

# SOURCES OF MAPPING USED IN HUMANITARIAN EMERGENCIES: THE CASE OF EBOLA

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**ABSTRACT:** The need to rapidly respond to health emergencies has generated various institutional initiatives to identify their location, through mapping. This study employs a qualitative-exploratory method, based on the daily monitoring of eight Ebola epidemics between 2013 and 2021, to make an assessment of the usefulness of maps created specifically for Ebola. The results show that at least 14 organisations produce maps in the face of emergencies and epidemics such as Ebola. Consequently, it has been possible to design a search plan to aid in the monitoring of emergencies and to design an Ebola map with data obtained from these organisations and the initiatives they promote, which confirms the usefulness of these data sources and maps.

**KEYWORDS:** mapping, epidemics, Ebola, humanitarian aid, emergencies, georeferencing

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## Introduction

Emergency situations are increasingly known about in real time, thanks to the media. This increased awareness was highlighted, for example, at the 2018 conference in Nairobi, Kenya, which brought together a large number of organisations dealing with emergency alert systems in Africa. Also, they contemplated the future by addressing the theme of the 'African Union: A Decade of Humanitarian Action (2016–2025)' (Global Monitoring for Environment and Security [GMES] 2018).

Koch (2015) said that 'Disaster medicine is characterised by shortages of everything, but patients. There are never enough beds, equipment, personnel, or supplies. In the 2014 Ebola epidemic, another scarcity was maps. The need for maps of the affected areas, and the ways the maps were used, served to emphasise the way maps have always been used in both disaster medicine and public health preparedness'.

Emergencies often occur in places that are poorly mapped, and mapping is essential to facilitate humanitarian relief work. Up-to-date and accurate maps support the fieldwork of teams, for example, to choose the places to focus on and

detect the spread of fevers, for example, which require x-rays to know when and where to monitor temperature using non-contact thermography systems (Cohen et al. 2016; Wickramage 2019). The Ebola virus produces a very lethal contagious disease that requires suspected cases to be isolated, and the location and monitoring of their contacts, so it is necessary to place checkpoints at the entrances and exits of population centres and on major communication routes to prevent the movement of infected people. This measure is highly effective since Ebola is only spread by contact with infected people with clear symptoms. However, the places where these epidemics occur lack sufficient mapping resources, as is the case in North Kivu (in the northeast of the Democratic Republic of the Congo [DRC]), which features high population density, violence, and misery; or in the province of Equateur in the same country, which is covered by equatorial forests crossed by endless streams and rivers and with minimal communication routes; or in the West Point neighbourhood in Monrovia (Liberia), which comprises a large number of precarious dwellings.

The objectives of this study are to address this concern and confirm the importance of mapping in emergencies and review the work already carried out; to design a plan of action that suggests where to start in the field of mapping in case of an emergency; and to develop a map on Ebola, as an example of mapping an epidemic, with data

from the same institutions that work with the cartographic sources studied in this work.

## Material and methods

The research method has a qualitative-exploratory character based on the daily monitoring of the eight Ebola epidemics that occurred from 2013 to September 2021, for which the bulletins described in Table 1 have been used. This study has been enriched by drawing on the cartographic bases of prestigious institutions, such as those of the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA), which is responsible for compiling all types of information related to emergencies. The origin of these maps has been investigated to identify the possible sources used, how they work, what they produce and how they are accessed.

## Results

The maps related to humanitarian missions, emergencies in general, and Ebola in particular, are produced by organisations and agencies that seek to respond to a professional need to monitor an emergency, by providing search plans from existing cartography, from medical science or from a military initiative. At the end, a map on Ebola has been created from the data obtained

Table 1. WHO bulletins consulted for locating Ebola mapping.

Report name	Organisation that publishes data	Content/web link
Weekly Epidemiological Record/ <i>Relevé Épidémiologique Hebdomadaire</i>	WHO	Weekly report that collects information on various infectious diseases and provides an overview of the status of each one. <a href="https://www.who.int/publications/journals/weekly-epidemiological-record">https://www.who.int/publications/journals/weekly-epidemiological-record</a>
External Situation Report, SITREP	WHO	This contains specific information on the current status of a given epidemic outbreak, and is sometimes updated daily, depending on the severity of the outbreak. It is located on web pages designed to address specific epidemics or, more generally, on the WHO institutional repository (2021), known as the <i>Institutional Repository for Information Sharing</i> (IRIS). <a href="https://apps.who.int/iris/?locale-attribute=en&amp;">https://apps.who.int/iris/?locale-attribute=en&amp;</a>
Outbreaks and Emergencies Bulletin	WHO (Regional Office for Africa)	Weekly updates data on active outbreaks in Africa. <a href="https://www.afro.who.int/health-topics/disease-outbreaks/outbreaks-and-other-emergencies-updates">https://www.afro.who.int/health-topics/disease-outbreaks/outbreaks-and-other-emergencies-updates</a>

Source: own elaboration based on the above-mentioned reports.  
WHO - World Health Organization.

from organisations and their initiatives, thus confirming the usefulness of its existence.

## Mapping initiatives related to humanitarian missions and emergencies

### United Nations Office for the Coordination of Humanitarian Affairs (OCHA)

This organisation hosts the Humanitarian Data Exchange (HDX) website, which specialises in the collection, organisation and downloading of data related to active humanitarian emergencies, by taking contributions from other agencies, especially those working in the field. Although many formats are supported, HDX presents the data mainly in shapefile (shp) files, which is native to the Environmental Systems Research Institute (ESRI), and which contain the information that is linked to the territory, and also in comma-separated values (csv) files, which are easy to read in spreadsheets. The information in the latter is reclassified following Humanitarian Exchange Language (HXL) standards, which is a dictionary of terms (hashtag) that allows us to precisely define all types of data (OCHA 2017). The reclassification process consists in adding a blank row just below the column headings to place the new labels from the dictionary, thus defining the content of each column in a standardised way, as shown in Figure 1.

### HXL - Humanitarian Exchange Language

Data on a specific situation can, for example, include updates (e.g. the number of cases affected

by an epidemic), and/or basic information (layered with administrative boundaries or demographic information, among others). Those who register can directly contact the organisations that have generated the information. OCHA also maintains the ReliefWeb web page (<https://reliefweb.int/about>) with reports on disasters and enhances the data on the HDX page with text.

