School-age populations exposed to natural hazards

An approach to triangulate internally displaced population estimates[1]

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Summary

Estimating the school-age population to be serviced by national education systems is the cornerstone of any educational planning process. Nonetheless, this is also one of the trickiest exercises, as population estimates by relevant age and sex breakdowns are not necessarily disseminated by the national statistical offices as often and granularly as they would be needed by the ministry of education, and other stakeholders. In disaster-prone areas, locating school-age populations exposed to natural hazards means that educational and emergency services can be deployed in the most efficient manner to reach them, and helps anticipate displacement.

The approach proposed here aims at combining spatialized school-age population estimates with data derived from satellite imagery (or with indices created from earth science data, earth observation, climate, etc.) produced during or right after a natural event, to estimate age and sex-disaggregated displacement exposure.

This background paper is prepared in the context of the 2022 IDMC GRID report, and the methodology presented should be of interest to all planners and managers in ministries of education, humanitarian organizations, and development partners, and anyone eager to better identify the school-age populations exposed to natural hazards, and better plan responses for potentially displaced students. Finally, the methodology presented here can be used to triangulate the estimates produced by other methodologies with regards to educational provision, especially those produced by direct observation or key informants.

Introduction

In October 2021, IIEP published a methodology to produce school-age population estimates for any territory or area, any educational level, and for any year since year 2000 (Gagnon and Vargas Mesa, 2021). This contribution is crucial in educational planning because it is the first global and standardized tool that combines existing open source data and open access statistical literature to resolve the typical unavailability of population estimates by single years of age at the super local level[2], thus allowing the reconstruction of any school-age group that match any geographic area, administrative or not. Therefore, educational planners or managers can now calculate sub-national education indicators based on population data, such as enrolment rates, as long as enrolment data is available at the same scale (e.g. province, district, catchment area, etc.).

The current paper proposes an application of the original method to disaster settings, where analysts and responders need to estimate the volume of the school-age population exposed to natural hazards. The application proposed here is innovative because it is based on school-age population estimates generated prior to the occurrence of natural events (with full age and sex structures), and combined with the geospatial detection of natural hazards produced during a natural event (such as floods, droughts, lava flows, snow avalanches, etc.).

Several organizations have developed methods to estimate the number of displaced people, internal or refugees. These methods have several elements in common, the most important being temporality. All methods that we could survey produce population estimates *after* a crisis happens, which means that populations are already on the move at the time they are measured, rather than in their original place of residence.

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[1] The designations employed and the presentation of the materials in this paper and related repositories do not imply the expression of any opinion whatsoever from the UN, UNOSAT, UNESCO, or IIEP-UNESCO concerning the legal status of any country, territory, city, area, authorities, concerning the delimitation of frontiers or boundaries.
Authors would like to thank colleagues Özge M. Ozcan, Blandine Ledoux, Leonora MacEwan, Jean Claude Ndabananiye, Sebastien Hine for their review and constructive feedback.
[2] The estimations can be produced for grids as small as 3 arcseconds, approximately 100 square meters at the equator. Authors recommend to use school-age population estimates at 1 sq. kilometre for large areas, and 100 sq. meter for smaller areas.

Existing models and their constraints

As its core mandate, IDMC seeks ways to estimate internally displaced people (IDP) disaggregated data by sex and age, but such granular information is rarely available, in part due to the intrinsic nature of IDPs and their dispersion in host communities. However, IDMC proposes to apply national-level proportions in order to obtain sex and age breakdown of IDPs where only total population estimates for IDPs are available—for example if 51% of the national estimates are female, then the proportion used to estimate the local number of females will be 51% (IDMC, 2021; IDMC & UNOCHA, 2008). Moreover, the UN Population Division's World Population Prospects (UN DESA, 2019) can be consulted in the absence of official population estimates at national level (Cazabat and Desai, 2020). Nevertheless, this method relies on a bold assumption on the similarity between *national* demographic profiles and local population dynamics and structures. This hypothesis might hold true in small areas but might be difficult to sustain in larger contexts.

The 2018 IDMC GRID report mentions that the best-case scenario in data production, is to rely on event-based, direct head-count observation of each flow (IDMC, 2018: 85). Over the last five years, IDMC has also introduced methods using satellite imagery, and probabilistic methods that do provide additional results (IDMC, 2017), but those methods are still generating aggregated data – total affected populations or data broken down by five-year age groups rather than age groups that are relevant to the education sector.

The International Organization for Migrations (IOM) Displacement Tracking Matrix (DTM) works a bit differently. The DTM provides multi-layered data to planners and decision makers for delivering humanitarian responses. The matrix consists of four components (mobility tracking, flow monitoring, registration, and surveys) to derive data at various levels by employing various methodologies (IOM, 2019). The components serve to draw a framework to standardize data collection processes in different crisis and regional setting. Depending on the component's objectives and contextual framework, key informant interviews, direct observation, focus group discussions, household or individual interviews, participatory mapping, household and individual surveys are the prevailing methodologies adopted or combined. Although DTM proposes an extensive and standardized information set for displaced people, our review of several matrices show that disaggregated data by sex and age is not collected systematically following a standard methodology, and population-related information is available by broad age groups (e.g. 0-18 years of age, without gender breakdowns), often inconsistent across contexts and time, and of little significance to the education sector and educational planning needs.

OCHA's & the Global Education Cluster People in Need methodology is also trying to estimate the people "whose physical security, basic rights, dignity, living conditions or livelihoods are threatened or have been disrupted, and whose current level of access to basic services, goods and social protection is inadequate to re-establish normal living conditions with their accustomed means in a timely manner without additional assistance" (Global Education Cluster, 2018). The PiN methodology is described here as an approach that is based on secondary data reviews, and complemented by information available through extra resources such as the national population census, the OIM DTM mentioned above, and the national education management information system. Although the PiN toolkit is extremely comprehensive and enables users to both analyse and estimate the number of people in need, it also allows them to document their methodological hypotheses and data/ information sources. Nonetheless, and even if the guidance provided emphasises the need to be specific on the different learning ages, a quick analysis of the materials developed for the Central African Republic, Myanmar, and Nigeria, all show that the age range used to estimate school-age populations is a generic interval running from 3 to 17 years old, with no distinction between educational levels and sex (Global Education Cluster, 2016, 2017, 2019).

UNHCR has prepared a "demographic projection tool to estimate the future size and composition of forcibly displaced populations" (UNHCR, 2018) which estimates population dynamics once they are 'settled' into camps, i.e. after the displacement. The demographic information used is based on UNHCR proGres database, which is self-declared (UNHCR, 2018).

