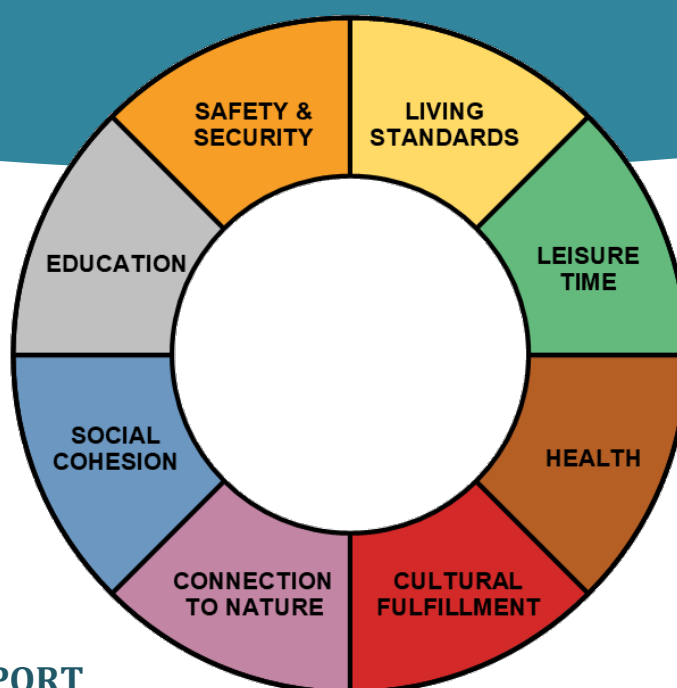


Assessment and Recommendations for Measuring Human Health and Well-Being in the Saginaw Bay Watershed



FINAL REPORT

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Executive Summary

The Saginaw Bay Watershed is home to a significant portion of Michigan's agricultural land and is a focal point for conservation and sustainable development efforts due to its ecological, economic, and cultural significance. Agricultural practices within the watershed have contributed to water quality degradation, necessitating interventions that address environmental quality and human health impacts. Through its Regenerative Agriculture Program, The Nature Conservancy (TNC) promotes practices such as reduced tillage and cover cropping to improve soil health, reduce carbon emissions, and mitigate over-nutrication of the Saginaw Bay and its interconnected water bodies.

While water quality improvements from these initiatives are well-documented, their direct impact on human health and well-being remains underexplored. Building on TNC's previous work to identify socio-economic indicators to inform where and how their conservation programming could benefit people and nature more effectively, this project seeks to address this gap by identifying suitable human well-being indicators and metrics for integration into ongoing watershed monitoring efforts. Specifically, the intent is for the metrics identified in this analysis to be integrated into an existing water quality monitoring dashboard operated by the Saginaw Bay Monitoring Consortium. Including human well-being metrics in the dashboard will allow for an engagement tool that considers the environmental impact of pollution in the watershed and the impact on Saginaw Bay community members.

To achieve this, the project identified and assessed three peer watersheds in the United States tracking human well-being indicators and metrics: Puget Sound, Lake Erie, and the Chesapeake Bay. Utilizing the Environmental Protection Agency's (EPA) Human Health and Well-Being Index as a guiding framework, the project team categorized the indicators and metrics identified by TNC and the peer watersheds according to the Index's eight domains of human well-being. From there, the project team assessed each metric's relevance to the Saginaw Bay and readiness for implementation based on data availability, temporality, and spatiality. The analysis resulted in 21 metrics recommended for immediate implementation, spanning over nine indicators of human well-being and seven EPA human well-being domains. The project team further recommends implementing a comprehensive survey program to collect data on qualitative metrics rated as highly relevant in the watershed but currently lacking a sustainable monitoring protocol, ensuring a balanced assessment of human well-being.

Key limitations of this analysis include a lack of stakeholder engagement in the selection and evaluation of metrics, a gap in education-related indicators aligned with the EPA's Human Well-Being Index framework, and a lack of clear targets for the recommended metrics. Future efforts building on this work should prioritize community involvement, identify education-related metrics, and develop meaningful benchmarks to effectively guide implementation and evaluate progress toward improved human well-being for each metric.

1. Introduction

The Nature Conservancy (TNC) has been a leader in conservation for many decades, and in recent years, the organization has begun explicitly considering and monitoring the connections between conservation and human health and well-being. A healthy and functioning ecosystem has often been assumed to have health benefits for humans, however the explicit nature of those benefits has not always been clearly understood or measured by conservation organizations, policy makers, or the public.¹ As TNC and other conservation-based organizations work toward addressing the co-occurring global threats of climate change and biodiversity loss, connecting human well-being to conservation of land and water is becoming increasingly important to furthering conservation goals in a just, equitable, and effective manner.² Food systems are one area where the connection between conservation-based best practices and human well-being is of crucial significance. Conventional agricultural practices have a variety of impacts on ecosystem health and human well-being, both on agricultural lands and to their connected lands and waters. In areas where conventional agriculture is the dominant land-use, the environmental impacts can be particularly acute, leading to declines in ecosystem health, water quality, and human well-being.³ In response to the negative environmental impacts associated with conventional agriculture practices, there are many initiatives, programs, and organizations across the world working to make agriculture more sustainable while also maintaining agricultural productivity and providing food, fibers, and livelihoods for a growing human population.

TNC's Regenerative Agriculture Program in the Saginaw Bay works with local farmers to promote soil health practices such as reducing tillage, maintaining vegetative cover strips, and cover cropping. These practices preserve on-farm soil fertility, reduce carbon emissions, and reduce over-nutrication of waterways. The Saginaw Bay is a recognized Environmental Protection Agency (EPA) Area of Concern⁴ for water quality due in large part to conventional agricultural practices, as well as other water quality threats in the region. TNC works with local partners in the Saginaw Bay Watershed Initiative Network (WIN) to monitor the water quality benefits associated with its Regenerative Agriculture Program in the Saginaw Bay, but it has not yet established a means of directly measuring the program's benefit to human health and well-being. This paper will build on previous work completed by TNC to identify suitable metrics and potential data sources for TNC to effectively track human health and well-being metrics. To conduct a comprehensive analysis of human health and well-being, the team conducted a literature review, reviewed the human well-being indicators (HWBI)/metrics of peer watersheds that are measuring human health and well-being, analyzed TNC's past work to identify potential metrics, and synthesized findings using the EPA's newly developed human health and well-being framework.

¹ Hilborn, Elizabeth, and Val Beasley. "One Health and Cyanobacteria in Freshwater Systems: Animal Illnesses and Deaths Are Sentinel Events for Human Health Risks." *Toxins* 7, no. 4 (April 20, 2015): 1374–95. <https://doi.org/10.3390/toxins7041374>.

² Liberati, Marjorie R., Christopher A. May, Scott P. Sowa, Stephanie R. Kyriakakis, Doug R. Pearsall, and Patrick J. Doran. "Planning for People and Nature: Comparing Quality-of-Life Outcomes across Environmental Systems to Inform Conservation Planning." *Conservation Science and Practice* 4, no. 10 (2022): e12782. <https://doi.org/10.1111/csp2.12782>.

³ Zhidkova, A Y, V V Podberesnij, R V Zarubina, and O A Kononova. "The Effect of Eutrophication on Human Health on the Example of the Gulf of Taganrog of the Sea of Azov." *IOP Conference Series: Earth and Environmental Science* 548, no. 5 (August 1, 2020): 052053. <https://doi.org/10.1088/1755-1315/548/5/052053>.

⁴ US EPA: Saginaw River and Bay AOC <https://www.epa.gov/great-lakes-aocs/saginaw-river-and-bay-aoc>

2. Overview of the Saginaw Bay Watershed

The Saginaw Bay Watershed accounts for about 20% of all of Michigan's agricultural land, and the watershed's 5.5-million-acres contain a high concentration of prime farmland and abundant freshwater resources that provide ideal growing conditions for the region's agricultural economy.⁵ The watershed is largely characterized by conventional farming practices and lands cultivated for agriculture cover approximately 45.6% of the watershed's total land area per 2021 National Land Cover Database records (**Figure 1**). As the dominant land-use, agriculture's impacts on watershed health are significant, both in terms of beneficial impacts for the economy, and negative impacts on water quality and associated metrics through over-nutrifcation of waterways.⁶

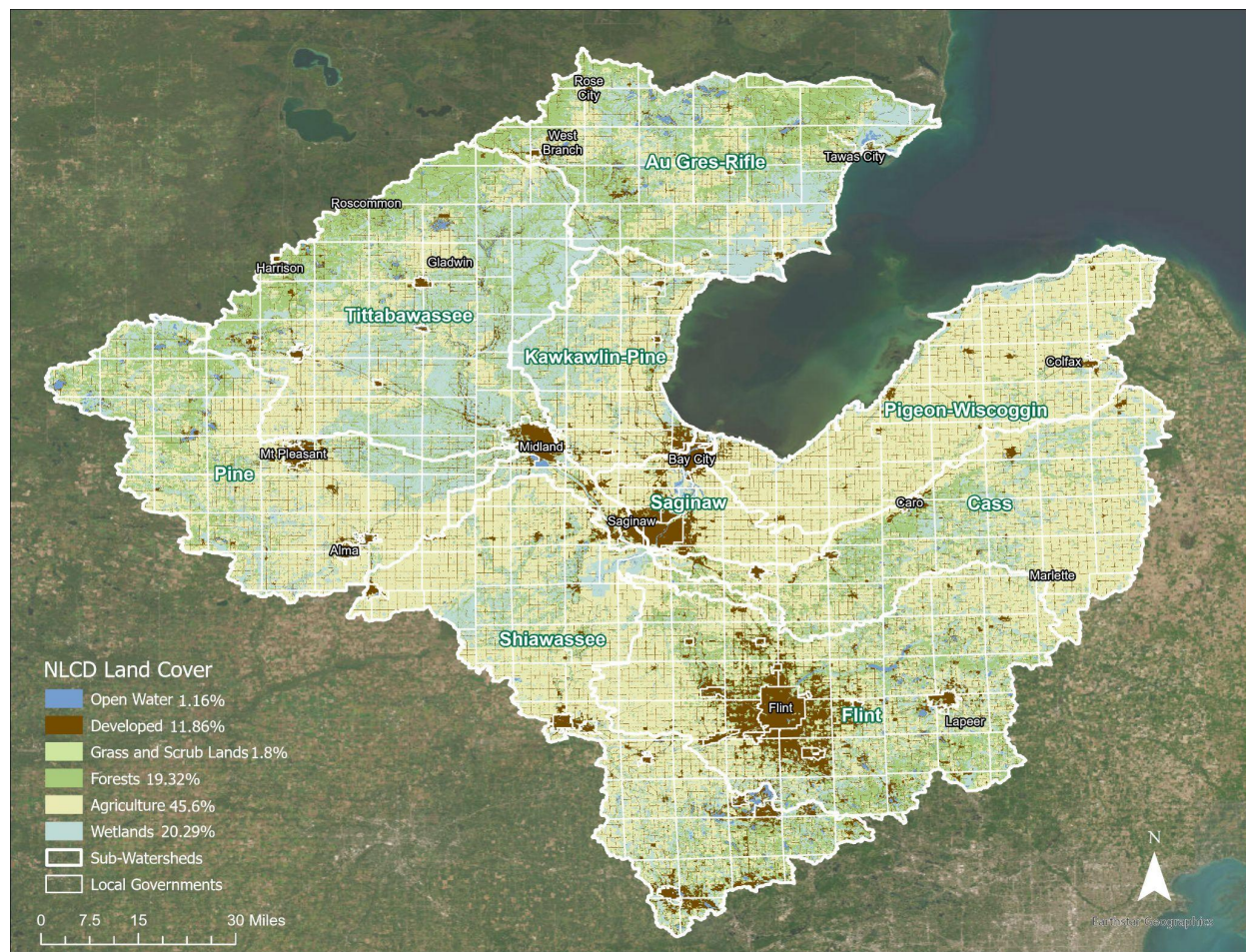


Figure 1. Saginaw Bay Land Cover and Sub-watersheds: An estimate of land cover for the entire watershed. Agriculture is the dominant land use however wetlands, forests, and developed areas also comprise a significant portion of land cover in some parts of the watershed. (Independent Geospatial Analysis by Jamie Brackman utilizing National Land Cover Database 2021, US EPA Sub-watershed data.)

⁵ The Nature Conservancy. "The Nature Conservancy Announces Soil Health Hero Award Winners." Accessed December 6, 2024. <https://www.nature.org/en-us/newsroom/2023-soil-health-hero-awards/>.

