GIS for Equity and Social Justice

Greg Babinski, July 21, 2020

Summary Abstract:

Where a person was born, or lives is a key success factor for individuals and families to thrive throughout their lives. Analysis of the equity and social justice (ESJ) impact of public agency policies, projects, and programs is an emerging practice of many government agencies. A geographic information system (GIS) is a powerful tool to analyze social justice issues and help government agencies apply an equity lens to every aspect of their overall administration of public resources.

Throughout history, and even in democracies, government agency policies and resource allocations have been unduly influenced by special interests, wealth, power, and privilege. Even in an environment where *equal* resources are allocated to each segment of society, many unserved and underserved segments of society are so disadvantaged that '*equal*' resources do not provide '*equitable*' opportunity to thrive throughout their lives. Race in the United States privileges whiteness to the detriment of people of color. A key concept of *social justice* is that any person born into society, no matter where they were born or live, will have an *equitable* opportunity to achieve successful life outcomes and to thrive.

Location based demographic data is a key indicator of disadvantaged segments of a community when viewed with an ESJ lens. Geographic analysis and geospatial technology are key tools throughout the equity and social justice process lifecycle. Geographic information science and technology can benefit interdisciplinary teams pursuing ESJ approaches. GIS can be used by GIS Users, GIS Toolmakers, GIS Scientists, and ESJ practitioners from other disciplines.

The GIS aspect of the ESJ lifecycle includes exploratory issue analysis, community feedback, pro-equity programs analysis, management monitoring and stakeholder awareness, program performance metrics, and effectiveness analysis. GIS analysis can produce actionable information to help decision makers decide equitable investments, upstream where the need is greatest.

The purpose of this article is to outline how GIS is effective for ESJ practices. Geospatial topics covered include spatial data management, data sources, geospatial analysis, cartography, data visualization, and management dashboards. This resource is best suited for GIS Users, GIS Toolmakers, GIS Scientists, and ESJ practitioners from other disciplines.

Keywords: *equity, social justice, pro-equity, ESJ, spatial data management, geospatial analysis, cartography, data visualization, alternatives analysis, dashboard, community participation, equity impact review*

Topic Description:

1. Why GIS for ESJ
2. Ensuring a voice for the community
3. GIS for ESJ conceptual lifecycle
4. Domains of GIS for ESJ best practices:
    4.1. Definitions
    4.2. Spatial data management
    4.3. Spatial data sources

1. Why GIS for ESJ

Where a person was born, or lives is a key success factor for individuals and families to thrive throughout their lives. Many types of inequities exist in society, but race and space are key predictors of inequity. The goal of an equity and social justice-based approach to government policies, practices, and systems is to create a society where this is no longer true.

A foundational concept for ESJ is the distinction between equality and equity. Equality assumes that each individual has access to the same level of societal resources despite their individual or family need. Equity assumes that each individual likely requires different types and levels of resources and is provided the societal support needed to thrive throughout life.

Analysis of the equity and social justice (ESJ) impact of public agency policies, projects, and programs is an emerging approach and practice of many government agencies. GIS is a powerful tool to analyze social justice issues and help government agencies apply an equity lens to every aspect of their administration of public resources.

Throughout history, and even in democracies, government agency policies and resource allocations have been unduly influenced by special interests, wealth, power, and privilege. Even in an environment where *equal* resources are allocated to each segment of society, many unserved and underserved segments of society are so disadvantaged that '*equal*' resources do not provide '*equitable*' opportunity to thrive throughout their lives.

Within the United States, color based racial narratives stratify society. 'Race…operates to simultaneously privilege and subordinate groups based on perceptions of racial difference, whether such perceptions are accurate or not' (Velez 2012). Whiteness in the United States was grounded not just in difference, but in supremacy. This supremacy continues to provide whiteness with many of the characteristics and benefits of property, to the detriment of people of color (Harris 1993).

A key concept of social justice is that any person born into society, no matter where they were born or live, will have an equitable opportunity to achieve successful life outcomes and to thrive. Government agency policies, practices, projects, and programs contribute to inequitable conditions in the community which impact long-term outcomes (Fig 1). Because of institutional racism and/or class bias, often in the past upstream policies and resource allocations have not been focused on long-term outcomes for unserved and underserved segments of the community where the need is greatest. ESJ focuses upstream to formulate 'pro-equity' policies and practices that focus on long-term outcomes that will allow individuals, families, and communities to thrive, regardless of race or place (Office of Equity and Social Justice 2016). Geographic information and geospatial technology are critical tools to channel government policies and resources into healthy, pro-equity streams (Gambhir, et.al. 2009).

Pro-equity policies should result in a future social environment where race or place of birth are no longer predictors of success in life.

The pursuit and application of effective ESJ practices will motivate the GIS profession to think systematically about how to do ESJ related work on an effective, defensible, and trusted basis. Other intended uses of this document include:

- Serve as a roadmap for doing impactful ethical work
- Ensure open, transparent, and trusted processes and products
- Facilitate effective use of GIS by interdisciplinary teams working within the ESJ domain
- Result in consistent products that can be compared against alternatives (Same time, same geography, alternate problem approaches)
- Result in products that can be compared meaningfully over time (Same problem approach, same geography, different time)
- Result in products that can be compared meaningfully across space (Same time, same or alternate approaches, different geography)
- Inform agencies to make nimble ESJ program course corrections as needed

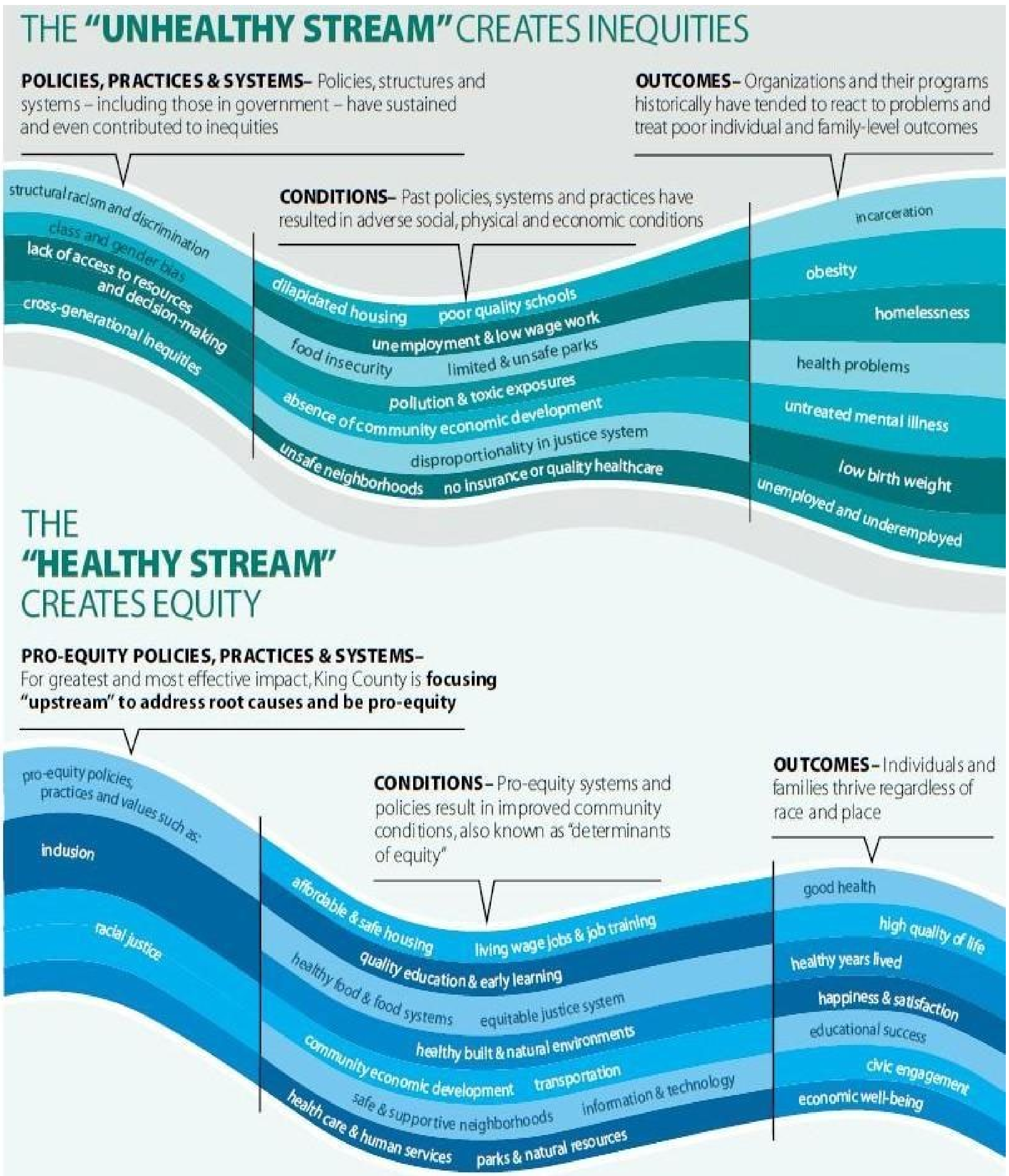

Fig. 1: Government policies, practices & systems create conditions which lead to outcomes

Other intended benefits include supporting efficiency and lean processes, enabling meaningful critique of ESJ work (by GIS or ESJ professionals), and promoting consistent standards that support transparency, repeatability, and trust.

1.1. Focus of this document: Guidelines for the use of GIS to support ESJ related work for government agencies and non-profits

The focus of this document is for government agencies, academia, and non-profits doing social justice-related analysis and formulating pro-equity policies and resource allocation. Many social enterprises that combine profit with purpose focused on helping to achieve the UN Sustainable Development Goals, as well as some private companies are also beginning to do work in this area. GARE - The Local and Regional Government Alliance for Race and Equity is a national network of government agencies working to achieve racial equity, unmask unserved and underserved communities, and advance opportunities for all.