Finally, Eurostat has published its recommendations on IDP statistics (European Commission (EC) and United Nations (UN), 2020). The report highlights the importance of disaggregating IDPs data by sex and age, but seems to only propose guidelines on how to integrate disaggregated data into official data collection processes, and not to actually create the figures.

The above methods allow to estimate the magnitude of the movement but do not allow for a reliable estimation of school-age populations. Therefore, such estimations are helpful to provide bulk relief (e.g., water, sanitation) but not necessarily appropriate age-specific social support and services, such as education. We conclude that there is a need for greater coherence between the design of the original data collection instruments for emergency relief, and data relevance and usability for further, longer-term, service provision in protracted crises.

Measurements are either not disaggregated by age or produced with inconsistent broad age groups. In the latter case, age groups are seemingly not connected to school-age ranges, and there is no uniformity in the collection methods, surveys, and information collected across crises. Finally, geographic boundaries used for the collection of information on displacement seldom match the area for which official population estimations are made.

In summary:

- Existing methodologies produce counts after the occurrence of a natural event.
- Counts are contingent on the availability of external staff to be deployed to the exposed area, and/or to analyse secondary data.
- The exposed area is not necessarily clearly bounded with geographic information (e.g. geographic coordinates, administrative boundaries).
- The counts do not provide a full picture of the volume of people exposed to a risk.
- Age-group estimates are based on the criteria set by the organization tasked with doing the observation/ estimations, and therefore has a potential mismatch with educational levels. This can be in the form of 5-year age groups, or other, broader, categorizations.

Table 1. Availability of items for five estimation methods

	Population counts by exact school-age group	Census based	Place-of-origin information	Identifiable geographical boundaries
IDMC GRID report	✕	✕	✕	✕
IOM DTM	✕	✕	✕	✕
OCHA/ ED Cluster PiN	✕	✕	✕	✕
UNHCR	⚠ *	✕	✕	⚠ **
IIEP 2021 approach	☑	☑	☑	☑

Sources: Gagnon and Vargas Mesa, 2021; Internal Displacement Monitoring Centre (IDMC), 2017, 2018; IOM, 2019; UNHCR, 2018

**: We assume that date of birth or age are available in the ProGres database but we could not get confirmation from UNHCR **: The geographic area examined is a camp.*

Generating school-age population estimations based on ex-ante population structures

Because earth observation can provide information on natural hazards (e.g. land surface temperature, sea elevation, night-time lights, etc.) and almost real-time data on natural events (flooded areas, snow avalanches, etc.), the method proposed here is useful in two ways. First, in risk assessment and preparedness contexts: when sufficient data is available, it is possible to map both school-age population estimates and potential hazards. This allows to estimate the overall displacement risk or exposure of the different school-age groups, and to take preventive measures to guarantee that schools are as safe as possible in the face of the measured potential risks. This approach will be described in a forthcoming IIEP paper (Vargas Mesa, Sheldon, and Gagnon, Forthcoming).

The second way that this methodology is useful is when a disaster occurs, so that specific school-age populations exposed to the event and at risk of displacement can be estimated. Combining UNOSAT rapid mapping data or a similar type if imagery (see Box 1 below) with spatialized school-age population estimates can help quickly assess the magnitude of the impact of the disaster on the education system, in the area under study. This method can also be adjusted to estimate people indirectly exposed to the natural disaster, by creating impact buffers for areas that might bear the blunt of the consequences (e.g., which community facilities could be used as schools, education facilities have been damaged, villages or settlements that are receiving the influx of displaced people, those who depend on flooded crops, etc.). As this approach is the most relevant to IDMC's work, it is the one described in the section below.

Box 1. UNOSAT Rapid Mapping Services

UNOSAT Rapid Mapping is a service that provides timely satellite imagery derived maps that can play a crucial role in the response (national or international) to natural and human-made crises. Typical situations for which UNOSAT Rapid Mapping is activated include floods, earthquakes, storms, landslides, volcanoes, oil spills, chemical waste, refugee and IDP camp mapping, conflict damage assessment and situation analysis.

During humanitarian emergencies, both natural disasters and conflict-situations, UN offices and agencies, Government agencies, International and regional organizations, Humanitarian Non-Governmental Organizations (NGOs), Red Cross and Red Crescent Movement (ICRC and IFRC), can request the deployment of UNOSAT's Rapid Mapping service.

The service processes requests at any time, and analysts ensure timely delivery of satellite imagery derived maps, reports, and data ready to be imported and analysed into any geographic information system.

Source: https://www.unitar.org/maps/unosat-rapid-mapping-service

Step-by-step school-age population exposure to natural events

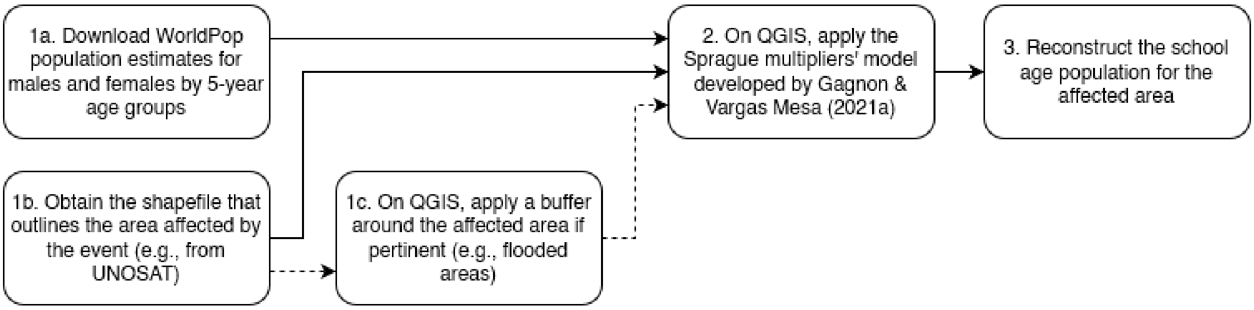
The purpose of this methodology is to help estimate by age and sex the proportions of different school-age populations exposed to a natural hazard, and their distribution across a territory. The methodology can help compare IDP estimates produced by observation after a natural event, as will be shown later in Table 1, and can help project how many educational facilities are exposed, or how many learning materials need to be furnished, or teachers need to be deployed, particularly when combined with national official education statistics. In spite of its high potential to allocate resources more efficiently, care should be taken in using the method and interpreting the results.

