Proximity-to-Hazard Dashboard: Visualizing Environmental Justice Conditions of Overburdened Communities

by

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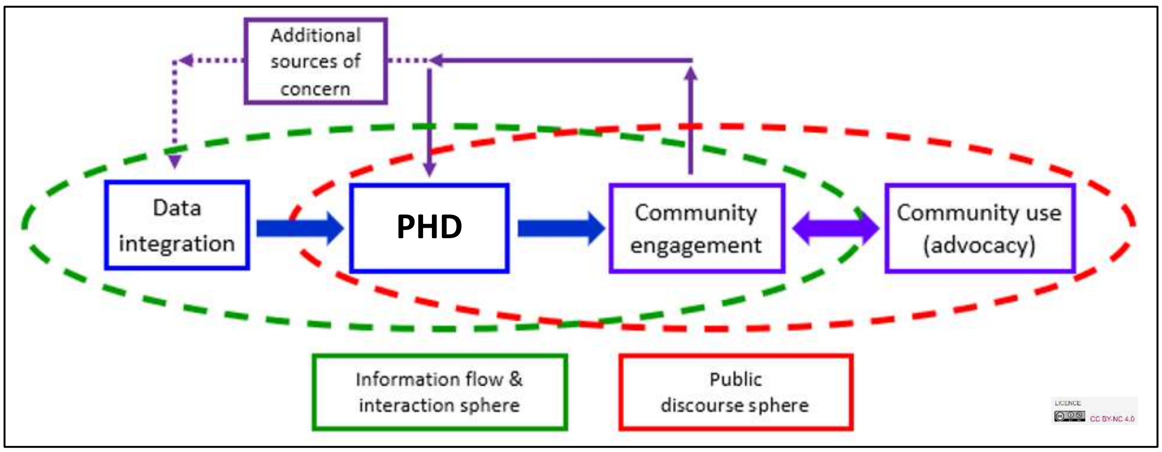
This article describes the Proximity-to-Hazard Dashboard (PHD) developed by a multidisciplinary team of researchers at the University of Illinois Chicago. The team used an interative community-based participatory design (CBPD) approach to identify environmental justice concerns among communities in the southwest area of Chicago and formulate the visualization interface.



Drawing from these insights, the PHD proposes a new approach based on 'proximity to a location' and the notion of 'cumulative burden' to assess the impact of an additional polluting source on local communities. After reviewing existing environmental justice dashboards released by state governments, the article describes how the PHD was developed and its unique characteristics. The PHD makes two substantial advancements to current EJ GIS applications. First, it proposes a localized decision support tool targeted to local communities and policymakers by providing an easily accessible representation of the cumulative environmental burden (EB). Second, it integrates a location proximity approach with socioeconomic disparities (SD) information with an emphasis on the unequal distribution of EB on a sensitive population, namely schoolchildren.

The current PHD interface is selected to provide an easy-to-replicate tool for other urban centers aiming to perform environmental justice interventions and provide access to environmental justice data and visualizations to historically marginalized communities.

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Abstract

This article describes the Proximity-to-Hazard Dashboard (PHD) developed by a multidisciplinary team of researchers at the University of Illinois Chicago. The team used a community-based participatory design (CBPD) approach to identify environmental justice concerns among communities in the southwest area of Chicago. Drawing from these insights, the PHD proposes a new approach based on 'proximity to a location' and the notion of 'cumulative burden' to assess the impact of an additional polluting source on local communities. After reviewing existing environmental justice dashboards released by state governments, the article describes how the PHD was developed and its unique characteristics. The goal is to provide an easy-to-replicate tool for urban centers to target environmental justice interventions and provide access to environmental justice data to historically marginalized communities.

Purpose of the Tool: Visualizing Overburdened Communities

In 1987, the groundbreaking work of Charles Lee and his coauthors led to the first visualization of the "socio-economic characteristics of communities with hazardous waste sites"[1]. Three decades later, the 2021 executive order (EO) 14008[2] and the Justice40 Initiative[3] are bringing to the forefront the plight of overburdened communities. "Overburden communities" are those where environmental burdens (EB; e.g., high pollution, proximity to hazardous facilities) and socioeconomic disparities (SD; e.g., low income or minority status) act cumulatively to produce harmful living conditions. Environmental justice (EJ) policies aim to reduce these environmental health inequalities and ensure equal access of all communities to policymaking[4].

Geographical information systems (GIS) applications have become critical to design EJ policy interventions. EJ actors (e.g., policymakers, local communities, public interest groups, individual activists, and researchers) can identify overburdened communities only by geographically linking both EB and SD data on a map[5]. This dual spatial representation is critical to visualize the outcome distribution of environmental policies and assess environmental health disparities created by such policies according to the socioeconomic characteristics of local communities.

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[1] 'Toxic Waste and Race in the United States: A National Report on the Racial and Socio-Economic Characteristics of Communities with Hazardous Waste Sites' (New York, NY, USA: Commission for Racial Justice, United Church of Christ, 1987), http://uccfiles.com/pdf/ToxicWastes&Race.pdf.