As an example, we searched the existing information on the HDX site for the DRC. Among the various search options offered by the site (countries, organisations, or direct data), we suggest using the locations tab, which contains an automatic sorting of the results according to relevant topics. In our case, for the DRC, the search engine returned 299 datasets provided by 58 different organisations classified into six themes: crisis-affected population, coordination and context, food security and nutrition, geography and infrastructure, health and education, and population and socioeconomics. There is also a list of total results and a filtering system to refine the search. It is worth mentioning the Common Operational Datasets (CODs) filter, which provides basic data of general interest, such as administrative boundaries and population. CODs also have filters to select file formats, which permitted identification of 77 results for shapefile format and 98 for csv files. Each result is a dataset containing numerous files, among which we can find, for example, a shapefile layer with population data, by age and sex, for each of the country's 520 health zones.

In a second search, within the results already obtained, the term 'Ebola' was added, which

**The 30-second HXL Tutorial**

**1**

A	B	C
Cluster	District	People affected
WASH	Coast	90
WASH	Mountains	100
Education	Coast	1550
Education	Mountains	75
Health	Coast	200
Health	Mountains	35

**1 Grab a spreadsheet of humanitarian data**

**2**

A	B	C
Cluster	District	People affected
WASH	Coast	900
WASH	Mountains	100
Education	Coast	1550
Education	Mountains	75
Health	Coast	200
Health	Mountains	35

**2 Insert a new row between the headers and the data**

**3**

A	B	C
#sector	#adm1	#affected
WASH	Coast	900
WASH	Mountains	100
Education	Coast	1550
Education	Mountains	75
Health	Coast	200
Health	Mountains	35

**3 Add some HXL hashtags**

Fig. 1. Capture from <https://hxlstandard.org> United Nations' HXL (screenshot). Source: Creative Commons Attribution 4.0.

returned 17 datasets. Furthermore, when the shape filter is added, the search result is reduced to three results or three datasets so that each includes at least one shapefile containing a layer related to Ebola. If we enter any of those sets, we can see the list of the files it contains, the update date, the metadata and a preview (a zoomable map) with several layers corresponding to the different shapefiles in the list. We can see the result of this double search in Table 2.

### United Nations Institute for Training and Research (UNITAR)

Through the Rapid Mapping Service of Satellite Analysis and Applied Research (United Nations Satellite Centre [UNOSAT]), satellite images are searched and analysed upon the request of any non-governmental organisation that is responding to humanitarian emergencies. The request is handled by a permanent on-call service that responds to e-mails or phone calls, as indicated on the service's own website (<https://www.unitar.org/maps/unosat-rapid-mapping-service>). The results are available within a few hours on the *Maps and Data* tab of its main menu and in formats suitable for use in geographic information systems (GIS). The usefulness of the satellite images lies, among many other things, in the fact that they update the available maps by incorporating the effects of a catastrophe. In addition, this institute has a specialised section on floods (UNOSAT Flood Portal).

### World Health Organization (WHO)

#### Global Health Observatory (GHO)

WHO compiles information on the health status of member countries through hundreds of indicators and a gallery of maps. The GHO is accessed from the *data* tab on the WHO home page (GHO 2021). The maps are classified by theme, one of which, Ebola Haemorrhagic Fever, provides two maps for different years and locations (Mbomo, Republic of Congo 2003 and Yambio, South Sudan 2004) (Fig. 2).

Sometimes a particular need leads to the creation of web portals that relate to specific epidemic outbreaks, such as *Portail de données et cartographie, riposte contre l'épidémie de la maladie à virus Ebola 2018*, created in collaboration with the government of the DRC, which provides data and maps related to the epidemic that broke out in 2018 in Bikoro, Equateur (DRC), and in which we find the following possibilities to access this information:

- A dashboard with the situation on 24 July 2018, when the epidemic ended (Fig. 3). During the period of its development, it offered data that were updated each day.
- An interactive map with two data layers: one with Ebola treatment centres (ETCs) and the other with existing laboratories in the field.
- A section dedicated to the download of thematic maps in a pdf or gif format (the latter when it shows temporal evolutions), which

Table 2. Results of the double search performed with the terms 'Democratic Republic of the Congo' and 'Ebola' in the HDX database.

Information found	Organisation providing data	Date of update
Sanitation facilities in the provinces of North Kivu, South Kivu and Ituri	WHO	19 March 2021
Administrative boundaries of the health areas of North Kivu, South Kivu and Ituri provinces	WHO	7 November 2019
Administrative boundaries of the health zones of the DRC	Référentiel Géographique Commun (the now defunct website created at the time by the DRC government to unify georeferenced information about the country)	4 March 2021
Level 1 and 2 health administrative boundaries (zones and health areas) of the DRC	WHO open data platform for the May 2018 Ebola outbreak	Undated
Administrative boundaries of the health zones of the province of Equateur (DRC) and of the health areas of the districts of Bikoro and Wangata in the same province	DRC Delegation in the UNOCHA	6 September 2018

Source: own elaboration based on HDX.

DRC - Democratic Republic of the Congo; HDX - Humanitarian Data Exchange; UNOCHA - United Nations Office for the Coordination of Humanitarian Affairs; WHO - World Health Organization.



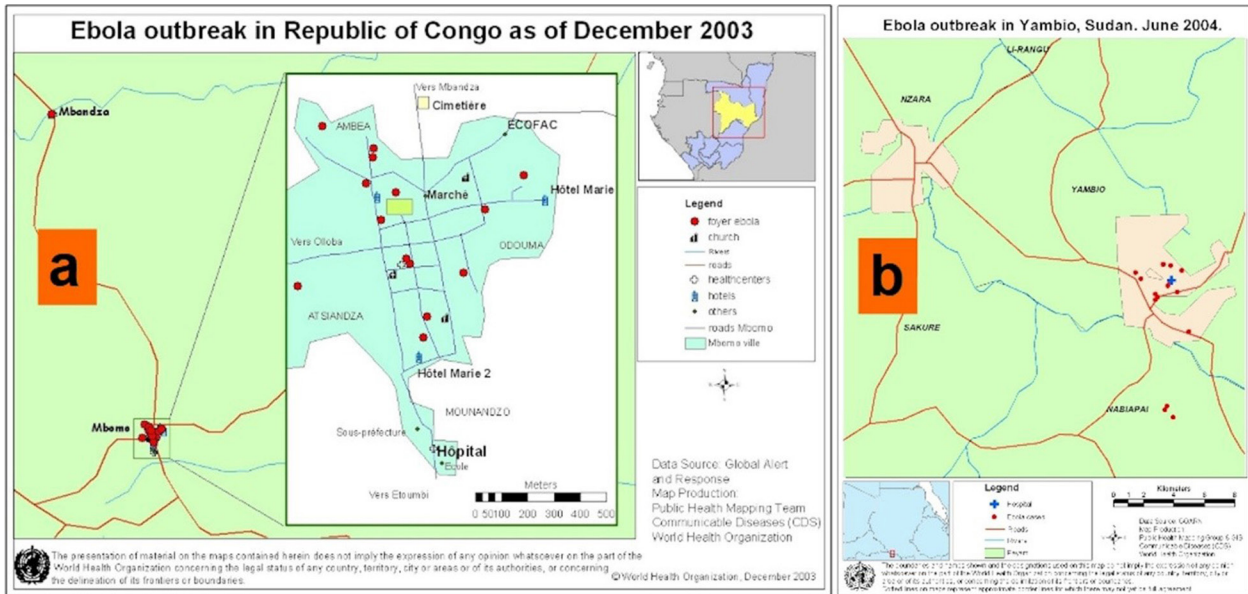


Fig. 2. Maps provided by WHO. a – 2003 epidemic in Mbomo, Republic of Congo (Congo Brazza). b – 2004 epidemic in Yambio, then Sudan, now South Sudan.