1.2. Users: Continuum of users from GIS professionals to ESJ practitioners within a spectrum of ESJ-related responsibilities from intensive to peripheral

Within government agencies and non-profit entities, there are two communities of users targeted by this document: GIS practitioners and ESJ practitioners.

GIS practitioners can include GIS professionals whose primary career focus is using GIS data and technology and GIS users whose primary career focus is in some other discipline, but who are highly competent GIS data and technology users. GIS professionals may be certified by the GIS Certification Institute (gisci.org) or other certifying bodies. Other GIS professionals may choose to not be certified. GIS professionals and GIS users are at the forefront of defining ethical GIS for ESJ analysis and reporting. Guided by the GIS Code of Ethics, GIS professionals '…have a unique opportunity to contribute to sound public policies and actions that clarify, inform, promote, and ensure equity and social justice. In fact, we have…an obligation to use our skills to serve the public interest' (Salling et.al 2019).

Among GIS practitioner there are three key categories. *GIS Tool Users* include technicians and analysts who are competent to develop and administer spatial data and to perform analysis and mapping using standard geospatial technology tools. *GIS Toolmakers* are competent to create custom solutions to develop, extract, or manage spatial data, perform geospatial analysis, or produce spatial visualization. *GIS Scientists* are competent to go further, in pursuing the fundamental concepts and theoretical application of geospatial technology beyond the limits of GIS tools. (Ricker 2020)

But public agencies and non-profits that choose to formulate policies and resource allocation practices based on equity and social justice principles, will also have many 'ESJ-practitioners' who know little or nothing about the appropriate use of GIS. ESJ practitioners will typically be grounded in domains of science which might include demographics, public health, public administration, sociology, etc. Interdisciplinary research which include GIS science has been shown to provide many benefits beyond a single discipline approach. ESJ-focused interdisciplinary collaboration is grounded in the concept of social constructivism and the benefits of inter-disciplinary knowledge creation. (Ricker 2020)

This document outlines ways that these two communities can support each other to ensure the most effective use of GIS for ESJ.

1.3. To ensure a voice for the community

GIS professionals and users who work with geospatial technology and geographic information for issues related to ESJ do so from the same power framework of government, academia, and industry that has used the power of maps for narrow special interests for centuries (Thatcher 2018). Social concerns are core to the utilization of GIS for ESJ. Involving the community in the design of the ESJ GIS can help avoid technological determinism (Ricker 2020). Utilizing GIS for ESJ and leading with a critical race spatial analysis focus '…challenges race-neutral representations of space…foregrounding the color line…and focusing practice on mapping the spatial expression of lived experiences…' of communities of color (Vélez & Solorzano 2017). GIS for ESJ should create an environment and processes to ensure an impactful voice for unserved and underserved communities.

1.4. To empower public agencies to do effective, defensible ESJ work with GIS

Agencies pursuing an ESJ-based approach to policies, projects, and programs will benefit from a multi-disciplinary approach grounded in geographic information science and technology. GIS should be included in early project planning. GIS professionals should advocate for their discipline, while pursuing understanding of other disciplinary methodologies. GIS can be used for ESJ as a simple tool by *GIS tool users*, or for advanced research and analysis by *GIS toolmakers* or *GIS scientists*.

Guidelines for using GIS for ESJ will provide a starting point for agencies. By outlining issues and challenges related to GIS for ESJ and proposing productive approaches, this document will enable agencies to start working efficiently with GIS throughout the ESJ lifecycle. The foundation laid by this document will support a lean approach to using GIS for ESJ. These guidelines will also support effective, trusted, and defensible work, to help guard against GIS for ESJ science denial.

2. Ensuring a voice for the community

2.1. Role and voice of the community, including indigenous communities

The cartographer wields power in what is included and excluded from the map. It has long been recognized that '…an artistic appearance, particularly a pleasing colouring, can deceive in regard to the scientific accuracy of a map.' (Johnson 2001). The history of map-making has been dominated by the power-interests that have the financial resources to determine what is shown on the map, and why (Thatcher 2018). For effective GIS for ESJ work, the related maps must serve the interests of the unserved and underserved community and reflect the lived reality of the community.

Nowhere is the tragedy of power and maps more blatant than in the history of colonialism. Many aboriginal communities lack access to mapping tradition and techniques that are considered valid within dominant non-aboriginal power-structures. Efforts to aid aboriginal mapping bridge the gap between traditional concepts of land occupancy, utilization, tradition, and culture have been documented in Canada (Tobias 2000) and Southeast Asia (Rambaldi 2005).

Geographic information science and technology provides a convenient epistemology that often shuts out the real world (Schuurman 2020). GIS and ESJ practitioners must be aware of this systematic flaw to ensure complete and effective ontologies that serve the community itself.

Critical race spatial analysis (Vélez & Solorzano 2017) postulates that cartography serves communities when it foregrounds the color-line, exposes how racism operates to construct space in ways detrimental to the entire community, focuses on the lived experiences of the community, and emphasizes that maps are a starting place to understand communities – they do not speak for themselves.

2.2. Bridge the divide between geographers, GIS professionals, and community members

To ensure that the voice of the unserved and underserved community and its interests are included as a critical part of using GIS for ESJ, a mechanism is needed to bridge the divide. The GIS for ESJ lifecycle (Fig. 2) provides a framework for stages when community input and collaboration is important for geographers, GIS professionals, and ESJ practitioners doing ESJ work.

W.E.B. DuBois pioneered issues-analysis mapping 120 years ago (Battle-Baptiste 2018). 50 years ago, the Detroit Geographical Expedition (Bunge 1971) brought mapping directly into the community. It focused on educating the community to do its own mapping, then use maps, validated by its own lived experiences, to do issues and alternatives analysis, advocacy, program implementation and monitoring.

Many GIS professionals and geographers are unaware of the concept of community participation in GIS. Each step of the GIS for ESJ lifecycle will benefit from involving the community to disambiguate or ground-truth or even to challenge what traditional agency geospatial analysis and mapping communicates.

Bridging the divide is further facilitated by the availability of free and open source software (FOSS) that can put geospatial technology in the hands of any segment of the community. The expense of commercial geospatial technology is a barrier to its use by the community, including activists and students. This perpetuates the power-structure environment in which most GIS use occurs. FOSS-based geospatial tools provide the community with the freedom to pursue its own analysis and mapping.

2.3. Support public participation GIS

Public participation in the community mapping and geographic analysis process is facilitated by GIS technology. The use of GIS for ESJ will be most effective if appropriate community involvement is included throughout the lifecycle. This community involvement should be an active partnership between the agency's GIS team and ESJ practitioners.

A variety of community public participation GIS (PPGIS) interaction types should be part of the GIS for ESJ process (Schlossberg & Shuford 2004). The domains of public *participation communities* can be categorized (from simple to more complex) as decision makers, implementers, affected individuals, interested observers, the unserved and underserved, and the random public. The domains of public *participation activities* include (from simple to more complex) to inform, to educate, to consult, to define issues, to plan jointly, to seek consensus, to partner, and to facilitate resident control.

An effective GIS for ESJ process will include meaningful community involvement, supported by a GIS for ESJ community participation plan (CPP). The CPP should empower members of the community to speak as respected and valued subject matter experts on the social dynamics of the community.

Elements of the CPP will typically include ground rules on how to interact with the community, when and where to interact, and who to include. Mobilizing community leadership in the process is a key step. Techniques for community participation can include face to face, surveys, web-based tools, and community visits – touring the community, led by the community (Planning Institute 2020). Throughout the process, data should be collected to document community input in a format that can factor into the GIS analysis.

3. GIS for ESJ conceptual lifecycle

The goal of pro-equity policies is a future community environment where race or place of birth are no longer predictors of the ability to thrive throughout life. The ultimate effectiveness of an ESJ based approach will be measured only in lifetimes or even in multiple generations.

The effectiveness of ESJ-related GIS work is aided by understanding the lifecycle of a typical equity and social justice process for a government agency or non-profit. While processes related to equity and social justice will vary considerably, a lifecycle approach provides context for understanding how and where in the value-stream GIS provides benefit to the organization and the community it serves.