⁶ "As Saginaw Bay Pollution Grows, Farmers Urge Other Farmers to Change Ways | Bridge Michigan," May 31, 2024. <https://www.bridgemi.com/michigan-environment-watch/saginaw-bay-pollution-grows-farmers-urge-other-farmers-change-ways>.

Historically, the Saginaw Bay Watershed was home to a rich diversity of natural communities, waterways, and ecosystems (**Figure 2**) that were largely altered and fragmented through the processes of colonization, industrialization, and modernization. The presence of natural areas is important to human health in terms of the ecosystem services they provide, such as stormwater mitigation, water filtration, opportunities for recreation, and spiritual and cultural connections.⁷ Natural communities are also essential to the healthy ecosystem functions and the conservation of wildlife habitat and biodiversity,⁸ which contribute to the Bay’s outdoor recreation economy.

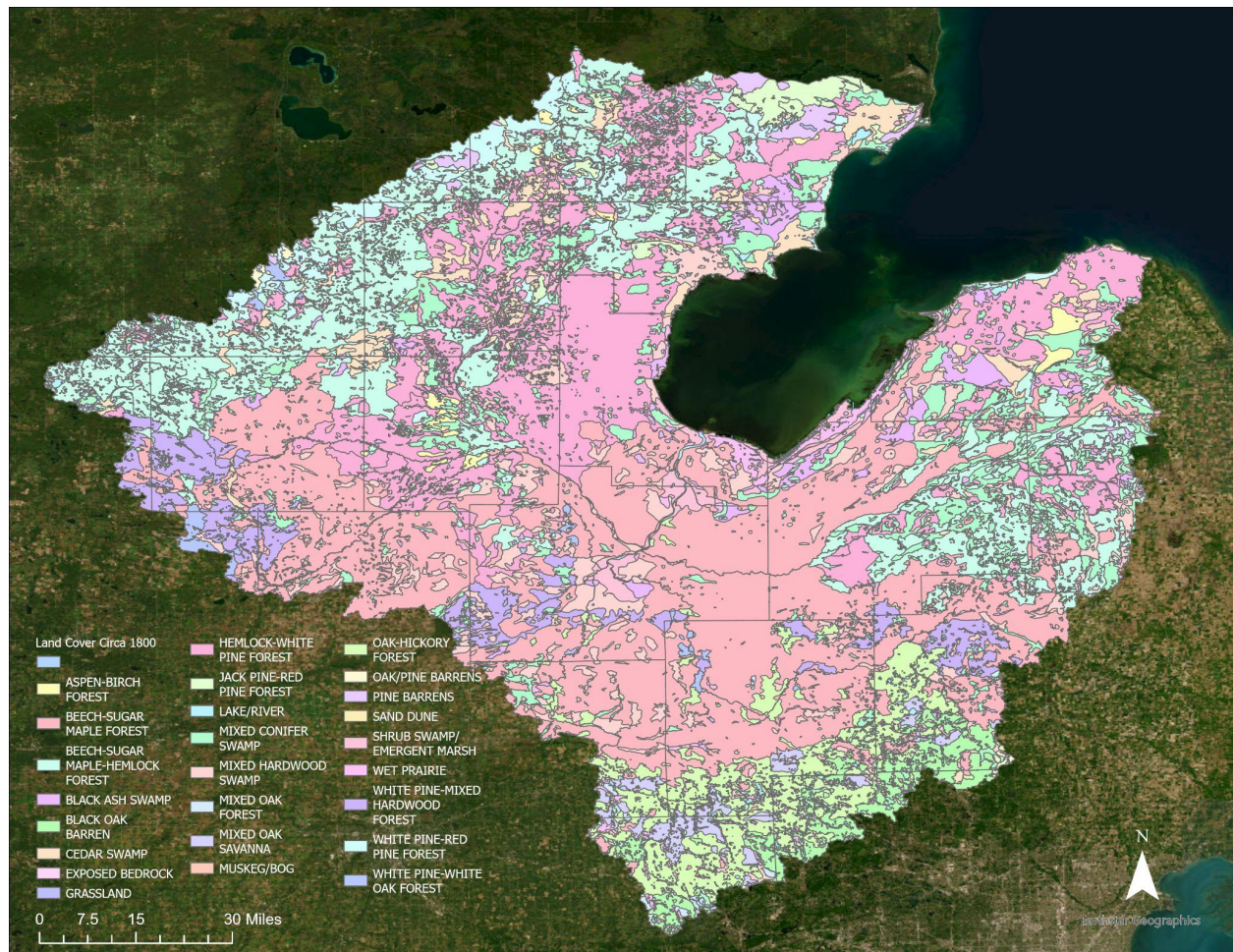


Figure 2. Natural Community Types in the Saginaw Bay Circa 1800: Like most of Michigan, the Saginaw Bay was once characterized by an array of highly biodiverse natural community types including Forests, Wetlands, Savanna’s, Prairies, and Coastal Dunes.

(Independent Geospatial Analysis by Jamie Brackman utilizing Michigan Natural Features Inventory Data.)

Some remnant natural areas persist in the watershed today, but differences between sub-watersheds in the Saginaw Bay Watershed are significant, with some regions being almost entirely devoid of

⁷ Conservation, Illinois Department of. *Readings in Outdoor Recreation Planning and Environmental Quality* / Jerry R. Van Meter and Russell J. Irvine, n.d.

⁸ “Michigan’s Natural Communities - Michigan Natural Features Inventory.” Accessed December 6, 2024. <https://mnfi.anr.msu.edu/communities>.

natural areas and others remaining relatively intact (**Figures 3 and 4**). These differences in land cover likely have a significant impact on environmental quality and human health and well-being in different parts of the Watershed. Understanding the geography and natural history of the region can prepare organizations and stakeholders to better grapple with the complex interconnections between social and environmental health at play in different parts of the watershed.

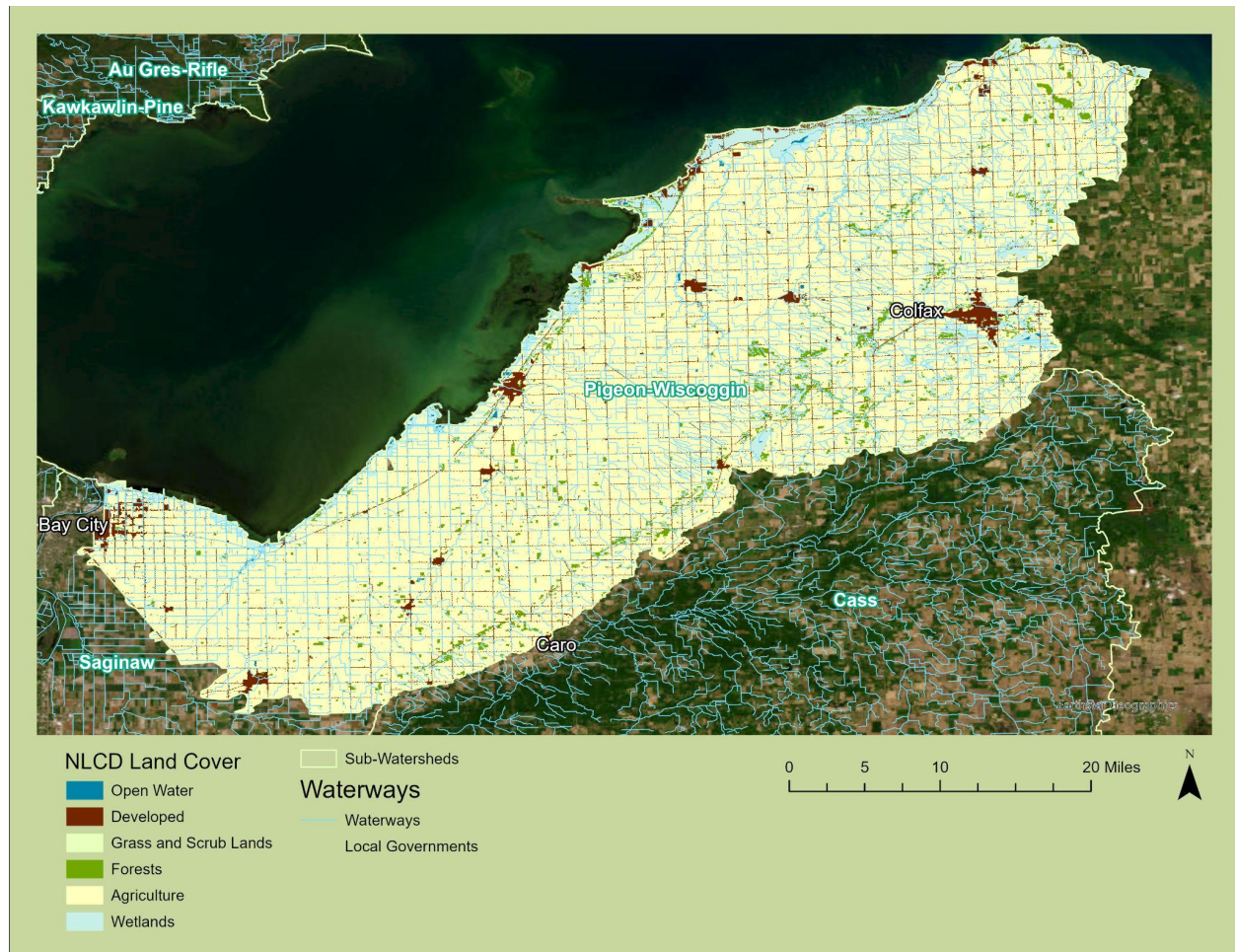


Figure 3. The Pigeon-Wiscoggin Sub-watershed This region is nearly entirely converted for agriculture and nearly all its water bodies are channelized for agricultural production per USGS hydrological data. Channelization of streams and rivers is known to accelerate the flow of nutrients and other contaminants into water bodies,⁹ which contributes to hypoxia and the algal blooms visible here in satellite imagery.

(Independent Geospatial Analysis by Jamie Brackman utilizing National Land Cover Database 2021 data, US EPA Sub-watershed data, and US Census Bureau Incorporated Places Data.)

⁹ “The Natural Flow Regime: A Master Variable for Maintaining River Ecosystem Health - Sofi - 2020 - Ecohydrology - Wiley Online Library.” Accessed December 6, 2024. https://onlinelibrary-wiley-com.proxy.lib.umich.edu/doi/full/10.1002/eco.2247?casa_token=KYkuFyOzoy8AAAAA%3Av0UvgCxQt3RMMzc-8S8bHc3QKJdw1x3O_EYDmTS8JfZdYTPZvPJTAIW9r3YqaR6CNlqIBpEY-c4zEQ.

