Low Cost IoT / WSN for Citizen Applications:
An Indonesian case

Presented by :

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Outline

- Citizen applications
  - Healthcare, smartcities, environment, …
    - Examples : Air Casting, TTN, ...
  - Home IoT market
- Low cost IoT Devices
  - IoT / WSN components
  - End Devices and Gateways
  - Driving factors : DIY and Open Source
- Technological challenges
- Disaster monitoring, an Indonesian case

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Citizen Applications

- Environment:
  - Pollutions:
    - Air, ground, water, sounds / noises
  - Environmental and natural disasters:
    - Haze (ex. from forest fires), floods, earthquakes, ...
- Toward smart-cities ?
  - Understanding, Monitoring and Management
    - Ex. floods: management, warning systems, impacts (traffics, …)
- Healthcare

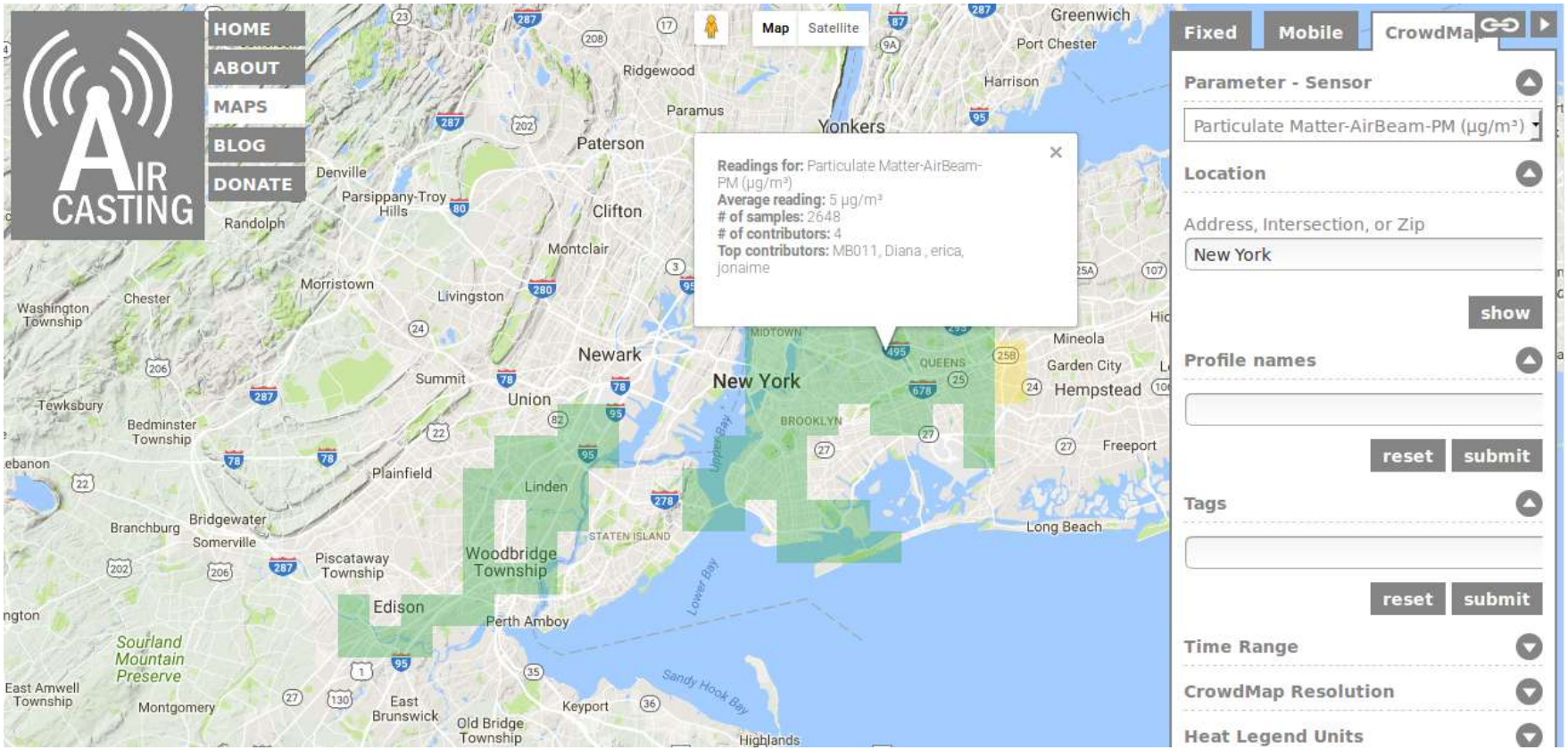
Air quality case

https://www.airparif.asso.fr/

Examples of citizen sensors

- Some examples of citizen sensor projects
  - https://citizensense.net/
  - http://making-sense.eu/
  - http://aircasting.org/
    - Temperature, air pollution, sound levels
    - DIY with Arduino

