



How Local Governments Can Promote Disaster Risk Management Through Adopting ICT-based Solutions

The case of lessening the impacts of heatwaves on public health through a mobile application

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Abstract

Heatwaves are a natural hazard and one of the deadliest extreme weather events. In future heatwaves are expected to become more frequent, more intense and longer lasting and cities have to adopt major actions so as to mitigate this disaster risk and maintain an acceptable quality of life. The health impacts of hot weather are largely preventable if populations, local governments and health and social care systems are prepared. ¹This requires disaster risk reduction management (DRMM) that emphasizes on prevention and preparedness and uses information and communication technologies (ICT) to enhance its effectiveness and reduce its cost. EXTREMA (EXTReme tEMperature Alerts for Europe) service is a successful example of utilizing ICT tools in DRRM so as to: (i) increase the awareness of the citizens and reduce their exposure; and (ii) support the local authorities with the implementation of their heat-health action plan.

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Heatwaves

How do they impact people?

Heatwaves are **extended periods of extremely hot weather** that are generally associated with specific atmospheric circulation patterns that dynamically produce clear skies, light winds, warm-air advection, and prolonged hot conditions at the surface². Today a universal definition of heatwaves is still lacking and most national meteorological offices have adopted their **own definitions** so as to issue heat alarms³. These definitions quantify the duration and/or intensity of either the nighttime minima or daytime maxima and are based on the outdoor air temperature measured at a height of 2 m above ground.

Extreme heat is a **natural hazard**³ and heatwaves have discernible impacts on human health and on socio-economics and natural systems⁴. High temperatures cause the clinical syndromes of heat stroke, heat exhaustion, heat syncope, and heat cramps³ and can exacerbate many pre-existing health conditions, such as cardiovascular or respiratory conditions⁵. The first sign of heat-related illness is usually heat exhaustion, which, if left untreated, might progress to heatstroke. Heatstrokes are especially dangerous since they can progress to death rapidly, even with prompt medical care (15% of heatstroke cases are fatal)⁵.

Today heatwaves are recognized as one of the **most dangerous extreme weather events** causing tens of thousands of premature deaths⁶. The European heatwave of 2003 in particular, which resulted in 25,000 to 70,000 excess deaths across Western Europe⁷, is a stark reminder of the dangers that extreme temperatures pose to the urban population^{6,8}.

Who are the most vulnerable?

Health effects can appear in all age groups. However, some people are more at risk of heat-related illness and death than others^{3,5}. **Variations in risk** are related to the state of the individual, the level of exposure to hot weather and the ability to adapt to these extreme conditions⁴. To that end, relevant research has revealed that:

- the impact of extreme heat is more pronounced among vulnerable populations, like the elderly, the infants, people that work outdoors and people with chronic diseases and regular medicine intake^{9,10};
- 2. not all heatwaves have a similar impact on mortality and the duration and timing of each event are very important^{7,11};
- 3. the heatwave risk is higher during days with high air pollution;
- people living alone and in communities with low neighborhood stability, e.g. communities with weak social cohesion and/or high crime have a higher heatwave risk^{11–13};
- low socioeconomic status as measured by education and income is an indicator of increased risk to excess heat^{9,11,14,15};
- poor housing quality, high imperviousness, and intra-urban hotspots have positive associations with higher mortality rates due to excess heat^{12,16,17}; and finally
- 7. air-conditioning and access to transportation can be protective factors^{11,16,18}.

Do they impact all countries the same?

Human populations are acclimatized to their local climates. This implies that there are clear and absolute limits to the amount of heat exposure an individual can tolerate³. In other words populations that are **acclimatized in warmer climates are less susceptible to heat**

related effects than populations living in colder climates. For instance, the study of heat-health exposure-response function in Europe has revealed that the threshold where the mortality rate increases due to elevated temperature is **29.4°C** for Mediterranean cities and **23.3°C** for north-continental cities¹⁹.

What is the impact of climate change on heatwaves?

Extreme temperature events are normal features of inter-annual temperature variability, but their frequency and intensity are increasing due to global climate change. In particular, in future, heatwaves are projected to become **more frequent, more intense and longer lasting**^{2,20}. However these future changes will not be evenly distributed in space, but affect certain parts of the world more². To that end, Europe and North America emerge as especially responsive areas to anthropogenically induced climate change where the warming will continue at a higher rate than the global mean².