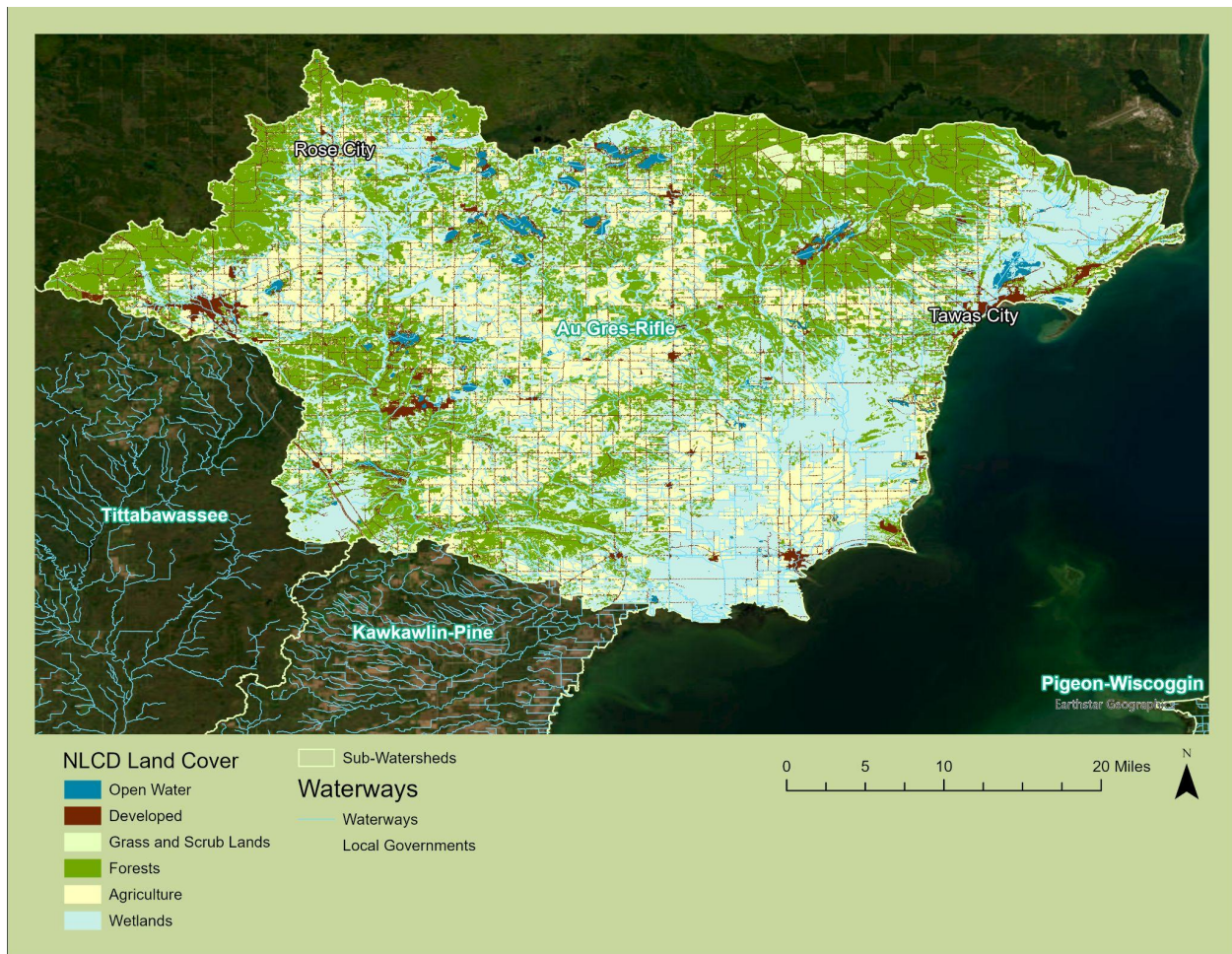


Figure 4. Au Gres-Rifle Sub-watershed This sub-watershed region contains the greatest surface area of wetlands and forests within the Saginaw Bay Watershed. These forests and wetlands provide critical water quality ecosystem services¹⁰ and also provide habitat for a wide range of wildlife.¹¹ While Agriculture remains a significant land-use in this sub-watershed, the runoff impacts are likely to be less severe here as a result of the presence of natural areas and higher percentage of natural flowing streams and waterways in this region.

(Independent Geospatial Analysis by Jamie Brackman utilizing National Land Cover Database 2021 data, US EPA Sub-watershed data, and US Census Bureau Incorporated Places Data.)

¹⁰ Daily, Gretchen Cara. *Nature's Services: Societal Dependence On Natural Ecosystems*. Island Press, 2012.

¹¹ Rewa, Charles A. "Fish and Wildlife Benefits Associated with Wetland Establishment Practices." United States Department of Agriculture-Agricultural Research Service / University of Nebraska-Lincoln: Faculty Publications, January 1, 2007. <https://digitalcommons.unl.edu/usdaarsfacpub/488>.

3. Literature Review

In this literature review, we delve into the concept of human well-being, its multidimensional nature, and its increasing integration into environmental conservation and watershed management. We begin by defining and conceptualizing well-being, tracing its evolution from a narrow focus on economic measures to a more holistic framework that encompasses physical, social, and ecological dimensions. We highlight the critical role of human well-being in conservation efforts, emphasizing its importance in achieving sustainable development goals and protecting ecosystems.

Next, we explore the intricate link between watershed health and human well-being, illustrating how ecosystem services provided by watersheds enhance community resilience and sustainability. We examine diverse approaches to assessing well-being, including objective, subjective, and mixed methods, while advocating for integrated frameworks like the Human Well-Being Index as a comprehensive tool. Finally, we draw lessons from U.S. watershed initiatives such as Chesapeake Bay, Puget Sound, and Hood Canal, focusing on the value of stakeholder collaboration, equity-driven strategies, and adaptable indicators in advancing human well-being and fostering sustainability.

3.1. Understanding Human Well-Being

3.1.1. Definition and Conceptualization

Human well-being is a multidimensional and complex concept, representing a spectrum of personhood and science.¹² Given its ambiguity and abstractness, there are numerous interpretations, yet no universally acceptable definition.¹³ From the analytical perspective, such ambiguity demands clarity to arrive at a “secure epistemological and empirical footing” before any attempt to measure it.^{14,15}

The evolution in what constitutes human well-being has led to a shift from solely economic measures to multidimensional frameworks that incorporate subjective and ecological dimensions.¹⁶ Today, the holistic yet dynamic concept of well-being incorporates the fulfillment of basic needs and capabilities and access to opportunities and resources besides physical, social, and mental aspects of well-being.¹⁷ Objective well-being includes measurable material and social factors like housing, income, education, and employment.¹⁸ Subjective well-being, on the other hand, involves personal perceptions and satisfaction with life, assessed through psychological indicators such as life satisfaction, autonomy,

¹² Gasper, Des. "Human well-being: concepts and conceptualizations." In *Human well-being: Concept and measurement*, pp. 23-64. London: Palgrave Macmillan UK, 2007. https://doi.org/10.1057/9780230625600_2

¹³ Brown, Katrina, and Elizabeth Westaway. "Agency, capacity, and resilience to environmental change: lessons from human development, well-being, and disasters." *Annual review of environment and resources* 36, no. 1 (2011): 321-342. <https://doi.org/10.1146/annurev-environ-052610-092905>

¹⁴ Gasper, "Human well-being," 2007.

¹⁵ McGregor, J. Allister. "Researching well-being: Communicating between the needs of policy makers and the needs of people." *Global social policy* 4, no. 3 (2004): 337-358. <https://doi.org/10.1177/1468018104047491>

¹⁶ Gasper, "Human well-being," 2007.

¹⁷ Gasper, "Human well-being," 2007.

¹⁸ Gasper, "Human well-being," 2007.

mastery, social connectedness, and personal security.¹⁹ According to the Millennium Ecosystem Assessment, well-being is a continuum opposite to poverty, which is “pronounced deprivation in well-being.”²⁰ Human well-being not only constitutes basic material needs, freedom, health, social relationships, and security but is also influenced by local geography, culture, and ecological conditions, shaping how individuals experience and perceive them.²¹

The most recent view considers that well-being is a positive state for individuals and societies, comprising quality of life, meaningful contribution, and purpose.²² Much like health, it serves as a vital resource for daily life influenced by social, economic, and environmental conditions. A society's well-being indicates its resilience, capacity for action, and ability to overcome challenges.²³ Aligning with the World Health Organization's conception, TNC defines human well-being as “a state of being in which one's needs are met, one can act meaningfully to pursue chosen goals, and one enjoys a satisfactory quality of life.”²⁴ Hence, emphasis on well-being, despite its dynamism and evolution, helps track equitable resource distribution, overall thriving, and sustainability.²⁵

3.2. Importance in Environmental Conservation

Human well-being is increasingly being considered as a driver and goal of conservation, emphasizing its importance in achieving sustainable development goals and ensuring long-term ecosystem protection.²⁶ Ecosystem services support physical, physiological, and psychological health.²⁷ They enhance quality of life by providing essential resources like food, fresh water, medicines, and building materials, along with cultural and spiritual benefits.²⁸ Environmental degradation undermines well-being by disrupting critical ecosystem services such as clean water, food security, and climate regulation.²⁹ Conservation strategies that incorporate human well-being foster stakeholder engagement, promote sustainable practices and ensure equitable resource distribution.³⁰ This integrated approach enhances resilience,

¹⁹ Gasper, "Human well-being," 2007.

²⁰ Assessment, Millennium Ecosystem. *Ecosystems and human well-being: a framework for assessment*. 2003.

²¹ Millennium Ecosystem Assessment, *Ecosystems and Human Well-Being*, 2005.

²² World Health Organization. "Health Promotion Glossary of Terms 2021." *World Health Organization* (2021). <https://iris.who.int/bitstream/handle/10665/350161/9789240038349-eng.pdf?sequence=1>

²³ World Health Organization. "Health Promotion Glossary," 2021.

²⁴ The Nature Conservancy. *Conservation by Design: A Strategic Framework for Mission Success*. 20th Anniversary Edition. Arlington, VA: The Nature Conservancy, 2016. <https://www.nature.org/media/aboutus/conservation-by-design-20th-anniversary-edition.pdf>

²⁵ World Health Organization. "Health Promotion Glossary," 2021.

²⁶ Díaz, Sandra, Unai Pascual, Marie Stenseke, Berta Martín-López, Robert T. Watson, Zsolt Molnár, Rosemary Hill et al. "Assessing nature's contributions to people." *Science* 359, no. 6373 (2018): 270-272. <https://doi.org/10.1126/science.aap8826>

²⁷ Millennium Ecosystem Assessment (MEA). *Ecosystems and Human Well-Being: Current State and Trends* (Vol. 5, p. 563). Washington, DC: Island Press, 2005. <https://www.millenniumassessment.org/en/Framework.html>.

²⁸ King, Megan F., Vivian F. Renó, and Evelyn MLM Novo. "The Concept, Dimensions and Methods of Assessment of Human Well-being within a Socioecological Context: a literature review." *Social indicators research* 116 (2014): 681-698. <https://doi.org/10.1007/s11205-013-0320-0>

²⁹ Millennium Ecosystem Assessment, *Ecosystems and Human Well-Being*, 2005.

³⁰ Woodhouse, Emily, Katherine M. Homewood, Emilie Beauchamp, Tom Clements, J. Terrence McCabe, David Wilkie, and E. J. Milner-Gulland. "Guiding principles for evaluating the impacts of conservation

supports vulnerable populations, and contributes to long-term sustainability.³¹ Communities with strong connections to their natural environment are more likely to support conservation efforts, reinforcing the link between environmental health and human well-being.

3.3. The Link Between Human Well-Being and Watershed Health

Watersheds, as vital ecosystems, play a crucial role in supporting human well-being through the provision of ecosystem services.³² They provide provisioning services like freshwater supply, regulatory services such as flood control and water purification, cultural services like recreational opportunities, and supporting services such as nutrient cycling.³³ Healthy watersheds enhance community resilience by buffering against environmental stressors, including climate change, pollution, and extreme weather events.³⁴ Conversely, degraded watersheds, characterized by erosion, pollution, and habitat loss, compromise ecosystem services and exacerbate vulnerabilities in dependent communities, particularly low-income or marginalized populations.³⁵

A study by Summers et al. explored the social-ecological condition of watersheds in the United States, highlighting the importance of considering both biophysical and social factors in watershed assessment.³⁶ Their findings suggest that areas with good social and watershed conditions are more resilient to environmental stressors and socioeconomic challenges, whereas areas with poor conditions in both dimensions face compounded vulnerabilities. This underscores the importance of preserving watershed health to enhance community well-being and adaptive capacity.³⁷

3.4. Approaches to Assess Human Well-Being in Watersheds

The evaluation of human well-being has undergone significant development, with three main approaches identified: objective indicators, subjective well-being, and mixed methods. As King et al. (2015) detail in their paper "*The Concept, Dimensions, and Methods of Assessment*

interventions on human well-being." *Philosophical Transactions of the Royal Society B: Biological Sciences* 370, no. 1681 (2015): 20150103. <https://doi.org/10.1098/rstb.2015.0103>

³¹ Wali, Alaka, Diana Alvira, Paula S. Tallman, Ashwin Ravikumar, and Miguel O. Macedo. "A new approach to conservation: using community empowerment for sustainable well-being." *Ecology & Society* 22, no. 4 (2017). <https://doi.org/10.5751/ES-09598-220406>

³² Bunch, Martin J., Karen E. Morrison, Margot W. Parkes, and Henry D. Venema. "Promoting health and well-being by managing for social-ecological resilience: the potential of integrating ecohealth and water resources management approaches." *Ecology and society* 16, no. 1 (2011). <https://www.jstor.org/stable/26268864>

³³ Brauman, Kate A., Gretchen C. Daily, T. Ka'eo Duarte, and Harold A. Mooney. "The nature and value of ecosystem services: an overview highlighting hydrologic services." *Annu. Rev. Environ. Resour.* 32, no. 1 (2007): 67-98. <https://doi.org/10.1146/annurev.energy.32.031306.102758>

³⁴ Schoon, Michael, and Sander Van Der Leeuw. "The shift toward social-ecological systems perspectives: insights into the human-nature relationship." *Natures Sciences Sociétés* 23, no. 2 (2015): 166-174. <https://doi.org/10.1051/nss/2015034>

³⁵ Millennium Ecosystem Assessment, *Ecosystems and Human Well-Being*, 2005.

