beyond the initial project. This is especially relevant in sectors such as energy and transportation, where detailed and up-to-date geographic data is required to develop investment programs. Having dynamic and detailed open data, generates economic value far beyond the project that initiates the data collection.

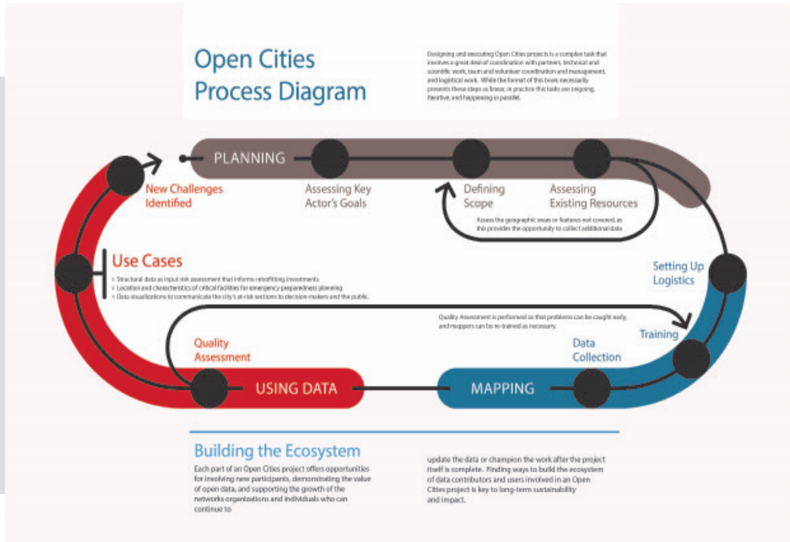
SOURCES

- Project websites: https://opendri.org/, https://opencitiesproject.org
- Collection of resources (Open Cities)
- Collection of resources (OpenDRI)
- Planning an Open Cities Mapping Project

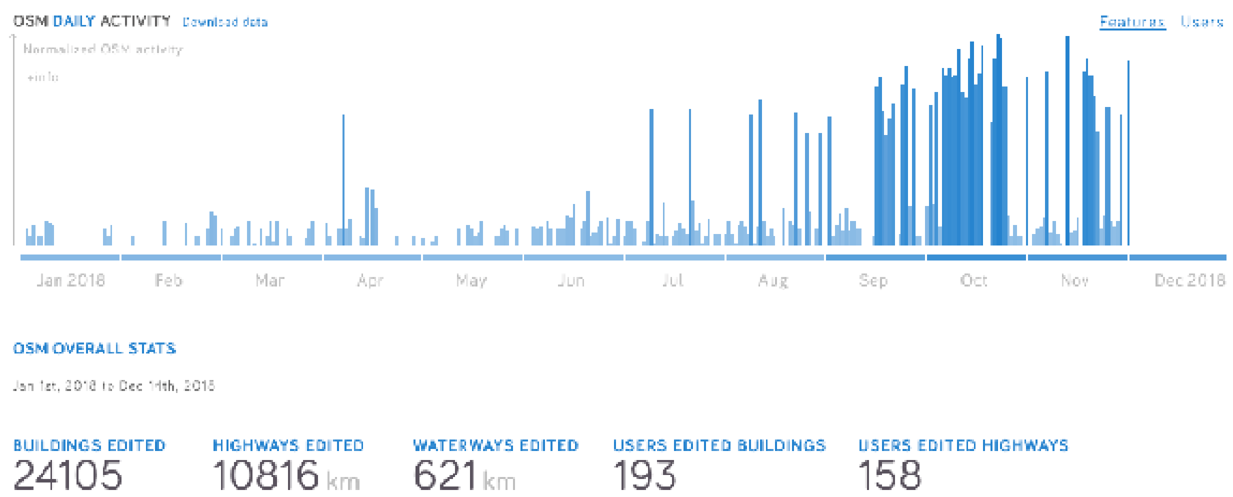
Interested in other mapping applications?