The ability to estimate the school-age children and youth exposed to a particular event is helpful to plan both bulk relief and social support, particularly those that are age-specific such as education. To do this, we propose to combine the methodology presented in Gagnon and Vargas Mesa (2021) on estimating local school-aged population using Sprague multipliers, with the shapefiles produced to delimit the areas affected by a hazard, for which the step-by-step approach is described on Figure 1 below. To illustrate the method, we will take the example of floods (satellite detected water extent) detected by UNOSAT as of 18-19 October 2021 over South Sudan[3]. A second, more recent analysis is provided in

[3] UNOSAT information is available here https://www.unitar.org/maps/map/3400, under glide number FL20211015SSD

Annex 1 for floods detected on 8 February 2022 over the Fitovinany Region, Madagascar[4]

Figure 1. Estimating school-age population directly and indirectly exposed to a natural event

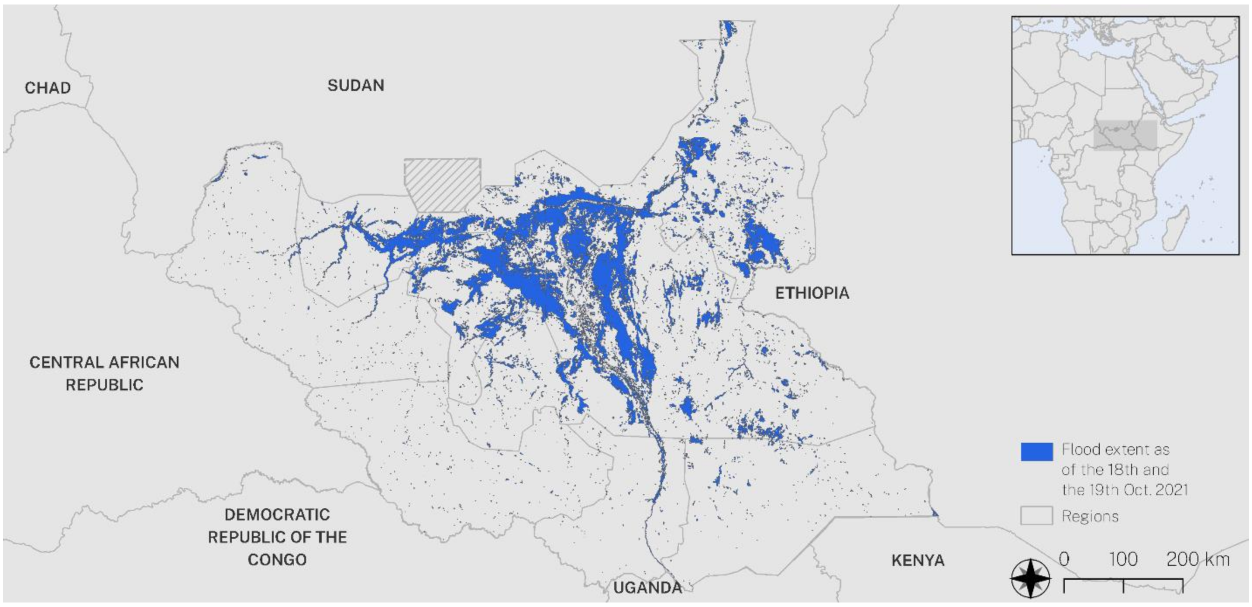


To start with, (Step 1a) the user downloads population estimates produced by WorldPop for 5-year age groups, for the relevant school year. As per international conventions, the population estimates to use are those for the calendar year in which the school year starts, e.g., if the school calendar runs from September 2021 to June 2022, the population estimates will be those for 2021, whereas a system running from January 2022 to October 2022 will use population estimates from 2022. In South Sudan, the most recent school year started on 3 May 2021 to end on 18 March 2022[5], so the indicators related to the school year ending in 2022 are based on the 2021 population estimates. At this stage, it is also expected that the users know the start ages and durations of all relevant educational levels, so that school-age populations can be calculated in Step 2.

In parallel, (Step 1b) users locate and download the shapefiles outlining the affected areas from one of the agencies working on the crisis. This includes climate-related events, such as floods and landslides, or other earth observation information, such as droughts, land surface temperature, etc. The image on Figure 2 shows the water extend detected by UNOSAT on 18-19 October 2021, through the activated rapid mapping exercise.

If advisable, (Step 1c) a buffer can be added to the polygons on a fit-for-purpose basis, which size will be evidenced by local knowledge, in order to estimate indirectly exposed school-age populations.

Figure 2. Satellite detected floods (flood extent) over South Sudan, as of 18-19 October 2021

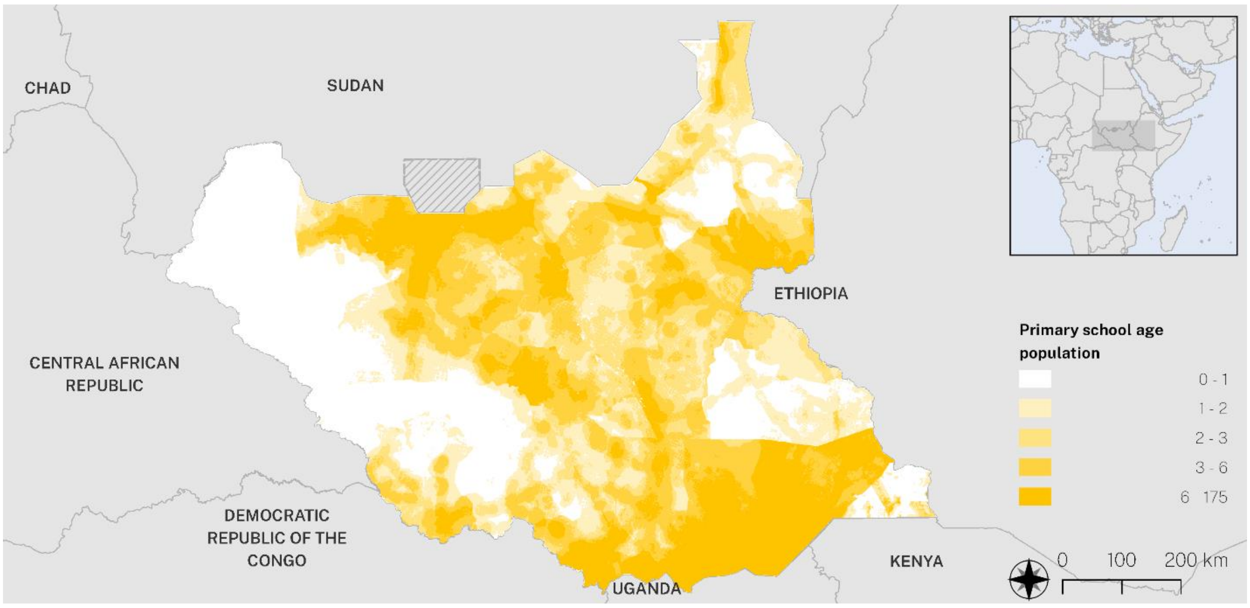


[4] UNOSAT information is available here https://www.unitar.org/maps/map/3462, under glide number TC20220201MDG
[5] Government of the Republic of South Sudan (2021) Reopening guidelines https://girlseducationsouthsudan.org/wp-content/uploads/2021/05/210427_MoGEI_Reopening-Guidelines-for-Schools-in-South-Sudan_A5_Signed.pdf

Source: Authors' own, based on UN Geospatial Information Section (Administrative boundaries, 2022), UNOSAT (Satellite-detected water extents, 3400).