³⁶ Summers, J. Kevin, Lisa M. Smith, Linda C. Harwell, and Kyle D. Buck. "The Development of a Human Wellbeing Index for the United States." *Quality of Life and Quality of Working Life* (2017): 97-135. <http://dx.doi.org/10.5772/intechopen.68596>.

³⁷ Brauman et al., "Nature and Value of Ecosystem Services," 2007.

of Human Well-Being within a Socioecological Context: A Literature Review," these approaches offer complementary perspectives on well-being measurement:³⁸

1.1. Objective Indicator Approach: This approach focuses on easily quantifiable attributes of well-being, such as health, income, and education. Key tools include indices like the [Human Development Index \(HDI\)](#), which aggregates metrics like life expectancy, educational attainment, and income to assess well-being across populations. However, the reliance on measurable data limits its ability to capture more nuanced, lived experiences.

1.2. Subjective Well-Being Approach: This view emphasizes individual perceptions and experiences of life satisfaction, happiness, and psychological well-being. Instruments like the [Satisfaction with Life Scale \(SWLS\)](#) and [Psychological Well-Being Scales](#) are used to assess subjective experiences. These metrics highlight that material conditions alone cannot fully explain well-being, as cognitive, emotional, and psychosocial factors also play vital roles.

1.3. Mixed Methods Approach: This method integrates quantitative and qualitative data to provide a holistic understanding of well-being. Tools like the [Happy Planet Index](#) and frameworks such as the [WeD-QoL](#) survey incorporate elements of natural, social, and human capital alongside personal satisfaction, offering a multidimensional view of sustainable well-being.

The integrated/mixed methods approaches and frameworks are vital due to the inextricable link of human well-being with ecosystem services.³⁹ One such approach is **Social-Ecological Systems (SES)**, which advocates the integration of natural and social sciences to address the interconnectedness of human and ecological systems.⁴⁰ This approach moves beyond traditional, discipline-specific methods to tackle complex environmental challenges through systems thinking, transdisciplinary approaches, and resilience science (**Appendix A**). By framing human and ecological components as part of a dynamic, multi-scale system with feedback loops, SES science fosters a holistic understanding of how social and environmental factors interact. While the approach fosters better integration and long-term solutions, its implementation is hindered by the lack of actionable frameworks, complexity in managing diverse variables, and challenges in stakeholder coordination.⁴¹

Given the context and scope of our study, the integrated approach of **Human Well-being Index (Index)** sounded most relevant (**Appendix B**). Published by the United States Environmental Protection Agency (US EPA) in 2017, the Index represents a comprehensive approach to assessing human well-being by integrating social, economic, and environmental service flows.⁴² According to EPA, the Index is a scalable framework with applicability at national,

³⁸ King et al., "The Concept, Dimensions and Methods of Assessment," 2014.

³⁹ Biedenweg, Kelly, and David J. Trimbach. "Human wellbeing in environmental management." In *A modern guide to wellbeing research*, pp. 247-267. Edward Elgar Publishing, 2021.
<https://doi.org/10.4337/9781789900163.00026>

⁴⁰ Virapongse, Arika, Samantha Brooks, Elizabeth Covelli Metcalf, Morgan Zedalis, Jim Gosz, Andrew Kliskey, and Lilian Alessa. "A social-ecological systems approach for environmental management." *Journal of Environmental Management* 178 (2016): 83-91. <https://doi.org/10.1016/j.jenvman.2016.02.028>

⁴¹ Virapongse et al., "Social-Ecological Systems Approach," 2016.

⁴² Summers et al., "Development of a Human Wellbeing Index," 2017.

regional, and local levels. Representing an integrated approach, the Index incorporates both objective and subjective measures to capture the eight domains of well-being holistically, i.e., *connection to nature, cultural fulfillment, education, health, leisure time, living standards, safety and security, and social cohesion*.⁴³ The authors argue that Index stands out from conventional approaches by its adaptability to different scales, its ability to link well-being to sustainability through measurable indicators, and its responsiveness to changes across the three pillars of sustainability—economic, societal, and environmental. Other challenges include insufficient longitudinal data, limited community participation, and difficulties in integrating ecological and social variables. Unlike traditional indices that often focus on specific aspects or rely heavily on subjective surveys, the Index balances diverse metrics, allowing decision-makers to predict sustainability shifts, evaluate policy impacts, and avoid unintended consequences. By embedding the Total Resource Impacts and Outcomes framework, the Index provides a unique, integrated tool for fostering sustainable, informed decision-making in communities. For reference, a table of Index’s eight domains, 25 indicators, and 80 metrics is given in **Appendix C**.

3.5. The State of Well-being in US Major Watersheds

To better inform the assessment of the current TNC HWBI and to make recommendations for the inclusion of potential new indicators, we explored similar other watersheds that could offer valuable lessons for the Saginaw Bay Watershed. For instance, the Puget Sound Partnership’s Human Well-being Vital Signs provides a comprehensive framework for assessing and monitoring human well-being concerning ecosystem health. Initiatives in the Chesapeake Bay and Great Lakes regions highlight the importance of integrated watershed management, and the Chesapeake Bay Program employs a multi-stakeholder framework that incorporates scientific data, public input, and policy collaboration to address pollution and habitat restoration. Lessons include the need for transparent governance, adaptive monitoring, and equity-focused strategies.

3.5.1. Chesapeake Bay and Eco Health Report Card

The Chesapeake Bay Watershed, the largest estuary in the United States, spans six states and the District of Columbia.⁴⁴ It serves as a vital source of drinking water for 75% of its residents and supports 3,600 species of animals and plants alongside recreational and economic activities such as fishing and boating.^{45, 46} The watershed has faced significant environmental challenges due to pollution from conventional agricultural practices and suburban development, prompting calls for a transition to regenerative farming methods.⁴⁷

⁴³ Summers et al., "Development of a Human Wellbeing Index," 2017.

⁴⁴ "Bay Facts." Chesapeake Bay. Accessed December 5, 2024. <https://www.chesapeakebay.net/discover/bay-facts>.

⁴⁵ "Bay Facts." Chesapeake Bay. Accessed December 5, 2024.

⁴⁶ "What Is a Watershed?" Chesapeake Bay, 2024. <https://www.chesapeakebay.net/discover/watershed>.

⁴⁷ "Agriculture." Chesapeake Bay Foundation. Accessed December 5, 2024. <https://www.cbf.org/issues/agriculture/index.html>.

In 2016, the University of Maryland Center for Environmental Science began publishing an annual Chesapeake Bay (Eco Health) Report Cards.⁴⁸ By 2018, the report card had expanded to include social, cultural, and economic indicators alongside ecological metrics, guided by the United Nations' 2030 Sustainable Development Goals.^{49,50} Indicators were selected based on three criteria: stakeholder-defined values and threats, guiding principles for representation, and flexibility for regional specificity. Of the 24 indicators currently used, ten are directly related to human well-being, encompassing domains such as water quality, governance, health, and cultural values.

3.5.2. Hood Canal Integrated Watershed Plan

Hood Canal, a fjord-like basin in Washington State, faces unique challenges due to water stratification and periods of low oxygen levels exacerbated by human activities. Despite these challenges, it remains a region of ecological and cultural significance, supporting fishing, shellfish harvesting, and timber activities.⁵¹

The Hood Canal Coordinating Council, in collaboration with researchers from Stanford University and the Puget Sound Institute, developed a framework for human well-being indicators. The process included a literature review, stakeholder interviews, community workshops, and a scientific review. The resulting 26 indicators span six quality-of-life domains: physical, psychological, governance, cultural, social, and economic. Seven key indicators, including a sense of place and natural resource-based employment, are now regularly tracked through household surveys.⁵² Notably, these indicators emphasize equity, with data disaggregated by demographics such as socioeconomic status, gender, and ethnicity to address disparities.

3.5.3. Puget Sound Vital Signs

Puget Sound, a significant estuary in Washington State, supports diverse economic, cultural, and ecological activities. It faces threats such as acidification, nitrogen pollution, and chemical waste. To address these challenges, the Washington legislature established the Puget Sound Partnership (PSP) in 2007.⁵³ The PSP developed 23 human well-being indicators under five domains over seven years through stakeholder engagement, literature reviews, and scientific assessments.⁵⁴ These indicators are categorized to address six common dimensions of well-being: psychological, physical, economic, governance, social, and cultural.

⁴⁸ "Chesapeake Bay Eco Health Report Cards." Eco Health Report Cards, 2024. <https://ecoreportcard.org/report-cards/chesapeake-bay/>.

⁴⁹ Chesapeake Bay Report Card Expansion 2018 <https://ian.umces.edu/projects/chesapeake-bay-report-card-expansion/>

⁵⁰ "The 17 Goals | Sustainable Development." United Nations, 2015. <https://sdgs.un.org/goals>.

⁵¹ "Hood Canal Integrated Watershed Plan." Hood Canal Coordinating Council, June 30, 2017. <https://hccc.wa.gov/resource/hood-canal-integrated-watershed-plan/>.

⁵² "Human Wellbeing." Hood Canal Coordinating Council, November 15, 2024. <https://hccc.wa.gov/our-hood-canal/human-wellbeing/>.

⁵³ "Vital Signs: About the Vital Signs." Vital Signs, 2022. <https://vitalsigns.pugetsoundinfo.wa.gov/About>.

⁵⁴ "Puget Sound Vital Signs." Puget Sound Partnership, 2022. <https://vitalsigns.pugetsoundinfo.wa.gov/>.

3.5.4. Lake Erie Quality Index (LEQI)

Lake Erie, like the Saginaw Bay Watershed, suffers from over-nutrition and hypoxia driven by agricultural runoff and land-use changes. It has been designated an Area of Concern by the EPA and is managed under the Great Lakes Water Quality Agreement.⁵⁵

The Lake Erie Quality Index (LEQI), published by the Ohio Lake Erie Commission, categorizes 36 indicators into five domains such as environmental quality, human exposure risks, and maritime economy (Ohio Lake Erie Commission, 2022).⁵⁶ Unlike other peer watersheds, much of the data in the LEQI is collected by state agencies, providing a direct connection between policy and monitoring efforts. Eight of the indicators identified in the LEQI report are considered applicable for human well-being assessments in the Saginaw Bay Watershed.

In summary, this literature review underscores the vital interplay between human well-being, ecosystem health, and watershed management. By examining multidimensional frameworks for well-being, the link between watershed health and community resilience, and lessons from watershed initiatives across the U.S., we highlight the importance of integrated approaches to sustainable development. The Saginaw Bay Watershed, while grappling with challenges like agricultural impacts and fragmented natural areas, presents significant opportunities for innovative approaches to watershed management. These approaches must prioritize human well-being considerations—that we attempted to explore in the next section—alongside ecological restoration, fostering sustainable practices, equitable resource distribution, and stakeholder collaboration to ensure long-term resilience and sustainability.

⁵⁵ “Great Lakes Areas of Concern.” EPA, December 3, 2023. <https://www.epa.gov/great-lakes-aocs>.

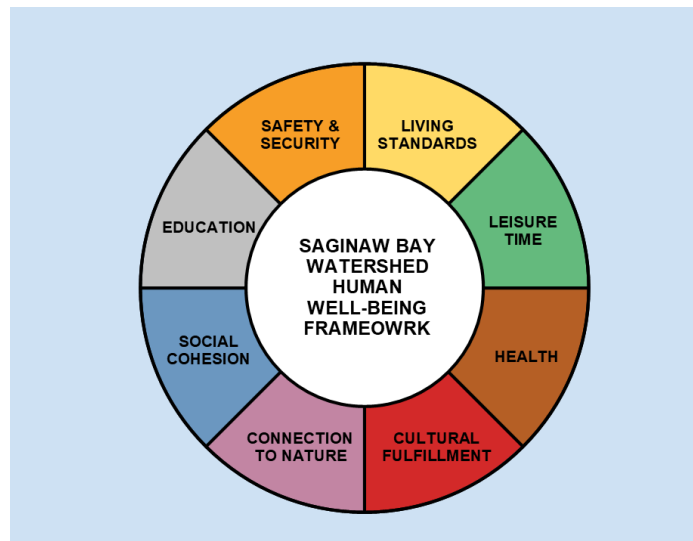
⁵⁶ “Lake Erie Quality Index.” Lake Erie Commission, 2022.
<https://dam.assets.ohio.gov/image/upload/epa.ohio.gov/Portals/35/lakeerie/2023-LakeErie-QAPP.pdf>.