Check out chapter 5.1

“Embodying the principles of Open Data and Free and Open Source Software, OSM is a primary example of the power of the collaborative use of technology and today serves as the backbone of countless mapping-related projects around the globe.”



Opem street map process diagram



OSM daily activity

5.3 CRISIS MAPPING - HUMANITARIAN OPENSTREETMAP TEAM (HOT)

INTRODUCTION

The Humanitarian OpenStreetMap Team (HOT) applies the principles of Open Source and Open Data sharing for humanitarian response and economic development.

> "HOT provides maps for disaster management, risk reduction and to help disaster responders."

HOT provides maps for disaster management, risk reduction and to help disaster responders. HOT mainly uses OpenStreetMap and publishes additional analytics tools and detailed guides to promote their approach and enable further replication.

HOT uses OpenStreetMap applications to

- create open map data that enables disaster responders to reach those in need
- create maps of highly vulnerable areas where data is scarce
- collaboratively collect geospatial data
- publish and analyse collected data openly

METHOD OF DATA COLLECTION

HOT projects identify data gaps and develop strategies to fill them. Maps, roads, buildings, infrastructure, administrative borders, refugee camps, outbreaks of infections and more are made visible through the involvement of volunteers.

HOT has applied the principles of collaborative mapping to a variety of complex issues. While the spatial data is collected from a variety of sources (see below), the actual process of mapping (collecting data) is astonishingly simple: Individual users compare a piece of information with the graphical display of the map. They transpose the information onto the map using simple computer mouse actions. The inherent potential that lies in that simplicity unfolds in its scalability: A single user may only be able to fill a few grid squares at a time, but thousands of users can map an entire city in a relatively short time to possibly save lives.

The following data sources and mapping formats are used by HOT to create / enrich maps:

- imports of existing datasets
- manual mapping and categorization bases on satellite images
- digitisations of satellite imagery (e.g. DigitalGlobe, Google Maps)
- community mapathons and trainings
- knowledge transfers and workshops
- validations of ground surveys / on-the-ground reports
- drone imagery

The data is transferred onto online maps based on OpenStreetMap using layers and data points. The maps are made openly available and additional functions such as mapping statistics are included and presented alongside.

SOURCES

- HOT Participatory Mapping Toolkit: Web | PDF
- learnOSM (Learn OpenStreetMap step by step)
- HOT Training Center: repository of courses related to HOT, volunteer activation and more
- HOT Export Tool: open service that creates customized extracts of OSM data in various file formats
- HOT on the Humanitarian Data Exchange: data repository with detailed search functions
- HOT Task Manager: display of currently available mapping initiatives
- OSM Analytics / Github: analytics tool to display metrics and analytics

INTERESTED IN OTHER MAPPING APPLICATIONS?

CHECK OUT CHAPTER 4.3

> "Safetipin therefore offers a unique proposition by providing qualitative data that is otherwise difficult – if not impossible – to obtain."

SIMILARPROJECTS

- *Ushahidi (paid collaborative mapping management tool)*
- *Standbytaskforce*

Universidad de Antioquia research staff and YouthMappers mapping fishing villages in Northern Colombia[33]

DATA INTEGRATION

Since HOT is active in a variety of different contexts, the data integration differs from project to project. In Semarang, a city critically prone to tidal flood and landslides, HOT collaborated, among others, with Petabencana to map over 482,000 buildings; 4.4 million meters of roads; 433 meters of waterways; and 11,000 infrastructures. The whole process took only four months, covering all 177 villages and 16 sub-districts. The project was part of InAWARE, a project funded by the U.S. Agency for International Development (USAID), the Office for Foreign Disaster Assistance (OFDA), and the Pacific Disaster Center (PDC) in order to provide the Government of Indonesia's National Agency for Disaster Management (BNPB) with technical assistance to improve early warning and disaster management decision making.