Once the base data is collected and that specifications are determined, one can apply the model developed by Gagnon and Vargas Mesa (2021) to estimate the number of school-aged population living within these polygons. This model can be run through a plugin available here. This methodology applies an interpolation method designed by Thomas Bond Sprague in the late 19th century, which allows to break down a population distribution by 5-year age groups into a distribution by single years of age (Sprague, 1880a).

This method is therefore applied in Step 2. to the gridded population estimates provided by WorldPop, and for which the population distribution is available by 5-year age groups for every 100m sq. From that breakdown, we can then reconstruct school-age populations for any relevant educational levels and aggregate the figures to user-defined areas. This method therefore allows to calculate school-age population estimates for South Sudan for age groups covering pre-primary (ages 3 to 5), primary (ages 6 to 11), and secondary education (ages 12 to 17)[6]. The spatialized school-age population density for these educational levels is visualized on **Error! Reference source not found.**, Figure 4, and Spatialized primary school-age population in South Sudan, 2021

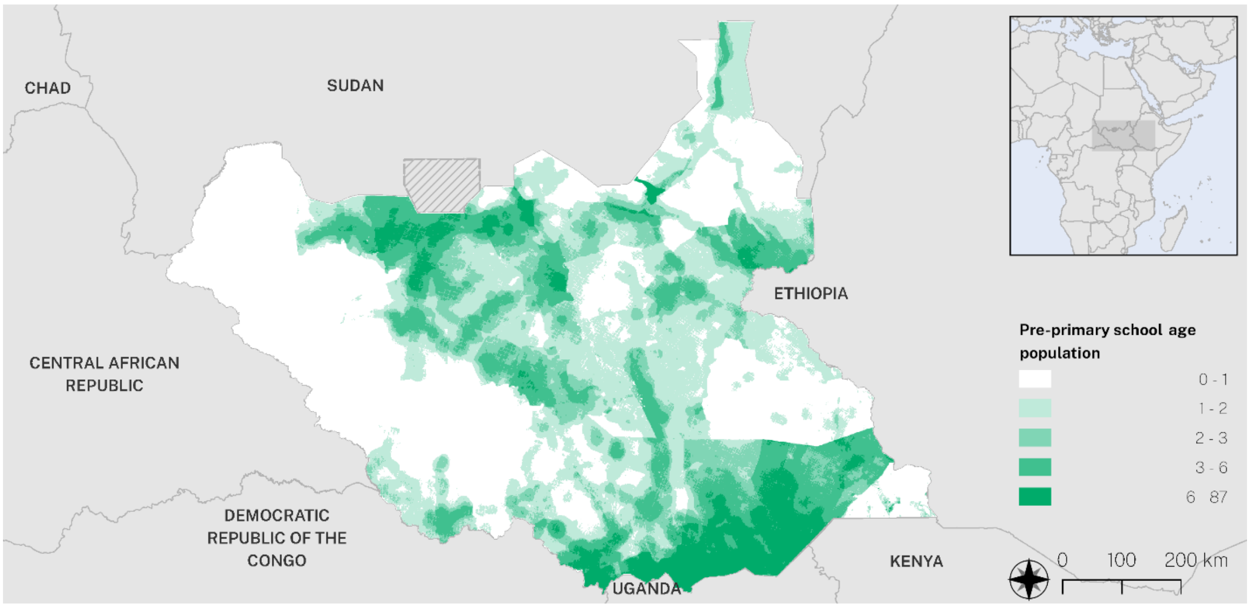


Source: Authors' own, based on UN Geospatial Information Section (Administrative boundaries, 2022), WorldPop (2020 gridded population density at 1 sq. kilometre grid), UN World Population Prospects (2021 Population estimates), UNESCO-UIS (ISCED 2011 mapping)

Figure 5, and show overall 108,139 pre-primary age children, 150,417 primary-age children, and 180,219 secondary-age children spreading across the region.

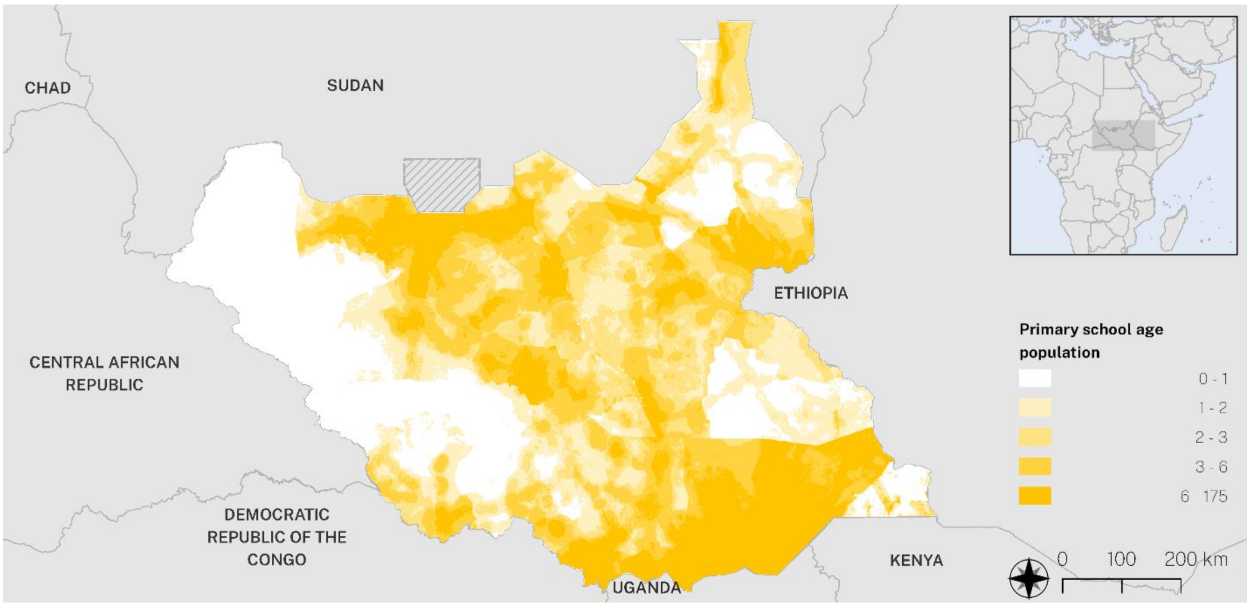
Figure 3. Spatialized pre-primary school-age population in South Sudan, 2021