Source: own elaboration based on <https://www.who.int/data/gho/map-gallery-search-results?&maptopics=22730bde-25e7-49e9-ae78-8ee9cdd6f65c> (Creative Commons Attribution-NonCommercial-ShareAlike 3.0). WHO – World Health Organization.

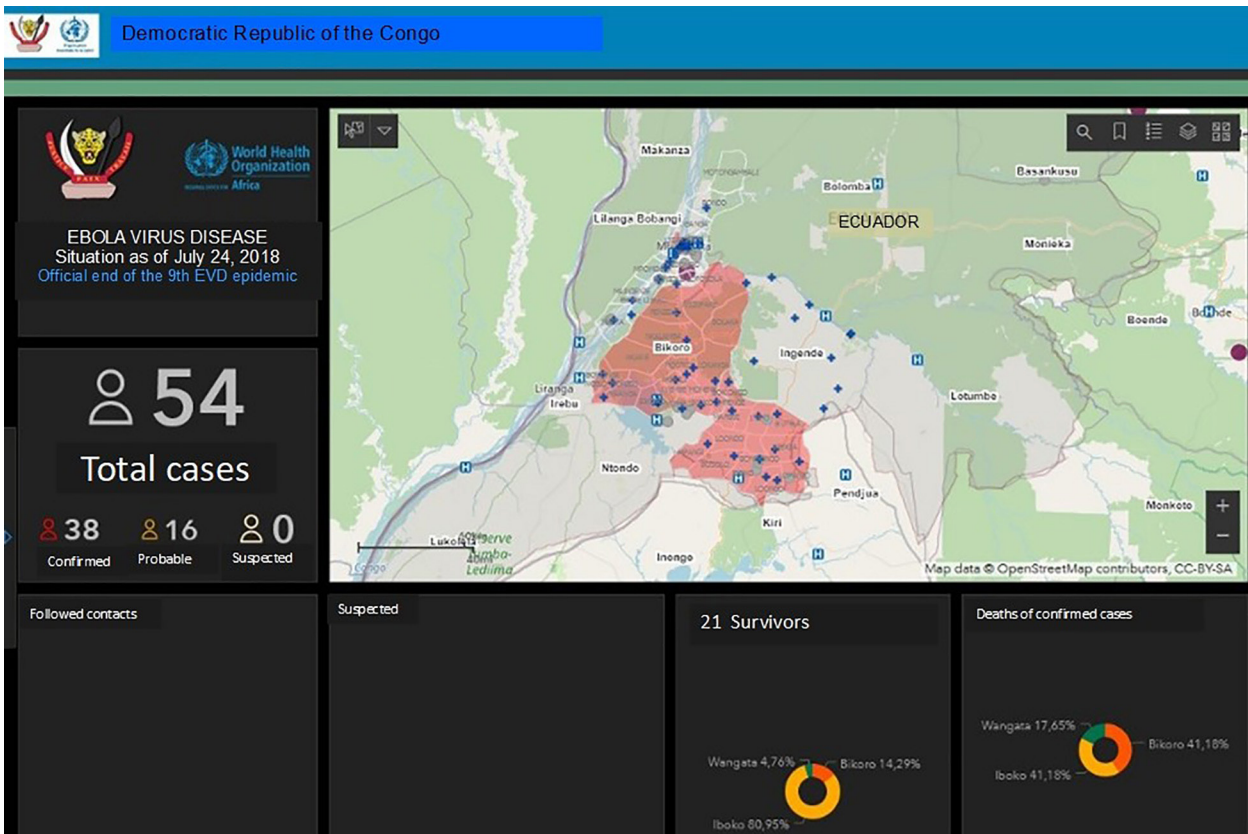


Fig. 3. WHO Dashboard for the 2018 epidemic in Bikoro (DRC).

Source: data portal and mapping, Ebola outbreak response. <https://ebolaoutbreak2018-who.opendata.arcgis.com/> (Creative Commons Attribution-NonCommercial-ShareAlike 3.0). DRC – Democratic Republic of the Congo; WHO – World Health Organization.

should be explored in-depth as it offers many resources. One of the pdfs, for example, has 16 pages showing maps of all the health areas affected by the epidemic.

- d) A section for downloading data in various formats, including shapefile.
- e) Access that allows data manipulation, for which authorisation is required.
- f) OpenStreetMap (OSM) mapping.
- g) Information on 4W (who does what, where and when). It also requires authorisation.

On the other hand, it is essential to take into account the maps that WHO includes in the External Situation Report (SITREP) (<https://www.afro.who.int/health-topics/ebola-virus-disease>), which show the real-time evolution of each epidemic outbreak (Fig. 4).

## WHO Regional Office for Africa

The Outbreaks and Emergencies Bulletin, published weekly (WHO Regional Office for Africa, no date), explains the status of various outbreaks in the office area of influence, which covers the African continent, with the exception of Egypt, Sudan, Tunisia, Libya, Morocco and Somalia (which belong to the Regional Office for the Eastern Mediterranean).

