

# Árbol IoT

## ENGAGING CITIZENS IN URBAN TREE MAPPING & ENVIRONMENTAL MONITORING

@Guadalajara, Mexico

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Implemented by:



On behalf of:



Federal Ministry  
for the Environment, Nature Conservation  
and Nuclear Safety

In cooperation with:



Federal Ministry  
of the Interior, Building  
and Community



In partnership with:

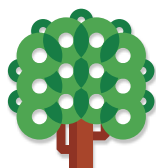


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Árbol IoT



CLIMATE DIGITAL  
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This project is part of the International Climate Initiative (IKI). The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports the initiative based on a decision of the German Bundestag.

# 01

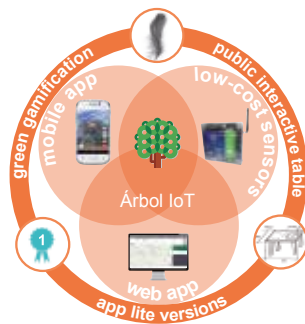
## Internet of Trees

### Árbol IoT in a Nutshell

Árbol IoT or Internet de los Árboles (IoTrees or the Internet of Trees in English) is a platform to engage citizens in urban tree mapping and environmental monitoring. Designed and implemented in the City of Guadalajara, Mexico, it aims to empower citizen advocacy and support municipal urban tree management to improve the greenery in the city. Thus, contributing to ameliorate high temperatures and buffer the impacts of flood events. The platform seeks to crowdsource an easy-to-update urban tree inventory, visualize and quantify the eco-benefits of trees and assist in public decision-making based on data and evidence.

Árbol IoT is a cross-platform composed of a mobile and web app, and a network of low-cost sensors that allows citizens to monitor the pollutants suspended in the environment, weather and noise on a street scale. The platform encourages engagement with

green gamification and enables participation of a wide range of the population, including the elderly. It fosters inclusion through a mobile interactive table that can be placed in public spaces and used by citizens who don't have access to digital technology. Lite versions of the mobile app allow citizens with limited or no mobile data connection on their devices to map and capture information offline and, later, upload it when WiFi connection is available.



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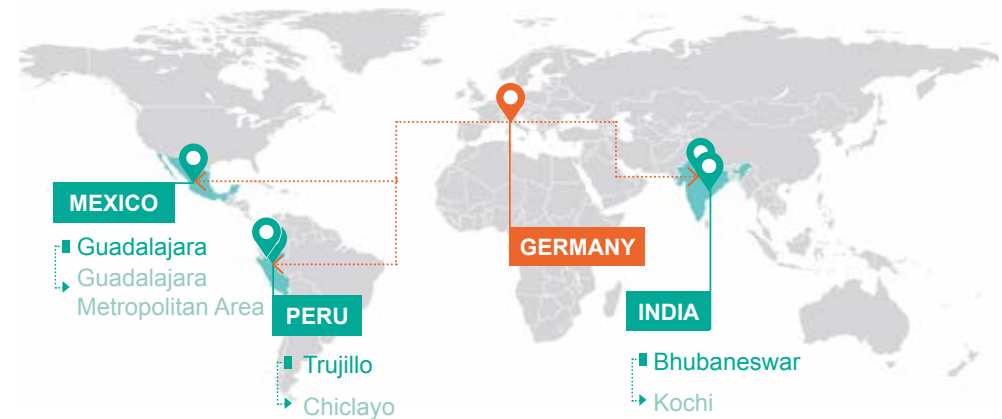




### Árbol IoT as part of the “ICT-based Adaptation to Climate Change in Cities” Global Program

Árbol IoT was conceived in the framework of activities of the Global Program “ICT-based Adaptation to Climate Change in Cities (ICT-A)”. The program’s goal is to ideate, implement and upscale digital solutions

to support selected cities in Peru, Mexico and India become more resilient. Following the program’s strategic principles (see p. 9-10) the digital solutions contribute to achieving Climate Digital Cities. ICT-A is implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the



German Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU) as part of their International Climate Initiative (IKI).