In another case in the Democratic Republic of Congo, HOT collaborated with the Ministry of Public Health to map over 250,000 buildings and thousands of roads to enable the ministry to support relief efforts related to the Ebola outbreak in mid-2018. In Osaka, Japan, heavily impacted areas following the earthquake were mapped to rapidly develop an overview of destroyed infrastructures.

06

CONCLUSION & RECOMMENDATION

Social Media

SMS Technology

DIY-Sensor-driven tools

Smartphone apps

Mapping applications

06

CONCLUSION & RECOMMENDATIONS

SOCIAL MEDIA

- Basic information such as text, images, GPS tags, voice and video recordings can easily be shared through social media if internet access is available. Due to their wide adoption, Social Media are powerful tools and may therefore be a preferable option to the creation of a new smartphone or web application.
- Group conversations (WhatsApp, Facebook, other messaging platforms) offer an easy yet unstructured way of coordinating groups of up to 256 users and are low-cost solutions to disseminate alerts and other messages
- Hashtags (Twitter, Facebook) offer a way to structure real-time data
- Online document processing applications such as Google Drive, HackMD and padlet offer ways to structure information rapidly
- Privacy concerns can be an issue, either because the data entered in social media is used for targeted advertising or because private data is made openly accessible

Recommendations: When information needs be spread immediately in emergency situations, social media provide a potential backbone.

> “For medium and long-term planning and management cities and municipalities should increase their independence from those international platforms in order to restore data ownership.”

For medium and long-term management, cities and municipalities should increase their independence from those international platforms in order to restore data ownership. Despite the above mentioned concerns, these channels offer the distinctive benefit of a pre-existing network and should be taken into consideration.

SMS TECHNOLOGY

- SMS-based tools and applications benefit from the wide distribution of mobile devices, even in developing regions and remote areas.
- Using SMS, users can interact with computers through a backend and corresponding software such as FrontlineSMS. This enables automated communication networks. For the efficient distribution of food and shelter in times of crisis, such systems can be established in regions where only cellular access is available.
- Combining a backend with other services (GPS, forecast algorithms and more) allows for the distribution of a wide range of data to individual receivers, such as weather alerts.

Recommendations: SMS may seem outdated as a technology in light of the rise of social media platforms like Facebook or WeChat. However, as an easily accessible, cheap, robust and energy-saving technology, it nonetheless has potential as a backbone technology and should not be dismissed.

> **“Innovations on the backend such as data processing, chat bots, artificial intelligence improve the utility of SMS technology.”**

Innovations on the backend such as data processing, chat bots, artificial intelligence improve the utility of SMS technology.

DIY-SENSOR-DRIVEN TOOLS

- DIY-Sensing tools are relatively low-cost programmable devices equipped with sensors that are commonly based on microcontrollers such as the Arduino platform.
- They are used by citizens, researchers and others to record specific environmental data (temperature, humidity, fine dust particle concentration, radiation, and more)
- The measurements are made:
  1. to complement data in case of scarcity or unavailability
  2. to create independent measurements as a means of control
  3. to raise awareness on environmental issues (e.g. problematic levels of fine dust)
  4. for research purposes
- All of the sensing projects presented below offer ways to automatically plot the generated data on interactive online maps.
- In most cases the generated information is published as Open Data.
- The technical experience required varies between the devices. Some (SenseBox, bGeige) require the user to assemble and program the device themselves, others (Breeze) are plug-and-play.
- The costs also vary greatly from 30€ on the low-end to 1000€ and more on the high-end, with self-assembly variants tending to be cheaper and more complex sensors (e.g. radiation) tending to be more expensive.
- Plug-and-play variants are commonly the most expensive solutions.

Recommendations: DIY-Sensors are easy and affordable solutions to gather environmental data. The accuracy of the measurements varies between the devices depending on the sensor setup, their design and the data recorded. Professional sensor systems operated by cities and public institutions commonly use much more expensive sensors, employ different and more complex measuring techniques and use standardized configurations making their measurements more accurate. Future changes in the design of the components used in DIY-sensors combined with sinking costs are variables that could improve their accuracy.