4. Methodology

Our project, *Assessment and Recommendations for the Nature Conservancy's Human Well-Being Indicators in the Saginaw Bay Watershed*, employed a qualitative descriptive research design to assess and refine human well-being indicators (HWBI) for the region. The methodology comprised four key stages: identifying a human well-being framework, selecting relevant indicators and metrics, establishing evaluation criteria, and scoring the indicators.

4.1. Stage 1: Identification of Human Well-Being Framework

To begin with, we adopted the [U.S. Environmental Protection Agency's \(EPA\) Human Well-Being Index](#) as the foundational framework.⁵⁷ The Index, published in 2017, is a comprehensive tool for assessing overall well-being at the county level. It encompasses eight domains that represent social, economic, and environmental dimensions. These domains include 25 indicators supported by 80 metrics and 22 associated services. Its adaptability and data-driven methodology are suited to the Saginaw Bay Watershed.



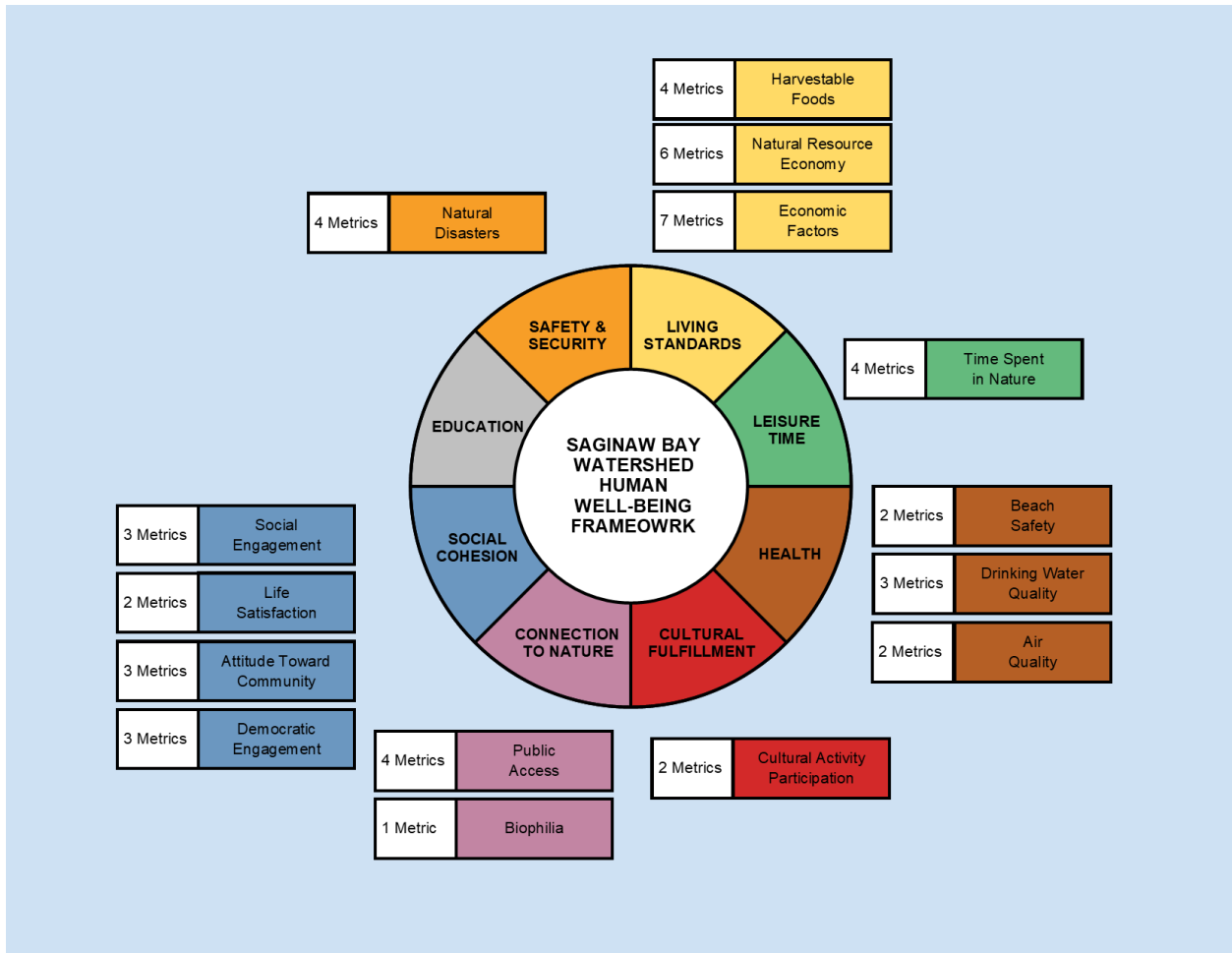
4.2. Stage 2: Identification of Human Well-Being Indicators and Metrics

Next, we identified relevant indicators and metrics by leveraging past TNC research (Liberati et al. 2020, 2022)^{58, 59} and reviewing indicators used in other major U.S. watersheds, including Chesapeake Bay, Puget Sound, Hood Canal, and Lake Erie. This approach ensured our work was built on established best practices while tailoring metrics to the unique context of the Saginaw Bay region. **Appendix D** overviews the reviewed domain, indicators, and metrics.

⁵⁷ Summers et al., "Development of a Human Wellbeing Index," 2017.

⁵⁸ Liberati, Marjorie R., Scott P. Sowa, Christopher A. May, and Patrick J. Doran. "Making measures count: Structured indicator selection to improve program success." *Environmental and Sustainability indicators* 8 (2020): 100077. <https://doi.org/10.1016/j.indic.2020.100077>

⁵⁹ Liberati et al., "Planning for People and Nature," 2022.



4.3. Stage 3: Identification of Evaluation Criteria for Selecting Metrics

The third stage involved developing criteria for evaluating these indicators. To align with our project's scope, we adapted the TNC's previously established indicator selection rubric (**Appendix E**). The adapted rubric included the following seven parameters:

- i. **Relevance:** Assesses the extent to which the metric is directly linked to the beneficial uses of the Saginaw Bay Watershed.
- ii. **Environmental Health Influence:** Examines how environmental health affects a specific HWBI metric. Notably, this parameter measures the inverse relationship—how environmental conditions influence human well-being rather than the opposite.
- iii. **Responsiveness:** Evaluates the indicator's ability to signal changes in environmental or social systems in a timely manner to inform decision-making. Considers whether the indicator can "move the needle" and provide clear, quick results along the results chain (final to intermediate outcomes).
- iv. **Realism:** Assesses whether the indicator has sustainable monitoring protocols, low associated costs, and accessible data. Scores were informed by web searches and peer-reviewed literature.

- v. **Data Availability:** Gauges the extent to which relevant data for the indicator is accessible, reliable, and readily obtainable for analysis.
- vi. **Data Temporality:** Examines the frequency and recency of data collection, ensuring the indicator's information reflects current and consistent trends over time.
- vii. **Data Spatiality:** Considers the geographic resolution and coverage of the indicator's data, ensuring it aligns with the spatial scope of the Saginaw Bay Watershed.

Our revised evaluation rubric diverged from the original TNC parameters in several significant ways, reflecting adaptations tailored to the specific needs and constraints of this project:

- a) **Addition of Environmental Health Influence:** The original TNC rubric did not explicitly account for the relationship between environmental health and human health. We introduced this parameter based on recommendations from TNC project partners and supporting literature, such as the Millennium Ecosystem Assessment (2005),⁶⁰ which underscores the critical role of healthy ecosystems in sustaining human health and well-being. This addition provided a nuanced perspective by focusing on how environmental health influences well-being indicators.
- b) **Omission of Resonance and Uncertainty:** The Resonance parameter, which measured whether an indicator was important to the affected community, was excluded due to the absence of direct community engagement in the project, a limitation imposed by time and resource constraints. Similarly, the Uncertainty parameter, which assessed variability in scoring among team members, was omitted because we did not use weighted scoring or involve diverse scoring teams. These omissions streamlined the evaluation process but also highlighted limitations in stakeholder inclusivity and scoring variability.
- c) **Disaggregation of Data Richness:** The original TNC rubric treated Data Richness as a single parameter encompassing data quality, frequency, resolution, and accessibility. For greater clarity and alignment with EPA standards, we split this into three distinct parameters: Data Availability (existence and accessibility of data), Data Temporality (frequency and recency of data collection), and Data Spatiality (geographic resolution and coverage). This refinement allowed for a more detailed assessment of data-related factors, ensuring each aspect received adequate attention.
- d) **Simplification of the Scoring Scale:** The original scoring system ranged from 0 to 5, providing granular variation but introducing potential complexities in a qualitative context. To better suit our qualitative analysis and reduce scoring variability, we adopted a simplified scale of 1 (low – Tier 3), 3 (moderate – Tier 2), and 5 (high – Tier 1). This approach maintained sufficient differentiation among metrics while facilitating more straightforward and consistent scoring across the evaluation parameters.

The rubric and scoring tiers used in this evaluation are in Table 1.

⁶⁰ Millennium Ecosystem Assessment, *Ecosystems and Human Well-Being*, 2005.

Table 1: Scoring Rubric for Metric Analysis

Metric Selection Parameters	Tier 1 Description (Score = 5)	Tier 2 Description (Score = 3)	Tier 3 Description (Score = 1)	Rationale
<i>Relevance</i>	The metric is directly connected to beneficial uses of the Saginaw Bay Watershed.	The metric is indirectly connected to beneficial uses of the Saginaw Bay Watershed.	The metric is not connected to beneficial uses of the Saginaw Bay Watershed.	Selection criteria established by TNC.
<i>Environmental Health Influence</i>	The metric is strongly influenced by the health of the environment.	The metric is moderately influenced by the health of the environment.	The metric is minimally influenced by the health of the environment.	Based on the recommendation of TNC project partner. Literature also indicated that healthy environments support human health and well-being (Millennium Ecosystem Assessment, 2005).
<i>Responsiveness</i>	The metric is able to signal changes in the environmental or social systems and does so quickly enough to inform decision-making. It has short results chains and simple theory-of-change (e.g., <5 steps)	The metric is able to signal changes in the environmental or social systems or does so quickly enough to inform decision-making. It has long results chains and mid-complexity theory-of-change. (e.g. 5-15 steps)	The metric is neither able to signal changes in the environmental or social systems nor does so quickly enough to inform decision-making. It has complex results chains/theory-of-change. (e.g., 15+ steps)	Selection criteria established by TNC.
<i>Realism</i>	The metric has a sustainable monitoring protocol <u>and</u> has low costs associated with monitoring or accessing necessary datasets.	The metric has a sustainable monitoring protocol <u>or</u> has low costs associated with monitoring or accessing necessary data.	The metric has <u>neither</u> a sustainable monitoring protocol <u>nor</u> has low costs associated with monitoring or accessing necessary data.	Selection criteria established by TNC.
<i>Data Availability</i>	The metric has long-term data sets that are publicly available.	The metric has short-term data sets or data that is privately held/ not publicly available.	The metric does not currently have data for tracking.	Selection criteria established by TNC and the Environmental Protection Agency .
<i>Data Temporality</i>	The metric has data that is updated at least annually.	This metric has data that is updated every 2-3 years.	This metric has data that is updated every >3 years.	Selection criteria established by TNC and the Environmental Protection Agency .
<i>Data Spatiality</i>	The metric has data that reports at the city/township level.	The metric has data that reports at the county level.	This metric has data that reports at the state level.	Data available at the smallest spatial scale, most commonly county level data, is most useful for impact (Environmental Protection Agency, 2016).

4.4. Stage 4: Scoring Well-Being Indicators/Metrics

Finally, the scoring process for evaluating the human well-being indicators/metrics was carried out collaboratively using the revised rubric. This process was informed by extensive secondary research and internal team consultations to ensure the assessment was both thorough and contextually relevant. Each metric was carefully evaluated against the rubric's parameters—using the simplified scoring scale. Individual metric scores were summed for *Relevance*, *Environmental Health Influence*, *Responsiveness*, and *Realism* (applicability criteria), for a maximum of 20 points, and then separately for *Data Availability*, *Data Temporality*, and *Data Spatiality* (data criteria), for a maximum of 15 points, to ensure an absence of data did not devalue the metrics' inherent scores.

Summed scores were then tiered for final recommendations. For applicability criteria, Tier 1 (high priority for inclusion) was awarded for 14-20 points, Tier 2 (moderate priority for inclusion) was awarded for 7-13 points, and Tier 3 (low priority for inclusion) was awarded for 1-6 points. For data criteria, Tier 1 was awarded for 11-15 points, Tier 2 was awarded for 6-10 points, and Tier 3 was awarded for 1-5 points. This systematic evaluation enabled the team to identify the most relevant and actionable metrics for assessing human well-being in the Saginaw Bay Watershed.