### The Climate Digital Cities Hub

The Climate Digital Cities Hub is an online platform designed to

showcase digital solutions that tackle climate change in cities. Here, further information and a transfer package (including links to a repository with the code source) about Árbol IoT and other digital solutions can be found:

[www.climate-digital-cities.com](http://www.climate-digital-cities.com)

# Árbol IoT & the SDGs

Árbol IoT contributes to the following Sustainable Development Goals (SDGs):



## Árbol IoT & Mexico's NDCs

Árbol IoT is contributing to the following goals of Mexico's Nationally Determined Contributions (NDCs<sup>1</sup>) in the Adaptation Area (Adaptation to climate change for the social sector):

- **Point 1.ii:** Ensure capacity building and participation of the society, local communities, indigenous peoples, women, men, youth, civil organizations and private sector in national and subnational climate change planning.
- **Point 1.iii:** Reduce the population's vulnerability and increase its adaptive capacity through early warning systems, risk management, as well as hydro-meteorological monitoring, at every level of government.
- **Point 1.iv:** Strengthen the adaptive capacity of the population through transparent and inclusive mechanisms of social participation, designed with a gender and human rights approach. planning.

- **Point 1.viii:** Reducing at least by 50% the number of municipalities in the category of "most vulnerable"

Overall, Árbol IoT contributes to the NDCs call for multi-level governance by offering an adaptive solution at the city level, with the option of upscaling it to additional municipalities. Moreover, it helps to fulfil the identified needs of

capacity-building, knowledge exchange and innovation in the context of adaptation measures in the section "Capacity Building, Transfer of Technology and Finance for Adaptation". Specifically, the digital solution directly supports the identified need of "methods and tools to assess climate impacts, vulnerability and adaptation in specific sectors and regions".

<sup>1</sup>Government of Mexico (2016)  
Intended Nationally Determined Contribution



# 02

## Strategic Principles for » Climate Digital Cities «



Created by  
Adnen Kadri  
from the  
Noun Project

### FOSTER CITIZEN ENGAGEMENT

- Carrying out the program for and with citizens;
- Supporting participation of vulnerable groups;
- Allowing a wider range of experiences and knowledge to jointly find solutions to harness collective wisdom.



Created by  
Creative Mania  
from the  
Noun Project

### TACKLE LOCAL CLIMATE CHALLENGES

- Focusing on challenges identified by the citizens and that have been shown in climate scenarios, vulnerability assessments, etc.;
- Collecting and collating data and information to develop measures for climate adaptation;
- Providing inputs to guide resilience in urban infrastructure.



Created by  
Martin Vanzo  
from the  
Noun Project

### CONTRIBUTE TO THE CITY'S PLANNING PROCESS

- Aligning activities to current urban planning processes;
- Identifying missing data needed to increase urban resilience;
- Anchoring collected data to current open data efforts and existing information systems.



Created by  
Yu Luck  
from the  
Noun Project

### PROMOTE LOCAL CO-CREATION

- Drawing upon local innovation ecosystems;
- Supporting involvement and further development of local talent;
- Enabling social appropriation of the jointly developed measures.



Created by  
BomSymbols  
from the  
Noun Project

### PLAN & IMPLEMENT FOR SUSTAINABILITY

- Contribute to the long-term vision of the city, setting short-term actions;
- Involving a wide range of stakeholders and communicating in an easy to understand manner;
- Aligning local, regional and national strategies.



Created by  
Deivid Sáenz  
from the  
Noun Project

### FACILITATE TRANSFERABILITY & UPSCALING

- Managing knowledge, documenting innovative approaches and good practices in a precise manner;
- Feeding back lessons learned and success factors to improve the process;
- Spreading the knowledge, i.e. tools, results, etc.



Created by  
Rajakumara  
from the  
Noun Project

### MAKE A RESPONSIBLE USE OF DATA

- Complying with international standards as well as national and local norms and regulations;
- Addressing and mitigating risks to data protection and cyber security;
- Strengthening the citizens digital competencies to recognize risks and threats, and protect themselves better.



Created by  
Rockicon  
from the  
Noun Project

### PRIORITIZE OPEN SOURCE

- Trying to reduce software and license dependencies for local governments and other stakeholders;
- Fostering collaboration with the local ecosystem and across sectors;
- Customizing existing open source solutions.