Example 1

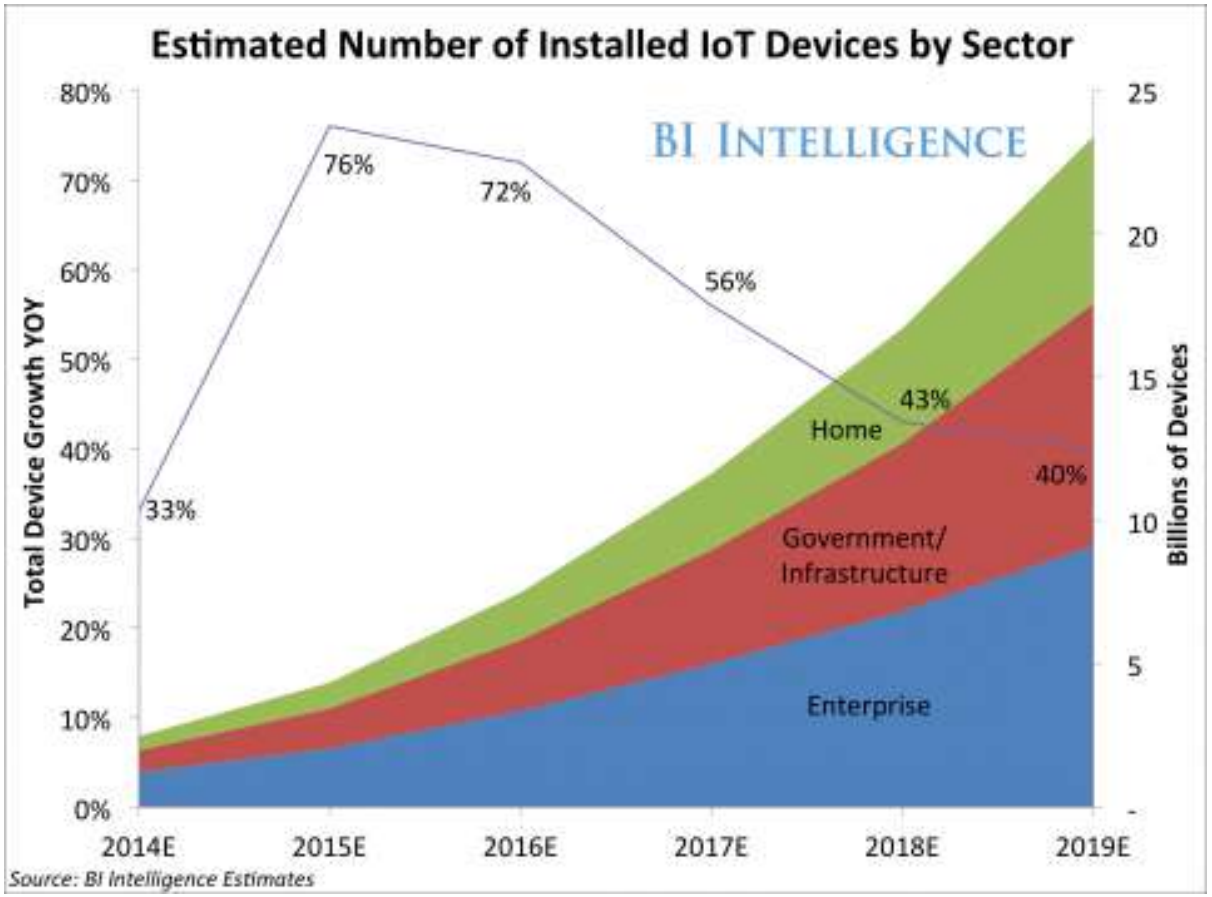


Source : http://aircasting.org/

Example 2

TTN : https://www.thethingsnetwork.org/

IoT Market : home