[6] Any age interval can be used for this calculation, for convenience here we use the UNESCO Institute for Statistics data based on ISCED mappings. Data is based on indicators 299902, 299905, 999975 and THDUR_2T3 from UIS database. www.data.uis.unesco.org. Last accessed 19 January 2022



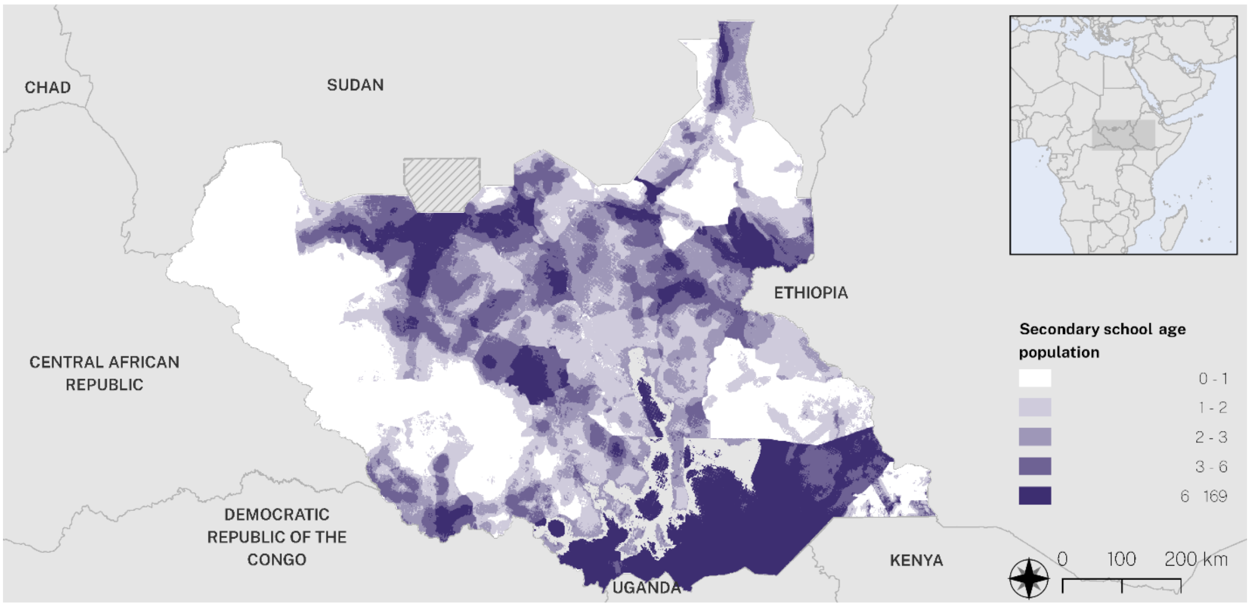
Source: Authors' own, based on UN Geospatial Information Section (Administrative boundaries, 2022), WorldPop (2020 gridded population density at 1 sq. kilometre grid), UN World Population Prospects (2021 Population estimates), UNESCO-UIS (ISCED 2011 mapping)

Figure 4. Spatialized primary school-age population in South Sudan, 2021



Source: Authors' own, based on UN Geospatial Information Section (Administrative boundaries, 2022), WorldPop (2020 gridded population density at 1 sq. kilometre grid), UN World Population Prospects (2021 Population estimates), UNESCO-UIS (ISCED 2011 mapping)

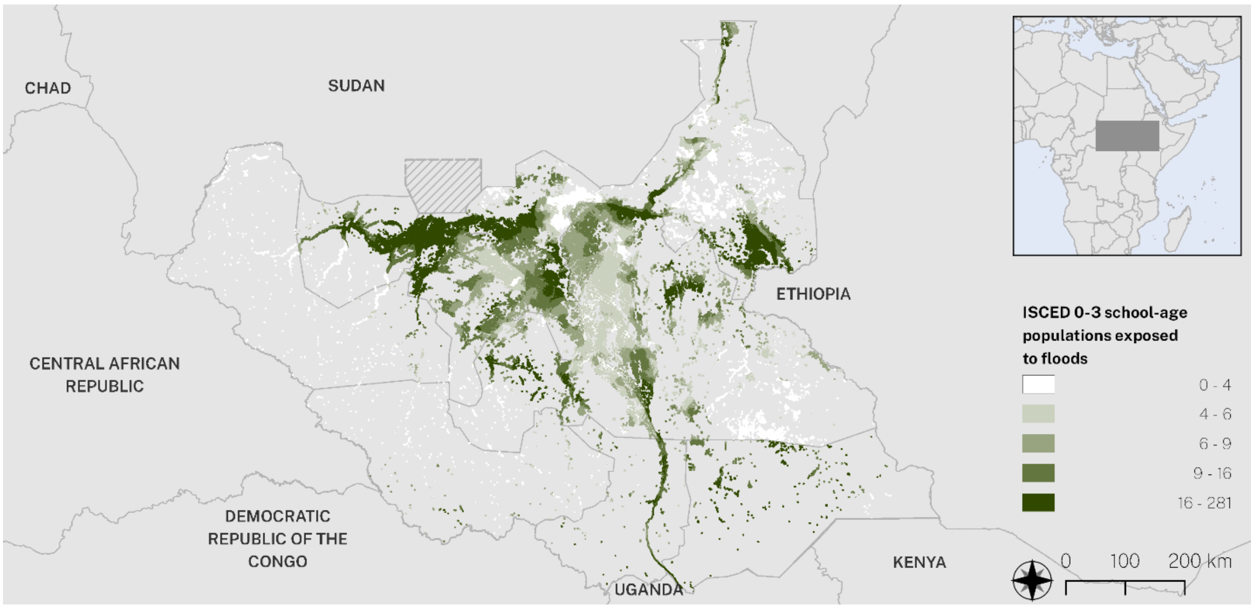
Figure 5. Spatialized secondary school-age population in South Sudan, 2021



Source: Authors' own, based on UN Geospatial Information Section (Administrative boundaries, 2022), WorldPop (2020 gridded population density at 1 sq. kilometre grid), UN World Population Prospects (2021 Population estimates), UNESCO-UIS (ISCED 2011 mapping)

In the case of floods, it is now possible to estimate not only the population directly exposed to these floods (i.e. population raster overlapping the water detected by UNOSAT, in our example) but also those that area exposed indirectly, meaning those living adjacent to these areas (e.g. those within a 1kilometre buffer), who might have depended on now spoiled crops, who might see a rise in mosquito-related diseases, or who might be exposed to the sudden arrival of displaced populations. This is visualized on Figure 6.