The expected increase in the frequency and intensity of heatwaves, raises the issue that to maintain an acceptable quality of life for the foreseeable future, urban areas have to be properly managed and major actions regarding the understanding, monitoring and mitigating of **Urban Heat Islands** and heatwaves and their impact on urban population have to be adopted²¹.



Heat-Health Action Plans and Disaster Risk Reduction

Adverse health effects of hot weather and heatwaves are **largely preventable** if populations, health and social care systems and public infrastructure are prepared¹. This requires actions that in order to be effective should be planned in advance adopting a long-term approach. Such actions should be broad and well tested and also be effectively communicated to the target audience, e.g. high risk population, volunteers, medical professionals, emergency responders etc. These actions can be integrated in a **heat-health action plan**, which purpose is to set out what should happen before and during periods of extreme heat; and how individuals and organizations should prepare and act^{1,22}.

The core elements of Heat-Health Action Plans

The World Health Organization (WHO) in the report "*Heat–Health Action Plans*" recognizes eight core elements that are important for the successful implementation of a heat–health action plan. These elements are:

Element 1: An agreement on which agency is going to be **the lead body** that will coordinate all the other actors and direct the response if an emergency occurs. Usually this lead body is a national or regional health authority and is responsible for designing the heat plan, coordinating and evaluating it during and after its implementation and making sure the communication and collaboration between the various actors is optimal.

Element 2: An accurate and timely **alert system** that will trigger warnings, determine the threshold for action and communicate the risks. These instruments should involve solid knowledge of the actual heat–health relationship at each locale and thus they should be designed to be location-specific²³.

Element 3: A **communication plan** that describes what is communicated, to whom and when. Depending on the heat alert level, this plan should provide information and advice to the general public and the relevant actors about extreme heat risks, prevention actions and responsibilities. Each communication should be tailored to each group, while special attention is required on how this information can reach elders, homeless and socially isolated people.

Element 4: A set of actions that describes who to reduce indoor heat exposure, e.g. practical advice on how to cool a place. According to WHO, to mitigate heat-health effects, it is important to reduce exposure as much and as quickly as possible¹.

Element 5: A set of actions that are addressed to **vulnerable population groups**, such as the activation of a telephone service to check if they are ok, proactive hospital admissions, home checks etc.

Element 6: An **operational plan** on the specific procedures hospitals, clinics, retirement and nursing homes should adopt before and during the summer period and during a heatwave. This plan should also include specific actions so as to fortify the

thermal environment of health services (e.g. hospitals) from extreme temperature events.

Element 7: A long-term urban planning strategy that sets out to mitigate the effects of the Urban Heat Island, the anthropogenic heat emissions and the lack of green spaces and also to improve the built environment, e.g. by improving building insulation, by promoting green roofs or green walls etc.

Element 8: A **real-time surveillance and evaluation system** for monitoring the health impact of a heatwave (through mortality data, hospital admissions etc.) and assessing the plan's performance so as to ensure that the designed actions have the intended effects.

These eight elements are not sequential but part of a **disaster planning cycle** that consists of five phases¹, namely:

- 1. longer-term development and planning;
- 2. preparation before the summer;
- 3. prevention during the summer;
- 4. specific responses to heat-waves; and
- 5. monitoring and evaluation.

Disaster Risk Reduction Management & Health

Heat-health action plans are in line with recent developments in Disaster Risk Reduction Management (DRRM), where a more proactive approach that emphasizes **prevention and mitigation** is promoted. Today DRRM is a core element of **sustainable development** and an essential part for a safer world. Reducing risk is a long-term development process, managed by communities and individuals working together, as the United Nations' **Sendai framework for disaster risk reduction** (SFDRR)²⁴ advocates. SFDRR is a global disaster risk reduction (DRR) policy framework adopted by the UN members that replaced the Hyogo framework for action (HFA) in 2015. In respect to HFA, the SFDRR gives a greater emphasis on health and emphasizes the need for a more integrative

DRR process that incorporates bottom-up as well as top-down actions, local scientific and technical knowledge, and establishes synergies with health, climate change, and sustainable development²⁵.