Source : http://uk.businessinsider.com/

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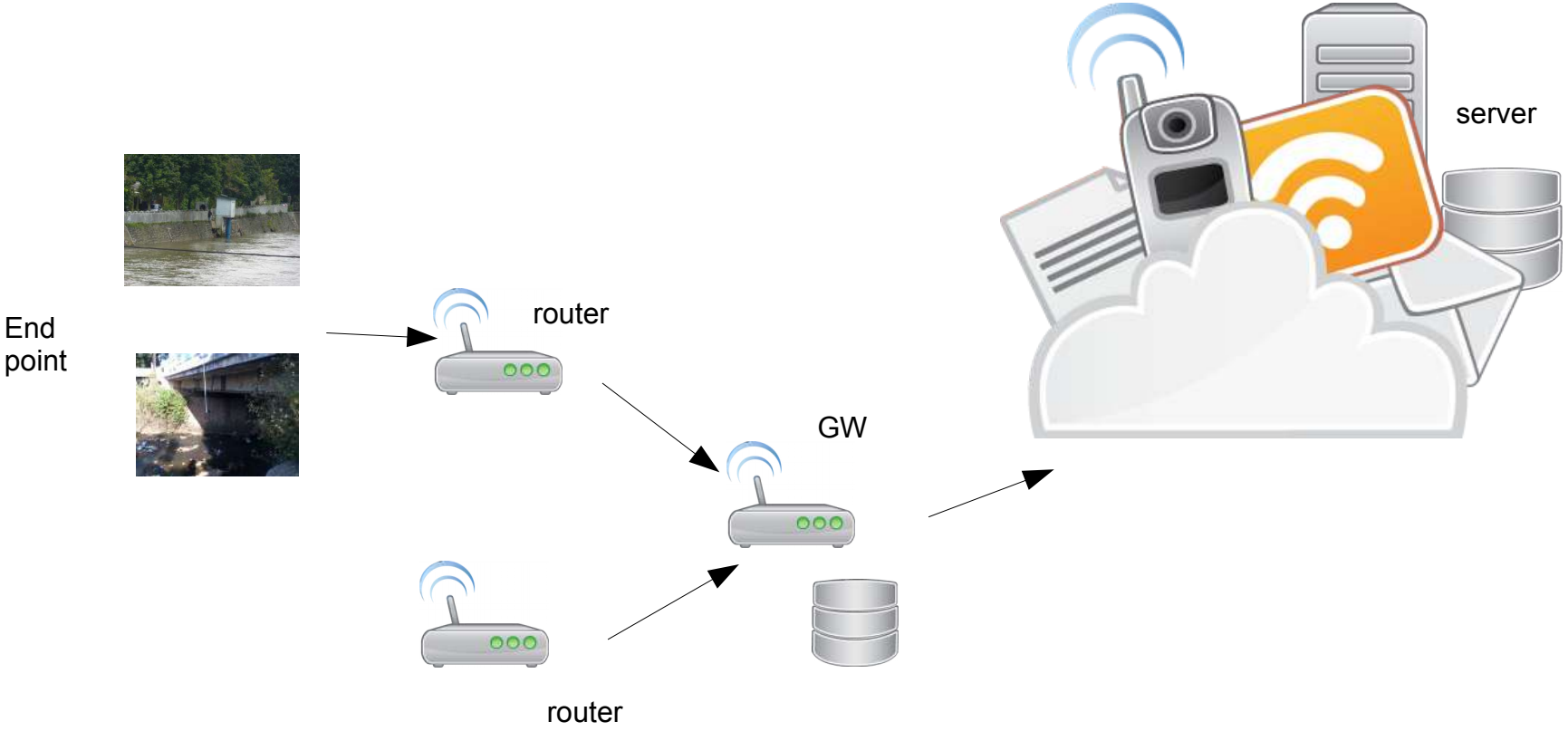
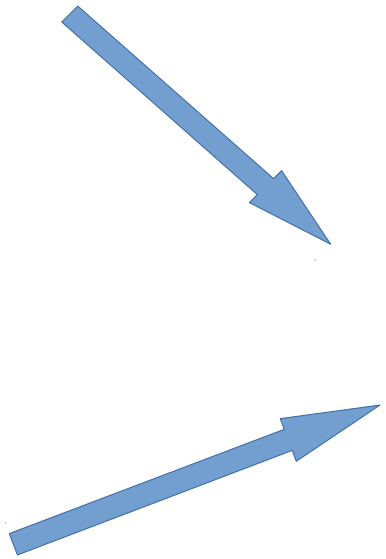
IoT Components