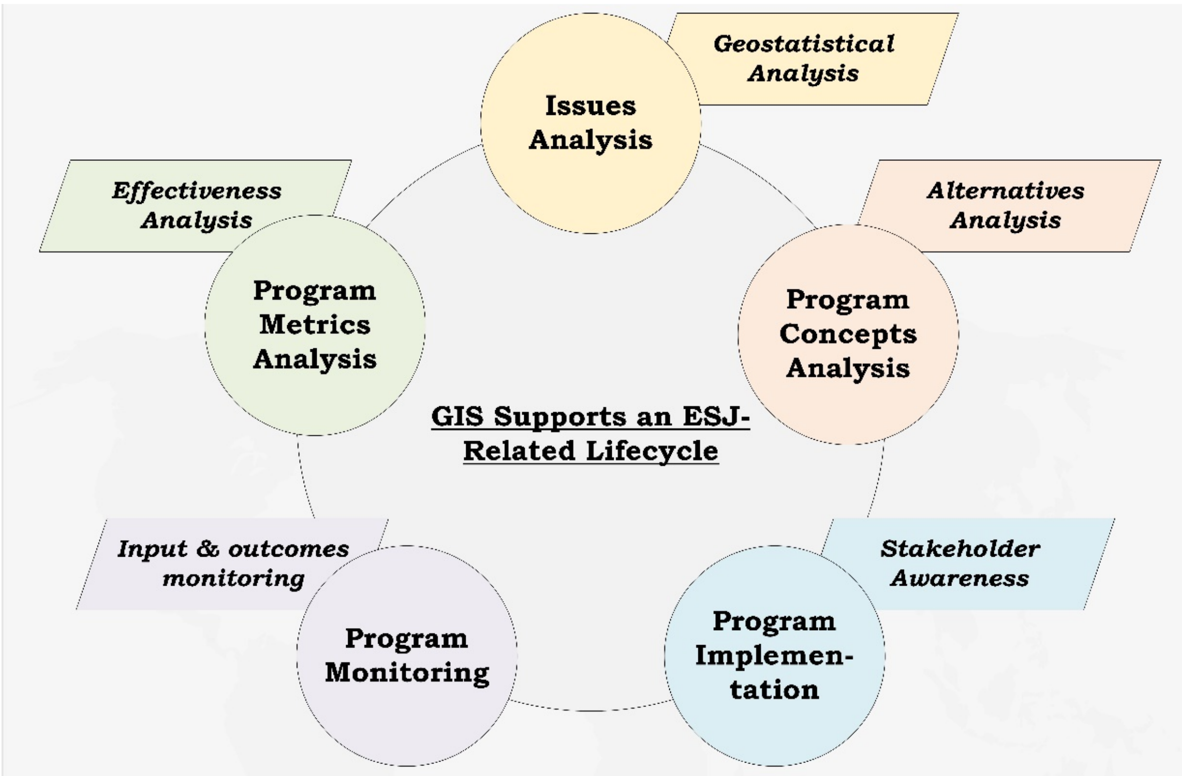

Fig. 2: GIS for ESJ Lifecycle

The five-step GIS for ESJ lifecycle (Fig. 2) suggests the focus for geospatial technology and data at each step. At each step, it is important to ensure that the voice of the unserved and underserved community is heard. The role of GIS in each step of the cycle is outlined below.

3.1. The role of community input and feedback throughout the lifecycle

The community is the ultimate stakeholder in the ESJ process. A GIS for ESJ community participation plan (CPP) should address each phase of the lifecycle. At any point through the lifecycle, the community should have an opportunity to learn about the specifics of a proposed policy, project, or program, and provide input into the decision-making process and feedback as the agreed action is implemented and evaluated. Community participation should start during the issues-analysis phase. While top-down conditions analysis might uncover significant issues, these should be validated with the community. Community stakeholders should also be invited to define issues from their viewpoint and in their terms.

Another key aspect of community input and feedback throughout the GIS for ESJ lifecycle is a ground-truthing process (see 4.3.5). The objective of community input and feedback is to validate the understanding of community conditions as perceived by the community itself. This helps ensure that the GIS process is transparent and trusted.

3.2. Issues analysis: exploratory research and analysis, development of the equity index(es)

This stage of the ESJ lifecycle focuses on current community conditions analysis. This is an exploratory phase that looks for segments of the community where downstream outcomes lag the community as a whole. It seeks to find locations, either individually or in aggregate where resource needs seem to be greatest and to channel resource investments upstream. Its focus within the equity policies/conditions/ outcomes stream (Fig. 1) is on undesirable outcomes within segments of the community.

One approach to exploratory research is speculation-focused. It seeks to identify communities where needs are greatest and to identify upstream policies or practices that led to the conditions that correlate with undesirable outcomes. This aspect of GIS for ESJ activity focuses on geospatial analytical practices, as described below (see 4.4).

This stage also identifies community determinants of equity that can be tracked over time. For ESJ programs to analyze results and show progress, determinants of equity that are meaningful for the community need to be defined and mapped. Progress in reducing inequity may take many years, generations in some cases, so carefully defined determinants of equity are needed to track progress over years and decades.

Part of the exploratory research and analysis phase is the development of baseline metrics analysis and mapping that form the determinants of equity. There are two approaches to defining baseline metrics: a composite equity index or multiple individual determinants of equity (see 4.3.8).

3.3. Program concepts analysis: policy, project, or program alternatives analysis, including equity impact reviews

This stage of the ESJ lifecycle focuses on future outcomes. It seeks actionable information to guide equitable policies, programs, and resource allocations. Its focus in the equity policies/conditions/outcomes stream (Fig. 1) is to explore policies or conditions that might be changed to result in a positive impact on outcomes within unserved and underserved segments of the population that lag the community as a whole.

The role of GIS is to work with program managers and ESJ practitioners to explore the potential future impact of new policies or investments to change conditions that might have a long-term impact on outcomes in the community.

An equity impact review (EIR) is a formal process used by many jurisdictions to analyze new policies or future resource allocations for their impact on equity and social justice goals. An EIR can also be used on a comprehensive basis within an agency to assess existing policies, programs, and projects, to determine if they have negative impacts on equity-related outcomes.

A typical equity impact process used by the City of Seattle (Race and Social Justice Initiative 2012) includes:

- Set outcomes – what are the priority outcomes that are the target for change
- Involve stakeholders including the community and analyze data
- Determine the potential benefits or burdens of a policy or program on desired equity outcomes
- Use the analysis to devise strategies to create positive impacts

GIS is used throughout this process to manage data, perform analysis of scenarios related to desired future outcomes, and to document and display the analysis with good cartographic and visualization practices.

The agency's GIS and ESJ practitioners should utilize their GIS for ESJ community participation plan to capture appropriate community input related to alternatives analysis and equity index development and incorporate it into a data format that can be utilized within the GIS.

3.4. Program implementation: awareness through management and stakeholder dashboards

This stage of the ESJ lifecycle also focuses on outcomes. Its focus in the equity policies/ conditions/outcomes stream (Fig. 1) is to communicate to stakeholders, both within the agency and across the community. Stakeholder awareness can be achieved by providing access to program-focused dashboards (see 5, below) which provide open and transparent data related to the policies or conditions that are being implemented or changed. Stakeholders should have access to appropriate data and tools to assess themselves the effectiveness of the program or policy in achieving the intended positive impacts.

This phase of the GIS for ESJ lifecycle is potentially long. The goal of this phase is to monitor progress on achieving the original intent of the policy or investment. Following on from the City of Seattle equity impact process first referred to in 3.3, above, it includes:

- Evaluating and raising awareness of progress
- Reporting back to the community

3.5. Program monitoring: performance metrics (including ground-truthing via community input)

This stage of the ESJ lifecycle focuses on monitoring, understanding, and reporting outcomes. Its focus in the equity policies/conditions/outcomes stream (Fig. 1) is to continually compile the data required to assess the impact on the community of the policies or conditions that are being implemented or changed. This phase of the GIS for ESJ lifecycle is potentially long.

The GIS for ESJ community participation plan should include periodic ground-truthing of data with the community. This phase is served best by GIS-enabled management dashboards (see 5, below) and by training the community in their creation, meaning, and use.

3.6. Program metrics (effectiveness) analysis (including ground-truthing via community input)

This stage of the ESJ lifecycle focuses on outcomes. This stage occurs when the agency, program owners, and/or community stakeholders evaluate the program for its effectiveness and to decide about future continuation. The GIS enabled dashboard or ad-hoc GIS analysis is used to evaluate if the original outcome-focused goals were achieved.

Understanding effectiveness should include input from the community itself, via the GIS for ESJ community participation plan.

This phase also generates ad-hoc geospatial analysis. To evaluate any single policy or program requires understanding all the factors that influence outcomes. Has the underlying demographics of the community changed over time via voluntary or involuntary population movement? What are the impacts of socio-economic factors that have occurred at the national, state, or regional level? What other public agency or non-profit policies or programs might have impacted the single specific agency program being analyzed?

Another aspect of effectiveness analysis is to compare the program in multiple dimensions as outlined in section 1, above. These include comparing the program effectiveness on outcomes over time, with other geographies, and against other programs that target the same desired outcomes.

4. Domains of GIS for ESJ best practices

Geographic information science and technology provide many benefits to inter-disciplinary teams focused on ESJ-related issues. Spatial data, analysis, and visualization can leverage insights of individual disciplines to ensure that issue-based research is more closely focused on the community (Ricker et.al 2020).

This section outlines aspects of the domains of geographic information science and technology that are most important for good and effective GIS for ESJ work. As appropriate they apply to any phase of the GIS for ESJ lifecycle.

Much of the business need for GIS work throughout the ESJ lifecycle will focus on mapping and analyzing two key variables. The first variable focuses on GIS-based population demographic analysis and documentation. Where are designated segments of the community population located? The second variable focuses on GIS-based analysis and documentation of economic, cultural, and environmental factors as they impact the lives of segments of the population. These two classes of variables also should be analyzed together, via GIS-based social demography, or the impact of economic, cultural, and environmental factors on segments of the population.

The science of geographic information requires careful methods and practices. GIS for ESJ practitioners must follow process-related rules and guidelines, or state and justify when and why they do not. They must focus on fact, not opinions. An aspect of science is to base results on systematic empiricism. GIS for ESJ practitioners should encourage peer-review of their work, and the results should be repeatable. GIS processes should be consistent, trusted, and transparent. Unless GIS for ESJ work is grounded in appropriate practices, ESJ science-deniers will be afforded an opening to challenge the validity of the work based on flawed or inconsistent process. The consequence could negatively impact unserved and underserved segments of the community.

A best practice for agencies is to designate an authority with oversight over the application of the domains of GIS for ESJ within the agency. For a small agency or non-profit, this might be a part-time responsibility. For a larger entity, this function could be given to an individual and/or a GIS for ESJ standards oversight committee. In any case, the organization should conduct periodic audits of its practices for alignment with the domains of GIS for ESJ outlined in this document.

4.1. Definitions

Precise definitions lead to common understanding and enable agencies to share analysis and results for temporal and inter-agency comparison purposes. Definitions include:

Creative plan/creative design brief: a document prepared to guide the coordinated development of a portfolio of maps, dashboards, and StoryMaps. It identifies the core message that is intended and the desired actions or outcomes. It can also clarify deliverables, the creative team, timeline, and where overall approval for process elements resides

Equality: equal access to opportunities and resources

Equity: access to opportunities and resources needed so that everyone can achieve equal outcomes

Equity and social justice lifecycle: a conceptual process for a government agency or non-profit to analyze equity issues, explore resource allocation options, decide on actions, manage programs, and analyze performance metrics.