> “While DIY-sensors are unlikely to replace professional sensor systems as a primary data source, cites could benefit from using them to increase the density of existing sensors network, raise citizen awareness and to perform pre-tests for urban innovation processes. “

While DIY-sensors are unlikely to replace professional sensor systems as a primary data source, cites could benefit from using them to increase the density of the pre-existing sensor network, raise citizen awareness and to perform pre-tests for urban innovation processes.

SMARTPHONE APPS

- In the context of climate adaptation Apps make creative use of smartphone sensors (sound, image, motion) and modules (GPS, Wi-Fi). Due to continuously decreasing prices, smartphones are on the way to substitute “traditional” mobile phones.
- Apps exist for a wide range of purposes from reporting damages to urban infrastructures, measuring noise in urban environments and generating safety reports based on subjective indicators.
- Firechat re-appropriates the Wi-Fi and Bluetooth sensors to create an ad hoc so called “mesh net” (communication network using devices as nodes) in case of unavailable cellular connections. This technology could be especially relevant when used to power urban emergency apps
- Smartphone apps are low-cost solutions to bring needed applications into the hands of citizens, but face the main challenge of acquiring and sustainably engaging users over time

Recommendations: While in the last years it becomes quite common for cities and municipalities to develop and integrate apps in the urban planning and management process, it is recommendable to review existing solutions before creating a new app. In some cases, the source code is publicly available and can be adapted (e.g. FixMyStreet), in others, the intended functionality can be performed using Social Media (see above), in others, app-based solutions have already been tested and did not achieved the expected results.

> “If cities are starting a development process for app-based solutions, the focus must be the user and the benefits for them to incentivize adoption and use.”

If cities are starting a development process for app-based solutions, the focus must be the user and the benefits for them to adopt and use the app.