An executive summary of UN's Sendai framework for disaster risk reduction

The main goal of SFDRR is the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries. To achieve this, SFDRR sets to substantially reduce the global disaster mortality; the number of affected people; the disaster damage to critical infrastructure; and the disruption of basic services (e.g. health). In addition it also sets to increase the availability of and access to multi-hazard early warnings. To meet the aforementioned goals, SFDRR recognizes the following **priorities for action**:

- 1. understanding of disaster risk in all its dimensions of exposure, vulnerability and hazard characteristics;
- strengthening of disaster risk governance, including national platforms;
- 3. accountability for disaster risk management;
- 4. preparedness to "Build Back Better";
- 5. recognition of stakeholders and their roles;
- mobilization of risk-sensitive investment to avoid the creation of new risk;
- 7. resilience of health infrastructure, cultural heritage and workplaces; and
- 8. strengthening of international cooperation and global partnership.

To achieve these priorities, SFDRR provides a list of key activities that correspond to two levels: the **national and local**; and the **global and regional**. These key activities include actions such as the collection, analysis, management and use of relevant data; the

development, periodic update and dissemination of location-based disaster risk information; and the enhancement of the national health systems resilience. Several of these actions are required by public health, and have thus been agreed as priorities for the WHO to act on in partnership with the UN system and relevant local, national, regional, and global partners²⁵.



Using ICT-based solutions for more effective DRRM actions

Why ICT-based approaches matter?

Over the last decades, the utility, application and capacity of Information and communication technologies (ICT)—including spacebased technologies—have increased considerably²⁶. This is due to the main advantage of ICT, which is their ability to connect vast networks of individuals over vast geographical areas and facilitate fast flows of information. Today ICTs, such as computers, the Internet and mobile phones, are essential tools for cooperation and collaboration and provide unprecedented opportunities to build resilience and enhance DRRM²⁶. To that end, UN's Economic and Social Commission for Asia and the Pacific (ESCAP) notes that experiences from around the world have proven that disaster prevention and preparedness, enabled by ICT, can be far **more effective** and **less costly** than ever before.

ICTs can play a catalytic role in reducing disaster risks through early warning, coordinating and tracking relief activities and resources, recording and disseminating knowledge and experiences, and raising awareness^{26,27}. In general the application of ICTs in DRRM can be divided into two broad usages:

- The first is associated with knowing the risks²⁶. In particular this implies: (i) being aware of the risks (vulnerability × hazard × exposure); (ii) having access to relevant information about them; and (iii) being able to minimize them in a timely manner²⁶. This type of ICT usage includes: weather forecasting and modeling, monitoring and mapping the disaster risk, as well as teaching and learning for fostering a culture of DRR.
- The second area of usage focuses on how best to manage risks and disasters by utilizing ICT tools for (i) alerting communities of impending disasters; (ii) coordinating response and rescue; and (ii) managing mitigation programmes and projects²⁶.

What can ICT solutions offer to LGs in the context of DRRM?

Local governments (LGs) can take advantage of both types of ICT's usage so as to strengthen their emergency preparedness and response actions. According to the UN ESCAP's publication *"Information and communications technology for disaster risk reduction"*²⁷, ICT can support the following key functions:

Information collection and sharing: ICT tools can help LGs systematically **collect data** and undertake **risk assessments** in order to understand better the socio-economic vulnerabilities of their communities²⁷. Such data can help monitor the hazard and form databases so as to support the different stages of DRRM and also policymaking, planning and research.

Decision support systems: ICT provides the technology to **functionally integrate** hazard and risk spatial information from various sources and to monitor parameters relevant to the hazard in a decision support system. Such systems can incorporate **GIS** capabilities that can assist with the **analysis** of vast amounts of historical and real-time spatial data and enable

their **visualization** and **interpretation**. They can also offer a platform for establishing **synergies** between various actors, such as scientific organizations, the health sector and local authorities.

Communication and dissemination: Effective voice and data communications with the public are key in DRRM. Over the last decades, these communications were based primarily on radio and television. Such mediums however, enable only a one-way mass communication. Today **smartphones**, which are over the extensively used all world, allow two-way communications, and access to location-based services. Hence state-of-the-art DRRM actions require new content and early-warning alerts that are suitable for these devices²⁷.