Figure 6. Estimated pre-primary, primary, and secondary school-age populations exposed to floods and 1kilometre buffers in South Sudan, 18-19 October 2021



Source: Authors' own, based on UN Geospatial Information Section (Administrative boundaries, 2022), UNOSAT (Satellite-detected water extents, 3400), WorldPop (2020 gridded population density at 1 sq. kilometre grid), UN World Population Prospects (2021 Population estimates), UNESCO-UIS (ISCED 2011 mapping)

In South Sudan, UNOSAT reported a number of flooded areas that were detected after heavy rains over the country, the most devastating in decades[7] (UNITAR, 2021). By combining these aerial observations with the spatialized school-aged population estimates for the same area in for the same reference period (see Figure 6 above), it is possible to determine the total number of pre-primary- (220,213), primary- (393,111) and secondary- (331,758) aged children and adolescents initially living in the areas affected by floods, both directly (those living in the flooded areas) and indirectly (those in the 1kilometre buffer around these areas).

These numbers represent about 22% of school-age children and youth in the whole of South Sudan, and for which the breakdown is very different depending on the administrative region. For example, if only 3.1% of any school age populations in Western Equatoria have been exposed to floods on 18-19 October, it is also the case for 66% of the pre-primary school-age population of Unity, and of almost 30% of the female primary school-age population of the Lakes. Such detailed information might directly influence the response. Table 2 below summarizes the type of information that can be estimated with the approach.

Table 2. School age populations exposed (or not) to floods in South Sudan, by State, 18-19 October 2021

		Est. total school age population	Est. **Female** school age population	Est. School-age population **exposed** to floods	Est. **Female** school-age population **exposed** to floods	**Proportion** of est. Total school-age population **exposed** to flood	**Proportion** of est. **Female** school-age population **exposed** to flood
Total	Pre-primary	947,550	473,401	220,213	109,548	23.2%	23.1%
	Primary	1,779,303	875,238	393,111	193,686	22.1%	22.1%
	Secondary	1,648,582	812,961	331,758	164,085	20.1%	20.2%
Unity	Pre-primary	67,746	34,413	44,432	22,718	65.6%	66.0%
	Primary	112,361	57,182	72,361	37,405	64.4%	65.4%
	Secondary	86,323	44,181	53,977	28,254	62.5%	63.9%
Warrap	Pre-primary	68,454	35,553	40,183	20,985	58.7%	59.0%
	Primary	117,894	60,882	69,979	36,285	59.4%	59.6%
	Secondary	94,931	50,721	57,110	30,510	60.2%	60.2%
Jonglei	Pre-primary	116,655	54,435	48,789	22,935	41.8%	42.1%
	Primary	217,538	100,269	91,616	42,338	42.1%	42.2%
	Secondary	192,141	88,871	80,031	36,912	41.7%	41.5%
Upper Nile	Pre-primary	88,951	42,523	34,916	16,498	39.3%	38.8%
	Primary	163,808	76,432	65,247	30,342	39.8%	39.7%
	Secondary	143,303	66,951	59,570	27,601	41.6%	41.2%
Northern Bahr el Ghazal	Pre-primary	48,862	25,349	18,223	9,492	37.3%	37.4%
	Primary	77,337	39,981	28,923	14,991	37.4%	37.5%
	Secondary	53,392	28,380	20,074	10,692	37.6%	37.7%
Lakes	Pre-primary	50,580	25,346	14,584	7,348	28.8%	29.0%
	Primary	96,785	47,975	27,291	13,593	28.2%	28.3%
	Secondary	84,296	41,202	23,025	11,292	27.3%	27.4%
Western Bahr el Ghazal	Pre-primary	29,257	14,878	1,835	934	6.3%	6.3%
	Primary	48,559	24,327	3,063	1,527	6.3%	6.3%
	Secondary	39,702	19,739	2,530	1,256	6.4%	6.4%
Central Equatoria	Pre-primary	99,899	50,627	5,002	2,538	5.0%	5.0%
	Primary	183,215	92,172	9,249	4,686	5.0%	5.1%
	Secondary	179,367	90,547	9,158	4,602	5.1%	5.1%
Eastern Equatoria	Pre-primary	329,696	166,285	10,760	5,352	3.3%	3.2%
	Primary	674,736	333,421	22,635	11,183	3.4%	3.4%
	Secondary	687,887	338,325	23,537	11,582	3.4%	3.4%
Western Equatoria	Pre-primary	47,450	23,990	1,487	747	3.1%	3.1%
	Primary	87,068	42,596	2,746	1,336	3.2%	3.1%
	Secondary	87,241	44,043	2,747	1,383	3.1%	3.1%

Source: Authors' own, based on UN Geospatial Information Section (Administrative boundaries, 2022), UNOSAT (Satellite-detected water extents, 3400), WorldPop (2020 gridded population density at 1 sq. kilometre grid), UN World Population Prospects (2021 Population estimates), UNESCO-UIS (ISCED 2011 mapping)