# Ideating, Implementing & Upscaling City Árbol IoT in Mexico



In each partner country, the Global Program ICT-A is carried out in two phases: (1) ideation and implementation, and (2) upscale. In Mexico, the program's political partner is the Ministry for Environment and Natural Resources (SEMARNAT in Spanish) through its General Direction of Climate Change Policies. The development partners for each phase are the following:

## PHASE 1

### Ideation & Implementation (Municipal Level)

- **Time frame:** 10/2017 - 09/2018
- **Partner:** Municipality of Guadalajara
- **Operative direction:** Direction of Government Innovation

## PHASE 2

### Upscale

(Metropolitan Level)



(Municipal Level)

- **Time frame:** 10/2018 - 12/2019
- **Partner:** Metropolitan Planning Institute of Guadalajara (IMEPLAN in Spanish)
- **Operative direction:** Direction of Sustainability and ICT

- **Time frame:** 10/2018 - 12/2019
- **Partner:** Municipality of Zapopan
- **Operative direction:** Directions of Environment and Economic Development

## KEY RESULTS (PHASE 1)

- > 2-month testing period
- > 5-day public mappathon
- > 5 installed sensor-prototypes
- > 477 app downloads
- > 11 272 notifications
- > 3 295 validated trees
- > 389 new captured trees





# 04

## Fighting Urban Flooding with Urban Trees

Throughout an innovative co-creation process, the Municipality of Guadalajara identified the need to improve the state, quality and quantity of their urban trees as a measure to adapt the city to the impacts of two major climate challenges: (1) increasing

temperatures and (2) extreme weather events. Also, the need to allocate more resources to improve urban trees was recognized by the citizens as priority in the participatory budgeting of 2017. Many trees have been planted in public areas by the municipality,

»Árbol IoT seeks to improve urban tree management and advocacy efforts to ameliorate high temperatures and buffer the impacts of flood events in Guadalajara.«

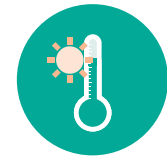
as well as by citizens. To efficiently plan and manage them towards improving their state and quantity, public officers need an overview of all the trees in the city and their current situation. Thus, the municipality needs to develop an easy-to-update urban tree inventory.

### EXTREME WEATHER EVENTS



Mature trees **regulate water flow**, preventing floods and reducing the risk of natural disasters.

### INCREASING TEMPERATURES



Urban trees can **cool the air** between 2 and 8 degrees Celsius.



Urban trees are priority for Guadalajara's citizens (**participatory budgeting 2017**).



»Árbol IoT was conceived putting citizens – not technology – at the core of its design! The platform is the result of an innovative co-creation process with the goal of meeting the city's and citizen's needs and desires, in a technologically feasible and iterative problem solving manner.«

# 05

## Citizen-Centered Design Approach

Digitally enhanced public services and citizen science hold great potential to increase climate resilience in cities, providing platforms for inclusion and improving the dialog between city administrations and citizens. Yet, tendencies to prioritize technology ahead of citizen's perspectives jeopardize their sustainability and scalability.

Árbol IoT was conceived putting citizens – not technology – at the core of its design. The platform is the result of an innovative co-creation process carried out under a citizen-centered design approach. It was the first time the City of Guadalajara developed a public service under such an approach.

The co-creation process carried out included Design Thinking Sprints - a multi-stakeholder method to develop digital solutions, meeting the city's and citizen's needs and desires, in a technologically feasible and iterative problem-solving manner. The co-creation process fostered cross-sector collaboration among several city departments.

It brought together representatives from different areas including those of environment, urban planning, citizen participation, government innovation, etc., as well as universities, research institutes, private companies, start-ups, activists, NGOs and citizen associations.

## 06

# Árbol IoT's Cross-Platform

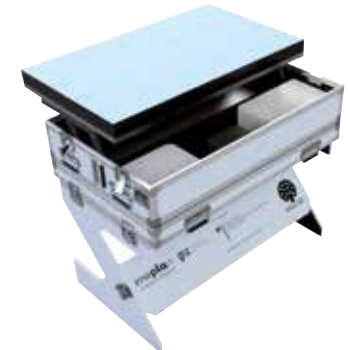
The cross platform is composed by four elements that generate or display information, which in turn can be administrated using a back-end system.