Emergency preparedness and response: ICT can offer reliable **emergency communication** tools to all DRRM actors that will enable them to fulfill their role in a timely and cost effective way. It can also provide tools to manage **logistical information** and monitor the disaster damage with the available and needed facilities and supplies²⁷.

It is important to note that in order for LGs to harvest the aforementioned advantages, they have to **develop** human resources and **strengthen** their capacities to integrate and make use of ICT applications. This change cannot take place from one day to the next, but requires a thorough, long-term strategy and successful policy innervations^{26,27}.



EXTREMA: A successful example of utilizing ICTbased solution to lessen the impacts of heatwaves on public

The **EXTReme tEMperature Alerts for Europe** (EXTREMA) service aims to improve the resilience of any individual to extreme temperatures by providing information about his/hers personalized risk, recommendations on protection, relief and routing instructions to the nearest cooling centers. It also aims to provide City authorities with tools to prepare for and manage heatwaves.

The core idea behind EXTREMA

State-of-the-art research^{28,29} suggests that certain levels of risk perception ('is there a threat?'), personal risk ('is the threat relevant to me?'), self-efficacy ('am I able to deal with the threat?') and response efficacy ('is the advice that I get to deal with the threat useful in the sense that it will successfully help me to cope with the threat?') are required for people to **adopt self-protective behaviors**.

Such behaviors can reduce the exposure of each individual, and in turn the need for intervention by the public authorities. However, the information that is required by any individual to answer these questions is rarely available in a timely manner. EXTREMA use EO technologies and information from meteorological models and epidemiological analyses to derive **extreme temperature risk assessments** for anyone in Europe. To achieve this, EXTREMA exploits the high penetration of smartphones in Europe to implement a digital infrastructure in the form of a mobile application for the public, and an administration web hub, called Dashboard, for the local authorities.

EXTREMA mobile App

The EXTREMA **mobile application** allows individuals in Europe to assess in real-time their own risk to extreme temperatures (no / low / increased / high risk). To do so, the mobile app uses the geo-location functionality of the smartphone to identify the location of the user and then retrieve from a dedicated web-service the outdoor air temperature. This temperature information is retrieved in real-time every 5 min from satellite thermal infrared images and numerical

weather predictions. The mobile app, after retrieving the collocated outdoor temperature, it turns it into personalized risk estimations using a set of predefined thresholds that have been derived from epidemiological analysis based on the age of the individual and if he/she has a chronic disease or takes daily medication.

In case that the personalized risk is high, the mobile application offers recommendations for reducing his/hers exposure. It also provides routing directions to the nearest cooling center, i.e. parks or air-conditioned public/ private spaces that each LG includes in its heat-health action plan. The



cooling centers are responsibility of the LG and may indicatively include municipal buildings, community centers, parks, fountains, libraries, swimming pools, or hospitals if necessary. Another useful feature of the EXTREMA app is the support of multiple profiles, which helps users to check on children or elder relatives by registering their profile and location.

EXTREMA Dashboard

EXTREMA Dashboard is addressed to LGs and is a management tool that can help them implement their heat-health action plans. The dashboard integrates policy options on extreme temperature impacts, as well as next day alerts retrieved from the **meteoalarm.eu** web service. In addition to these alerts, it also provides real-time maps of the distribution of temperature for every square kilometer in their city, updated every 5 minutes together with other relevant variables such

as humidity. In this way, EXTREMA dashboard helps city authorities to better manage their response actions during heatwaves.

A major feature of EXTREMA dashboard is a tool for managing the cooling centers. Using this tool LGs can update the opening hours, change the addresses and add new centers or provide other relevant information, e.g. entrance fee, capacity etc.. This information is communicated to the citizens through the EXTREMA mobile application.



Who uses **EXTREMA**

The EXTREMA mobile app is available both for **Android** and **iOS** smartphones though the corresponding stores and is already used in Athens, Paris, Rotterdam and the Island of Mallorca. The next cities are Lisbon and Milan.

EXTREMA is addressed to every city aiming to strengthen its resilience against extreme temperatures.

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