End Devices and Gateways

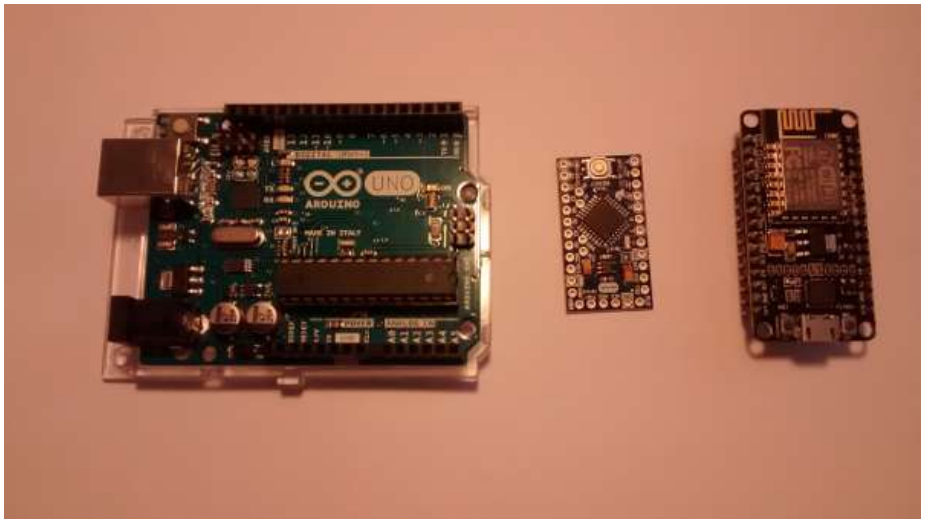
- End points
  - Micro-controller
  - Communication
  - Sensors
- Router/Gateway



Low cost

End Devices and Gateways

- DIY Platforms :
  - Arduino Uno, Arduino Pro mini, ESP 8266, Raspberry Pi



End Devices and Gateways

- Communication:
  - LoRa, ZigBee, BluetoothLE, …
- Sensors
- Open Source :
  - Arduino (HW + SW)
  - Raspberry Pi (SW)
  - Communication : SW (LoRa, Xbee API, …)

End Devices and Gateways

Budget examples:

End Device, pollution, CO

- Arduino mini pro : 4-15 €
- LoRa inAir9B : 15 €
- Sensor MQ7, CO : 6 €
- Antenna : 10 €
- Accessories : 10

Total 56 € → 60 €

End Devices and Gateways

- Budget DIY Gateway

  - Raspberry Pi : 32 €
  - iC880A-SPI – LoRaWAN Concentrator 868MHz : 155 €
  - Others (antenna, Power Supply, …) : 70,5 €
  - Total (HT) : 257,5 €

- https://github.com/ttn-zh/ic880a-gateway/wiki#ordering-the-parts

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Technological Challenges

- What should be measured rather than what is technically feasible to measure :
  - What kind of sensors ? What kind of measured data ?
  - Coverage :
    - AirParif data, number of stations ?
    - Low cost sensors, better coverage
- Calibration, accuracy :
  - Official data (good quality) vs low cost sensor data
  - Data from low cost sensors : reference, indicative, informative [1], or complementary ?
  - Calibration certificates ? Standard/regulation for sensors ?
  - Grid of low cost sensors with the official one as reference

Technological Challenges

- Public access to pertinent and right information
  - People are exposed to some risks : pollution (health), disaster events, …
  - Interpretation of data ? Individual limit of expertise, over interpretation, ...
  - Who owns data ? Sharing citizen data, open data ?
  - Finances, who pays ?
  - How data is shared, modeled, analyzed, by whom ? Standards, interoperability ?