[2] 'Tackling the Climate Crisis at Home and Abroad', Pub. L. No. Executive Order 14008 (2021), https://www.regulations.gov/document/EPA-HQ-OPPT-2021-0202-0012.

[3] 'Justice40 A Whole-of-Government Initiative', *White House* (blog), accessed 16 August 2022, https://www.whitehouse.gov/environmentaljustice/justice40/.

[4] 'Environmental Justice', *Environmental Protection Agency* (blog), accessed 16 August 2022, https://www.epa.gov/environmentaljustice.

[5] Juliana Maantay, 'Mapping Environmental Injustices: Pitfalls and Potential of Geographic Information Systems in Assessing Environmental Health and Equity.', *Environmental Health Perspectives* 110, no. Suppl 2 (April 2002): 161–71; Jeremy Mennis, 'Using Geographic Information Systems to Create and Analyze Statistical Surfaces of Population and Risk for Environmental Justice Analysis', *Social Science Quarterly* 83, no. 1 (2002): 281–97, https://doi.org/10.1111/1540-6237.00083.

However, there is great variation in how EJ GIS applications measure and visualize both EB and SD, leading to different approaches to identify overburdened communities and making EJ data accessible to the public[6].

This article presents the Proximity-to-Hazard Dashboard (PHD) developed at the University of Illinois Chicago (UIC) by a multidisciplinary team of researchers using a community-based participatory design (CBPD) approach involving the southwest communities of Chicago. Based on the notions of 'proximity to a location' and 'cumulative burden', the PHD supports identifying overburdened communities and addresses the need of local communities to know "Which polluters are near my home?" and "How does my exposure to pollution compare to other communities?" The dashboard makes two substantial advancements to current EJ GIS applications. First, it proposes a localized decision support tool targeted to local communities and policymakers by providing an easily accessible representation of the cumulative EB. Second, it integrates a location proximity approach with SD information and emphasizes the concrete impact of unequal distribution of EB on sensitive populations, namely schoolchildren.

Rationale for the Development of the Tool

An increasing number of government agencies are implementing EJ GIS applications to facilitate public access to EJ data and provide support to policymaking. In 2015, the US Environmental Protection Agency (EPA) released the EJSCREEN after a three-year long deployment process. With California leading the way[7], state environmental departments are also releasing EJ GIS

[6] Arianna Zrzavy et al., 'Addressing Cumulative Impacts: Lessons from Environmental Justice Screening Tool Development and Resistance', *Env't L. Rep.* 52 (2022): 10111.
[7] Charles Lee, 'A Game Changer in the Making? Lessons From States Advancing Environmental Justice Through Mapping and Cumulative Impact Strategies', *Environmental Law Reporter* 50, no. 3 (28 February 2020), https://elr.info/news-analysis/50/10203/game-changer-making-lessons-states-advancing-environmental-justice-through-mapping-and-cumulative-impact.

applications. A recent review shows that approximately one out of five US states provide data that is accessible, complete, and usable enough for the public to identify a community's EB and SD[8]. Based on Fusi and colleagues' review[9] and dataset[10], we identified and analyzed the main EJ GIS applications implemented by states' environmental agencies as illustrated in Table 1. Differences in how EB and SD are visualized and measured delineate two approaches: the *aerial unit approach* classifies pre-defined geographical areas into various EJ levels while the *location proximity approach* identifies EB within a user-identified area. Our PHD draws from this latter approach but it addresses a few crucial limitations.

[Table 1 approximately here]

Areal Unit Approach

The areal unit approach relies on a color-coded scheme to rank pre-defined geographical areas, generally a Census tract or a block group, according to SD and EB the areas experience. The California's CalEnviroScreen showed in Figure 1 offers an example.

[Figure 1 approximately here]

This approach provides a quick, high-level view of SD and EB experienced by communities across the state allowing state policymakers to identify and prioritize areas of intervention. SD and EB indicators are generally reported in absolute values (amount or percentage) and as rankings (e.g., percentiles). Particularly, EB data include sources of pollution (e.g., permit

[8] Federica Fusi, Fengxiu Zhang, and Jiaqi Liang, 'Unveiling Environmental Justice through Open Government Data: Work in Progress for Most US States', *Public Administration* (2022), no. n/a, accessed 16 August 2022, https://doi.org/10.1111/padm.12847.
[9] Fusi, Zhang, and Liang.
[10] Federica Fusi, Fengxiu Zhang, and Jiaqi Liang, 'Replication Data for: Unveiling Environmental Justice Through Open Government Data: Work in Progress for Most US States' (Harvard Dataverse, 19 April 2022), https://doi.org/10.7910/DVN/XDN7ZU.

requiring facilities, brownfields, superfunds and cleanup sites) and pollution levels (e.g., water or air quality). A few states display multi-dimensional EB scores, such as the Minnesota's Air Pollution Score[11], the California's EB scores[12], and the New Jersey's stressor summary index[13] (see Table 1). However, this approach has three primary drawbacks.