## World Food Programme (WFP)

### Automatic Disaster Analysis & Mapping (ADAM)

This service is designed to provide immediate information in the event of earthquakes and tropical storms (WFP 2021). It is an automatic

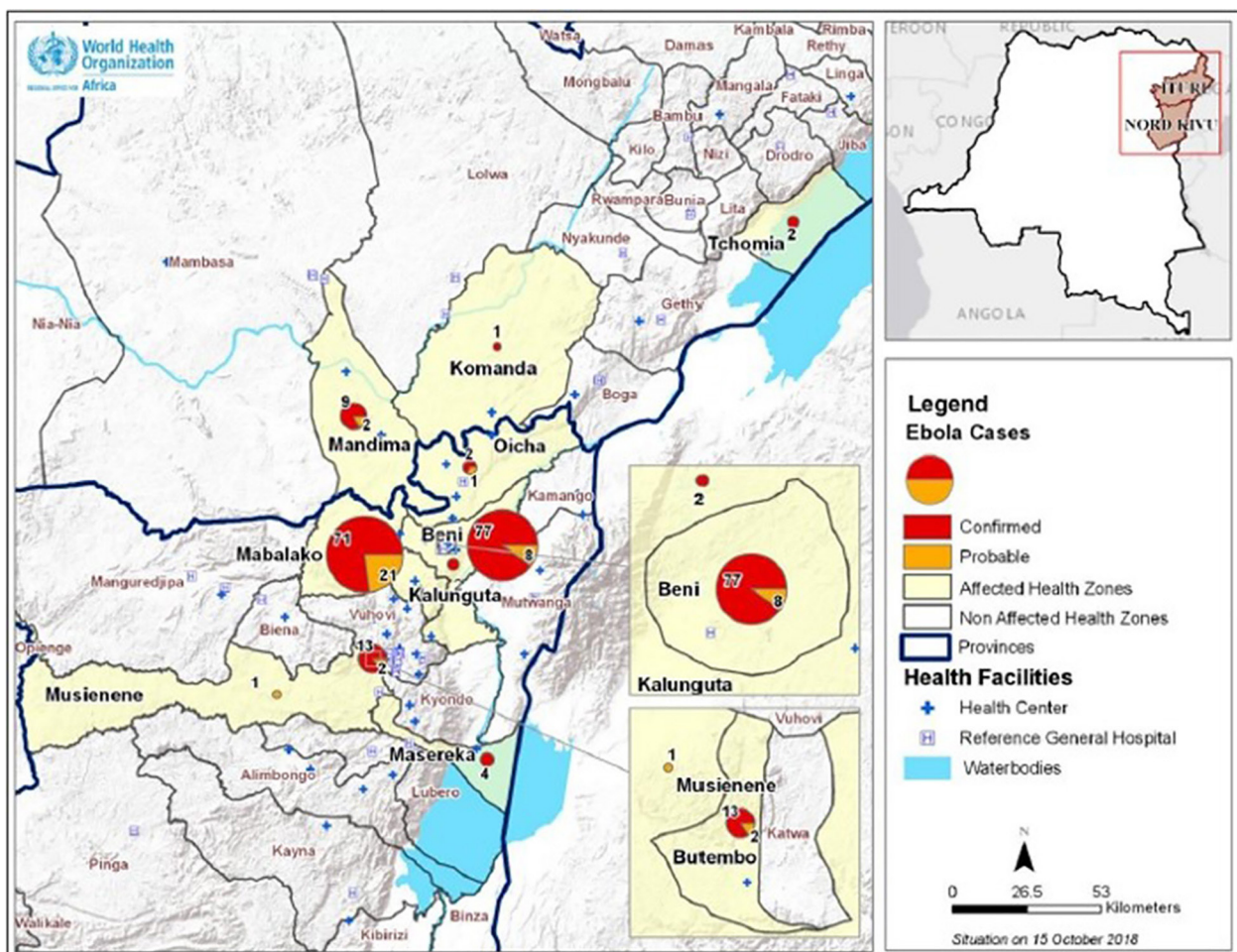


Fig. 4. Map from the WHO SITREP.

Source: <https://www.afro.who.int/health-topics/disease-outbreaks/outbreaks-and-other-emergencies-updates> (Creative Commons Attribution-NonCommercial-ShareAlike 3.0).

WHO - World Health Organization.



mechanism that, in the case of a catastrophic event, collects information, creates a dashboard on the web and sends to subscribers by e-mail, within approximately one hour, maps and information on population, infrastructure, affected resources and proximity to WFP facilities, among other data. Any institution can sign up on ADAM's website to receive the information directly, while the general public can follow it through its Twitter account ([https://twitter.com/wfp\\_adam?lang=es](https://twitter.com/wfp_adam?lang=es)).

## European Union

### Copernicus Earth Observation Programme

The programme has launched a series of space satellites (sentinels) to observe the natural conditions on our planet supported by other means of measurement from land, sea and air (EC 2015). Its products are openly and freely available to any user, although their complexity sometimes requires a certain level of technical knowledge.

It has a rapid mapping service that is activated upon the request of authorised users and whose results are also openly available. Searching

among them for the term 'Ebola', three activations were found (Fig. 5): one for the 2018 Ebola epidemic in the northwestern DRC (Mbandaka and Bikoro, Equateur province), requested by Denmark, which provides three maps; and two for the West African Ebola epidemic, requested by the European Union in 2014, which offers seven maps. All of them are freely available in jpeg, tiff, pdf and shapefile formats.

The European Commission (EC) through the Global Monitoring for Environment and Security and Africa (GMES and Africa 2018) aims to extend to Africa the resources of the *Copernicus* programme.

## Collaborations among organisations

### International Charter Space and Major Disasters

This is a partnership agreement between "space agencies and space system operators around the world working together to provide satellite imagery for disaster monitoring purposes", which is an agreement that was signed in 2000. It has members in 126 countries that

The screenshot shows the Copernicus Emergency Management Service - Mapping interface. The page title is "COPERNICUS Emergency Management Service - Mapping". The navigation bar includes "Home", "What is Copernicus", "EMS - Mapping", "Linking with Early Warning Systems", and "News". The main content area is titled "List of EMS Rapid Mapping Activations".

Search filters include:

- Title:** Contains Ebola
- Event Type:** Epidemic
- Event Date (UTC):** Start date (empty), End date (2021-09-30)
- Affected Countries:** Afghanistan, Albania, Algeria, Australia, Austria, Bahamas, Bangladesh

The search results table is as follows:

Act. Code	Title	Event Date	Type	Country/Terr.	Feed
EMSR285	Ebola outbreak in the Democratic Republic...	2018-05-17	Epidemic	Congo (Kinshasa)	
EMSR110	Ebola Crisis In West Africa	2014-11-22	Other	Guinea	
EMSR076	Ebola epidemic in Guinea	2014-03-01	Other	Guinea	

Displaying 1 - 3 of 3 items

Fig. 5. Result of a search for the term Ebola in the list of activations of the Emergency Management Service of the Copernicus system (screenshot).

Source: European Union <https://emergency.copernicus.eu/mapping/list-of-activations-rapid>.

provide access to 61 space satellites. Faced with an emergency situation, an authorised user can request activation of the charter and access a permanent on-call service that requests information from the most appropriate satellite and converts the data it provides into maps, following a protocol clearly defined on its web page (International Charter Space and Major Disasters 2021).