Equity impact review: a formal process used by many jurisdictions to analyze current or new policies or resource allocations for their impact on equity and social justice goals.

Equity index: a composite numerical score that combines social determinant factors in categories such as livability, economics, education, and accessibility and that can be applied to the entire agency or sub-units of geography

Equity indicator: a numerical score for a single social determinant factors that can be applied to the entire agency or sub-units of geography

GIS for ESJ Community Participation Plan (CPP): a plan to include community participation and input throughout the GIS for ESJ lifecycle to reflect community perception of space and issues.

Ground-truthing: validating data sources by a process to test the accuracy of the data via field verification process

Map abstract/use case: a statement of the purpose or focus of the map (the use case), how the map was created and key findings

Pro-equity: agency policies or program that advance equity so that all members of the community can achieve equal outcomes

Public-participation GIS: a process to help communities use GIS for their own issues and advocacy purposes

Race: race in the United States is an artificial identity imposed by the dominant white culture on groups of people based on perceived color. It is a social construct based on rules that do not have inherent biological meaning. Racial categorization enables a dominant race to exert authority, power and privilege over subordinate groups (Barnshaw 2008).

Runbook: a compilation of the data, routines, and processes used in a geospatial analysis

Social justice: fair and just distribution of and access to public goods, institutional resources and life opportunities for all people

4.2. Spatial data management

Data that is used by GIS through the ESJ lifecycle will come from a variety of sources (see 4.3, below). The management of GIS for ESJ data is important for effective analysis and reporting. Careful data management is critical for efficient work that will stand scrutiny and enable the testing and replication of the results of analysis.

4.2.1. Consistent database schemas

An agency initiating the use of geographic information science and technology for ESJ should architect its database schema carefully. Considerations should include the entire ESJ lifecycle, as well as the geographic scope of the communities of concern, as well as other likely partners or stakeholders.

Data schemas are constrained by the underlying data model that the GIS technology utilizes. A conceptual GIS for ESJ data model specifies the entity classes, their characteristics, and interrelationships. A conceptual data model should be easy for even non-GIS stakeholders to understand. The data model should support understanding of the data use case for ESJ-related spatial analysis and visualization (Nyerges 2017).

From the conceptual data model, logical and physical data models are derived that utilize the specific database schema within the GIS.

Database schema consistency throughout the ESJ GIS lifecycle is important to ensure the repeatability of analysis over time and across geographies.

4.2.2. Metadata

Metadata is simply descriptive data about data. Because of the vastness of geospatial data, accurate metadata is important for selection of appropriate data for GIS for ESJ work. Within GIS, the Federal Geographic Data Committee (FGDC) provides rigorous standards for metadata that should be utilized by any GIS organization. Good metadata describes the limitations of the data. It represents the preserved institutional knowledge of the stewards of the data.

Much of the data used for ESJ analysis may come from valid sources outside of the GIS environment. These data sources should be scrutinized for the types of criteria within the FGDC metadata guidelines. Their suitability for use and any use limitations or concerns should be well-documented.

4.2.3. Managing data regionally

A regional approach to managing GIS for ESJ data is necessary because of the inherent disconnect between how space is organized by institutions versus how space is experienced by members of society.

Each person’s life-time opportunities or impediments within society is strongly constrained by organizations that control resources. Most organizations also utilize GIS (and rely on GIS data). Organizations that use GIS include national, regional, and local governments, agencies that provide utility services, contained-site facilities, private companies, non-profits, academic institutions, and others (Croswell 2018).

Any entity utilizing GIS for ESJ should consider the broadest possible universe of geography that impacts the lives of those within its narrowly defined community. Analysis of new pro-equity policies or programs should consider all resource opportunities and constraints from every organization that impacts the lives of members of the community. For example, analysis of the optimum location of a new childhood health clinic should consider other existing and planned clinics or related services provided by governments, non-profits, companies, churches, etc. Likewise, analysis of the long-term effectiveness of any single policy or program should analyze all the other resources that might impact or have impacted the original goals.

Each entity utilizing GIS for ESJ should seek or create regional GIS for ESJ data sharing infrastructure.

4.2.4. Managing and preserving temporal data

The ultimate effectiveness of an ESJ based approach or practice will be measured only across a lifetime or multiple lifetimes. Effective GIS for ESJ must support long-term preservation of data to support analysis of the effectiveness of actions taken.

For most traditional GIS applications, the concept of time is ignored, outside the assumed present. Data can be added or replaced in the GIS, but time-related changes may not be maintained. However, for the GIS for ESJ lifecycle, understanding, managing, and preserving spatial data within its temporal dimension is critical. Three states of spatio-temporal data have been identified (Song 2019): ‘…valid-time (when an event occurs/is observed), transaction-time (when an event is recorded), and user-time (when an additional event is perceived and registered by users).’

Key components of managing GIS for ESJ data include:

- Data sources should use consistent data schemas to support future year to year comparisons.
- Historical data should be preserved in 'year series' format to support recreating analysis.

4.3. Spatial data sources

GIS for ESJ data sources should always be well-documented. Metadata should include information about the limitations and confidence levels of the sources.

One key challenge is integrating tabular and spatial data. Public agencies should provide an integrated portal for all public data. Open data access should be facilitated via public portals that facilitate download via common data formats, as well as by providing map service and GIS application programming interface (GIS API)-based access.

Research is needed to determine if location-based services can be a future source for community input data and/or spatial data ground-truthing (Huang & Gao 2018). If so, care must be exercised to ensure personal location privacy.

4.3.1. Authoritative and accessible data sources

Good GIS for ESJ science should be grounded in authoritative data. The concept of authoritative data is an information technology term '…to identify a system process that assures the veracity of data sources. These IT processes should be followed by all geospatial data providers. The data may be original, or it may come from one or more external sources all of which are validated for quality and accuracy' (FGDC Subcommittee for Cadastral Data 2008). The authoritative nature of the data should be documented in the related metadata.

The spatial data used for ESJ work should also be publicly open to the degree possible by law. Constraints might be related to personal privacy issues. Also, data should be non-siloed with open access to other researchers and to the public at large.

4.3.2. Primary versus policy-focus data

A key concept of social justice is that any person born into society, no matter where they were born or live, will have an equitable opportunity to achieve successful life outcomes and thrive. Policy-focused data describes the resources that are provided to the community and that have various social-demographic impacts on lifetime development equity.

Primary authoritative spatial data for ESJ is built upon the National Spatial Data Infrastructure framework, supplemented by key empirical community conditions-related spatial data sources. Every day, GIS practitioners choose data that inform our thinking about questions and issues in the real world. The foundational spatial data for ESJ comes from the decennial United States Census and the American Community Survey (Castagneri 2019). The decennial census provides actual demographic counts every 10 years. The American Community Survey (ACS) provides annual estimates. The ACS 5-year average estimate is updated annually and is intended to provide accurate estimates to the Census Tract level and slightly less accurate estimates to the Block Group level. Other nations provide similar authoritative data, like Census Canada.

In the United States and Canada, states and provinces, and below them other local government agencies are the stewards of valuable primary and policy focused data. For example, in Washington State the Departments of Labor and Industry, Health, and

Office of Public Instruction provide policy related data that corresponds to many of the policy-specific conditions in the community of interest to ESJ related policy.

Some private GIS software companies (Esri, Tableau, etc.) provide access to libraries of spatial data formatted for easy analysis. Many of these data sets are contributed by end-users and often have incomplete or questionable documentation.

Other data sources will be driven by the focus of the issue of concern. Non-profits and many foundations may be the source of credible data related to health, crime, employment, housing, retail, digital, environmental, and other resources or community conditions. Any data that supports valid ESJ-related analysis of the focus of a public policy is a candidate. But the GIS for ESJ practitioner is obligated to document the validity of any data used.

4.3.3. Spatial data uncertainty

GIS for ESJ practitioners should be aware of uncertainty in the data utilized and its potential impact on geospatial analysis and cartographic visualization. The very concept of cartographic representation of the real world *requires* some abstraction of the world. Types of spatial data uncertainty include location of features, attributes of features, and geo-semantic uncertainty. Crowd-sourced data provides useful opportunities to understand community conditions, but the process of correlating the location of reported conditions with authoritative framework data provides accuracy challenges. Geo-semantic uncertainty refers to differing understanding of the precise meaning of a locational term or attribute by members of the community. Asking members of a community to draw the boundary of their community's 'downtown' or of a specific neighborhood invariably results in disagreement (Li 2017).

The GIS for ESJ practitioner should document any known limitations or uncertainty related to the data utilized for their analysis or visualization.

4.3.4. Making data sources open versus privacy considerations

The foundation for good GIS for ESJ work requires transparency, trust, and repeatability of analysis, as well as appropriate respect for the privacy rights of individuals. Both imperatives are incorporated into the GIS Code of Ethics: 'Make data and findings widely available' and 'Protect individual privacy, especially about sensitive information' (URISA 2003).

Open data can be defined as '…data that can be freely used, re-used and redistributed by anyone - subject only, at most, to the requirement to attribute and sharealike.' Benefits of open data include transparency and democratic control, enabling public participation, impact measurement of policies, and new knowledge from combining data sources (Open Knowledge Foundation 2020). The use of open GIS data sources for ESJ analysis enables others to reproduce and challenge the original analysis.

GIS for ESJ assumes that the location of where the need is greatest to achieve long-term equity, requires identifying the locations of individuals within society. The long-term success of ESJ requires positive impact on individuals within unserved and underserved communities. Geographic analysis looks for locations where multiple individuals share similar characteristics, so that resources can be directed to locations for maximum impact. GIS professionals should take the lead within their organizations to defend the privacy rights and consider the reasonable privacy expectations of individuals (Kerski 2016).