First, the unit of analysis is the Census track or block group. As these are the smallest geographical units for which SD and EB data are typically available, this choice offers a relatively high granularity. However, they represent abstract communities, as residents are unlikely to know their block group (or tract) number and do not identify with them. Moreover, since EB and SD measures are reported at such an aggregated scale, they lack address level specificity. State government agencies can also miscalculate an area's EB by excluding sources of pollution that are adjacent to but not part of it. A few states (e.g., California) adopt corrective measures, such as a one-mile ring buffer or include all facilities at a given distance from the Census block/tract.

Second, indicators and metrics are compared and ranked at the state level (e.g., percentiles show where an area falls in comparison to all other areas in the state). As disparities are defined in relative terms, this fixed unit of reference can distort the true magnitude of a community's EB and SD. For instance, SD indicators of major urban centers (which tend to be richer and more diverse) can distort state-level rankings of rural towns (which tend to be poorer and less diverse). By changing the unit of reference (e.g., using counties or cities), a community's rankings could be different, making it a higher (or lower) priority for EJ intervention. Because of these

[11] More information can be found: https://www.pca.state.mn.us/air/air-modeling-and-human-health
[12] More information can be found: https://oehha.ca.gov/media/downloads/calenviroscreen/report/calenviroscreen40reportf2021.pdf#page=126
[13] More information can be found: https://experience.arcgis.com/experience/548632a2351b41b8a0443cfc3a9f4ef6

limitations, available dashboards fall short in supporting EJ policymaking at the local level when working with historically marginalized communities that are often disproportionately affected by environmental injustice (e.g., whether or not a city should release a permit for an industrial facility in a Latinx community that already contains multiple industrial permits).

Third, identifying EJ areas mostly relies on SD indicators, notably the percentage of minority population and the median household income. States might define SD threshold criteria to designate EJ areas (e.g., areas with a median household income less than the state's median). This unidimensional definition excludes EB data and tends to overestimate the number of EJ communities. For instance, Massachusetts' EJ designation includes "cities and towns containing fairly high concentrations of EJ neighborhoods that one would hardly describe as environmentally overburdened"[14]. A similar issue was identified for Illinois[15].

Location Proximity Approach

A location proximity approach allows the user to select a central location, define a customized area around it, and visualize sources of pollution within it to ascertain its cumulative environmental burden. For instance, the North Carolina's Community Mapping System (Figure 2) allows users to pinpoint a location and display the facilities within a customized radius.

[Figure 2 approximately here]

Location proximity applications have a major advantage since residents can easily identify areas of concerns based on an understandable location (i.e., an address or landmark) and define a

[14] Bruce Mohl, 'Environmental Justice Designation Coming under Scrutiny: Is Lexington Really Environmentally Overburdened?', *CommonWealth* (blog), 3 August 2021.
[15] Marisol Becerra et al., 'Putting the Environment Back in "Environmental Justice": A Two-Dimensional Approach for Area Identification.', 12 August 2022, https://doi.org/10.25417/uic.20469177.v1.

walking distance space with familiar identifiers (i.e., streets and landmarks). The EJ status of a community is, therein, defined by the number of environmental hazards within the area. Users can then select multiple areas of interest and compare their exposure to EB. This approach has also a few important limitations.

First, since the visualization of the EB is limited by the small scale of the selected area, it can be difficult to use location proximity tools to make big picture policy decisions. These applications do not offer an immediate overview of a larger area (e.g., a state) and subsequent comparisons of multiple points of interest require the user to select multiple adjacent locations.

Second, since SD indicators are only available at the aggregate level (Census tract or block group), applications adopting this approach tend to overemphasize EB (e.g., sources of pollution and their location) and rarely provide information on SD (the EPA's EJSCREEN is an exception as it proportionally adjusts SD data). Because of this, it can be difficult for users to evaluate the dual nature (SD and EB) of EJ.

Finally, a location proximity approach uses the number of pollution sources and hazards (e.g., permit requiring facilities, brownfields, superfunds, and cleanup sites) located within the user-selected area to measure EB. By doing so, it assumes that all environmental hazards and pollution sources equally contribute to the area's EB, even if this might not be true (e.g., some facilities might release more hazardous substances than others). In this way, residents who lack the expertise to individually assess each hazard and pollution source and to evaluate their cumulative impact may misinterpret these environmental burdens. Moreover, this measurement approach differs from those generally adopted by policymakers who rely on pollution thresholds established by the EPA (e.g., PM levels) in order to inform their policy decisions.

Table 1 shows that only a few states exclusively adopt one or the other approach, with several dashboards combining features of both. For instance, several areal unit dashboards provide tools to draw a customized area on the map even if they do not count the number of environmental hazards (e.g., New Mexico).

Overall, a location proximity approach seems better suited to assess overburdened communities because it does not rely on predefined abstract boundaries nor does it use a fixed unit of reference to prioritize areas of intervention. Additionally, most areal unit applications use ordinal measures, such as percentiles, and multidimensional indexes, which can be challenging to understand for residents. By contrast, a location proximity approach uses more intuitive measures (e.g., the number of environmental hazards in a given area) to assess a meaningful EB. However, both approaches apply a unidimensional definition of EJ by overemphasizing either EB or SD data, challenging the identification of overburdened communities as defined by EO 14008[16].