The Charter has a principle of universal access that allows any government, even if it is not a partner, to be an authorised user and subsequently request activations. The application for membership or activation of the Charter has minimum requirements (having a national disaster management authority, which is enabled when you become a user; having the capacity to download and manage maps; and being able to communicate in English) and is processed via the aforementioned Charter web page. Figure 6 shows the countries that have the capacity to activate it in dark blue and shows that only 13 African countries (Algeria, Tunisia, Ghana, Togo, Nigeria, Cameroon, Sudan, Ethiopia, Uganda, Tanzania, Malawi, Eswatini and Madagascar) had access to its services in March 2021. This is a good example of how poor countries do not

always have the capacity to access mechanisms in international institutions.

UNOSAT has the capacity to request Charter activations on behalf of United Nations' (UN) organisations, and did so in the face of the major 2013–2016 Ebola epidemic in West Africa. As a result, a web map with satellite imagery for West Africa and a pdf Atlas of Ebola-related health facilities in Guinea, Sierra Leone and Liberia were created (UNITAR, UNOSAT 2014).

### Global Disaster Alert and Coordination System (GDACS)

This service is the result of a collaboration between OCHA, UNOSAT, the European Union and various disaster response organisations. Its objective is to coordinate efforts, share information and, ultimately, avoid both duplication and gaps in emergency response.

It has three main services that are accessible from the main website (GDACS 2014):

- a) An automatic system for issuing alerts and risk assessment based on real-time information gathering. The alerts, classified into four levels due to their automatic and immediate status, must be properly interpreted. Alerts can

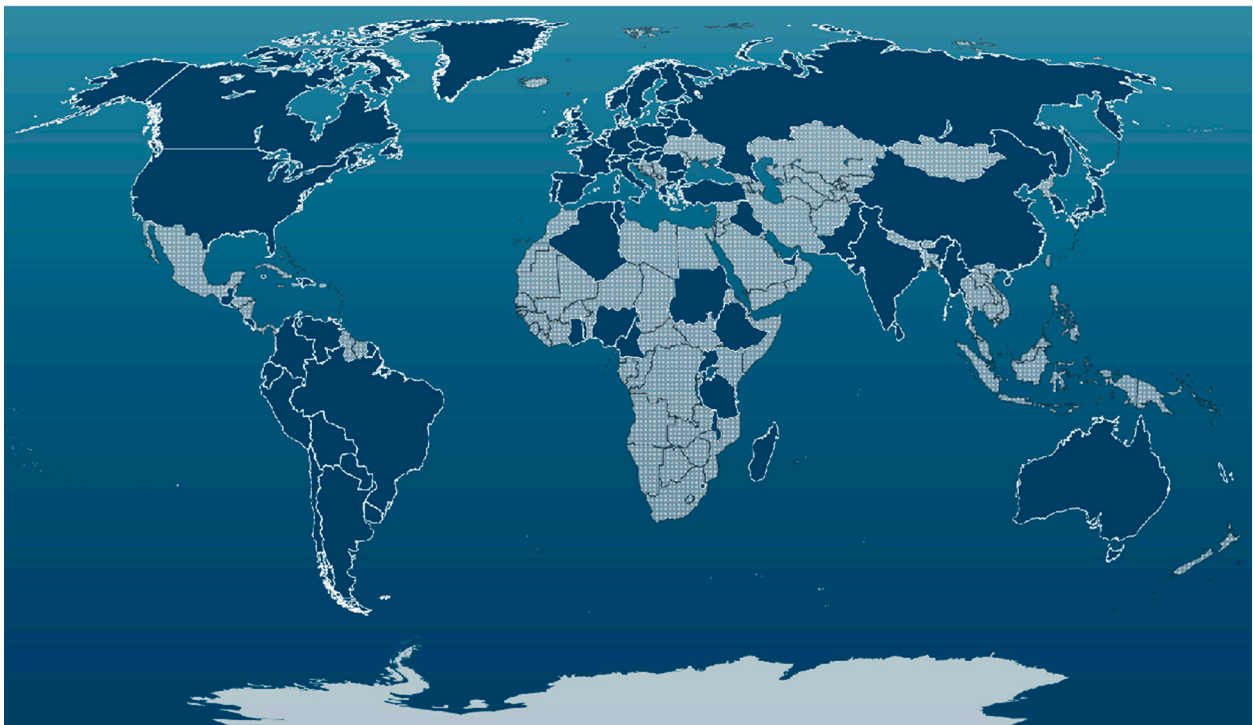


Fig. 6. Countries with access to Charter services in March 2021 (dark blue).

Source: International Charter Space and Major Disasters, p. 54. <https://disasterscharter.org/documents/10180/14622/20th-Charter-Annual-Report.pdf>.



be received directly via subscription or RSS or can be freely followed on GDACS Facebook (<https://www.facebook.com/gdacs>) or Twitter (<https://twitter.com/gdacs>) accounts.

- b) The On-Site Operations Coordination Centre (OSOCC) is a virtual platform with a section enabled for each specific emergency, where the actors involved can exchange various kinds of information with the aforementioned objective of coordinating and rationalising efforts. Access, which is via the corresponding tab on the GDACS home page, is restricted, but any organisation or government can request it from the OSOCC page itself.
- c) The Satellite Mapping and Coordination System (SMCS), managed by UNOSAT and available from the 'Maps and Satellite Imagery' tab on the GDACS home page, provides the maps produced by both the organisation itself and that provided by response agencies or affected countries, which can also indicate their areas of interest to the SMCS. It is necessary to register to interact on the page, but not to access the resulting mapping, which is freely available on the SMCS-UNOSAT page. It can also be accessed from the OSOCC, which also offers to any registered entity the possibility of requesting specific maps.

## Private initiatives

### Humanitarian OpenStreetMap Team (HOT)

OSM is a collaborative map of the world that is in permanent construction, open, available on the network and with editing mechanisms designed to allow anyone, from anywhere in the world, to make changes and modifications easily and quickly.

Among the many entities that carry out activities around OSM is HOT, a non-profit organisation whose objective is to improve the mapping available in OSM for areas in emergency situations. The mapping improvement projects are initiated at the request of organisations working in the affected areas, via the following process: delimitation of the OSM sector to be mapped, subdivision into manageable grids and searches of the most recent aerial or satellite photographs available and making it available on a web site designed for this purpose, called Tasking Manager (<https://tasks.hotosm.org/>). Anyone can choose one of these grids, edit and correct it or draw missing elements on it by using both aerial photographs and field observation. This first phase of the work is completed by subsequent use of a web page called Field Papers (<http://fieldpapers.org/?locale=en>), from which fragments of the OSM map from any place in the world can be easily extracted in a pdf format. Figure 7 shows a