MOBILE APP

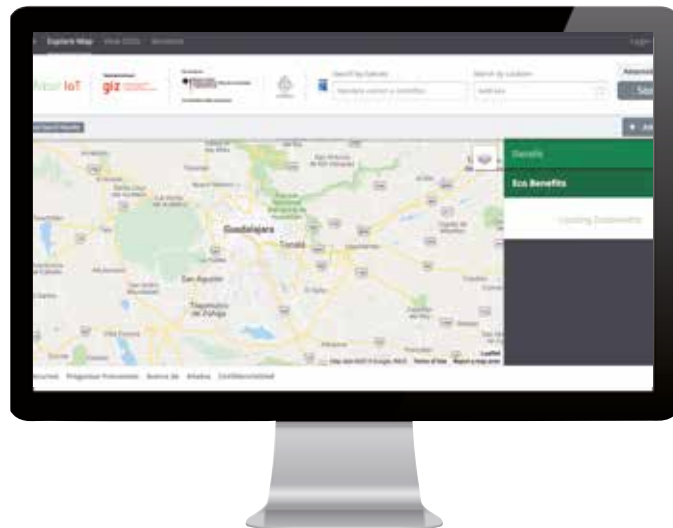


WEB APP

ENVIRONMENTAL  
SENSORPUBLIC  
INTERACTIVE TABLE

BACK-END

# Web APP & Back-End in Detail



## WEB APP

A web dashboard for citizens to access all the data and information collected with the app and low-cost sensors. Users can download the data and make basic data analytics such as the amount of carbon captured by trees.

[www.arbolesmapa.guadalajara.gob.mx/](http://www.arbolesmapa.guadalajara.gob.mx/)



## BACK-END PLATFORM

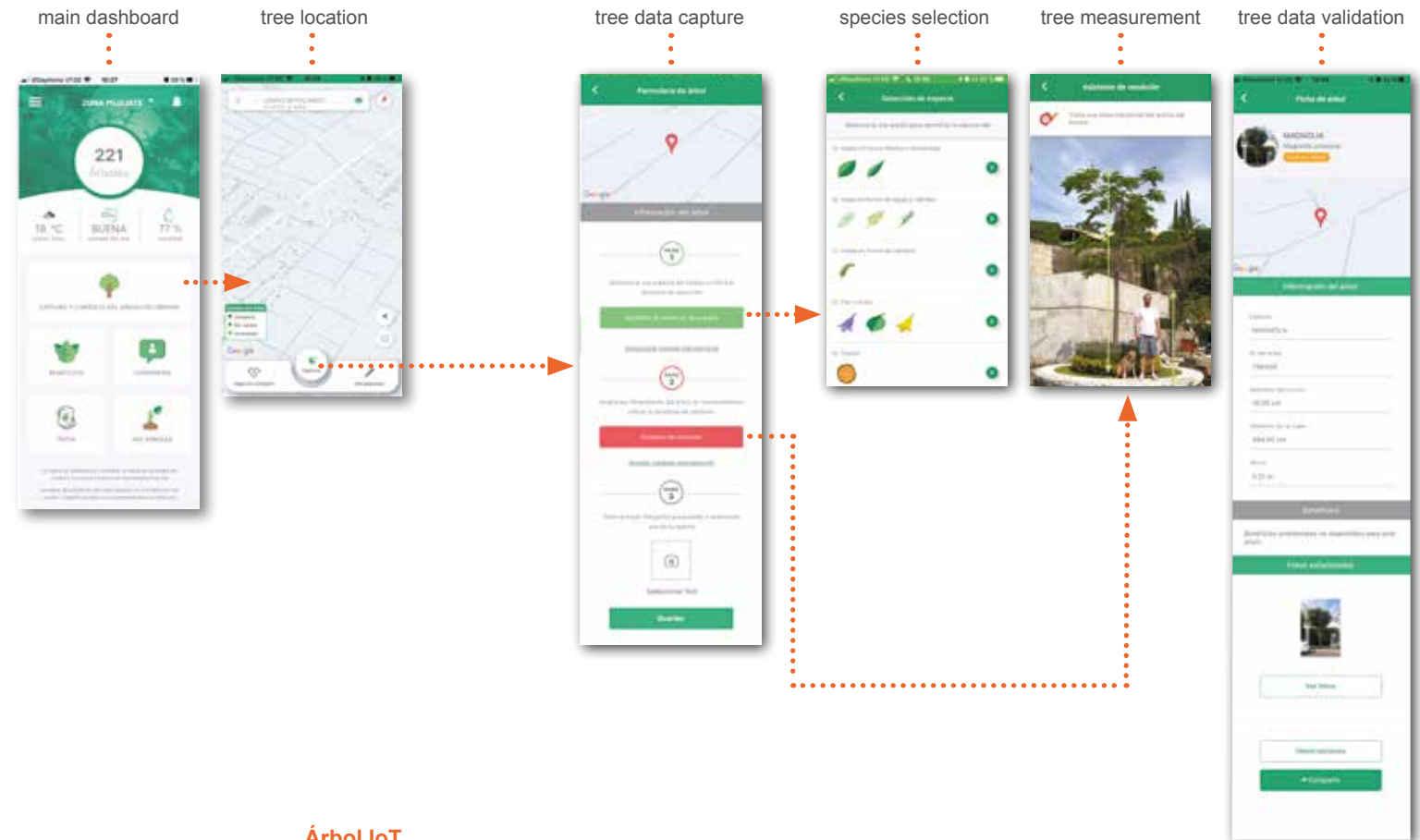
A back-end platform for internal use and management by the city. This web administrator is based on no-code accessibility allowing the municipally staff to make any update through the cross-platform (example push notifications, user management, content update, etc.).