MAPPING APPLICATIONS

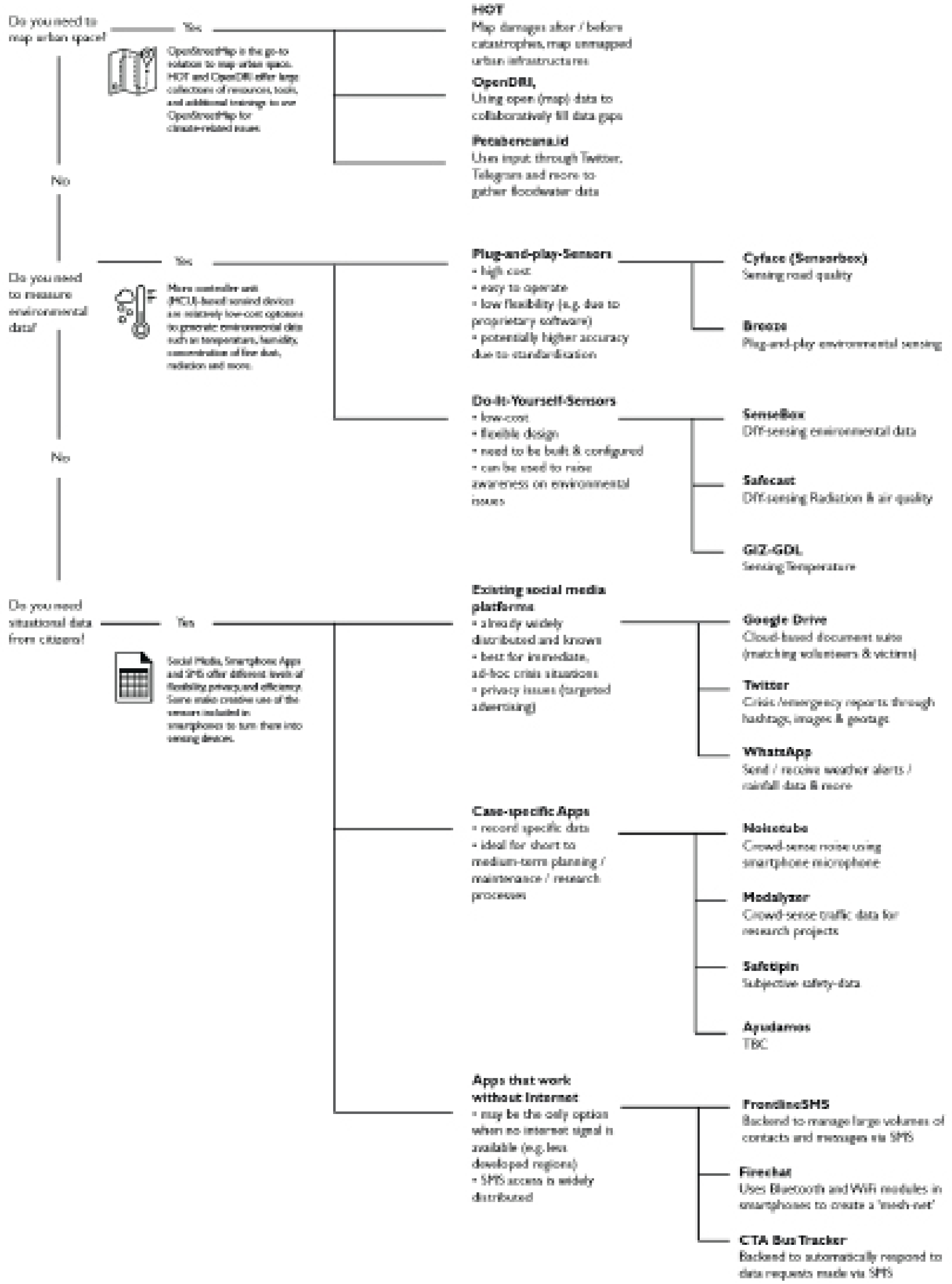
- Online-Maps are highly important tools to coordinate humanitarian efforts, research geospatial phenomena, display environmental data and plan urban strategies of disaster risk reduction and resilience building
- The most common purpose of mapping initiatives is to fill data gaps, e.g. by mapping infrastructures or whole cities in areas prone to risk or by geotagging the spread of diseases
- OpenStreetMap is the main driver behind mapping applications in the context of climate adaptation and numerous resources exist to train collaborators
- The principles of Open Data and Open Source are key to the success of mapping initiatives and OpenStreetMap demonstrates this with high numbers of specific applications, tools and services that have been built on top of it

Recommendations: Google Maps and Open Street Maps (OSM) disrupted the provision of spatial information by offering a single portal for worldwide highly detailed and freely accessible maps.

> "While Google Maps has a commercial and closed-source business model, OSM is a non-profit based on openly available source code that can be flexibility adapted to case-specific contexts."

While Google Maps has a commercial and closed-source business model, OSM is a non-profit based on openly available source code that can be flexibility adapted to case-specific contexts. Most of the web services and apps presented here rely on OSM due to the fact that Google Maps only offers highly limited options to enter new data onto their Maps, while OSM is entirely community-built. The actual process of mapping (entering new data into OSM) is simple and benefits from its scalability. Users transfer information derived from datasets, satellite images and first-hand sources onto the map using simple computer mouse gestures. A single user may only be able to fill a few grid squares at a time, but tens, hundreds or thousands of users can map an entire city in a relatively short time to possibly save lives. .