Presentation and Consultation

The project team shared the developments through a poster presentation at Dow Headquarters on October 14, 2024, and a virtual presentation to the Saginaw Bay Monitoring Consortium on November 4, 2024. These engagements provided valuable feedback from stakeholders, including TNC liaison Ben Wickerham, project mentor Elsa Starmann of Dow, and the Graham Sustainability Institute–University of Michigan, Ann Arbor.

Limitations

While the study yielded actionable insights, two limitations emerged, i.e., lack of community engagement and simplified scoring criteria. Due to time and resource constraints, we could not involve community members or external stakeholders in the selection and evaluation of metrics. Also, the absence of weighted criteria limited the ability to capture nuanced variability across indicators. Future studies should prioritize community involvement and explore weighted evaluation frameworks to enhance robustness and inclusivity.

5. Findings

5.1. TNC & Peer Watershed Comparative Analysis

After conducting their 2019-2020 process to select socio-economic indicators for their Soil Health & Nutrient Strategy, TNC identified 13 priority human well-being indicators. When compared with peer watersheds in this analysis, eight of these indicators aligned with metrics being tracked in at least one peer watershed, summarized in Table 2. The five indicators not tracked in any peer watershed were “Waterbodies are ‘impaired,’” “Property flooding”, “Property flooding risk”, “Hospital visits, water-related illness”, and “Crime”. The eight TNC indicators found in other watersheds were carried forward in the metric analysis.

Table 2: TNC and peer watershed comparative analysis summary.

TNC Indicator 2019/2020	Peer Watershed Tracking of Indicator*			
	CB	HC	PS	LE
Property damage from floods and storms			X (Frequency of Flood Events)	
Waterbodies are "impaired"				
Waterbodies exceed human health thresholds				X (# of Harmful Algal Blooms)
Beach/water closures		X (% of Safe Swimming Beaches)	X (Condition of Swimming Beaches)	X
Drinking water warnings		X (Drinking Water Quality)	X (Nitrate Concentration in Drinking Water)	
Air quality warnings	X (Environmental Justice Index**)	X (# of days/year that Air Quality was ‘Good’, ‘Moderate’, ‘Unhealthful’, ‘Very Unhealthful’, or ‘Hazardous’)	X (Exposure to Impaired Air Quality)	
Property flooding				
Financial assistance programs (FAP)	X (Income Inequality***)			
Property flooding				

TNC Indicator 2019/2020	Peer Watershed Tracking of Indicator*			
	CB	HC	PS	LE
risk				
Household income	X (Mean Income)	X (Number of Jobs and Living Wages/Worker by Resource)		
Hospital visits, water-related illness				
Unemployment rate	X (Job Growth)		X (Employment in Natural Resource Industries)	
Crime				
*CB: Chesapeake Bay & Watershed Report Card; HC: Hood Canal Integrated Watershed Plan; PS: Puget Sound Vital Signs; LE: Lake Erie Quality Index, **Includes Air Quality, ***Includes FAP				

5.2. Indicator Synthesis

The analysis of peer watersheds that are tracking HWBI resulted in the identification of 15 indicators of human well-being relevant to the health of the Saginaw Bay Watershed. Indicators and their subsequent metrics were analyzed for similarities in context despite alternative naming to result in the 15 indicators being proposed to TNC. Table 3 lists the proposed indicator naming, their definitions, the domain of well-being of best fit under the EPA's framework, and the peer watersheds that are tracking each indicator. Notably, "social engagement", "drinking water quality", and "economic factors" were indicators being tracked by all four peer watershed programs while "time spent", "beach safety", "harvestable foods", and "air quality" were tracked by three of the peer watersheds. The remaining indicators were tracked by at least two peer watershed programs.

Table 3: Summary of proposed indicators of human well-being.

Indicator	Indicator Definition	EPA Domain of Human Well-Being	Peer Watershed Tracking of Indicator*			
			CB	HC	PS	LE
Social Engagement	The level of citizen engagement, responsibility, behaviors, and attitudes surrounding the Saginaw Bay Watershed.	Social Cohesion	X	X	X	X
Life Satisfaction	Citizens' perception of life satisfaction, in part due to living within the Saginaw Bay Watershed area.	Social Cohesion		X	X	
Attitude Toward	Citizens' sense of connection and	Social Cohesion		X	X	

Indicator	Indicator Definition	EPA Domain of Human Well-Being	Peer Watershed Tracking of Indicator*			
			CB	HC	PS	LE
the Community	belonging to the Saginaw Bay Watershed area.					
Democratic Engagement and Governance	Governmental action and citizen trust in government environmental decision making.	Social Cohesion		X	X	
Biophilia	Citizens' connection to life or spiritual fulfillment from being in nature.	Connection to Nature		X	X	
Public Access	The availability and satisfaction of public accessibility to the Saginaw Bay Watershed.	Connection to Nature	X	X		
Time Spent	Citizen time spent and satisfaction with engaging in recreational activities associated with the Saginaw Bay Watershed.	Leisure Time		X	X	X
Beach Safety	Beaches that are safe for human recreation in the Saginaw Bay Watershed.	Health		X	X	X
Drinking Water Quality	The quality of water in the Saginaw Bay Watershed as it enters public and private drinking water systems.	Health	X	X	X	X
Air Quality	The quality of air in the Saginaw Bay Watershed.	Health	X	X	X	
Harvestable Foods	Safe and available harvestable foods sourced from the Saginaw Bay Watershed.	Living Standards		X	X	X
Economic Factors	Traditional measures of economic activity within the Saginaw Bay Watershed area.	Living Standards	X	X	X	X
Natural Resources Economic Factors	Measures of economic activity related to natural resources and the environment within the Saginaw Bay Watershed area.	Living Standards		X	X	
Natural Disasters	The impact and frequency of natural disasters on human well-being and community response.	Safety and Security	X		X	
Cultural Activity Participation	Citizen engagement in cultural practices, especially those related to the environment.	Cultural Fulfillment		X	X	
*CB: Chesapeake Bay & Watershed Report Card; HC: Hood Canal Integrated Watershed Plan; PS: Puget Sound Vital Signs; LE: Lake Erie Quality Index						

5.3. Metric Analysis

A total of 50 metrics were identified through TNC's previous work and via analysis of the peer watersheds to serve as a measurement of the 15 indicators. The results of the metric scoring by selection criteria for both applicability and data criteria are represented in Table 4.

Table 4: Results of individual metric scoring by selection criteria.

Indicator	Metric	Selection Criteria*						
		REL	EH1	RES	REA	DA	DT	DS
Social Engagement	Engagement in natural resource stewardship	3	3	3	1	1	1	1
	Community support for resource management	3	3	1	1	1	1	1
	Attitudes of citizens regarding social engagement	3	1	3	1	1	1	1
Life Satisfaction	Overall life satisfaction	3	3	3	1	1	1	1
	Life satisfaction due to living in the Saginaw Bay Watershed area.	3	3	3	1	1	1	1
Attitude Toward the Community	Citizen connection to the region	5	3	3	1	1	1	1
	Citizen trust in community	5	1	3	1	1	1	1
	Sense of place	5	3	1	1	1	1	1
Democratic Engagement and Governance	Trust in government	5	3	3	3	3	5	1
	Good environmental governance	5	3	3	3	3	5	1
	Pollution correction and identification failures with corrective action	5	5	5	3	5	5	5
Biophilia	Psychological well-being while in nature	5	5	3	1	1	1	1
Public Access	Walkability	3	3	5	3	3	5	5
	Land use and distribution	5	3	3	5	5	5	5
	Citizen satisfaction with accessible shorelines	3	1	3	1	1	1	1
	Publicly accessible shoreline	5	5	5	3	5	5	5
Time Spent	Nature-based recreation days/year	5	5	3	1	1	1	1
	Fishing participation	5	5	3	3	3	3	5
	Fishing satisfaction	5	5	3	3	3	3	5
	State Park camping	5	5	3	3	3	5	5
Beach Safety	Percentage of safe beaches	5	5	5	5	5	5	5
	Annual beach closures	5	5	5	5	5	5	5
Drinking Water Quality	Source water nitrate concentration	5	5	5	5	5	5	5
	Drinking water warnings/advisories	5	5	5	5	5	5	5
	Cyanobacterial microcystin toxins	5	5	3	5	5	5	5
Air Quality	Air quality warnings	3	5	5	5	5	5	5
	PM 2.5 exposure	3	5	3	5	5	5	5
Harvestable Foods	Frequency of collecting commonly harvested foods	5	5	3	1	1	1	1
	Fisheries health	5	5	5	3	3	3	5
	Fish advisories	5	5	5	5	3	5	3
	Citizen desire for access to commonly harvested natural resources	5	1	3	1	1	1	1

Indicator	Metric	Selection Criteria*						
		REL	EHI	RES	REA	DA	DT	DS
Economic Factors	Job growth	3	1	3	5	5	5	3
	Housing affordability	1	1	1	5	5	5	3
	Income inequality	3	1	1	5	5	1	3
	Tourism	5	3	3	3	5	5	3
	Unemployment rate	3	3	3	5	5	5	3
	Financial assistance programs	3	3	1	5	5	5	3
	Median income	3	3	1	5	5	1	3
Natural Resources Economic Factors	Employment in natural resource industries	5	3	3	3	3	1	3
	Number of new jobs in natural resource sector/year	5	3	3	3	3	1	3
	Percent of economic activity from natural resource small businesses	5	3	3	1	1	1	1
	Percent of revenue to local economy from natural-resource adjacent industries	5	3	3	1	1	1	1
	Number of businesses supported by natural resource sector	5	3	1	1	1	1	1
	Natural resource industry output	5	3	3	3	1	1	1
Natural Disaster	Social vulnerability index	1	3	3	5	5	5	3
	Property damage from floods/storms	3	3	3	5	5	5	3
	Property flooding risk	3	5	3	5	5	5	5
	Flooding events	3	5	3	5	5	5	3
Cultural Activity Participation	Natural resource cultural activities	5	3	3	3	3	1	3
	Participation in cultural practices	5	5	3	3	3	1	3
*REL: Relevant; EHI: Environmental Health Influence; RES: Responsive; REA: Realism; DA: Data Availability; DT: Data Temporality; DS: Data Spatiality								

Summed applicability criteria and data criteria for each metric, along with their designated tiering recommendation, are listed in Table 5. 31 of the 50 metrics received Tier 1 designation on applicability criteria. Of these 31 metrics, 21 metrics have Tier 1 supporting data, 6 metrics have Tier 2 supporting data, and 4 metrics have Tier 3 supporting data. The remaining 19 metrics met Tier 2 designation on applicability criteria, with no metrics meeting Tier 3 applicability criteria. Of these 19 metrics, 4 metrics have Tier 1 supporting data, 2 metrics have Tier 2 supporting data, and 13 metrics have Tier 3 supporting data.

Table 5: Summed metric applicability criteria scores and data criteria scores with overall tiering recommendation designation.