A key challenge for the GIS for ESJ practitioner is to balance both the data privacy and data openness societal imperatives.

4.3.5. Community feedback and ground-truthing

Within the GIS for ESJ lifecycle, the validity of spatial data will directly impact the effectiveness of policy, project, and program decisions that will impact community lives for a generation. Ground-truthing and community involvement are critical to build trust in ESJ-related GIS data. The community is critical to validate the accuracy of data and inferred information produced within a GIS.

The concept of ground-truthing is familiar to many GIS practitioners, but usually related to calibrating analysis processes for remotely sensed data. Ground-truthing can also be applied to the ESJ-related process of validating community conditions that have impacts on equity index values. This can be a costly process, but to enhance trust in data sources and analysis process, a ground-truthing process may be warranted. Sampling-based ground-truthing has been shown to yield satisfactory data validation results at reduced cost (Caspi & Friebur 2016).

A community participation plan (see 3.1) impacts each of the GIS for ESJ domains outlined in this document. As data sources are the foundation for GIS for ESJ analysis, this is a key area for community involvement, feedback, and ground-truthing. This CPP should achieve community involvement in defining problem statements, data acquisition, analysis methodologies, and decision metrics (URISA 2003).

Attempts to understand the way that communities perceive the dynamic geography of the places that they occupy requires that we set aside the preconceived assumptions that spatial scientists learn through academic research. To '…study America through spatially disjointed biopsies is to slice its humanity to pieces' (Bunge 1971).

A pioneering structured approach was the Detroit Geographical Expedition that was based on the concept '…that community members could be involved in knowledge production. Instead of seeing knowledge as something to be transferred, either up the chain to the academy or down to students, they favored training people to be able to identify the roots of problems, and then solve them' (Knudson 2017).

A structured methodology for aboriginal mapping provides a possible framework for a community participation plan. Components of working with community members to provide data that can be included in the GIS for ESJ lifecycle might include: engage with the community to develop a consensus approach, develop an agreed community engagement protocol, interview the community to compile 'map biographies', transcribe map biographies into cartographic form, enter data into a database, create a map composite, and facilitate a community review verification process (Tobias 2000).

Involving citizen-scientists in GIS-based analysis of ESJ issues is critical to validate problem definition, data acquisition, analysis methodology and findings. Methodologies should address inputs, activities, outputs, outcomes, and impacts. Community-scientist based inputs have been shown to increase the quality of data in many types of spatial research. Sensitivity to cultural concerns and expectations is also important for a well-designed citizen-science based approach to ground-truthing (Rickles et.al 2017).

Another structured approach to achieving community involvement is the concept of public participation GIS (PPGIS). PPGIS has been defined as an approach '…to make GIS and other spatial decision-making tools available and accessible to all those with a stake in community decision-making' (George & Ramasubramanian 2014).

Other possible future sources of ground-truthing data is from well-designed community survey and from analysis of social media-based data. GIS professionals should be key stakeholders in developing and utilizing the CPP.

4.3.6. Searching beyond default data

A key challenge for applying GIS throughout the ESJ lifecycle is identifying the best sources of data that support analysis of specific issues. Many sources will be outside the default data sets that the typical municipal agency GIS maintains.

For example, an analysis of equity issues related to the arts and culture economy in the Seattle area combined both local and state agency demographic and arts infrastructure data, as well as specialized data related to the arts economy from the National Arts Index of the Vitality of the Arts and Culture in the United States (Moch 2020).

The GIS professional should collaborate with ESJ practitioners, policy experts, and community members to identify appropriate data sources. Data quality and appropriate use must be well documented in the metadata.

4.3.7. Data validation toolkits

The GIS professional working within the ESJ realm has primary responsibility to validate the quality of data used for spatial analysis. This responsibility extends beyond simply accepting the use constraints stated in the metadata. Especially for data obtained from sources without strong GIS data management practices, appropriate data validation tools and methodology are required to ensure ESJ analysis is based on good geospatial data science. A process for data quality validation should focus on GIS data from three perspectives: spatial data maintenance prioritization and data review, validation of spatial data warehouse objects, and quality assessment of metadata completeness and content (Leathers 2017-2018).

The GIS for ESJ practice should include a validation process to assess the quality of any GIS data set. Data quality attributes include completeness, topological consistency, resolution, thematic accuracy, positional accuracy, temporal accuracy, physical consistency, referential integrity, and attribute validation. A spatial data quality assurance (QA) practice should start with a statement of data accuracy acceptance criteria based on what is required for the intended analysis. To assess if a data set meets the acceptance criteria, QA steps should include defined visual and automated QA routines that sample positional accuracy, data completeness, thematic accuracy, attribute accuracy, and data inconsistencies (Balakrishnan 2019).

The GIS for ESJ community participation plan should also explore a role for using the community's expertise to validate data.

4.3.8. The equity index and equity indicators

The equity index or the choice of individual determinants of equity was introduced in 3.2, above. These indicators are intended to answer the question: how is equity to be defined and assessed on a geographic and temporal basis? An equity indicator is similar in concept to environmental indicators – science-based aggregates of data to support analysis, track progress, and inform the public. (OECD Secretariat 2008)

Part of the exploratory research and analysis process is to develop baseline metrics analysis and mapping that form the determinants of equity. There are two approaches to defining baseline metrics: an equity index or individual determinant of equity.

An equity index is a numerical score that can be determined by a jurisdiction and applied to sub-units of geography, and that combines social determinant factors in categories such as livability, economics, education, and accessibility. For example, the City of Tacoma, Washington includes the following factors in its citywide equity index:

Livability social determinant category:
- Nuisance/neighborhood quality
- Crime
- Median home value for owner-occupied units
- Housing cost burden
- Life expectancy
- Urban tree canopy

Economic social determinant category:
- Employment index
- Unemployment rate
- Poverty ratio
- Median household income

Education social determinant category:
- Student mobility rate
- 3rd grade reading proficiency
- 7th grade math proficiency
- Highest educational attainment

Accessibility social determinant category:
- Parks & open space
- Healthy food index
- Transportation access
- Voter participation
- Road condition
- Household internet access

The Tacoma example combines individual social determinant scores to create an index score for sub-units of geography. Scores for the overall equity index or for categories of social determinants are categorized as: very high, high, moderate, low, or very low (Fig. 3). The role of GIS is to display the results of the analysis to inform the community of areas where equity-related needs are greatest.

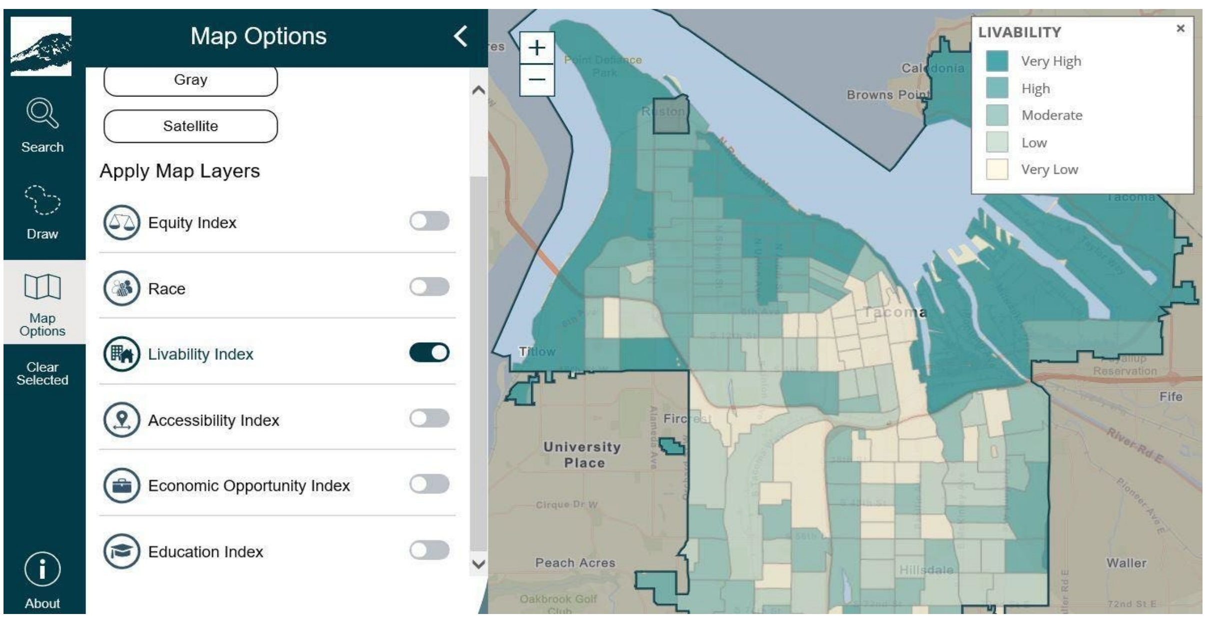

Fig. 3: Equity index mapping

Alternately, King County, Washington utilizes 39 individual determinants of equity. If a composite index is used, the individual elements that make up the composite should have significance on their own. These should align with the key business lines and services that are significant for the agency.

Whether an agency uses a composite equity index or individual determinants of equity, the basis for the decision should be well documented. The selection and weighting of the equity index or determinants of equity should be informed by community input, as outlined in the CPP. Documentation should focus on defining the determinant(s) for the community and why they are significant. The individual elements of an equity index or stand-alone elements should be metrics whose change is meaningful and that support a clear diagnosis to demonstrate that conditions are improving, declining, or remain unchanged over time.