Technological Challenges

- Security
  - Vandalisms : low cost, still OK to loose a sensor
  - Network security
- Reliability
  - Robustness : waterproof, heat resistance, lifespan, ...
  - Redundancy : low cost allows more redundancy
- Low cost sensor system as “black box”, not the case for DIY

Power consumption

- Platforms

Nom	Processor	Power consumption	Price €
Arduino Uno Rev3	ATmega328P	ATmega328P : Active Mode 0.2 mA Pw down mode: 0.1 uA	20
Arduino Pro mini	ATmega328	ATmega328 : Active Mode 0.2 mA Pw down mode: 0.1 uA Current max: 150 mA	5-12
ESP8266	32-bit RISC CPU: Tensilica Xtensa LX106	Transmit 14dBm : 135 mA Deep sleep 10 uA	6 €
Raspberry Pi 3B	BCM2837 64bit ARMv7 Quad Core Processor	Idle : 310 mA Load : 580 mA	40 €

Technological Challenges

Sensors

Sensor	Power Consumption	Calibration	Robustness	Price
MQ7, CO	Heating power consumption < 900 mW, 180 mA	Sensivity curve, regression		6 €
Cozir, CO2	Average Current <1.5mA	Auto-calibration		109 €
HCSR04, Ultrasonic	Working Current 15 mA			5 €
Maxbotix Ultrasonic Rangefinder	3.4mA average current requirement		Weather resistance	85 $

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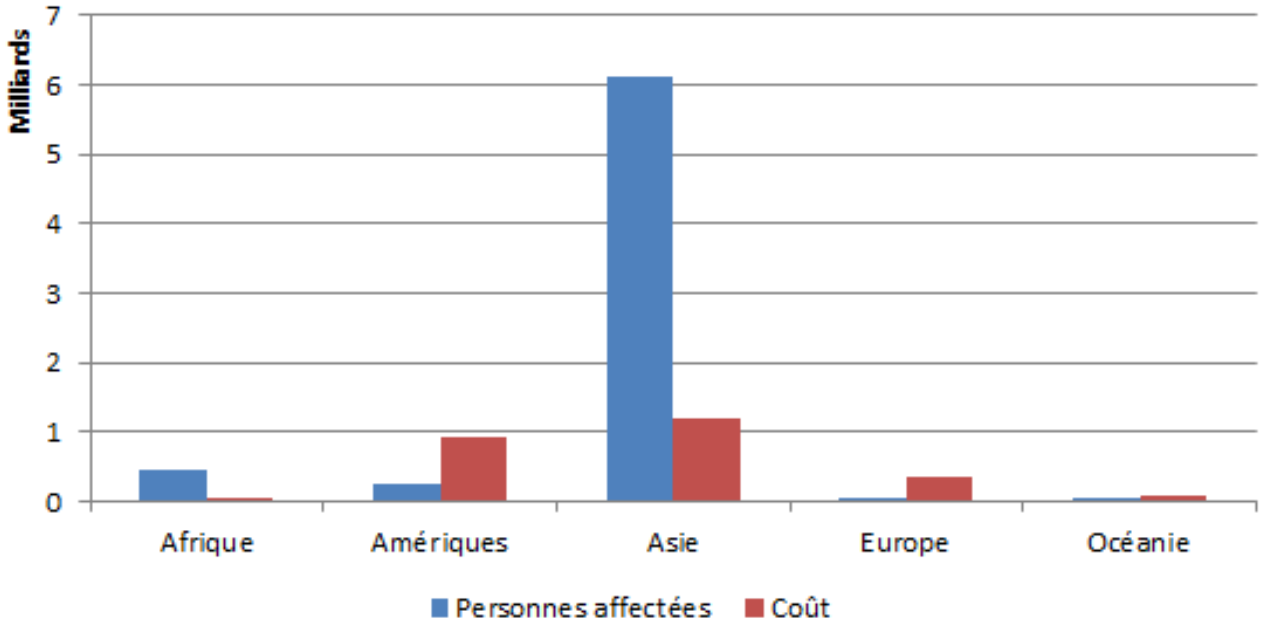
Natural Disasters