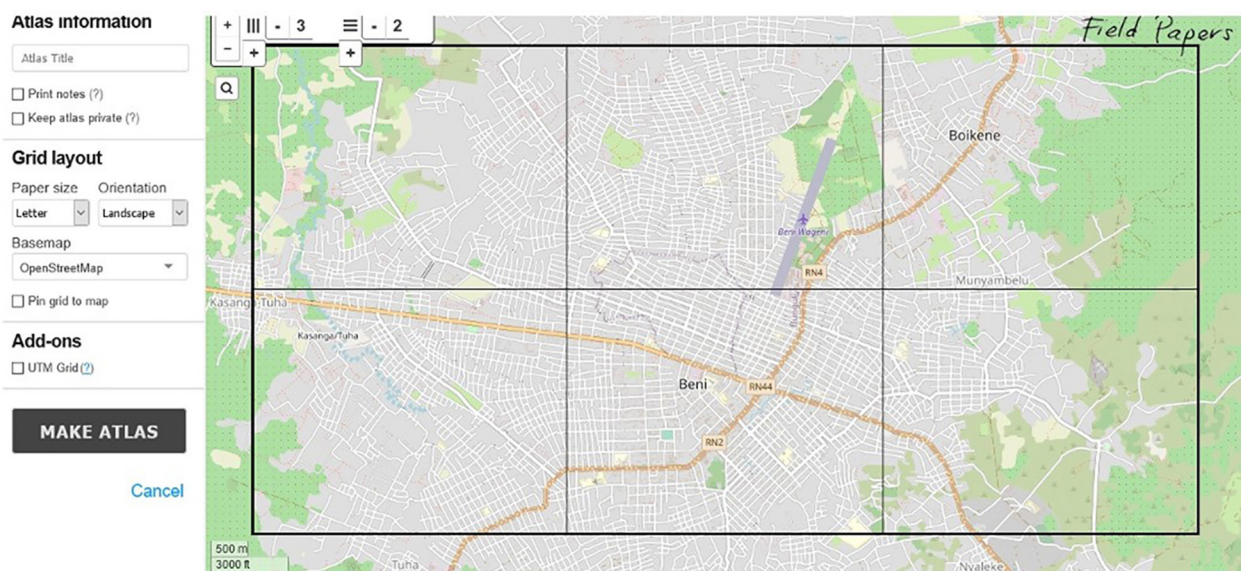


Fig. 7. Preparatory screen in Field Papers to obtain a map in a pdf format of the city of Beni, North Kivu Province (DRC).

Source: <http://fieldpapers.org/compose#13/0.4983/29.4689>.  
DRC – Democratic Republic of the Congo.

moment in the process of obtaining a map of the city of Beni, North Kivu (DRC). The usefulness of Field Papers in the process of cartographic improvement lies in the fact that it allows us to print on paper the maps that have been improved in Tasking Manager in order to – in the field, by handwriting – add missing elements, identify those that have a singular function, correct errors, annotate street names or make clarifications. This map, which is full of new data, can be scanned and/or uploaded back to the Field Papers page, where the system will correctly georeference it, thanks to a Quick Response (QR) code, which appears in a corner of the pdf. Any contributor can then access the OSM overview map, choose the Java OpenStreetMap Editor (JOSM) (one of several editing systems available in OSM) and search for the scanned image uploaded from the field. The JOSM editor allows hand-drawn drawings and annotations to be converted into digital elements that will immediately become visible on the main OSM map.

An example of this working system is the participatory mapping project carried out in 2013 in Rwanda by the College of Geographers of Spain (Colegio de Geógrafos 2013), or that which was conducted in the Isla León neighbourhood of Cartagena (Colombia) by the non-governmental organisation TECHO (Da Silveira Arruda, Yances 2016).

Collaborative mapping has great potential, but it can also portray a biased view of reality if those who participate in it or coordinate it have their own interests, as Specht (2021) demonstrates in his study of the intervention carried out by HOT in Dar es Salaam in 2018.

HOT mechanisms have been activated numerous times to contribute to the control of Ebola epidemics. In the case of the West Africa epidemic, HOT launched the 2014 West Africa Ebola Response project, and for the 2018 DRC northeast epidemic, it activated the Congo-Kinshasa/2018 Ebola Outbreak OSM Response project, both of which are available on separate wikis (OSM 2014, 2018). Figure 8 shows the HOT Ebola interventions.

### MapAction

This is a non-profit organisation that, in emergency situations, provides and analyses cartographic information and collaborates very closely with OCHA. With the support of the German government, it has launched the Moonshot programme, which produces between seven and nine basic maps for each of 20 countries chosen from among the most vulnerable in the world (Duarte, Turner 2020).

For the Ebola virus disease, a search on the ‘Maps and Data’ tab of its website reveals a total of 95 maps, of which 63 are for Sierra Leone and 32 for Liberia (Fig. 9).

The screenshot displays the HOT Tasking Manager interface. At the top, there are navigation links for 'EXPLORE PROJECTS', 'LEARN', and 'ABOUT', along with 'Log in' and 'Sign up' buttons. Below the navigation, there are filter options for 'Difficulty level', 'Any project', 'More filters', and 'New projects'. A search bar contains the text 'Ebola'. To the right of the search bar, there are 'Clear filters' and 'Show map' buttons. The main content area shows a list of projects and a map of West Africa. The projects listed are:

- #8901: 2020 Ebola #2, ZS Bikoro, road update. Description: Updating road network within the Bikoro health. 30 total contributors.
- #8761: 2020 Ebola #1, Mbandaka, road update. Description: Updating road network within the city of. 8 total contributors.
- #6732: Ebola Preparedness Mapping, Zombo. Author: Missing Maps / HOT Uganda \*. 484 total contributors.

The map shows the number of tasks in various West African countries: 3 in Senegal and 18 in South Sudan.

Fig. 8. Mapping improvement Ebola projects carried out by HOT.

Source: HOT <https://tasks.hotosm.org/explore>.

HOT - Humanitarian OpenStreetMap Team.