7 As per UNHCR, see https://news.un.org/en/story/2021/10/1103442

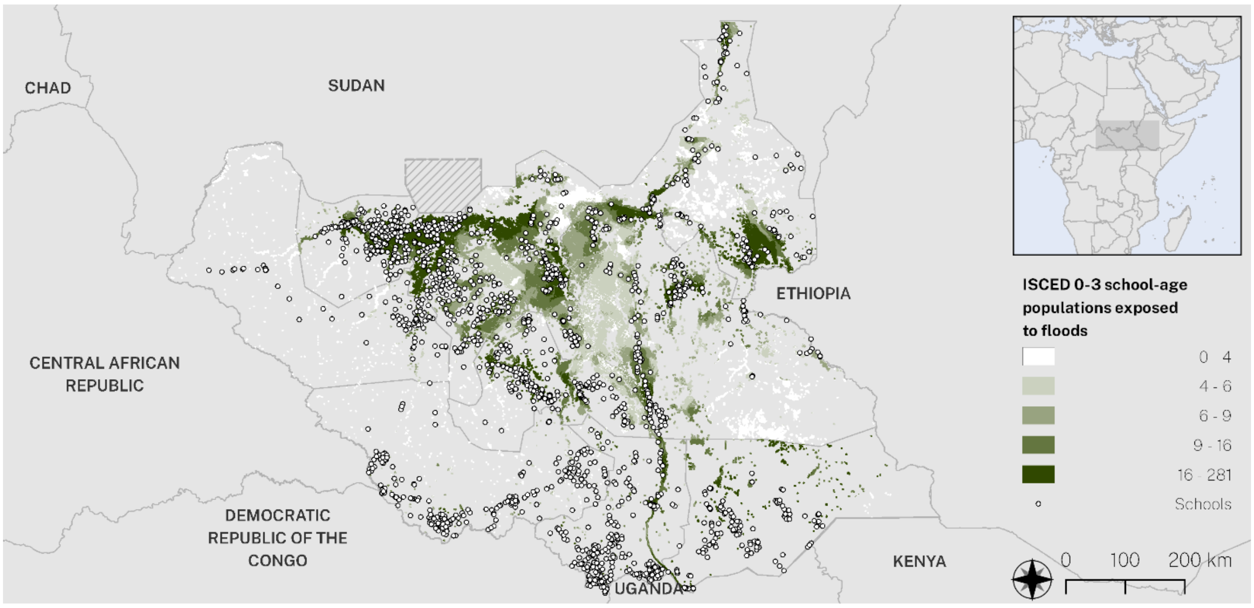
Being able to estimate the volume of the different populations exposed to a disaster supports efforts to measure the proportions of these that are exposed to the event. Furthermore, adding schools on top of this analysis (their location, but also their size, amenities, etc.) can support efforts for providing relief – educational or otherwise.

Furthermore, when school locations are available, adding them to the database can quickly highlight which educational infrastructure is also exposed to the hazard, and which could still be used as a resource, as shown on Figure 7. For instance, using similar information, the South Sudan Ministry of Education could run a flash survey to estimate the damage on the schools. Even with very simple information drawn from the South Sudan Ministry of General Education and Instruction EMIS, one can identify how many schools are in the flooded areas (direct or indirect), and where interventions on infrastructure might be most needed. within the limitations of the publicly available data, Table 3 shows that no pre-primary schools have been exposed to floods, but 17.4% of primary schools have, overall, in the country. Most affected are the schools in Northern Bahr el Ghazal, where more than 1 in 3 (35%) primary schools are in flooded areas. Cross-checking each of these schools with their EMIS record will allow to evaluate the impact of the floods on the educational facilities.

Table 3. Number of schools in flooded areas, 18-19 October 2021

State	Primary schools in flooded areas	Secondary schools in flooded areas	Total number of schools in flooded areas	Proportion of primary schools in flooded adeas	Proportion of secondary schools in flooded adeas
Northern Bahr el Ghazal	202	8	210	35.4%	21.6%
Lakes	46	2	48	12.3%	11.8%
Unity	95	2	97	25.4%	14.3%
Central Equatoria	34	13	47	5.5%	13.8%
Eastern Equatoria	15		15	4.0%	0.0%
Western Equatoria	2		2	0.5%	0.0%
Western Bahr el Ghazal	9		9	3.9%	0.0%
Jonglei	134	2	136	26.9%	12.5%
Upper Nile	31	1	32	7.1%	2.8%
Warrap	207	7	214	37.5%	28.0%
Total	775	35	810	17.4%	10.3%
% of total	17.4%	10.3%	16.9%		

Figure 7. Affected areas, exposed school-age populations, and educational facilities, in South Sudan, 2021



Source: Authors' own, based on UN Geospatial Information Section (Administrative boundaries, 2022), UNOSAT (Satellite-detected water extents, 3400), WorldPop (2020 gridded population density at 1 sq. kilometre grid), UN World Population Prospects (2021 Population estimates), UNESCO-UIS (ISCED 2011 mapping), South Sudan Schools' Attendance Monitoring System (SSSAMS) of the Ministry of General Education and Instruction (School locations).

Limitations

This methodology presents a few limitations to keep in mind. Firstly, its use in contexts with seasonal or reiterative population movement (e.g., in pastoralist communities, or areas with prolonged conflict-induced internal displacement) is limited, as the population estimates constructed by WorldPop rely, among others, on census track information and assumptions on demographic inertia (see Pezzulo et al., 2017; Tatem et al., 2013).

The methodology identifies the origin of the affected school-age population but is not sufficient to identify the destination of displaced populations, nor is it good for identifying the number of returnees. Therefore, the methodology could be combined by others, including direct observation and on-site surveys.

School-age population estimations should be made as soon as possible after an event as the more populations are exposed and affected, the more their profile becomes elusive. The methodology does not allow to estimate accurately the population that could be affected by multiple occurrences of a similar crisis. For example, a student affected by floods in Region A on week 1 could be displaced to another area, Region B, which could itself be flooded on week 2. Nonetheless, the methodology could still help assess the school-age population *at least once* affected by the floods.

Special care should be given to the quality of input data that are used in the model. The spatialized school-age population presented above and in Gagnon, and Vargas Mesa (2021) uses Sprague multipliers (Sprague, 1880). This is an interpolation method that should be used on population estimates created through regular censuses, and therefore would not be appropriate to be used on poor-quality population estimates. Moreover, the more a country will have available regular national population censuses and household surveys, the more the WorldPop estimates will be realistic, and the more the estimations produced for school-age populations will be relevant. The quality of the geolocalized risk data will also affect the quality of the estimations produced by the above method.

Conclusion

This methodology has great potential to better guide Ministries of education, development organization, relief agencies, and national government bodies to assess the potential number of school-age children exposed to natural hazards, and has the potential to be extended to other hazards, such as human-made disasters or armed conflict. It provides flexibility, allowing for the calculation of this single years of age for any administrative boundary, while admitting other types of geographic areas (such as flooded or conflict-affected zones). It can provide high granularity of data (up to a 100m grid) for almost all territories in the world, so that it can be deployed anywhere, at minimal cost. Finally, this methodology relies exclusively on FOSS and open science, removing all access barriers, and permitting its utilization in all sorts of contexts and countries.

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Annex 1. Use case of Fitovinany Region, Madagascar, as of 8 February 2022

In the wake of tropical cyclone Batsirai, active 24 Janvier to 11 February 2022, IIEP created an estimation of the school-age population exposed to floods in the region of Fitovinany in Madagascar[8]. Indeed, Batsirai has hardly hit the island country and was recorded as the strongest tropical cyclone to hit Madagascar since 2017.

IIEP created estimations based on the water detected by UNOSAT on 8 Februray 2022, and with 2021 spatialized school-age population estimates built from WorldPop 2020 gridded population density at 1 sq. metre grid, adjusted to the UN World Population Prospects for 2021 Population estimates, and to which the national structure of programmes was applied, as recorded by UIS (and mapped to the 2011 ISCED standards). In the end, we calculated school-age population estimates for the Fitovinany Region for age groups covering pre-primary (ages 4 to 5), primary (ages 6 to 11), and secondary education (ages 12 to 18)[9].