The equity index will need to be re-examined and republished as the underlying demographic data changes. With each publication of new demographic data (the decennial census and editions of the American Community Survey data in the U.S.) the indexes should be re-assessed. The methodological assumptions for the indexes should be clear and transparent and applied consistently over time.

4.4. Geospatial analytical practices

Geospatial analysis is based on geographic theory. Tobler's first law of geography states that '…everything is related to everything else, but near things are more related than distant things' (Waters 2017). The power of geospatial analysis comes from the fundamental data-information-knowledge concept. The basis of this concept is that individual units of attribute data, when arrayed across space, can be analyzed against various scientific geographic processes and classified to provide spatial information. This spatial information can then be further analyzed via geo-statistics to reveal new knowledge about relationships and underlying processes. The Geographic Information Science and Technology Body of Knowledge describes geospatial analysis topics within the Analytics and Modeling Knowledge area as:

> *'A variety of data driven analytics, geocomputational methods, simulation and model driven approaches designed to study complex spatial-temporal problems, develop insights into characteristics of geospatial data sets, create and test geospatial process models, and construct knowledge of the behavior of geographically-explicit and dynamic processes and their patterns.'* (Wilson 2020)

A small sampling of analytical and modeling approaches described in the GIS & T BOK that might be applicable to ESJ include: Spatial autocorrelation infers that geographically weighted regression coefficients can be used to smooth relationships between a response and a covariate across a landscape (Griffith 2017).' Agent-based modeling: These are analysis of complex geographic factors and processes over time as they impact agents that are assigned goal-seeking objectives. These align with the ESJ focus on understanding the geographic factors that impact individuals within a community. The geographic information scientist can define and refine their models with the community, by expressing them in plain-language narrative terms (Bone 2018). Other GIS & T BOK topics of interest for ESJ include GIS-Based Computational Modeling, Location and Service Area Problems, Modelling Accessibility, and Point Pattern Analysis.

GIS practitioners should look beyond the default analysis provided in common geospatial tools. They should become familiar with the analysis approaches outlined in the GIS & T Body of Knowledge to build a broad toolkit to apply to specific ESJ related analysis.

4.4.1. Community level units of analysis

The units of geography that governments and agencies use to classify spatial data do not often conform to the movement of individuals in the community through time and space. Individuals in society often classify location in terms of 'neighborhood'. Administrative boundaries are usually defined along real or abstract geographic features that do not correspond to how individuals classify their concept of space based on concepts of social movement theory. In addition, the computational geometry that drives much geospatial analysis also often does not correspond to spatial organizational concepts of the individuals or the community. But the geographer can capitalize on community efforts to define neighborhoods for purposes of issue identification and activism (Mu & Holloway 2019).

The importance of appropriate community level units is based on the concept that true understanding of conditions based on geospatial analysis may be dependent on determining the correct scale and boundaries of the community for a given process. This is referred to as the modifiable areal unit area problem (MAUP). Correlations of data calculated as percentages or per capita tend to increase as a small number of larger areal units are defined and decrease as a larger number of smaller areal units are defined (Mennis 2019).

Community level units of analysis should also be validated with input from the communities studied.

4.4.2. Consistent, trusted, and transparent analysis methods

Most non-GIS professionals will only ever see the product of a geospatial analysis process applied to an ESJ issue. Anyone should be able to ask the GIS professional: are your analysis methods *consistent* and *transparent*, and can the data that you used and the analysis processes that you applied be *trusted*?

The use of a code version control system such as Git allows distributed sharing of code among developers, as well as version documentation. Consistent and transparent analysis methods should be documented as runbooks. Use of Jupyter Notebooks or ArcGIS Notebooks provides for easily documented analytics and preservation of the code set and associated documentation.

Consistent and transparent analysis methods create a sense of trust in the results. GIS for ESJ practitioners should also consider methodologies to quantify the level of trust in their analysis content and processes. To know if GIS for ESJ analysis and reporting should be trusted, the provenance of the processes must be transparent and reliable. Within GIS '…provenance has been described as the history of processes used within a workflow or study.' Provenance processes can be used to quantify the quality of the data content and the workflow processes within an analysis. Factors that might impact the level of content trust include data bias, quality, and authority. Process trust is based in part on evaluation of the results of the workflow (Linck 2015).

To ensure good scientific practices, GIS based ESJ analysis should be based on consistent and transparent methodologies. The goal is to be able to recreate GIS for ESJ results or to rerun analytic routines when data changes with time or for other reasons.

4.4.3. Analytical methodologies should be applicable to the use of both COTS and open-source software and tools

GIS practitioners typically choose their analytical tools based on personal expertise, experience, and preferences. Geospatial analytical tools for ESJ analysis could include open source options (Q-GIS, etc.) or commercial off-the-shelf (COTS) options (ArcGIS, Esri Insights for ArcGIS, Tableau Analytics, etc.).

However, the goal of consistent, trusted, and transparent analysis (4.4.2) suggests that trusted data can be analyzed against multiple processes, to determine if results are consistent. If they are not, the trust level is brought into question.

4.4.4. SQL languages, R, Python

To maximize the effective use of geographic information science and technology for ESJ, GIS practitioners often must go beyond the capabilities that commercial and open source geospatial software provide. A simple analysis within GIS for example might overlay one conditions layer over a geography in question to extract demographic data. But if multiple and complex spatial analysis is required, this can sometimes be performed more efficiently by using open source data analysis tools like SQL queries, Python, and R (Lott 2019).

Structured query language (SQL) is a declarative programming language to query a relational database. SQL can be applied against typical spatial analysis methods, including data format conversions, retrieval of geometry properties, determining spatial relationships between geometries, and generating new geometries (Hachadoorian 2019). A common free and open source tools for using SQL for geospatial analysis is PostgreSQL with PostGIS, which enables locational queries of geographic objects.

Python is a high level, general-purpose programming language that supports multiple data programming environments, including structured, object-oriented, and functional. Used within GIS processes, Python provides many categories of enhanced functionality. These include spatial data I/O (input/output) into memory for processing, geoprocessing, visualization, geostatistical analysis, spatial modeling, and web publishing (Rey 2017).

R is another programming language for statistical analysis and display. Because R can combine data content and code plus process narrative in one document, it provides a convenient and portable environment for documenting and sharing processes and analysis. R can accommodate both vector and raster spatial data, as well as supporting geoprocessing and spatial statistics. R can also be used to generate interactive maps that receive user input and output dynamic maps for on the fly visualization and analysis (Engel 2019).

4.5. Cartographic practices

The topic of cartography is vast. GIS practitioners should have knowledge of general cartographic design theory and practice, in addition to their skills and abilities to make a default map from data with GIS. For appropriate and defensible mapping in support of ESJ, an understanding of the basic conceptual theory of the map and its limitations is important.

Cartographic products will be used throughout the GIS for ESJ lifecycle. Because of the criticality of geographic analysis and cartography for ESJ, intuitive and defined practices should be utilized for consistent and trusted interpretation and understanding across multiple dimensions. These dimensions include consistency within the organization and to compare with other agencies, consistency across types of issues, and consistency over time.

Cartographic practices also apply to the various steps in the process of conceptualizing and then creating a map or map series. These steps include setting up the map space; compiling, preparing, and processing the subject data; constructing the spatial elements; representing the data geometry; applying the map symbology; representing the data attributes; labeling the map features; and developing and constructing the map marginalia (Jankanish 2011).

As an output of geographic information science, a map produced for ESJ analysis or information should include an abstract statement, similar to scientific articles. The map abstract should include a statement of the purpose or focus of the map (the use case), the problem or issue that the map is intended to address, the data and methodology used to create the map, the degree to which the map development process was informed by the CPP, key findings displayed in the map, and conclusions or recommendations that the map is intended to support. For traditional static map publications, the map document space available for the map abstract is severely limited. However, for web maps and story maps, an extensive abstract can be easily provided. For web map and story maps, another useful option is a graphical abstract, to help the reader quickly comprehend the focus of the map and the processes and resources utilized in its creation.

The meaning of most of the cartographic elements described below should be clarified for the end-user by an appropriate map legend. Only a sampling of key issues related to cartographic practices is presented below.

4.5.1. Natural breaks analysis versus quantiles for showing conditions and progress spatially

Geospatial attribute data can be classified, analyzed, and displayed via a variety of techniques for specific purposes. Data so classified can be univariate or multivariate. Clustering is the process of putting data into meaningful groups. The geostatistician looks for natural breaks in the area of spatial statistics and geodemographics, then groups data into clusters based on the natural boundaries in the data. Classification can be based on natural breaks in the data clusters, equal data intervals, or on defined quantiles that place the same number of observations in each classification unit (Lamb 2020). Within the GIS for ESJ lifecycle, the exploratory nature of a data clustering is more useful for initial issue and alternatives analysis and later effectiveness evaluation of performance metrics. The standardized nature of data classification via defined quantiles is a more useful methodology for consistent performance monitoring and stakeholder awareness.

4.5.2. Cartographic display should be consistent, trusted, transparent, and defensible

As with geospatial analysis, cartographic display of ESJ related data should be consistent, transparent, and trusted. In addition, the spatial data display options applied by the cartographer should be defensible. The cartographer should have and be able to state the use-case for the map or map series. Geospatial technology allows a GIS user to focus each map to a specific use case.

An agency utilizing GIS for ESJ should develop cartographic standards specific to equity and social justice work. These standards should also include general ESJ-related data visualization (see 4.6). The goal of data mapping and visualization standards should be to ensure an environment where map and visualization users can quickly and consistently interpret the conditions shown as intended.

A sampling of topics (many of which are addressed in the GIS & T Body of Knowledge) include: maps as infographics, maps as narratives, maps as data visualization, visualizing continuous versus discrete data, when to visualize with one color or multiple colors, options for visualizing two or more variables, surface mapping (choropleth, cartograms, dot density, heat v. hotspot maps, binning proportionate symbology, etc. Other considerations include the intended purpose – is it to measure or interpret data?