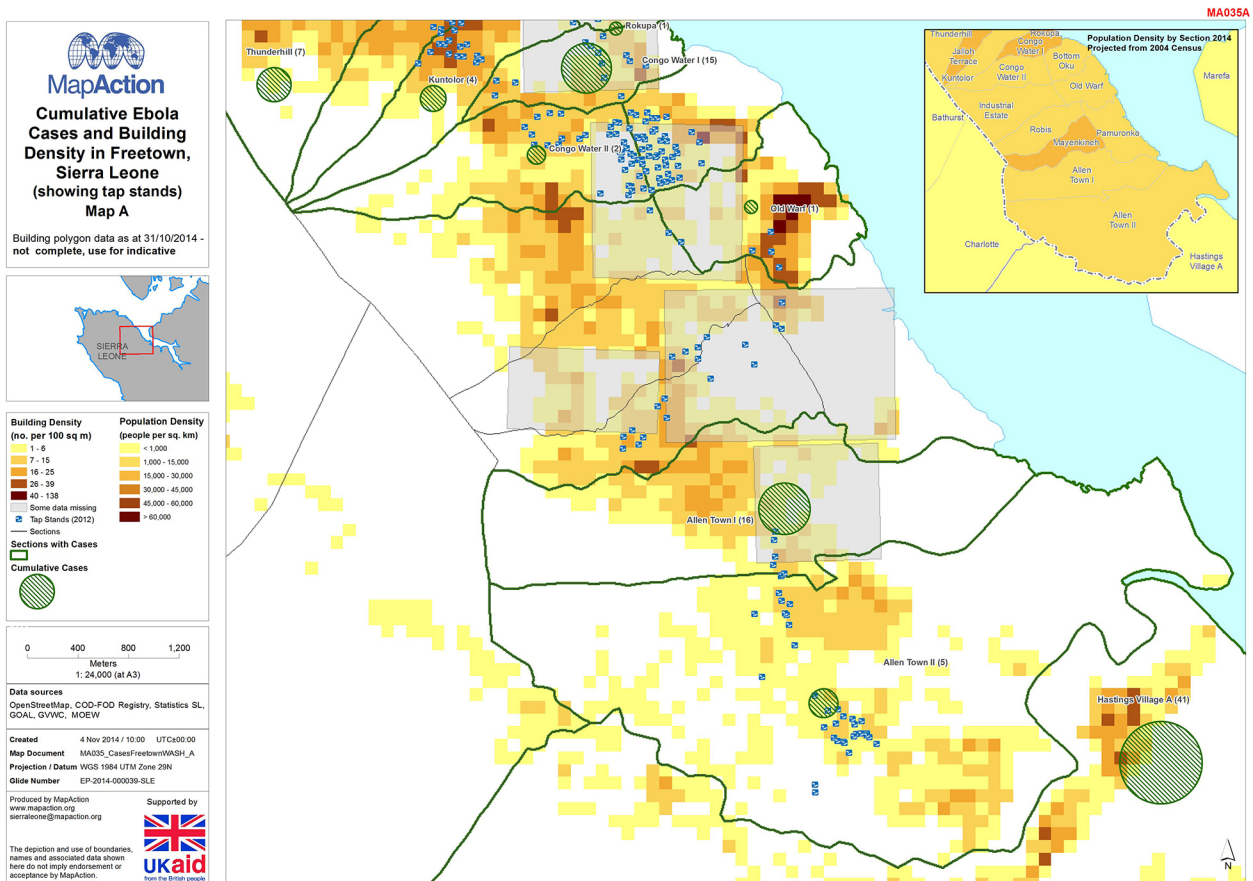


Fig. 9. Map provided by MapAction for a sector of Freetown (Sierra Leone) overlaying Ebola cases with building density.

Source: <https://maps.mapaction.org/dataset/232-3611>.

### Médecins Sans Frontières (MsF) (Doctors Without Borders)

MsF, in collaboration with HOT and the non-profit company CartONG, provided an important cartographic work during the West African Ebola epidemic (CartONG 2014). It has a platform intended for storing maps, although only the catalogue can be accessed, with the possibility of locating a map on it by copying its name and searching for it on OCHA pages or Google. A search for the term 'Ebola' yielded 129 results (MsF 2021). The three organisations mentioned earlier are part of the Humanitarian Action Support (H2H network), which brings together agencies in the humanitarian sector and coordinates them so that they can provide services to each other. H2H raises funds to activate humanitarian-humanitarian cooperation in the face of urgent needs, at no cost to the parties involved (H2H 2021).

### Environmental Systems Research Institute

This is a leading North American company in geographic information systems that has a non-profit organisation programme aimed at providing its software at low cost to non-profit organisations (<https://bit.ly/2ZeoTAq>). During the coronavirus (COVID-19) pandemic, and in collaboration with WHO, it provided the ministries of health of the countries that requested it with its mapping and analysis tools (ESRI 2020). It also has a disaster assistance programme, whose help can be requested in emergency situations (ESRI 2019). In fact, its cartography has been made available to all those working on data analysis with maps in the COVID-19 pandemic through the 'Request Geographic Information System (GIS) Assistance' button on the COVID-19 GIS Hub page (<https://bit.ly/39p69zX>).

However, if users of the ArcGIS Online (AGOL) platform do not publicly share the layers they create, it is not possible to access them, even if another AGOL platform is available, as is



the case with the 32 mapping products related to the West African Ebola epidemic hosted by the Standby Task Force (STF), which are not open access (<https://bit.ly/3lVykfU>).

### Creation of map products

Maps are needed in several circumstances.

#### Emergency monitoring

A plan for searching existing maps for re-use in monitoring emergencies is proposed here. After an evaluation of the cartographic information obtained and considering its ease of access, it is suggested that in an emergency situation where it is necessary to search for maps, interested parties go directly to the HDX and GDACS pages of the United Nations, where it is possible to freely access many resources. If you do not find what you are looking for in the two pages (HDX and GDACS), you will need to log in and register to access the information exchange forums, and through the GDACS OSOCC, you can request the specific maps you need. On these pages, in addition to the resources generated by the GDACS, resources provided by MapAction, MsF, UNOSAT, Copernicus and HOTOSM, among others, are available.

If these resources cannot provide the necessary maps, there remains the possibility of asking HOT to activate one of its collaborative maps. For African countries, it is considered essential that their governments register with HDX, GDACS, OSOCC and the International Charter Space & Major Disasters in order to access these useful resources.

#### Medical science

Sometimes maps become tools of medical science by incorporating epidemiological aspects. In relation to Ebola, maps, in general, have an eminently practical use that is aimed at facilitating the work of field teams; however, there are also good examples of maps that include health parameters in their representations. Thus, we have seen WHO maps representing the number of Ebola cases by health district, or those of MapAction, which offers maps such as those already mentioned in Figure 9, in which the number of Ebola cases is superimposed on the density of buildings in a sector of Freetown (Sierra

Leone). Pigott et al. (2014) produced maps relating the location of Ebola epidemics to the geographical distribution of bats in fruit trees, which are considered natural reservoirs of the virus, while Hossain et al. (2016) geolocated chains of contagion by establishing networks to try to understand the evolution of the disease.

#### Military aims

The Vector Map Level 1 (VMap1) project was launched at the end of the 20th century, with this area of the world being mapped at a scale of 1:250,000 (Rodríguez Ruiz, Pérez Hernández 2014). The VMap Level 0 project was also undertaken for the scale of 1:1,000,000, and the Multinational Geospatial Co-Production Programme (MGCP) is underway with the aim of obtaining a global cartography at a scale of 1:50,000. All these initiatives are closely linked to the North Atlantic Treaty Organization (NATO).