# Mobile App in Detail

A mobile app for Android and iOS to crowdsource data about urban trees, inter alia using Augmented Reality (AR) and GPS. Besides capturing and validating urban trees, the app offers other complementary features that foster social a network and awareness raising:

- **Urban Trees:** To locate trees, identify the species and provide their measurements.
- **Eco-benefits:** To inform about the number of trees in a certain neighborhood and the positive impact that these have (e.g. energy savings in kWh).
- **Community:** To enable an exchange among users.
- **My Trees:** To inform the user about the green contributions generated by planted or adopted trees that they tend.
- **Reports:** To report anomalies.

## URBAN TREES (ÁRBOLES URBANOS)





## ECO-BENEFITS & MY TREES (BENEFICIOS & MIS ÁRBOLES)

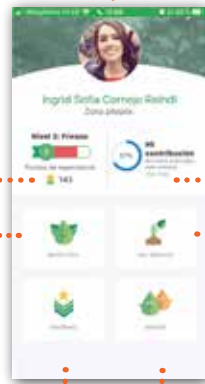
recognitions



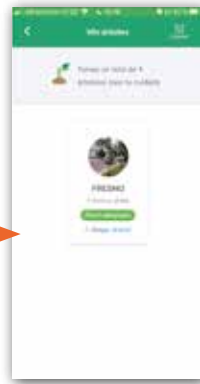
user level



user profile /  
account management



my trees



my contributions



eco-benefits



my friends



notifications



## QUIZ (TRIVIA)

quiz  
⋮



## COMMUNITY & REPORTS (COMUNIDAD Y REPORTES)

community  
⋮



reports  
⋮



»Árbol IoT is a good example of how digital solutions enable citizen participation to fight the impacts of climate change. It allows every small input to contribute to a pool of resources that help cities adapt and be more resilient.«



## Environmental sensor in Detail

The environmental sensor of Árbol IoT is a prototyped low-cost sensor with a microcontroller compatible

with Arduino Pro Mini that helps citizens to monitor:



AIR POLLUTION



SOUND



LIGHT



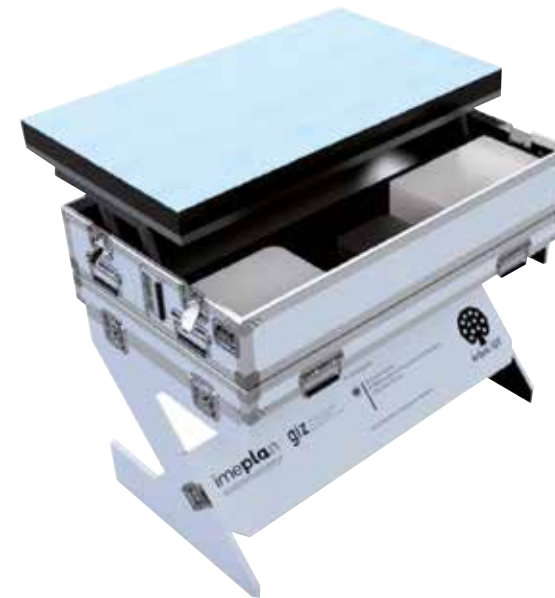
WEATHER



The device contains an internal rechargeable battery (LiPo) through USB or solar feed. The environmental sensor devices are interconnected through a NBIoT

(Narrow Band IoT) network. The data can in turn be accessed and visualized through the web and mobile app. It can also be piped to any other source.