Usually individual map products are compiled and produced by a single map author. To help achieve cartography that is consistent, trusted, transparent, and defensible, a quality assurance and quality control process should be in place before publication of ESJ maps. Two approaches to cartographic QA/QC are checklist-based and/or peer-review. In both cases, the draft product should be checked against the applicable agency cartographic standards.

A map QA process should begin with reference to the use case and map abstract. Quality assurance should be accomplished by editing the product against various factors. Editing for accuracy includes proofreading the text, checking the data (is it current and correct?), verifying that the legend corresponds to the map content, and verifying the scale. Editing for completeness verifies if all the specified data is included, if the data is symbolized according to the design specifications, if the labeling is complete, and if all the required marginalia elements are present.

QA editing for style includes verification that the map conforms to agency styles, if the map is internally consistent regarding graphic and typographic styles, if the map design is compatible and consistent with its publication environment. QA editing for effectiveness addresses the overall legibility, are the various data elements clearly distinguishable from one another and is there enough contrast and hierarchy throughout the map, and if the map design reveals a spatial pattern or distribution as specified in the use case and map abstract (Jankanish et.al 2011).

4.5.3. Cartographic symbology (icons)

One of the most powerful semantic elements of a map is the choice and utilization of symbols to convey the meaning intended in the map use case. Icons are powerful map elements that convey complex meaning with simple shapes. The referent is the real-world object or activity that the icon represents. Map icons will be either pictorial, associative, or geometric. Because any map will have many features that can detract from the symbol, care in design is important for the map and its icon(s) to convey the intended message.

Development of libraries of standard map icons for ESJ is a key function for the GIS professionals within the agency, to achieve consistent, trusted, transparent, and defensible interpretation of maps created throughout the ESJ lifecycle. Standard symbol libraries published by ANSI and ISO can be used to bridge cultural differences in map interpretation. However, ESJ work will require new specialized icons as analysis and mapping captures and displays more abstract geospatial concepts. As part of the GIS for ESJ CPP, GIS should work with the community, with a focus on unserved and underserved segments, to define meaning and design for new features or conditions (Bell 2020).

Careful design map icons can also help alleviate map interpretation impediments that those with color perception deficiencies experience (Leff et.al 2016).

4.5.4. Cartographic symbology (color)

Another powerful semantic element of a map is the choice and utilization of color to convey the meaning intended in the map use case. Depending on the use case, color schemes in thematic maps can be used to convey sequential values, diverging values, or qualitative values.

A key practice is the development of a palette of colors that are defined for consistent use across all agency ESJ map products. The GIS for ESJ practitioner should be familiar with the aspects of color: hue, saturation, and value (HSV). Hue represents the dominant wavelength to create the basic colors. Saturation refers to the intensity of a hue, and value refers to variation in a hue in terms of perceived lightness or darkness.

A foundation for displaying ESJ related thematic data on individual maps is based on sequential data as it is distributed across space. In this scheme colors of defined saturation and hue are selected to correspond to defined feature attributes. The colors are then applied to thematic maps utilizing value variations that correspond to standardized and consistent sequential values as defined in the map use case. The selection of the color palette should also be sensitive to the connotation of certain colors within the community, and to the fact that a significant portion of the community population may have color vision deficiencies that affect the ability to perceive certain shades of color (Christophe 2019).

Consistent application of the sequential values concept applied to GIS for ESJ mapping means that within the color palette, lighter values always correspond to smaller values and darker values always correspond to greater values. Care should also be taken to avoid palettes that appear to transfer systematic prejudice about unserved and underserved communities where the needs are greatest.

Because GIS for ESJ will often focus on the spatial patterns of racial groups within the community, consistent use of symbols and color to depict race is important. One approach is to depict the spatial distribution of people of each race on a single set of thematic maps. For each map, one hue with a range of values can be used whichever race is depicted, or separate hues can be assigned to each race with a consistent range of values to depict the proportion of the race in the community. Depicting more than one race on a thematic map creates problems of depicting each race and its share of the total population. One approach is a bivariate map where two variables and a small number of values can be depicted with a carefully designed color matrix. This approach may be useful to depict two races or two community conditions (Nelson 2020).

Another approach to depicting multiple races on maps is the use of color dot maps. Developed by the University of Virginia Weldon Cooper Center for Public Service, Demographics Research Group, in this approach, one dot represents one person with the color correlated with the person's race as reported on the US Census. The Racial Dot Map allows navigation from the national level to the census block level. Within census blocks, the locations of individual dots are randomized to preserve locational privacy. The entire code used to create the map is available in Github (Racial Dot Map 2013).

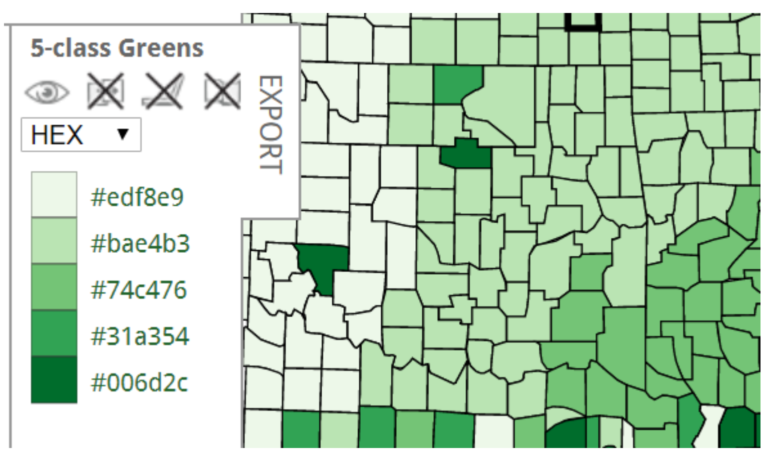

Fig. 4 Typical five-value colorblind-safe color value scheme derived from ColorBrewer
Brewer, Cynthia A., 2020. http://www.ColorBrewer.org, accessed April 29, 2020

A topic of potential sensitivity is the choice of colors used to represent ethnic or racial distribution on maps. Without careful selection, color choice may be perceived as reflecting bias on the part of the cartographer and the agency. Conventional meanings assigned to colors on maps need to be considered in relation to the cultural symbolism assigned to colors. In Europe there was a long history of biased color selection and use on maps designed to make claims to territory based on language use and related assumed ethnicity. The cartographer working with GIS for ESJ should be aware of the challenges of personal or institutional bias related to color selection (Johnson 2001). To minimize perceived bias from either societal priviledge or systematic associations, standard color choices intended to denote the race of segments of the community should be developed that are ideally validated by the communities represented by the colors, and well documented in the agency cartographic and general visualization standards.

Another consideration for the use of color in thematic maps is to ensure that the map reader can interpret the spatial values shown in terms of locations that are meaningful. This may mean a neighborhood, a street network or other physical features, or points of interest. The cartographer should select color values that provide transparency to the key locational features needed by the map reader.

A useful resource for exploring and selecting a standard color palette is the online ColorBrewer (Brewer 2020). This resource allows a user to test palettes that are appropriate for sequential, diverging, or qualitative data, based on multi-hue or single hue schemes (Fig. 4). It also helps to determine if palettes accommodate people with color deficiencies.

4.6. General visualization practices

Throughout the GIS for ESJ lifecycle, data will need to be visualized using both spatial and non-spatial formats. Non-spatial visualization (charts, graphs, histograms, cartograms, etc.) will be created by GIS staff, as well as by ESJ practitioners, graphic artists, web designers, and others. A typical report, web site, or StoryMap will often include a combination of narrative text, raw statistical data in tabular form, graphics, and maps. Each of these data visualization elements should be prepared with consistent design that helps the end-user to clearly and consistently interpret the intended message.

When developing cartographic standards for ESJ, the display of non-spatial data or spatial data displayed in non-map format should be considered. Many of the cartographic considerations outlined elsewhere should have similar graphic display elements.

The initial development of agency cartographic standards for ESJ can be coordinated with graphic designers and ESJ practitioners. Alternately, an agency can develop a comprehensive ESJ design brief and data visualization guidelines document that includes cartographic standards.

4.6.1. Accessibility practices

ESJ visualization guidelines should also address community accessibility goals and the steps to be taken to achieve such goals. The CPP will identify key community stakeholders. The stakeholder community can provide input on considerations to achieve the desired level of accessibility.

Common accessibility issues can include color and other visual disabilities, language, digital access, and other factors. In addition to general color perception issues, sensitivity to special community meaning ascribed to certain colors must be considered. Other visual disabilities may require tactics like creating visualizations and maps in other formats or display scales.

If there are significant non-English speaking segments of the community, a text translation strategy is needed. An understanding of unserved and underserved community access to digital devices and Wi-Fi should also inform the need for alternate visualization and map media. An innovative approach to bring maps to segments of the public without smartphones or Wo-Fi in Nairobi is to paint maps depicting community conditions on billboards or on walls in prominent locations (Map Kibera 2020).

To maximize stakeholder community accessibility, the CPP must also include community training resources, to aid in understanding maps and other visualizations. Periodic outreach and information sharing sessions in the community can help achieve this and serve as gauges of the effectiveness of ESJ related maps and visualizations.

4.6.2. Clarify the story you are trying to tell – the creative plan

The use of use case documentation for ESJ-related mapping was described. Often major data visualization resources will be developed throughout the ESJ lifecycle. These might include periodic published reports, StoryMaps, or Dashboards. Each of these will combine narrative text, statistics, graphics, and maps. Content will be provided from multiple sources.

To clarify a common understanding of a complex and critical story that needs to be told, a creative plan or design brief can be developed. A creative brief is commonly used in advertising and marketing. Many of the features can be useful for major ESJ related messaging campaigns. The creative design brief provides background information about the issue and the impacted community. It identifies the core message that is intended and the desired actions or outcomes. It can also clarify deliverables, the creative team, timeline, and where overall approval for process elements resides.