Since these are international projects, it is essential to develop data standardisation and interoperability, as well as to specify the degree of availability of each participant involved in the mapping produced; which is an extremely complex issue. This military cartography is provided to organisations working in situations of catastrophe and humanitarian aid, when the army is involved.

#### A self-designed map that draws on the above-mentioned sources

Using some of the sources studied in this work, the authors have constructed a map showing the health zones affected by the Ebola epidemic that occurred during 2018 and 2019 in the provinces of North Kivu and Ituri, in the northeast of the DRC. We draw on shapefile layers with administrative boundaries of DRC provinces and health zones from HDX, and data collected from SITREPs, which is issued by the WHO, to build the map (Fig. 10). As can be seen, the sources that have been cited throughout this work are highly useful and provide both accurate and understandable maps. This particular map is based on a csv file that has been uploaded to ESRI's AGOL GIS website and makes the areas with the greatest impact of the epidemic visible. There are no online data for smaller territorial units, so the mapping should be seen as giving an overview only.

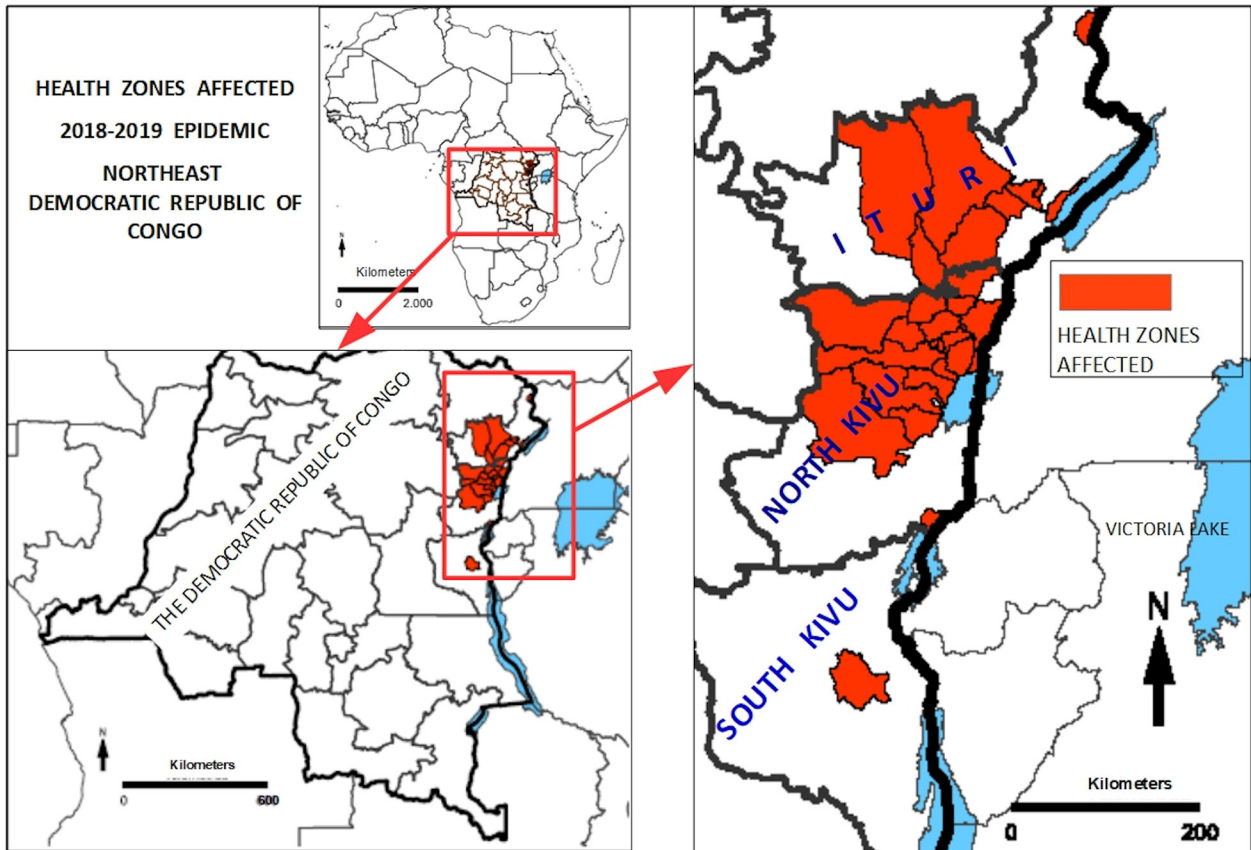


Fig. 10. Affected health zones are given in red.

Source: map prepared by the authors based on the sources cited in the text.

## Discussion and conclusions

In this research, we have identified at least 14 initiatives within organisations that produce mapping and whose complementarity becomes a facilitating agent of the spatial dimension that an epidemic may have, and thus offer solutions that help mitigate it through controls in strategic locations. There is evidence of greater reliability in official agencies than in the production of collaborative mapping, which may be more subject to personal or group interests.

Although the production of the aforementioned sources and organisations is abundant, we believe that it is still lacking when it comes to developing updated mapping in real time. In fact, we were unable to obtain full complementarity when contrasting the data, and therefore, it is recommended to advance an integrative map that brings together the geographical space and its physical and human characteristics with the emergence of the disease, and its possible expansion. At the same time, a certain duplication of effort has been observed, so it is considered

important to support the coordination work that the GDACS is currently undertaking.

Another limitation found in our research is in the availability of cartographic information since some pages of WHO sometimes disappear or are reorganised, which makes it impossible to find the bulletins cited in the text; although with the name it is possible to search in the Institutional Repository for Information Sharing (IRIS) (<https://apps.who.int/iris/?locale-attribute=en&>).

On the other hand, more specifically, the bulletins issued by the government of the DRC are only available on the web for a few weeks; moreover, they refer exclusively to serious epidemics that are ongoing at the time of their publication, so it is not possible to find references to Ebola in them once the epidemic has passed.

Despite the aforementioned drawbacks, and following the study carried out, mapping is considered a key tool that gathers data located in the territory and allows its spatial analysis to search for patterns in the spread of an epidemic and to be able to address it by developing strategies for its containment.

The cartographic representation of health emergencies in our case of Ebola is a very helpful tool for governments and institutions that need to urgently combat this disease.

Finally, it should be noted that except for part of the collaborative work undertaken by HOT, the maps presented in this work have not been produced in Africa and have not even been activated by any African governments or organisations. This is considered to be an indicator for a critical review of the whole system.

### Author's contribution

JAB, FJM and MLL: conceptualisation and design. JAB: data collection and analysis, and creation of figures and tables. JAB, FJM and MLL: manuscript preparation and revision, and References section.

### Conflict of interest disclosure

The authors declare that no conflicts of interest exist.

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