Indicator	Metric	Overall Scores and Tiering			
		Applicability Score (Max. 20)	Tier	Data Score (Max. 15)	Tier
Social Engagement	Engagement in natural resource stewardship	10	2	3	3
	Community support for resource management	8	2	3	3
	Attitudes of citizens regarding social engagement	8	2	3	3
Life Satisfaction	Overall life satisfaction	10	2	3	3
	Life satisfaction due to living in the Saginaw Bay Watershed area.	10	2	3	3
Attitude Toward the Community	Citizen connection to the region	12	2	3	3
	Citizen trust in community	10	2	3	3
	Sense of place	10	2	3	3
Democratic Engagement and Governance	Trust in government	14	1	9	2
	Good environmental governance	14	1	9	2
	Pollution correction and identification failures with corrective action	18	1	15	1
Biophilia	Psychological well-being while in nature	14	1	3	3
Public Access	Walkability	14	1	13	1
	Land use and distribution	16	1	15	1
	Citizen satisfaction with accessible shorelines	8	2	3	3
	Publicly accessible shoreline	18	1	15	1
Time Spent	Nature-based recreation days/year	14	1	3	3
	Fishing participation	16	1	11	1
	Fishing satisfaction	16	1	11	1
	State park camping	16	1	13	1
Beach Safety	Percentage of safe beaches	20	1	15	1
	Annual beach closures (TNC)	20	1	15	1
Drinking Water Quality	Source water nitrate concentration.	20	1	15	1
	Drinking water warnings/advisories (TNC)	20	1	15	1
	Cyanobacterial microcystin toxins	18	1	15	1
Air Quality	Air quality warnings (TNC)	18	1	15	1
	PM 2.5 exposure	16	1	15	1
Harvestable Foods	Frequency of collecting commonly harvested foods	14	1	3	3

Indicator	Metric	Overall Scores and Tiering			
		Applicability Score (Max. 20)	Tier	Data Score (Max. 15)	Tier
	Fisheries health	18	1	11	1
	Fish advisories	20	1	11	1
	Citizen desire for access to commonly harvested natural resources	10	2	3	3
Economic Factors	Job growth	12	2	13	1
	Housing affordability	8	2	13	1
	Income inequality	10	2	9	2
	Tourism	14	1	13	1
	Unemployment rate (TNC)	14	1	13	1
	Financial assistance programs (TNC)	12	2	13	1
	Median income (TNC)	12	2	9	2
Natural Resources Economic Factors	Employment in natural resource industries	14	1	7	2
	Number of new jobs in natural resource sector/year	14	1	7	2
	Percent of economic activity from natural resource small businesses	12	2	3	3
	Percent of revenue to local economy from natural-resource adjacent industries	12	2	3	3
	Number of businesses supported by natural resource sector	10	2	3	3
	Natural resource industry output	14	1	3	3
Natural Disaster	Social vulnerability index	12	2	13	1
	Property damage from floods/storms (TNC)	14	1	13	1
	Property flooding risk (TNC)	16	1	15	1
	Flooding events	16	1	13	1
Cultural Activity Participation	Natural resource cultural activities	14	1	7	2
	Participation in cultural practices	16	1	7	2

6. Recommendations

6.1. Restructuring of Current TNC Domains to Categorize Indicators

Based on the findings of this report, TNC should restructure their human well-being indicators to align with the domains of the EPA’s Human Well-Being Index framework.⁶¹ These domains represent a scientifically validated framework that comprehensively captures the social, economic, and environmental factors that constitute human well-being. This would replace TNC’s current Conservation by Design Quality of Life domains,⁶² providing a more standardized approach that explicitly connects human well-being to environmental drivers and services.

The realignment with these eight evidence-based domains would not only streamline TNC’s indicator tracking with a federally recognized framework but would also facilitate better comparison and collaboration with peer watersheds and organizations that use similar domain structures. As demonstrated by our analysis, where we had to recategorize each indicator from each peer watershed to conduct our analysis, having standardized domains enables more meaningful cross-watershed comparisons. Therefore, this restructuring would not only help TNC better evaluate how their Regenerative Agriculture Program impacts ecosystem health and human well-being, but also make their findings more readily comparable to other conservation efforts around the country.

Table 6: Comparison of TNC and EPA’s human well-being frameworks.

TNC’s Conservation by Design Quality of Life Domains	EPA’s Human Well-Being Index Domains
Living Standards	Living Standards
Health	Health
Education	Education
Social Cohesion	Social Cohesion
Security	Safety & Security
Governance	Cultural Fulfillment
Equity	Connection to Nature
	Leisure Time

⁶¹ Summers et al., "Development of a Human Wellbeing Index," 2017.

⁶² Liberati, Marjorie. "Soil Health & Nutrients: Socio-Economic Indicators for Strategic Planning," February 14, 2020.

6.2. Recommendations for Human Well-Being Indicators

The literature review and indicator comparative analysis conducted in this report supports the following recommendations for the inclusion of new indicators/metrics into TNC’s HWBIs. The list of metrics, their scores, and data sources can be found in Appendix H. Justification for the scoring of these indicators can be found [here](#).

6.2.1. Tier 1 Applicability & Data Metrics (High Priority for Inclusion)

We recommend implementing the 21 metrics identified as Tier 1 for applicability and data. Six of these metrics were identified in TNC’s 2019/2020 analysis. These recommended metrics span six out of the eight EPA Human Well-Being Index domains: (1) Safety & Security, (2) Living Standards, (3) Social Cohesion, (4) Health, (5) Leisure Time, and (6) Connection to Nature. Recommended data sources for these metrics are in Table 7.

Notably, “Property damage from floods/storms” was a metric recommended for implementation by Marjorie Liberati in the 2019/2020 analysis.⁶³ This indicates this metric is a high priority for implementation. The other metric Liberati recommended for implementation was “Proportion of waterbodies classified as ‘impaired’”. However, this metric was not considered in our analysis as it was not a metric tracked in any peer watersheds assessed.

Table 7: Tier 1 applicability and Tier 1 data metrics.

EPA Domain	Indicator	Metric	Description	Tier		Recommended Data Source(s)*
				Applicability	Data	
Connection to Nature	Public Access	Walkability	The number of citizens that can walk to a park within the Saginaw Bay Watershed in 10 minutes.	1	1	Trust for Public Land
		Land use and distribution	Measures the distribution of land within the Saginaw Bay Watershed (federal, state, private, indigenous) and land use (urban, rural, agriculture, forest, conservation, etc.)	1	1	Michigan DNR, NLCD by GIS
		Publicly accessible shoreline	Percent of shoreline that is publicly accessible or	1	1	USGS PAD Public Access Areas

⁶³ Liberati et al., "Making Measures Count," 2020

⁶³ Liberati et al., "Planning for People and Nature," 2022.

EPA Domain	Indicator	Metric	Description	Tier		Recommended Data Source(s)*
				Applicability	Data	
			owned.			
Leisure Time	Time Spent	Fishing participation	The total number of fishing boat trips taken on an annual basis and the total number of hours annually citizens spent fishing within the Saginaw Bay Watershed.	1	1	Michigan DNR
		Fishing satisfaction	Measures the degree to which fishers self-report their fishing experience within the Saginaw Bay Watershed as "successful" or "unsuccessful".	1	1	Michigan DNR
		State park camping	The number of stays in state park campgrounds within the Saginaw Bay Watershed annually.	1	1	MI Park System
Health	Beach Safety	Percentage of safe beaches	Percent of beaches that meet safe swimming standards at all times during the summer.	1	1	EGLE: BeachGuard
		Annual beach closures (TNC)	The number of annual beach closures/water access closures due to water not meeting water quality standards that risk human health.	1	1	EGLE: BeachGuard , NOAA: National Marine Ecosystem Status
Living Standards	Harvestable Foods	Fisheries health	Measures the health and quality of Saginaw bay's fisheries in terms of the health of game fish and other species that sustain recreational fishing	1	1	MI DNR Status of Fishery Resource Reports

EPA Domain	Indicator	Metric	Description	Tier		Recommended Data Source(s)*
				Applicability	Data	
			in the watershed.			
		Fish advisories	Number of annual fish advisory warnings within the Saginaw Bay Watershed.	1	1	MDHHS Eat Safe Fish Guides
Health	Drinking Water Quality	Source water nitrate concentration	The concentration of nitrate in ground water prior to treatment.	1	1	EGLE Water Chemistry Monitoring Program
		Drinking water warnings/advisories (TNC)	Number of drinking water warnings/advisories annually in the Saginaw Bay Watershed.	1	1	SDWA & NPDWR , EPA ECHO , MDHHS MI Tracking
		Cyanobacterial microcystin toxins	Detection of microcystin toxins in raw, untreated water within the Saginaw Bay Watershed.	1	1	MI Harmful Algal Bloom Maps
Health	Air Quality	Air quality warnings (TNC)	Number of air quality warnings/advisories annually in the Saginaw Bay Watershed.	1	1	EPA Air Now , MiAir , National Air Quality Standards , EGLE Air Quality Division
		PM 2.5 exposure	Percent of the Saginaw Bay Watershed population exposed to PM 2.5 concentrations that do not meet the state of Michigan's standard of 9.0 ug/m ³ annually.	1	1	EPA Air Now , MiAir , National Air Quality Standards , EGLE Air Quality Division
Social Cohesion	Democratic Engagement and Governance	Pollution correction and identification failures with corrective action	Percent of identified pollution correction and identification failures with corrective action taken in a timely manner.	1	1	EGLE
Living Standards	Economic Factors	Tourism	Tracking the overall sales,	1	1	Pure Michigan , MI Tourism Economic

EPA Domain	Indicator	Metric	Description	Tier		Recommended Data Source(s)*
				Applicability	Data	
			employment, wages, state taxes, and local taxes generated through tourism in the Saginaw Bay Watershed communities.			Impact Report, 200sMichigan, Connolly Cove
		Unemployment Rate (TNC)	The unemployment rate within Saginaw Bay Watershed communities.	1	1	Bureau of Labor Statistics, US Census Bureau (American Community Survey), Michigan Department of Technology, Management and Labor, MI Labor Market
Safety and Security	Natural Disasters	Property damage from floods/storms (TNC)	Annual cost of flood or storm damage, both public and private, in the Saginaw Bay Watershed.	1	1	FEMA Preliminary Damage Assessment Tool
		Property flooding risk (TNC)	Number of properties at risk for flooding/storm-related damages.	1	1	FEMA: Federal Flood Risk Management Standard, USGS, EGGLE
		Flooding events	Number of annual flooding events in the Saginaw Bay Watershed.	1	1	National Centers for Environmental Information

6.2.2. Tier 1 Applicability Metrics & Tier 2 or 3 Data

Several metrics in our analysis received high priority Tier 1 designation for Applicability while scoring in Tier 2 or 3 for Data. This discrepancy was particularly evident for qualitative metrics that assess subjective aspects of human well-being. Analysis of peer watersheds, notably Puget Sound and Hood Canal, demonstrates that these metrics are typically measured through systematic resident surveys within the watershed. The absence of readily available data sources should not diminish the significance of these metrics in evaluating human well-being outcomes. Therefore, we recommend implementing a comprehensive survey program to collect data for these high-priority qualitative indicators, or explore these proxy data sources in more detail, ensuring a more complete assessment of human well-being in the watershed. Specifically, we recommend including either "Natural resource-based cultural activities participation" or "Satisfaction with participation in natural resource-based cultural activities" as a metric because incorporating one of them

would satisfy representation of the EPA's Cultural Fulfillment Human Well-Being Index domain, creating a more balanced and complete evaluation of human well-being in the watershed. These metrics and their relevant data sources, if available, are outlined in table 8.

Table 8: Tier 1 applicability and Tier 2 or 3 data metrics.

EPA Domain	Indicator	Metric	Description	Tier		Recommended Data Source(s)
				Applicability	Data	
Leisure Time	Time Spent	Nature-based recreation days/year	The average number of days/year citizens participate in nature-based recreation in the Saginaw Bay Watershed area during all seasons including passive and active recreational activities.	1	3	No Data Available
Living Standards	Harvestable Foods	Frequency of collecting commonly harvested foods	Frequency of private collection of commonly harvested species including walleye, yellow perch, lake trout, whitefish, animal meat, mushrooms, and plants.	1	3	No Data Available
Connection to Nature	Biophilia	Psychological well-being while in nature	The percent of citizens who experience inspiration and/or stress reduction while in nature.	1	3	No Data Available
Social Cohesion	Democratic Engagement and Governance	Trust in government	Number of Saginaw Bay Watershed citizens who report trust in experts and local and state government and collaborative government efforts	1	2	MSU SOSS Data
		Good environmental governance	Citizen perception of the way decisions are made regarding management of the natural environment.	1	2	MSU SOSS Data
Cultural Fulfillment	Cultural Activity Participation	Natural resource-based cultural activities participation	Percent of citizens who participate in natural resource-inspired cultural activities.	1	2	MI DNR Statewide Comprehensive Outdoor Recreation Plan Survey
		Satisfaction with participation in	This indicator describes citizens' satisfaction in	1	2	MI DNR Statewide Comprehensive

EPA Domain	Indicator	Metric	Description	Tier		Recommended Data Source(s)
				Applicability	Data	
		natural resource-based cultural activities	regard to their participation in cultural practices such as those linked to the natural environment, including recreational, civic, and social activities, as well as tribal cultural practices related to natural resources.			Outdoor Recreation Plan Survey
Living Standards	Natural Resources Economic Factors	Employment in natural resource industries	Number of jobs supported by natural resource industries in the Saginaw Bay Watershed, including aquaculture, timber, fishing, agriculture, and recreation and tourism.	1	2	US Census Bureau, BLS
		Number of new jobs in natural resource sector/year	Number of new jobs created by natural resource employment sector/year.	1	2	US Census Bureau, BLS
		Natural resource industry output	The output of natural resource industries, such as fishing, agriculture, timber, and tourism and recreation.	1	3	No Data Available

6.2.3. Tier 2 Applicability Metrics (Moderate Priority for Inclusion)

Our analysis identified 19 metrics with Tier 2 Applicability scores, several of which present opportunities for efficient implementation. Four of these Tier 2 metrics already have strong Tier 1 data availability, making them candidates for relatively straightforward inclusion in a HWBI monitoring framework if desired. These metrics include “Financial Assistance Programs”, “Job Growth”, “Housing Affordability”, and “Social Vulnerability Index”.