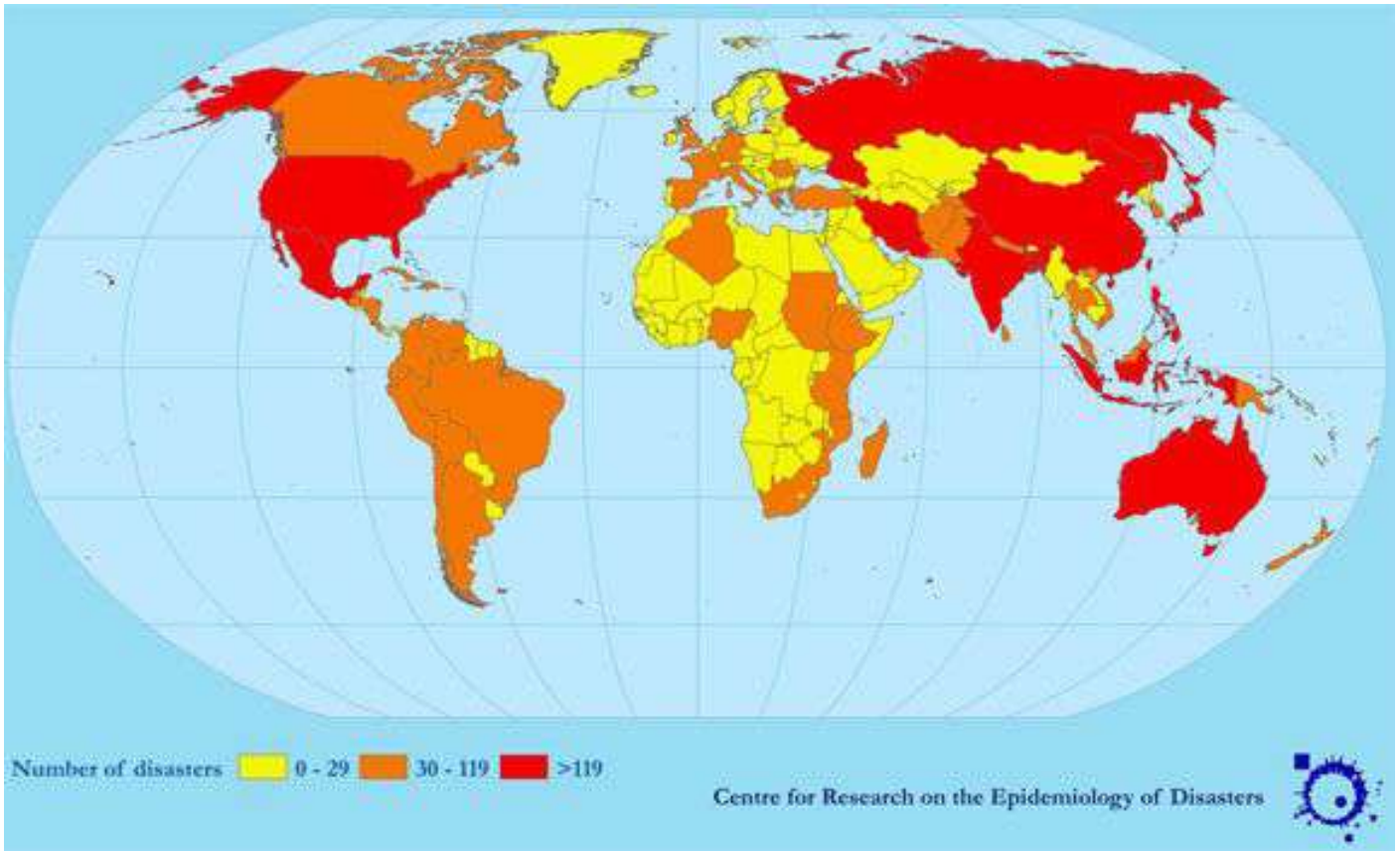
From 2000 to 2012, in average per year, more than 220 millions people have been affected by natural disasters and more than 92 000 have been killed*.

Number of people affected and cost of natural disasters from 1950 to 2012



Natural Disasters

Natural disasters events from 1976 to 2005



Crédit : CRED, 2007. Source : notre-planete.info, https://www.notre-planete.info/terre/risques_naturels/catastrophes_naturelles.php

Flood monitoring, an Indonesian case

Source: http://omeoo.com

Source : DRR Indonesia Foundation - Zerorisk

Source: https://m.tempo.co/

Jakarta Flood Data

- Population :
  - Jakarta > 10 millions
  - Jakarta + suburban area > 20 millions
- Jakarta is the first city most at mortality risk to floods, and the second at economic loss risk to floods in East Asia (World Bank)

Jakarta Flood Data

	1996	2002	2007	2013	2014
Inundation Points	90	160	70	109	
Rainfall Intensity (mm)	288.7	361.7	401.5	40-125	
Évacuees (thousands)	30	380	398	>100	>90
Deaths	10	22	57	41	26
Losses (IDR)	> 1 Billion	1.8 Trillion	4.3 Trillion	32 Trillion	