5. GIS based dashboards for ESJ program management

Central elements of the ESJ lifecycle are identifying issues and deciding on action, based on alternatives analysis. GIS based dashboards are a key tool for describing conditions and issues in the community, then tracking progress of policies, programs, and/or resource allocations intended to change the conditions. A dashboard that combines data about the issue and related actions is a type of progress report. Its interactive nature makes it a useful management tool and means of communicating key performance indicators to the community. GIS based dashboards for ESJ provide functionality to management and stakeholders to explore data and metrics in statistical, spatial, and temporal form.

GIS for ESJ dashboards are based on concepts of geovisualization and geovisual analytics. Geovisualization is based on an interactive environment that supports viewing integrated spatial, temporal, and attribute data. It facilitates visual thinking by synthesizing a context of known reference points with a variety of data sources to help the user reveal previously unknown conditions (Çöltekin et.al. 2018). Geovisual analytics goes beyond with integrated interactive tools to help the end-user analyze spatial data (Robinson 2017).

Components of a GIS-based dashboard will include a web-based data exploration portal based on an end-user focused multi-function architecture that links inter-related data presentation strategies. Dynamically linked views allow the user to explore the data across time and space (Jern et.al 2020).

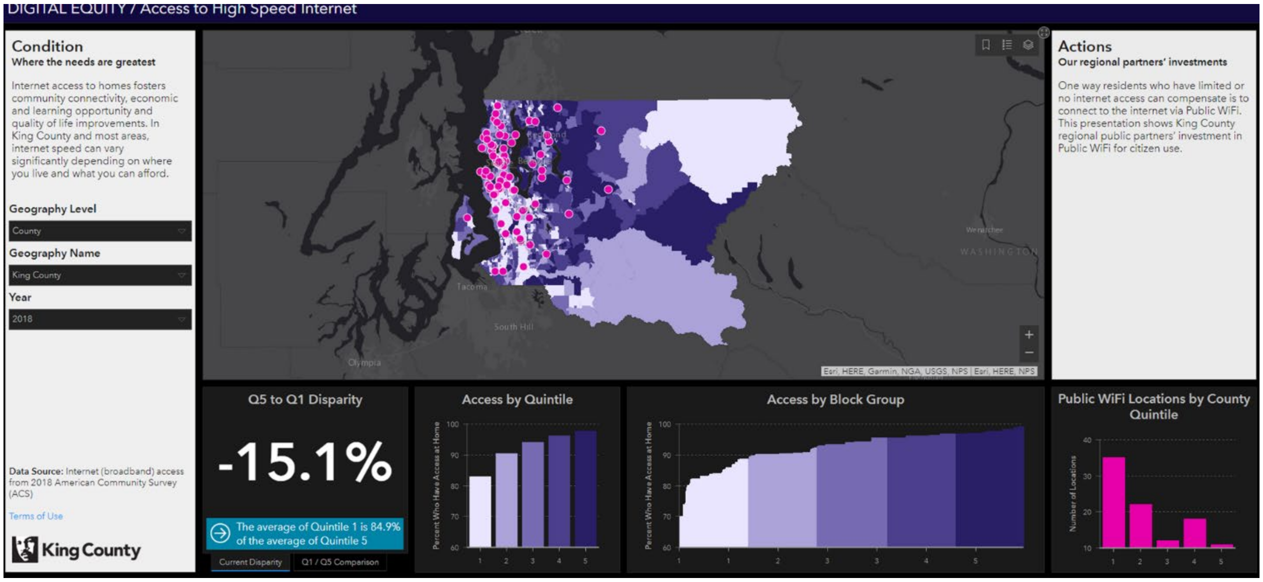

Fig. 5 Typical GIS based ESJ dashboard

GIS based dashboards for ESJ rely on good design principles. Open-source or commercial GIS-based dashboard templates facilitate side-by-side comparison of issues and programs between different regions and jurisdictions. The spatial aspect of ESJ dashboards should allow users to look at conditions across the entire region or drill down to specific sub-units of the region. The CPP should identify the level of sub-unit detail that will be meaningful by the community.

Dashboards (or instances of dashboards) should also display data related to the agency equity index, or to the individual equity indicators. Dashboard design should consider integrating progress, spatial variations, local conditions, and temporal variations. Because dashboards combine multiple data visualization methods, an integrated legend should be included. An ESJ dashboard must provide elements that both display metrics and facilitate action.

If the application of GIS for issues related to equity and social justice is to have a meaningful and positive long-term impact, GIS based ESJ dashboards are a key tool. They encapsulate the multi-disciplinary work of the ESJ team within an agency, including GIS tool users, tool makers, and GIS scientists. They connect the multi-disciplinary scientific GIS for ESJ approach with community stakeholders. Informed by the community participation plan, the foundation of GIS based ESJ dashboards is grounded in solid spatial data sources and data management practices, in transparent, trusted, and repeatable geospatial analysis, and in clear and consistent geovisualization practices. GIS based ESJ dashboards will prove for the future the progress towards achieving today's vision of achieving racial equity and social justice.

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7. Learning Objectives

Discuss the ESJ lifecycle

Discuss why trust in GIS data and analysis is important for ESJ

Describe how to involve the community in the GIS for ESJ process

Describe how data privacy can be threatened by ESJ analysis with GIS

Discuss the use of GIS-enabled dashboards for ESJ

Discuss how geo-analytical tools can be used during the issues-analysis phase

Discuss equity index versus equity indicators

8. Instructional Assessment Questions

Why is GIS important to understand inequity?

Why is geographic analysis critical for equity and social justice?

What are challenges assessing ESJ-focused program metrics?

Why are consistent data schemas important?

What is the purpose and components of a map abstract?

Why is preserving data in time series format important?

What is the benefit of regional ESJ data sharing?

What are tools to analyze and process data efficiently outside of GIS tools?

What are key factors in choosing a color palette to depict race on maps?

9. Additional Resources

GARE - The Local and Regional Government Alliance for Race and Equity (https://www.racialequityalliance.org/) is a national network of government working to achieve racial equity and advance opportunities for all.

EthicalGEO (https://ethicalgeo.org/) is an initiative of the American Geographical Society that seeks to activate thinkers, innovators, entrepreneurs, policymakers, practitioners, students, and everyday citizens and bring them in to a global dialog that shines a light on their best ideas about the ethical challenges and opportunities posed by the many geospatial technologies and data sources that are reshaping our society.

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The work and writings of Edward Tufte (www.edwardtufte.com) is a valuable resource for any GIS or ESJ practitioner to understand optimal data visualization practices.

Linköping University's Statistics eXplorer (https://ncva.itn.liu.se/explorer?l=en) provides geovisual analysis dashboards that provide examples of integrating common information and geospatial visualization methods to understand and explore statistical data, uncover patterns of interests, gain insights, tell-a-story and communicate knowledge.

City of Tacoma, Washington Equity Index: (https://www.cityoftacoma.org/cms/One.aspx?portalId=169&pageId=175030).

Git code version control system: (https://en.wikipedia.org/wiki/Git).

Jupyter Notebooks to document analytics and preserve code set and associated documentation: (https://en.wikipedia.org/wiki/Project_Jupyter#Jupyter_Notebook).

United Nations Sustainable Development Goals: https://www.undp.org/content/undp/en/home.html.

Acknowledgement

The development of this document was supported by an EthicalGEO Fellowship (https://ethicalgeo.org/) awarded to the author by the American Geographical Society in 2019. Without this fellowship development of the GIS for ESJ best practices would have much slower and would not have attracted as large a group of qualified and highly motivated collaborators.

The original concept for GIS for ESJ best practices was from the development of the *Introduction to GIS for ESJ Workshop* developed by Nicole Franklin and the author for URISA in 2019. The original GIS for ESJ best practices outline included in the workshop was developed collaboratively by the author with Mary Ullrich, Patrick Jankanish, and Mike Leathers of the King County GIS Center, Nicole Franklin, King County IT Chief Equity Officer, Jennifer Schmidt of Herrera Engineers in Seattle, and Prof. Vero Vélez of Western Washington University.

Development of the final GIS for ESJ best practices was also aided by an ad-hoc committee of more than 55 interested GIS and ESJ users and academics, who provided advice, criticism, review comments and suggestions.

Key committee input was provided for development of the working outline (February 2020), first review draft (April 2020), and the final draft (June-July 2020). Individuals who contributed to this process included: Christopher Ahmed of the Washington State Department of Health, Royal Alley-Barnes of King County Information Technology, Sachi Arakawa of the Mapping Action Collective, Tommy Brown of the Washington State Department of Transportation, Joel

Creswell of the Puget Sound Clean Air Agency, Dr. Mike Dolan Fliss of the University of North Carolina Injury Prevention Research Center, Nicole Franklin, Richard Gelb of King County Public Health, Joe Gordon of Oregon Metro, Valrie Grant - Managing Director GeoTechVision (Jamaica) and Vice-Chair UN-GGIM PSN-Americas, Ben Hughey - environmental policy and public administration professional, Dr. Rhoda K. Moise of the University of Miami Miller School of Medicine, Kristi Silk of Licker Geospatial Consulting Ltd. (Vancouver BC), Prof. Sheila Steinberg of Brandman University, Holly Valenta of the City of Boulder, Amelia L. Vargas of the Oregon Department of Education, Antonio Vargas of the Oregon Department of Consumer and Business Services, Prof. Vero Vélez of Western Washington University, Jackson L. Voelkel of the Kaiser Foundation Health Plan, and Andrea Wong of the King County Department of Natural Resources Policy and Performance Unit.

I appreciate the encouragement, thoughtful advice, and criticism of everyone who aided development of this document, but all of the flaws and deficiencies are mine alone.