Process Development and Uses of the PHD

The PHD[17] addresses the aforementioned limitations and provides a new scalable but localized decision support tool. The team's approach was inspired by the notion of "cumulative impacts" recently identified by the US EPA[18] [text highlighted by the authors]:

> "Communities that have multiple industrial and energy facilities and are saturated with legacy pollution want to see EPA […] **taking cumulative impacts and risks into account**, even if they cannot be measured with precision. Permitting and rulemaking have typically not reflected the reality of overburdened communities,

[16] Becerra et al.
[17] The PHD can be accessed at the following link: https://univofillinois.maps.arcgis.com/apps/instant/nearby/index.html?appid=486f6e438ecf4b048deebc8dafd9f2c1&sliderDistance=1.1
[18] 'FY 2022-2026 EPA Strategic Plan' (Environmental Protection Agency, 28 March 2022), 30, https://www.epa.gov/system/files/documents/2022-03/fy-2022-2026-epa-strategic-plan.pdf.

> which means that **it is often easier to site an eighth facility in a community that already has seven than in a community that has none**."

Thanks to the PHD, residents can assess whether adding a new facility within a community is acceptable according to the EJ principle of equitable distribution (i.e., by asking: is our community's cumulative EB too high?) and to what extent the new facility impact socioeconomically disadvantaged groups (i.e., is the new facility located to a sensitive location where historically marginalized communities are already overburdened?).

We used a community-based participatory design (CBPD) approach to develop the PHD, which was instrumental to identify EB sources for the local community and design parameters for the visualization interface (see below). This approach relied on several online meetings organized by the Southwest Environmental Alliance (SEA) during their regular monthly meetings over 12-month period. SEA represents Chicago southwest communities: Pilsen, Little Village, New City, Bridgeport, Canaryville, Brighton Park, and McKinley Park. Other stakeholders included local aldermen, the Latinx caucus, and local Environmental Protection and Energy Committees. The beta version of the PHD was tested for two months. We conducted three meetings with presentations to community groups with the support of SEA.

Figure 3 provides a visual overview of the interactive relationship between the community, the data, and the dashboard. The PHD development process laid at the intersection of the "information flow and interaction sphere" and the "public discourse sphere" and aimed to connect the community to environmental justice issues through a visualization interface that takes into account their data needs.

[Figure 3 approximately here]

Empirically, the PHD was built using the customizable ESRI ArcGIS "Nearby" app template, which is used to generate maps and information reports with its interface optimized for both desktop and mobile browsers. A deciding factor for selecting this template was its ease of use, maintenance, and replicability. This implies that other communities from different cities can create similar interfaces without resorting to complex programming or infrastructure solutions, such as SQL, PostGIS, and D3.js.

The Nearby app allows the user to enter a location using one of three options – clicking on the map, entering the address in the search bar, or using their current location. Then, the user specifies the search radius. The application displays all results within the search radius by default and provides estimates of their distance from the center. The viewer can then use a slider to adjust the search radius (see Figure 4).

Based on community and expert's input, we selected five sources of hazards to display in the PHD as summarized in Table 2. Asphalt plants and rail yards, particularly, emerged as concerns for the local communities. These data are usually absent from state-level dashboards and demonstrate the value of a CBPD approach.

[Table 2 here]

As shown in Figure 4, the cumulative EB is measured by the number of potential pollution sources within the defined areas. In the example, within a 1.5 km radius from the selected location, there are 5 asphalt plants, 5 toxic chemicals emitted by TRI, and 1 brownfield. Adding another asphalt plant or TRI facility might easily overburden the community given the number of already existing facilities.

[Figure 4 here]

Another important aspect of our PHD is to emphasize a sensitive and relatively immobile population living in these communities: kindergarten (age 5 to 6) to 8th-grade schoolchildren (henceforth K-8). In recognition of their vulnerability, the 1997 Executive Order (EO) 13045[19], states that:

> *"each Federal agency: (1) shall make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children; and (2) shall ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks."*

The PHD responds directly to this executive order by mapping all Chicago public schools with an attendance boundary. Moreover, it provides summary demographic information for each school within the selected zone of concern (i.e., number of students, percent minorities, and percent below poverty level). As shown in Figure 5, through such a visualization, the cumulative EB has an identifiable potential impact endpoint: schools. This emphasis aims to materialize the EPA policy goal that "no group of [children] should bear a disproportionate share of the negative environmental consequences resulting from industrial, governmental and commercial operations or policies."[20] The PHD also aligns itself with the "child-centered" approach to cumulative risk assessment promoted by the World Health Organization[21].

[Figure 5 here]

[19] 'Executive Order 13045 of April 23, 1997, Protection of Children From Environmental Health Risks and Safety Risks', 62 Code of Federal Regulation § 19885 (1997), https://www.federalregister.gov/documents/1997/04/23/97-10695/protection-of-children-from-environmental-health-risks-and-safety-risks.