THE FLOWCHART BELOW SUMMARIZES THE TOOLS PRESENTED IN THIS COLLECTION OF CASE STUDIES AT A GLANCE. IT AIMS TO PROVIDE URBAN PRACTITIONERS A QUICK AND ACCESSIBLE OVERVIEW OF THE TOOLS PRESENTED HERE WITH THE CORRESPONDING FIELD OF APPLICATION. IT GUIDES THE USER FROM THE TYPE OF DATA NEEDED TO THE VARIOUS OPTIONS AVAILABLE, WITH EXPLANATIONS AND RECOMMENDATIONS PRESENTED ALONGSIDE



SOURCES

1 https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html retrieved 15.10.19
2 Monthly active Facebook users (Statista), retrieved 15.12.2018 via https://www.statista.com/statistics/264810/number-of-monthly-active-facebook-users-worldwide/
3 Monthly active WhatsApp users (Statista), retrieved 15.12.2018 via https://www.statista.com/statistics/260819/number-of-monthly-active-whatsapp-users/
4 Monthly active Twitter users (Statista), retrieved 15.10.2019 via https://www.statista.com/statistics/282087/number-of-monthly-active-twitter-users/
5 Internet and social media use shows no growth in advanced economies but continues to rise in emerging and developing countries (Pew Research Center) http://www.pewglobal.org/2018/06/19/social-media-use-continues-to-rise-in-developing-countries-but-plateaus-across-developed-ones/pg_2018-06-19_global-tech_0-00/
6 You think Facebook is free? Well, it'll only cost you your private life (Observer editorial) https://www.theguardian.com/commentisfree/2013/dec/29/observer-editorial-digital-privacy
7 Screenshots of the Petabencana map view (Last Access: 09.09.2019)
8 https://www.thehindu.com/news/national/tamil-nadu/what-led-to-the-2015-chennai-floods/article23326651.ece (last access 09.09.2019)
9 © GIZ / Robert Heine
10 Complete case study of FrontlineSMS in Pakistan. Retrieved 15.12.2018 via: http://static1.squarespace.com/static/56e1a99907eaa0941d037b0a/56e1aaff06dcb7bbf42a7ba7/56e1aaec06dcb7bbf42a7954/1457629932722/frontlineSMS_Pakistan_Floods_280513.pdf?format=original
11 Bus Tracker API Documentation: https://www.transitchicago.com/developers/bustracker/ (Last Access: 09.09.2019)
12 Bus Tracker API Documentation: https://www.transitchicago.com/developers/bustracker/ (Last Access: 09.09.2019)
13 https://blockclubchicago.org/2018/10/22/busy-no-66-chicago-bus-to-get-its-own-lane-as-part-of-5-million-mayoral-push/ (Last access 10.09.2019)
14 Retrieved 15.12.2018 via: https://safecast.org/tilemap/
15 Grouphunt Crowdfunding product page of bGeige. Retrieved 15.12.2018 via: https://www.grouphunt.sg/product/kickstarter-gold-safecast-bgeigie-raku
16 Reproducible Environmental Observations and Analysis: https://nuest.github.io/sensebox-binder/sensebox-analysis.html (Last Access 09.09.2019)
17 Reproducible Environmental Observations and Analysis: https://nuest.github.io/sensebox-binder/sensebox-analysis.html (Last Access 09.09.2019)
18 © GIZ / Andreas König
19 Breeze Website https://www.breeze-technologies.de/
20 http://hamburg.breeze-technologies.de/
21 https://en.wikipedia.org/wiki/FireChat#/media/File:FireChat_logo.png (Last Access 09.09.2019)
22 https://www.wired.com/2015/10/giant-network-for-free-messaging/ (Last Access 09.09.2019)
23 https://www.google.de/search?q=fixmystreet&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiH_In76rbkAhW8TxUIHc4PDMkQ_AUIEygC&biw=1301&bih=619#imgrc=tbrqlbQAv6dViM:&spf=1567588718302 (Last Access 09.09.2019)
24 https://www.google.de/imgres?imgurl=http%3A%2F%2Fsafetipin.com%2Ftheme-assets%2Fsafetipin_common%2Fimages%2Fbanner-track.png&imgrefurl=http%3A%2F%2Fsafetipin.com%2F&docid=szj2XE21I28qvM&tbnid=Foeo24hx1UniZM%3A&vet=10ahUKEwiI7oT6l7fkAhVeVRUIHV0bCJAQMwhPKAkwCQ..i&w=1354&h=520&bih=867&biw=1821&q=safetypin%20app&ved=0ahUKEwiI7oT6l7fkAhVeVRUIHV0bCJAQMwhPKAkwCQ&iact=mrc&uact=8#spf=1567600803541 (Last Access 09.09.2019)
25 https://play.google.com/store/apps/details?id=com.safetipin.mysafetipin&hl=en (Last Access 09.09.2019)
26 http://centromariomolina.org/wp-content/uploads/2016/09/Enrico-Howe-2.pdf (Last Access 09.09.2019)