We then clipped the population directly exposed to these floods (i.e. population raster overlapping the water detected by UNOSAT) and also those exposed indirectly within a 1 kilometre buffer.

We could then estimate the total number of pre-primary- (26,755), primary- (37,585) and secondary- (45,135) aged children and adolescents initially living in the areas affected by floods, both directly (those living in the flooded areas) and indirectly (those in the 1 kilometrebuffer around these areas).

These numbers represent about 25% of every school-age populations the whole Fitovinany region of Madagascar, and this proportion varies a lot across administrative regions. For example, if only 0.2% of any school age populations in the Ikongo District have been exposed to floods on 8 February 2022, it is also the case for 33% of the primary school age population of the Manakara-Atsimo District, and of almost 55% of the primary school-age population of the Vohipeno District. Such detailed information might directly influence the response.

Table 4. Estimated school-age populations exposed (or not) to floods in Fitovinany Region, Madagascar, as of 8 February 2022

		Estimated Total School Age Population	**Est. School-Age Population Exposed to Floods**	**Proportion of Est. Total School-Age Population Exposed to Flood**
Ikongo District	Pre-primary	38,865	86	0.2%
	Primary	54,061	121	0.2%
	Secondary	64,763	146	0.2%
Manakara-Atsimo District	Pre-primary	48,940	15,786	32.3%
	Primary	68,074	22,176	32.6%
	Secondary	81,551	26,630	32.7%
Vohipeno District	Pre-primary	20,334	10,883	53.5%
	Primary	28,282	15,288	54.1%
	Secondary	33,905	18,359	54.1%
Total, in Fitovinany	Pre-primary	108,139	26,755	24.7%
	Primary	150,417	37,585	25.0%
	Secondary	180,219	45,135	25.0%

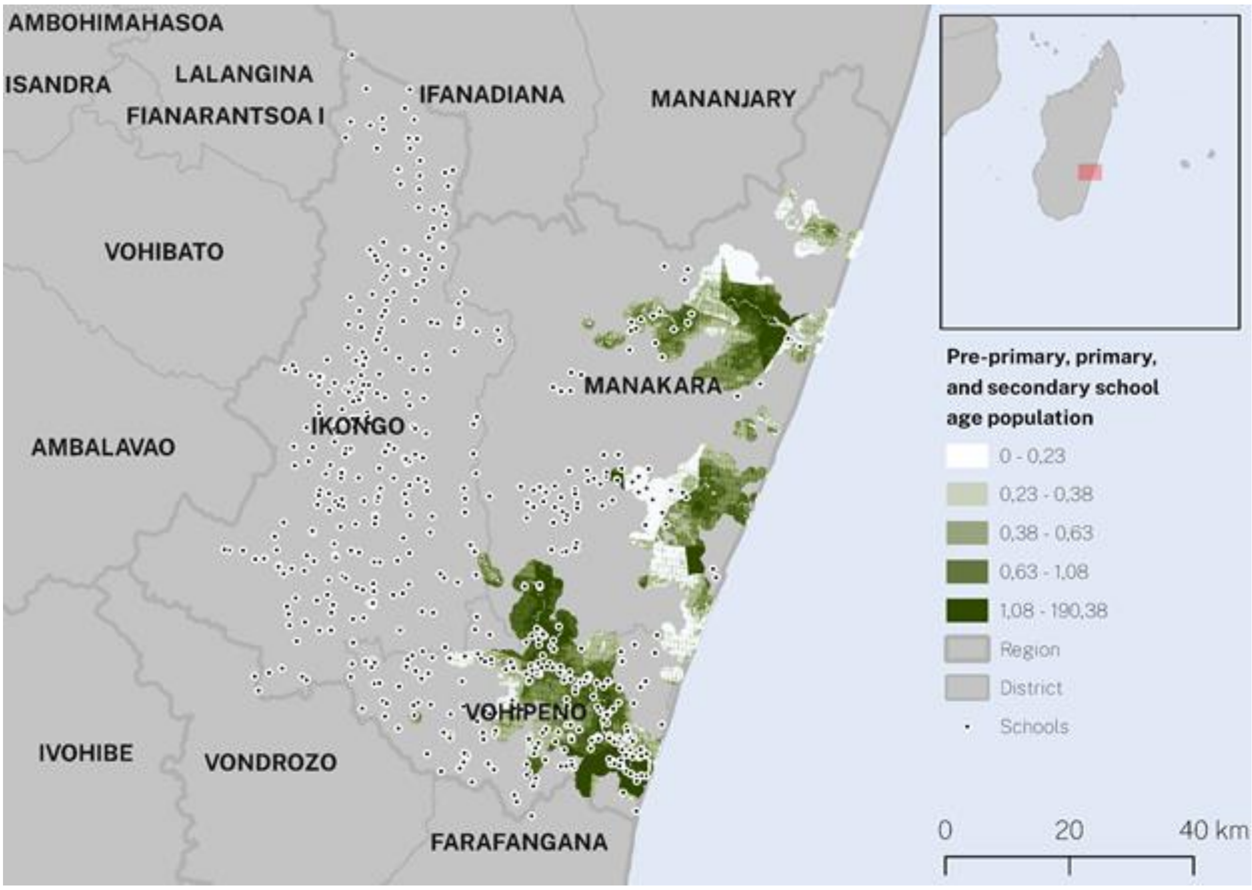
Source: Authors' own based on WorldPop (2020 gridded population density), UN World Population Prospects (2021 Population estimates)

Furthermore, when school locations are available, adding them to the database can quickly highlight which educational infrastructure is also exposed to the hazard, and which could still be used as a resource, as shown on Figure 8Figure 7. For instance, using similar information, the South Sudan Ministry of Education could run a flash survey to estimate the damage on the schools.

8 Based on unitar.org/maps/map/3462 glide number TC20220201MDG

9 Based on indicators 299902, 299905, 999975 and THDUR_2T3 from UIS database. www.data.uis.unesco.org. Last accessed 19 January 2022

Figure 8. Affected areas, exposed school-age populations, and educational facilities, in Fitovinany Region, Madagascar, as of 8 February 2022



Source: Authors' own, based on UN SALB Programme (Administrative boundaries), UNOSAT (Satellite-detected water extents), WorldPop (2020 gridded population density at 1 sq. metre grid), UN World Population Prospects (2021 Population estimates), UNESCO-UIS (ISCED mapping), Ministère de l'Éducation Nationale de Madagascar (School locations)