[20] 'Environmental Justice'.

[21] 'Principles for Evaluating Health Risks in Children Associated with Exposure to Chemicals' (World Health Organization, 2006), https://apps.who.int/iris/handle/10665/43604.

School demographic characteristics also offer an alternative way to provide SD information, which are not available at such a high level of granularity in state governments' dashboards (see page 6). Schools reflect a location's demographic characteristics. They can also show the impact of EB on a sensitive population exposed to nearby hazards for a possibly long period of time (i.e., 8 hours/day for 8 years). Unlike the aerial unit and the proximity to location approaches, the PHD integrates both EB and SD data at the community level by using schools as a reference point.

Research Findings, Limitations, and Social Impact of the Tool

The PHD is a new tool to deploy EJ GIS applications targeted to localized policymaking. It draws from a location proximity approach but expands it in two major ways. First, it overcomes the lack of granular SD data at the community level by using school as reference point for community characteristics. This method highlights the impact of EJ policies on a particularly sensitive population, namely elementary schoolchildren. Second, it relies on community inputs to measure the cumulative EB and helps empower these communities to better understand EB. Thanks to a CBPD, the PHD includes data on asphalt plants and industrial corridors that are missing from state-level dashboards but relevant for city policymaking. Moreover, the PHD is easily reproducible in other areas; it was created using the ESRI ArcGIS "Nearby" app template which can be easily employed by other community groups with a minimal level of GIS expertise.

The value of the PHD and its integration of SD and EB data at the local level have already been realized. Driven by several community meetings, Chicago Aldermen made a request to the UIC team to submit a report to the US EPA Region V regarding the proposed operational permit of an industrial facility operating on the city's southwest side. The report's findings substantiated the claims of local residents for a disproportionate share of EB in comparison to other communities in Chicago. According to the PHD, the proposed facility would increase the EB of a local school, already exposed to five TRI reporting facilities, one railyard, one asphalt plant, and one brownfield, and in close proximity to industrial corridors to both the north and the south[22]. Following meetings with federal, state, and city environmental agencies, EPA Region V issued a request for information to the facility under the Clean Air Act, Section 114. These events corroborate the impact of the PHD as an understandable decision support tool that assists community groups to visualize the incremental impact that one more facility is likely to create by focusing on the cumulative EB for the community in general and schoolchildren in particular.

In the future, the PHD will be improved in several ways. While the current version selects five hazard sources, additional sources deemed important for local communities could be added. These sources could include length of industrial roads, proximity of selected sites to the closest industrial zone boundary, superfund sites, air permitted facilities, and locations of noise (e.g., airports) and traffic pollution. Other sensitive population indicators could also be added, such as location of day care centers and assisted living facilities. Some of these additions will require a more elaborate data analysis and integration phase. Moreover, additional work is needed to understand the best visual strategies to display the data. Currently, the distribution of the data is aggregated to a single value that is then displayed on a map in line with the interaction modes allowed by the PHD. We are focusing on comparing the effectiveness of different visualizations, from techniques that rely on aggregations to ones that visualize the underlying distribution[23].

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[22] Michael Cailas et al., 'Environmental Justice Conditions of Communities Adjacent to a Proposed Facility in Southwest Chicago' (Chicago: University of Illinois Chicago, 2 August 2022), https://indigo.uic.edu/articles/report/Environmental_Justice_Conditions_of_Communities_Adjacent_to_a_Proposed_Facility_in_Southwest_Chicago/19137902/1.

[23] Sanjana Srabanti et al., 'A Comparative Study of Methods for the Visualization of Probability Distributions of Geographical Data', *Multimodal Technologies and Interaction* 6, no. 7 (July 2022): 53, https://doi.org/10.3390/mti6070053.

Tables

Table 1. Summary of EJ Dashboards Implemented by State Environmental Agencies[24]

General information		Approach	Data				Scale
State	**Dashboard name**	**Areal unit or location proximity**	**SD data**	**EB data**	**Other data**	**Are EJ areas identified?**	**Unit of reference**
USA	EJSCREEN	Mixed (Tract)	Percentiles (6 individual and multidimensional indicators)	Percentiles (11 individual and multidimensional indicators on exposure, potential threats, and proximity)	Health disparities, climate change data, critical service gaps. (EJSCREEN 2.0, June 2022)	11 EJ indexes (combines multiple social indicators with a single environmental indicators to identify most overburdened communities)	State, EPA region, national
CA	CALSCREEN	Areal unit (Tract)	Percentiles	Percentiles (multidimensional indicators on exposure, potential threats, and proximity)	Overall indexes of burden (pollution burden, social vulnerability, EJ burden)	Yes (based on overall EJ index)	State
MN	Understanding EJ in Minnesota	Areal unit (Block group)	Percentages	Air pollution score - multidimensional index including multiple sources of air pollution		Yes (poverty only, minority only or both)	State
MN	What's in my neighborhood	Location proximity (Tract/ Municipality)	None	# sites and facilities that pose an environmental risk (e.g., formerly contaminated sites, permitted businesses…)		No	Local
NM	OpenEnviroMap	Mixed[25] (Block group)	Percentages	Location of facilities		No	State

[24] Website coding updated on 06/10/2022. Only applications developed by state governments' departments in charge of environmental quality were included. We exclude dashboards developed by non-governmental organizations or city and county governments.