Source : Agustan et al. BNPB

Budget Jakarta 2014 : 2,3 Trillion IDR (Indonesian governement)
Source :
http://www.kemenkeu.go.id/sites/default/files/Banjir_Inflasi_MK%20Jan%202014.pdf
2014, 40 Billion IDR, from the budget of DKI Jakarta (72 trillion IDR)
Source :
http://sp.beritasatu.com/home/selama-januari-2014-137-tewas-dan-11-juta-jiwa-mengungsi-akibat-bencana/48627

Flood monitoring, an Indonesian case

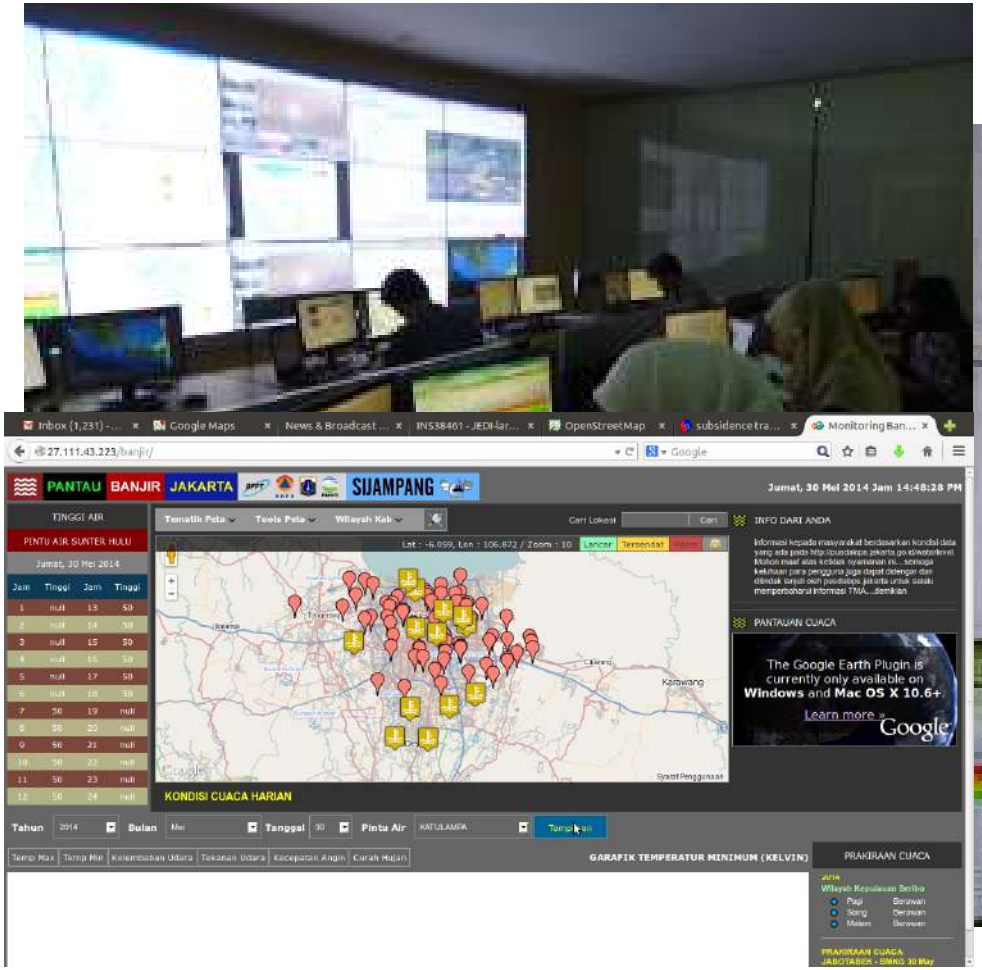
Flood monitoring, an Indonesian case

Data from Monitoring

- Monitoring : WSN, IoT, …
  - Weather, climate and seismic : BMKG (Badan Meteorologi, Klimatologi dan Geofisika)
  - Water systems (water ways, rivers, lakes, …) : Public work department
  - Research equipments : BPPT has installed some AWLR (Automatic Water Level Recorder) in the rivers (water gates)
  - Local states : BPBD (Regional Agency for Disaster Management) Jakarta for monitoring and Early Warning Systems