SOURCES

27 GIZ Fotowettbewerb Urban October
28 https://www.cyface.de/app/ (Last Access 09.09.2019)
29 WHO Europe Press release explaining the impact of noise pollution: http://www.euro.who.int/en/media-centre/sections/press-releases/2009/10/one-in-five-europeans-is-regularly-exposed-to-sound-levels-at-night-that-could-significantly-damage-health
30 GIZ Fotowettbewerb
31 Wikipedia Stats. Retrieved 15.12.2018 via: https://wiki.openstreetmap.org/wiki/Stats
32 https://de.wikipedia.org/wiki/OpenStreetMap#/media/Datei:Openstreetmap_logo.svg (last access 09.09.2019)
33 Universidad de Antioquia: Mapping Coastal Wetlands (HOT project). via: https://www.hotosm.org/projects/universidad-de-antioquia/ (Last Access 09.09.2019)

APPENDIX

Ashok, K., December 12, 2015. Chennai after the deluge: How social media came to the rescue. [WWW Document]. Livemint. [WWW Document] URL https://www.livemint.com/Sundayapp/S89VfrXLGaoRSSKPBC6qLL/Chennai-after-the-deluge-How-social-media-came-to-the-rescu.html (accessed 12.15.18).

International Bank for Reconstruction and Development. Development Association or The World Bank., 2014. OPEN DATA FOR RESILIENCE INITIATIVE: PLANNING AN OPEN CITIES MAPPING PROJECT. URL https://opendri.org/wp-content/uploads/2014/12/Planning-an-Open-Cities-Mapping-Project_0.pdf (accessed 12.15.18).

International Telecommunication Union, 2017. Measuring the Information Society Report 2017 Volume 1 (2017). URL https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2017/MISR2017_Volume1.pdf (accessed 12.15.18).

Fuchs, H., December 29, 2017. New Year's Eve: Are fireworks harming the environment? [WWW Document]. DW. URL https://www.dw.com/en/new-years-eve-are-fireworks-harming-the-environment/a-41957523 (accessed 12.15.18).

Free Software Foundation Europe, 2018. Definition of Free and Open Source Software. [WWW Document]. Free Software Foundation Europe. URL https://fsfe.org/about/basics/freesoftware.en.html (accessed 12.15.18).

Future Climate for Africa., February 15, 2017. Capitalising on communication channels – How Malawi uses WhatsApp for weather information. [WWW Document]. Future Climate for Africa. URL http://www.futureclimateafrica.org/news/blog-capitalising-on-communication-channels-how-malawi-uses-whatsapp-for-climate-information/ (accessed 12.15.18).

FrontlineSMS. 2018. CASE STUDY Sending a Message of Accountability: SMS Helps Improve Services after Pakistan Floods. [WWW Document]. URL http://static1.squarespace.com/tatic/56e1a99907eaa0941d037b0a/56e1aaff06dcb7bbf42a7ba7/56e1aaec06dcb7bbf42a7954/1457629932722/frontlineSMS_Pakistan_Floods_280513.pdf?format=original (accessed 12.15.18).

Malik, D., February 2, 2016. Emergency response in the Whatsapp era! [WWW Document]. URL http://blogs.worldbank.org/endpovertyinsouthasia/emergency-response-whatsapp-era (accessed 12.15.18).