[25] It is possible to draw circles of a given radius on the map and count the number of facilities. The count is not automatized

NC	NC DEQ Community Mapping System	Mixed / Location proximity[26] (Block group)	Percentages	Location of facilities, permits, and incidents		Yes (higher percentage compared to state, county or both)	State, county
PA	Pennsylvania's Environmental Justice Viewer	Areal unit (Tract)	Percentages (for EJ communities only)	Location of facilities		Yes	State
RI	RIDEM Environmental Resource Map	Mixed	Percentages (for EJ communities only)	Location of facilities, impaired waters		Yes	State
WA	Information By Location - Washington Tracking Network	Areal unit (Tract)	Deciles	Deciles (single environmental indicators)		No - ("You should not interpret rankings as absolute values. Do not use them to diagnose a community health or to label a community")	State
WA	What's in my neighborhood: Toxics Cleanup	Location proximity	None	Count of cleanup sites within a one-mile radius		No	Local
UT	DEQ Interactive Map Viewer	Mixed[27] (Block group)	Percentages & Percentiles	Location of facilities and indexes of pollution and exposure (e.g., air toxics respiratory hazard index, proximity index)	EJ indexes drawn from EJSCREEN	Yes	State
NJ	NJ DEP EJ mapping, assessment, and protection tool (EJMAP)	Areal unit (Block group)	Percentages & Values (EJ communities only)	Location of sites and facilities (e.g., major sources of air pollution, resource recovery facilities or incinerators, sewage treatment plants…)	Stressor summary index combining 26 environmental or public health stressors for each community. Comparison with	Yes	State

[26] Using the "Screening" option in the NC dashboard, it is possible to count facilities, permits, and incidents in a predefined mile-radius from a given point.
[27] The dashboard allows for a radius-based search but results are not very clear.

					the lower of the 50th percentile of the state or relevant county non-overburdened community		
MD[1]	MDE EJ Screening Tool	Areal unit (Tract)	Percentages and percentiles (and EJSCREEN indicators)	Location (and EJSCREEN indicators)	Socioeconomic score	Yes	State
MI	EGLE MiEJScreen *(draft)*	Areal unit (Tract)	Percentile	Percentile (exposure, environmental effects, proximity)		Yes	State

Table 2. Hazard Sources Included in the PHD

Hazard Sources	Description	Data Source
Toxic Release Inventory (TRI) reporting facilities	Location of TRI sites and background information about the toxic emissions (i.e., quantity, carcinogenicity, etc.)	USEPA TRI Basic Plus Database
Rail yards	Railroad hubs are a major source of particulate matter pollution and represent an important structural legacy.	US Department of Transportation on-line data portal
Asphalt plants	Communities were concerned by the numerous facilities producing and processing asphalt within residential zones. These facilities were de-listed from the TRI section 313 reporting program in 2002. They are still regulated by state and federal agencies and require a permit to operate.	Data provided by the Southwest Environmental Alliance.
Brownfields	Location of brownfields	US EPA's "Cleanups In My Community" (CIMC) data set
Landscape burden	EB caused by the mere presence of industrial zones.	City of Chicago's shape files

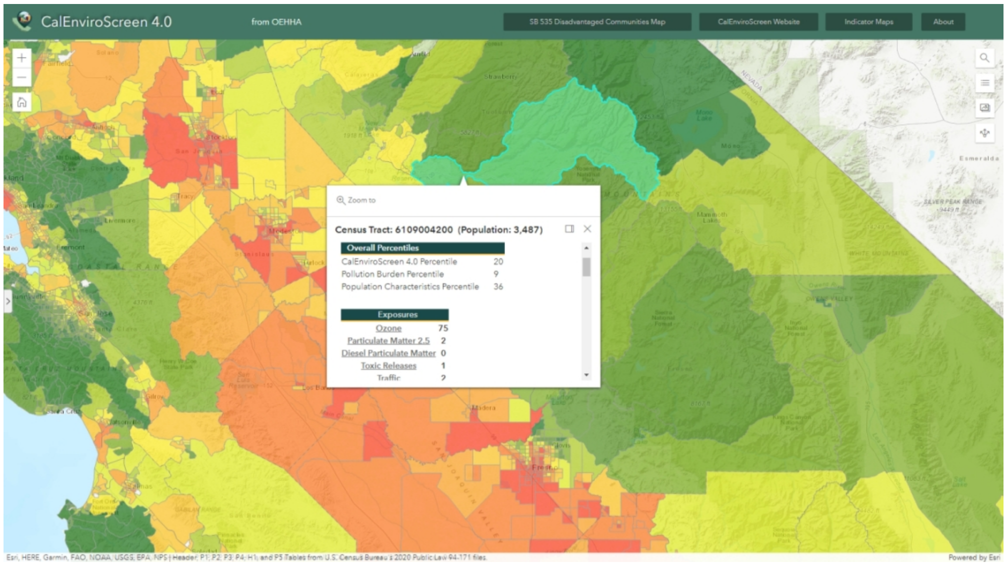

Figure 1. Screenshot of the CalEnviroScreen 3.0. The figure shows the application of the areal unit approach, where pre-defined geographical areas are color-coded based on their environmental justice index. The screenshot was taken on June 10th 2022.