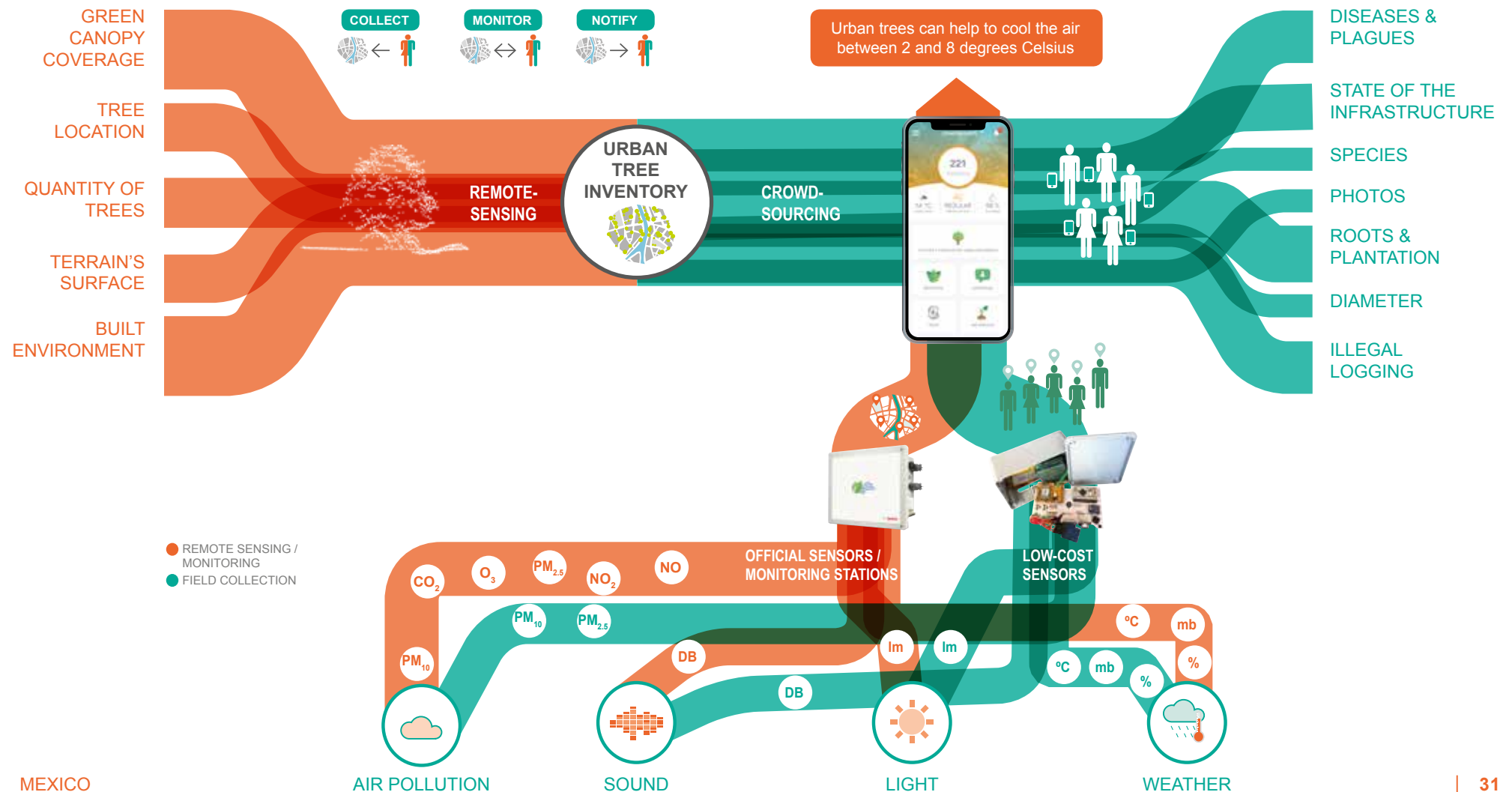
## Public Interactive Table in Detail



## 07

# Árbol IoT's Data Flow

The urban tree inventory is based on existing databases such as a 3D scanning of the city with LiDAR (Light Detection Ranging), which enables the number and location of trees. These databases needed to be complemented with tree data from the ground, for example species, height and trunk diameter. The eco-benefits of trees are visualized by crossing data from the inventory with real-time data about environmental conditions (air quality, noise, light and temperature).





## 08

# Digital Citizen Engagement & Inclusion

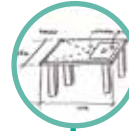
1

## GREEN GAMIFICATION

Árbol IoT uses gamification to encourage engagement. Citizens are motivated to use the platform and provide data through green point scoring. The green points can be earned by providing information about urban trees and environmental measures. Later on, the points can be exchanged for virtual awards in the form of local landmarks such as a virtual tequila bottle or a virtual cathedral building. In the future, these virtual awards will have the possibility to be exchanged for public services (e.g. parking time or discounts on property tax).

## APP “LITE” VERSIONS

For citizens who have access to smartphones but have very limited or no mobile data connection, a lite version of the mobile App is available. This lite version allows users to map and capture information offline and, later on, upload it when WiFi connection is available.



## PUBLIC INTERACTIVE TABLE

To “leave no one behind”, Árbol IoT envisions means to allow participation of citizens who don’t have access or don’t know how to use a smartphone or tablet. Thus, Árbol IoT will prototype a mobile public interactive table that can be placed in public spaces.

## 09

# International Transfer

**I want Árbol IoT in my city!  
How can I transfer it?**

As an open source technology, Árbol IoT is fully replicable! We are currently working on an interactive documentation package to transfer and upscale the platform to other international cities. The idea is to make the platform available using web-based hosting services. Interested cities can easily transfer and customize the platform to their specific needs, capacities and IT requirements. So, if you are thinking about developing something similar in your city, this is an option that can be easily transferred and tailored to fit your needs!

For further information and downloads of Árbol IoT please visit the Climate Digital Cities Hub:

[www.climate-digital-cities.com](http://www.climate-digital-cities.com)





# List of Abbreviations

<b>BMI</b>	Bundesministerium des Innern, für Bau und Heimat (German Federal Ministry of the Interior, Building and Community)
<b>BMU</b>	Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)
<b>DIY</b>	Do It Yourself
<b>GIZ</b>	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
<b>ICT</b>	Information and Communication Technology
<b>ICT-A</b>	Global Program Information and Communication Technology based Adaptation to Climate Change in Cities
<b>IKI</b>	Internationale Klimaschutzinitiative (International Climate Initiative)
<b>IMEPLAN</b>	Instituto Metropolitano de Planeación (Metropolitan Planning Institute) Guadalajara
<b>IoT</b>	Internet of Things
<b>LiDAR</b>	Light Detection Ranging
<b>NDC</b>	Nationally Determined Contributions
<b>NGO</b>	Non-Governmental Organization
<b>SEMARNAT</b>	Secretaría de Medio Ambiente y Recursos Naturales (Mexican Ministry for Environment and Natural Resources)
<b>SDG</b>	Sustainable Development Goals (17 goals of the 2030 Agenda for Sustainable Development developed by the UN in 2016 for a more sustainable future)
<b>UV</b>	Ultraviolet

# The Team