Warning Level Monitoring

Flood monitoring : Jakarta



Countries getting involved in Indonesia

- Infrastructures and monitoring for floods in Jakarta
  - Australia: SMART Infrastructure Facility (University of Wollongong), in collaboration with BPBD DKI Jakarta and Twitter Inc
    - https://info.petajakarta.org/
    - Funds: Wahana Visi / USAID, University of Wollongong Global Challenges Program, Australia—Indonesia Facility for Disaster Reduction (AIFDR), Australian National Data Service
  - USA: MIT, UrbanRISKLab
    - https://petabencana.id/
  - Netherland
- Tsunami Early Warning System, INA TEWS
  - Contributors : Germany (GITEWS), UNESCO : US, China, Japan
  - http://www.gitews.org/tsunami-kit/index_en.html
- Examples in knowledge management:
  - World Bank Washington, with a local NGO partner

Countries getting involved in Indonesia

- France:
  - Cirela/IRD/BPPT (2015)
    - Small budget
    - Prototype for flood monitoring
  - STIC Asie project (2016-2017)
    - France (UBO, IRD, Cirela), Indonesia (BPPT), Vietnam (CTU)
    - Project on networking for environmental modeling
  - CEREMA
    - Semarang city

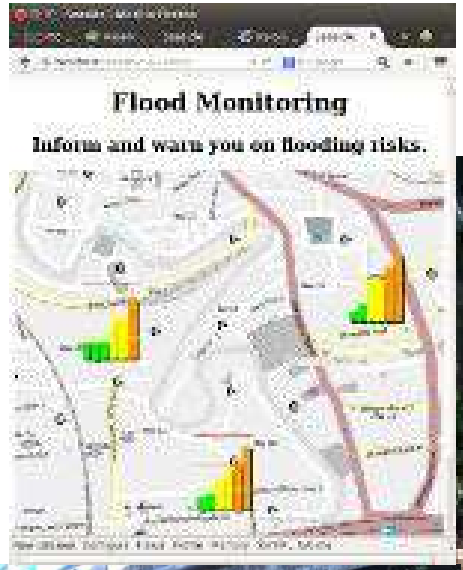
CIRELA

- Communication and Information technology for REsilience to disAsters and climate change
- Non-profit NGO
- Goal :
  - Using communication and information technology to:
    - Build and increase people's resilience before, during and after natural and environmental disasters.
    - Contribute to people's resilience to climate change.
    - Raise people's awareness about environmental issues.
- Currently focuses on Wireless Sensor Networks

  for environment -> flood monitoring
- http://www.cirela.org
- Work on Simulation and Modeling for the Environment, with UBO, IRD, and indonesian and vietnamese partners (STIC Asie project)
  - SAMES : http://sames.univ-brest.fr

Prototype

- Current prototype in Jakarta
  - BPPT
  - Diponegoro University.
  - IRD
  - Cirela
- Technology : Arduino, XBee
- Next:
  - LoRa / XBee
  - Jakarta real use case
    - LoRa / Xbee



Conclusion and Opportunities

- Low cost IoT / WSN opportunities, especially for citizen applications
- Still a lot of challenges (technological, organizational)
- Citizen applications for disaster monitoring for disaster-prone countries
  - Challenges : technologies, funds, cultural ?

Cirela : A Master Plan For the future

- City plus citizen IoT
  - City: backbone, sensors in core areas
  - Citizen : subsidised, low cost, DIY IoT
    - In mesh with city backbone
    - Drive costs lower by numbers !
    - Get people concerned by participation !
    - Build people's trust in system by self-involvement !
- More dual-usage IoT
  - Usefull for citizens
  - Dual usage in emergency / disaster : warnings, etc !

Cirela : A Master Plan For the future

- Build a research setup
  - Experiment on a large scale
  - Raise TRL
  - Integrate multiple providers (DIY, COTS)
- Once stable
  - Move in full scale production
  - Build next generation research setup
- Loop : research, mature, production + research again !

References

[1] SHAPE and EU FP7 CITISENSE project, ‘Use of Low Cost Sensor Technology to monitor air quality and engage citizens’, SECURE Workshop organised at COSLA, Edinburgh, 31 March 2016

[2] Charith Perera et al., ‘The Emerging Internet of Things Marketplace From an Industrial Perspective: A Survey, IEEE Transactions on Emerging Topics in Computing, 31 January 2015