1034x578mm (38 x 38 DPI)

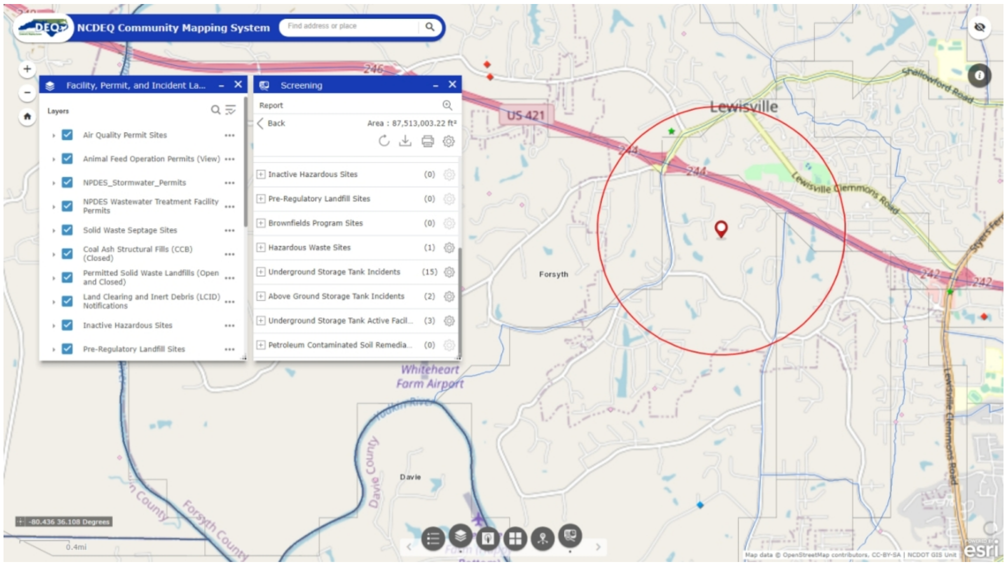

Figure 2. Screenshot of the North Carolina's Community Mapping System. The figure shows the application of the location proximity approach, where users can pinpoint a location and display the facilities within a customized radius. The screenshot was taken on June 10th 2022.

1034x578mm (38 x 38 DPI)

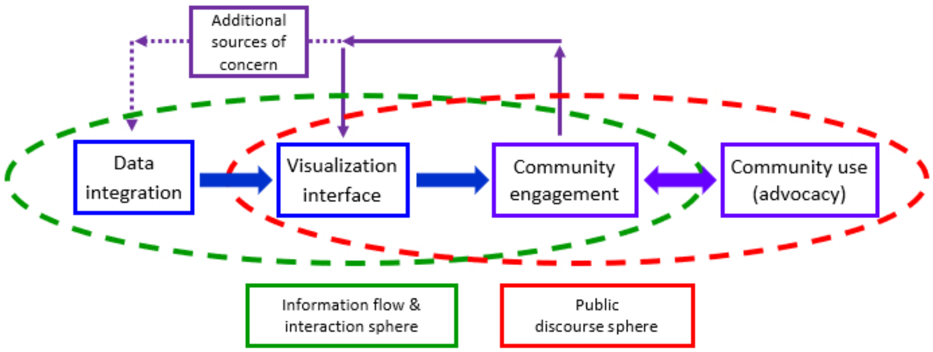

Figure 3. Schematic of the community based participatory design approach. The figure illustrates the CBPD approach taken for the development of the PHD. Whereas GIS dashboards are often developed through four linear steps: data integration, visualization interface, community engagement and community use (advocacy), the CBPD approach creates a feedback loop between the visualization interface and local communities. The PHD is a visualization interface that takes into account communities' data needs.