Merriam Webster, 2018. Definition of Social Media [WWW Document]. URL http://blogs.worldbank.org/endpovertyinsouthasia/emergency-response-whatsapp-era (accessed 12.15.18).

Opensource.com, 2018. Definition of Open Hardware [WWW Document]. URL https://opensource.com/resources/what-open-hardware (accessed 12.15.18).

Pew Research Center, 2018. Internet and social media use shows no growth in advanced economies but continues to rise in emerging and developing countries [WWW Document]. URL http://www.pewglobal.org/2018/06/19/social-media-use-continues-to-rise-in-developing-countries-but-plateaus-across-developed-ones/pg_2018-06-19_global-tech_0-00/ (accessed 12.15.18).

APPENDIX

Safecast, 2018. ABOUT CALIBRATION AND THE BGEIGIE NANO. [WWW Document]. URL https://blog.safecast.org/faq/about-calibration-and-the-bgeigie-nano/ (accessed 12.15.18).
Stinson, E., December 12, 2015. THIS APP IS BUILDING A GIANT NETWORK FOR FREE MESSAGING [WWW Document]. Wired. URL https://www.wired.com/2015/10/giant-network-for-free-messaging/ (accessed 12.15.18).

Statista, (2018). Number of monthly active Facebook users worldwide. [WWW Document]. URL https://www.statista.com/statistics/264810/number-of-monthly-active-facebook-users-worldwide/ (accessed 12.15.18).

Statista, (2018). Number of monthly active WhatsApp users. [WWW Document]. URL https://www.statista.com/statistics/260819/number-of-monthly-active-whatsapp-users/ (accessed 12.15.18).

Statista, (2018). Number of monthly active Twitter users. [WWW Document]. URL https://www.statista.com/statistics/282087/number-of-monthly-active-twitter-users/ (accessed 12.15.18).

Technology Enquirer, October 12, 2015. Marikina unveils messaging app for disaster alert that works sans Wi-Fi, phone signals. [WWW Document]. Technology Enquirer. URL https://technology.inquirer.net/44812/marikina-unveils-messaging-app-for-disaster-alert-that-works-sans-wi-fi-phone-signals (accessed 12.15.18).

The Guardian, (2013). You think Facebook is free? Well, it'll only cost you your private life. Observer editorial. [WWW Document]. The Guardian. URL https://www.theguardian.com/commentisfree/2013/dec/29/observer-editorial-digital-privacy (accessed 12.15.18).

The Open Definition, (2018). Definition of Open Data. [WWW Document]. URL https://www.merriam-webster.com/dictionary/social%20media (accessed 12.15.18).

Toor, A., May 19, 2016. This app lets rescue workers send offline alerts when disaster strikes [WWW Document]. The Verge. URL https://www.theverge.com/2016/5/19/11711686/firechat-alerts-app-natural-disaster-mesh-network (accessed 12.15.18).

Verma, S., 2018. Chennai is Flooding and It Really Needs Your Help!. [WWW Document]. tripoto. URL https://www.tripoto.com/trip/chennai-flood-helplines (accessed 12.15.18).

WHO Europe., October 8, 2009. One in five Europeans is regularly exposed to sound levels at night that could significantly damage health. [WWW Document]. WHO Europe. URL http://www.euro.who.int/en/media-centre/sections/press-releases/2009/10/one-in-five-europeans-is-regularly-exposed-to-sound-levels-at-night-that-could-significantly-damage-health (accessed 12.15.18).

Wikipedia, 2017. Wikipedia Statistics. [WWW Document]. Wikipedia. URL https://wiki.openstreetmap.org/wiki/Stats (accessed 12.15.18).

IMPRESSUM

Published by:
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn, Germany

Friedrich-Ebert-Allee 36 + 40
53113 Bonn

T +49 228 44 60-0

E climatedigitalcities@giz.de
I https://www.climate-digital-cities.com/
Bonn, Germany 2019

Author/responsible for content/editor:
Bela Seeger and The Open Knowledge Foundation
GIZ is responsible for the content of this publication.