496x195mm (38 x 38 DPI)

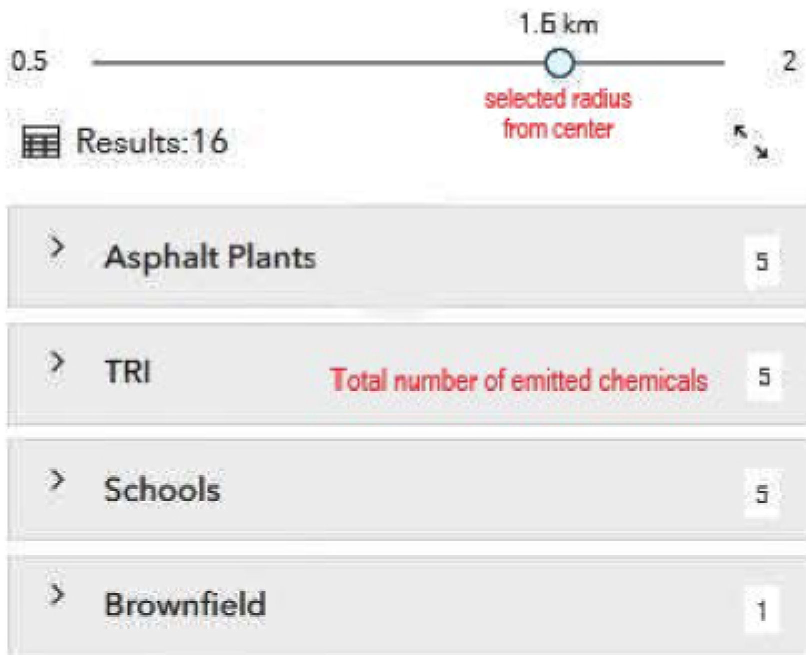

Figure 5. Screen-capture of the PHD interface results with the list of places of

Figure 4. Summary output page from PHD results panel. The figure shows the results panel returned by the PHD after a user input a location and select a radius from the center. The selected radius is 1.5 km. Results show that the selected area contains 5 asphalt plants, 5 chemicals emitted by TRI facilities, 5 schools and 1 brownfields.

320x286mm (38 x 38 DPI)

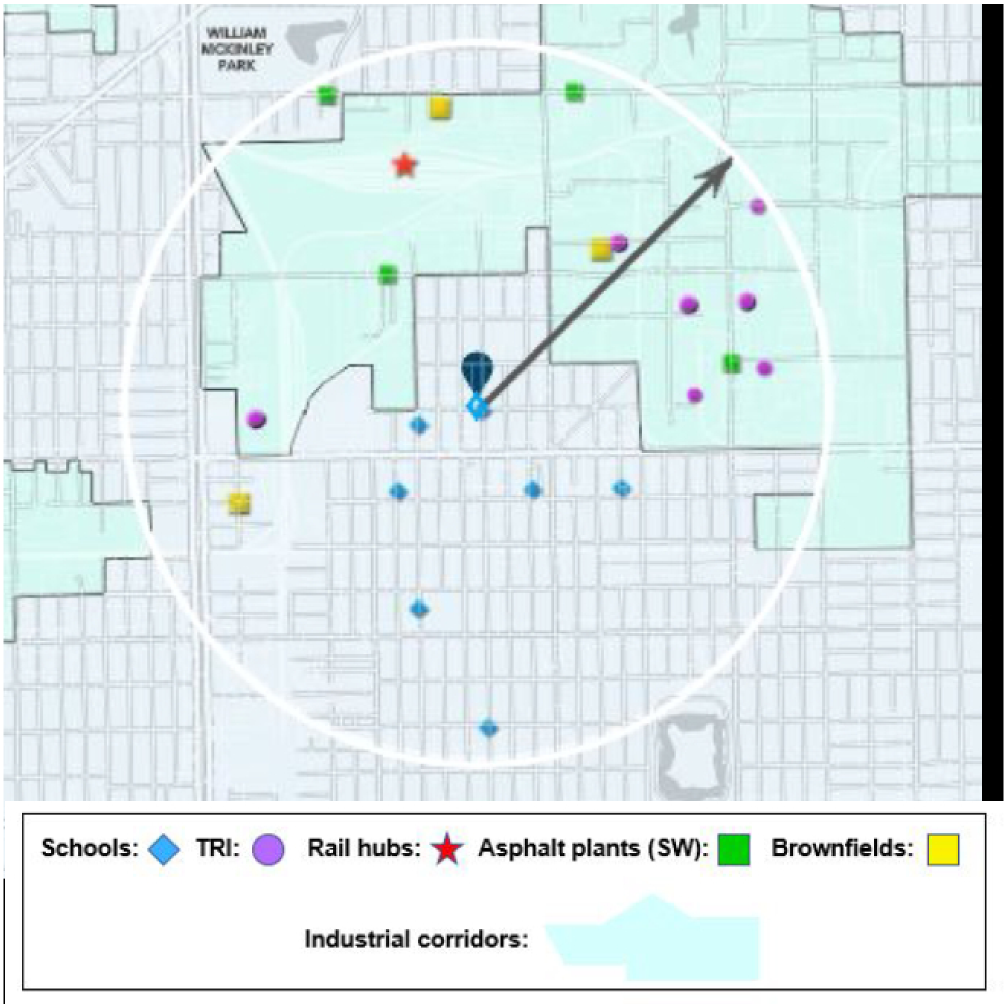

Figure 5. PHD visualization with a school as a location of interest (map pin) and a 1.6 Km zone. The figure shows the map displayed by the PHD after a user input a location and select a radius from the center. The figure reports the results illustrated in the result panel described in Figure 4.

282x281mm (59 x 59 DPI)