Additionally, if the recommended survey program for high-priority qualitative indicators in the previous section is pursued, many of the remaining Tier 2 metrics could be efficiently incorporated into the same data collection effort with minimal additional resource investment. This approach would allow for gathering data on these secondary-priority metrics while leveraging the infrastructure established for Tier 1 metrics. However, the decision to include any Tier 2 metrics should be balanced against resource constraints and program objectives, with priority given to implementing and maintaining the Tier 1 metrics first. The Tier 2 metrics and their relevant data sources, if available, are outlined in table 9.

Table 9: Tier 2 applicability metrics.

EPA Domain	Indicator	Metric	Description	Tier		Recommended Data Source(s)
				Applicability	Data	
Social Cohesion	Social Engagement	Engagement in natural resource stewardship	The percentage of citizens engaging in a natural resource stewardship activity in the Saginaw Bay Watershed area per year.	2	3	No Data Available
		Community support for resource management	Number of community organizations that participate in natural resource management or stewardship in the Saginaw Bay Watershed.	2	3	No Data Available
		Attitudes of citizens regarding social engagement	The attitudes of citizens regarding how their actions matter, their desire to do more, and beliefs about the impact of pollution and quality of water in the Saginaw Bay Watershed on their well-being	2	3	No Data Available
Connection to Nature	Public Access	Citizen satisfaction with accessible shorelines	Percent of residents who are satisfied with their access to public shorelines in the Saginaw Bay Watershed.	2	3	No Data Available
Living Standards	Harvestable Foods	Citizen desire for access to commonly harvested natural resources	Percent of citizens that desire regular access to traditionally/commonly harvested natural resources from the Saginaw Bay Watershed.	2	3	No Data Available
Social Cohesion	Life Satisfaction	Overall life satisfaction	The percent of citizens that express varying levels of overall life satisfaction.	2	3	No Data Available
		Life satisfaction due to living in the Saginaw Bay Watershed area.	The percent of citizens that express life satisfaction in part due to residence within the Saginaw Bay Watershed area.	2	3	No Data Available
Social	Attitude	Citizen	Percent of citizens that	2	3	No Data Available

EPA Domain	Indicator	Metric	Description	Tier		Recommended Data Source(s)
				Applicability	Data	
Cohesion	Toward the Community	connection to the region	feel a positive connection to the region.			
		Citizen trust in community	Percent of citizens who trust people in their surrounding community.	2	3	No Data Available
		Sense of place	Percent of residents that feel a sense of pride belonging to the Saginaw Bay Watershed area.	2	3	No Data Available
Living Standards	Economic Factors	Job growth	Measures the percentage of jobs gained or lost (net) per capita from the past 4 years.	2	1	Michigan Department of Technology, Management and Labor, 2023 Michigan Annual Economic Analysis Report, MI Labor Market, MI Senate Fiscal Agency (SFA), Bureau of Labor Statistics (BLS), US Census Bureau (American Community Survey), University of Michigan (Michigan Economic Outlook), The Michigan Economic Outlook for 2024–2026, USA Facts
		Housing affordability	Measures the percentage of households that spend 30 percent or more of their income on housing costs.	2	1	MI State Housing Development Authority (MSHDA), MI Housing Data Portal, HUD, HUD User, MI State Housing Development Authority, US Census Bureau (American Community Survey), Zillow Housing Data, DataUSA
		Income inequality	Use of the Gini Coefficient to measures the inequality in income distribution to citizens in the Saginaw Bay Watershed.	2	2	US Census Bureau, Federal Reserve Economic Data (FRED), Current Population Survey (CPS), American Community Survey (ACS), Survey of Income and Program Participation (SIPP), MI Senate Fiscal

EPA Domain	Indicator	Metric	Description	Tier		Recommended Data Source(s)
				Applicability	Data	
						Agency, DataUSA, World Inequality Database (WID)
		Financial Assistance Programs (TNC)	Proportion of families needing support from financial assistance programs (e.g., SNAP, EBT)	2	1	MI Department of Health and Human Services: Annual State Summary, Administration for Children & Families, USDA Food and Nutrition Services, USDA Economic Research Services
		Median income (TNC)	The median income of citizens living in the Saginaw Bay Watershed annually.	2	2	US Census Bureau, US Census Bureau 2, Federal Reserve Economic Data (FRED), Census Reporter, Statista, DataUSA, Statistical Atlas
Safety and Security	Natural Disasters	Social vulnerability index	Social Vulnerability refers to the demographic and socioeconomic factors (such as poverty, lack of access to transportation, and crowded housing) that adversely affect communities that encounter hazards and other community-level stressors. (CDC)	2	1	CDC/ATSDR SVI
Living Standards	Natural Resources Economic Factors	Percent of economic activity from natural resource small businesses	Percent of economic activity that is from natural resource---based small business.	2	3	No Data Available
		Percent of revenue to local economy from natural-resource adjacent	Percent of revenue to local economy from agriculture, commercial fishing, timber, non---timber products and tourism.	2	3	No Data Available

EPA Domain	Indicator	Metric	Description	Tier		Recommended Data Source(s)
				Applicability	Data	
		industries				
		Number of businesses supported by natural resource sector	Number of local supporting businesses to industry, by natural resource sector.	2	3	No Data Available

7. Limitations and Future Considerations

The intent is for the metrics identified in this analysis to be integrated into an existing water quality monitoring dashboard operated by the Saginaw Bay Monitoring Consortium.⁶⁴ The dashboard is a collaborative tool that tracks the ecological effects of changes in agricultural practices, and the inclusion of human well-being metrics will allow it to capture and communicate the direct and indirect benefits to communities. Before integrating these recommendations into the dashboard, the following items should be considered.

7.1. Stakeholder Engagement

A significant limitation of this analysis is the absence of community and stakeholder engagement in the metric selection and evaluation process. In contrast to the peer watersheds analyzed in this assessment, which implemented comprehensive stakeholder engagement strategies, our assessment was conducted through remote analysis alone. For example, the Hood Canal methodology incorporated stakeholder interviews and several community workshops to refine and prioritize their human well-being indicators, while the Puget Sound Partnership undertook a seven-year development process with multiple rounds of stakeholder engagement, including structured forums, surveys, and community feedback sessions. Although the metrics evaluated in our analysis have undergone rigorous peer review processes in their respective watersheds, validation within the specific socio-ecological context of the Saginaw Bay Watershed is still needed. Although the recommended metrics above provide a scientifically rigorous foundation for assessing human well-being, their successful implementation will require systematic stakeholder engagement to ensure alignment with local values and priorities.

7.2. Addressing all Eight EPA Domains for Human Well-Being

A critical gap in our analysis is the absence of metrics aligned with the Education domain of the EPA's Human Well-Being Index framework. None of the assessed peer watersheds monitored education-related metrics, and we were unable to identify appropriate indicators that demonstrated clear connections between the health of the Saginaw Bay Watershed and education outcomes. This creates a significant limitation in our assessment, as education represents one of the eight fundamental domains of the EPA's framework for evaluating human well-being. Future research should investigate metrics that could address this gap, such as environmental education programs, watershed literacy assessments, or educational initiatives related to agricultural practices and water quality. Moreover, structured community engagement could facilitate the identification of education-related metrics specifically relevant to the Saginaw Bay Watershed.

Furthermore, the other seven domains do not have an equal or similar number of associated indicators and metrics. For example, our methods only identified one indicator and two proposed metrics for "Cultural Fulfillment," while we identified three indicators and 17 metrics for "Living Standards." This unevenness could reflect biases toward some domains of human

⁶⁴ ArcGIS StoryMaps. "Tracking Water Quality in the Saginaw Bay Watershed," September 23, 2024. <https://storymaps.arcgis.com/stories/7861c81d6cfc40519c4870a8a8db100e>.

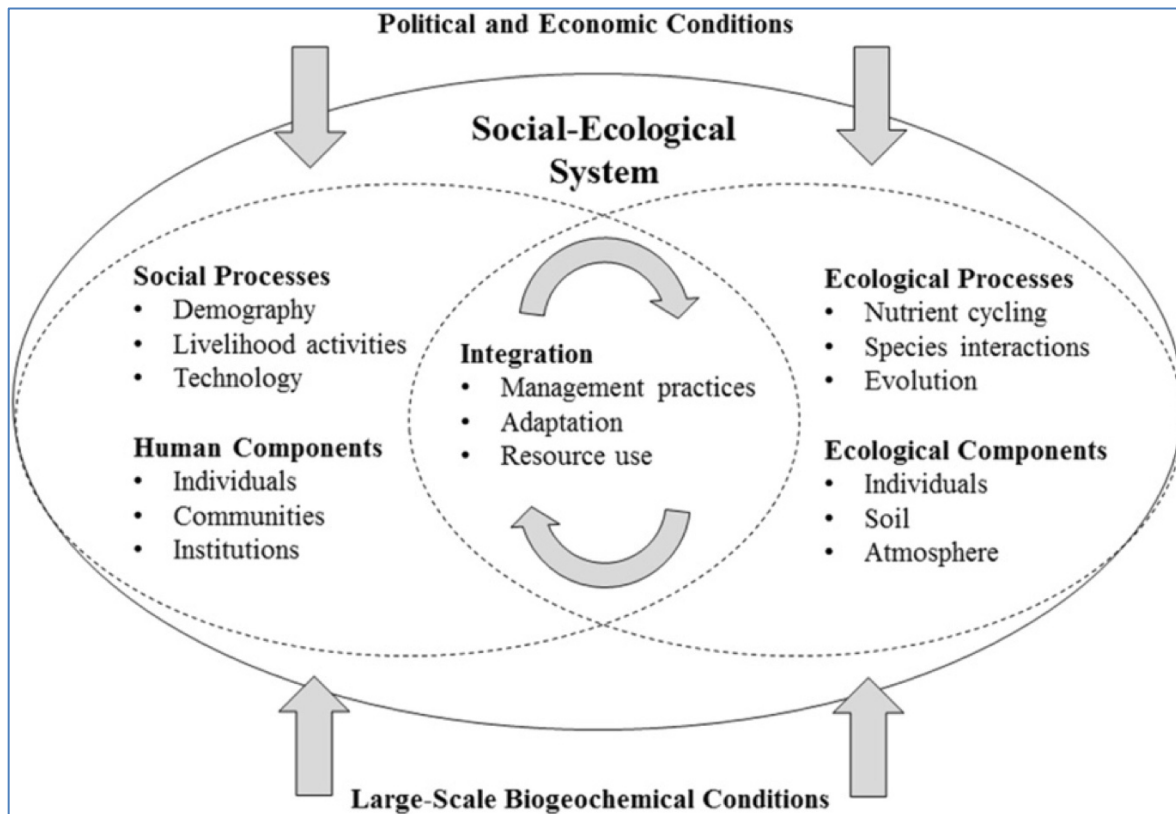
well-being over others either on the part of the project team, peer-watersheds reviewed, or other materials referenced by the authors. Categorization of human-wellbeing metrics into their corresponding domains is an inherently subjective process, and in some cases the categorization of metrics and indicators into closely related domains can be debatable. Therefore, categorizations into domains should be understood as guideposts for future research and exploration, rather than fixed structures inherent to the metrics themselves. Increasing the evenness of metrics across all eight domains should nevertheless be a goal of future efforts to promote a holistic and complete framework for measuring human well-being.

7.3. Identifying and Setting Human Well-Being Metric and Indicator Targets

Another final key limitation is the lack of clear targets or benchmarks for these recommended metrics. While we found useful indicators from other watershed programs, most didn't specify targets for their human well-being metrics - with only Puget Sound setting concrete goals for a handful of select indicators. Without clear targets, it becomes challenging to evaluate progress, drive accountability, and determine whether observed changes in metric values represent meaningful improvements in human well-being outcomes. Not having these benchmarks also makes it tougher to prioritize which management actions to take and where to focus resources. Moving forward, we recommend developing meaningful targets by looking at historical data, considering relevant regional standards, and working with stakeholders to set goals that are both ambitious and achievable for the Saginaw Bay Watershed.

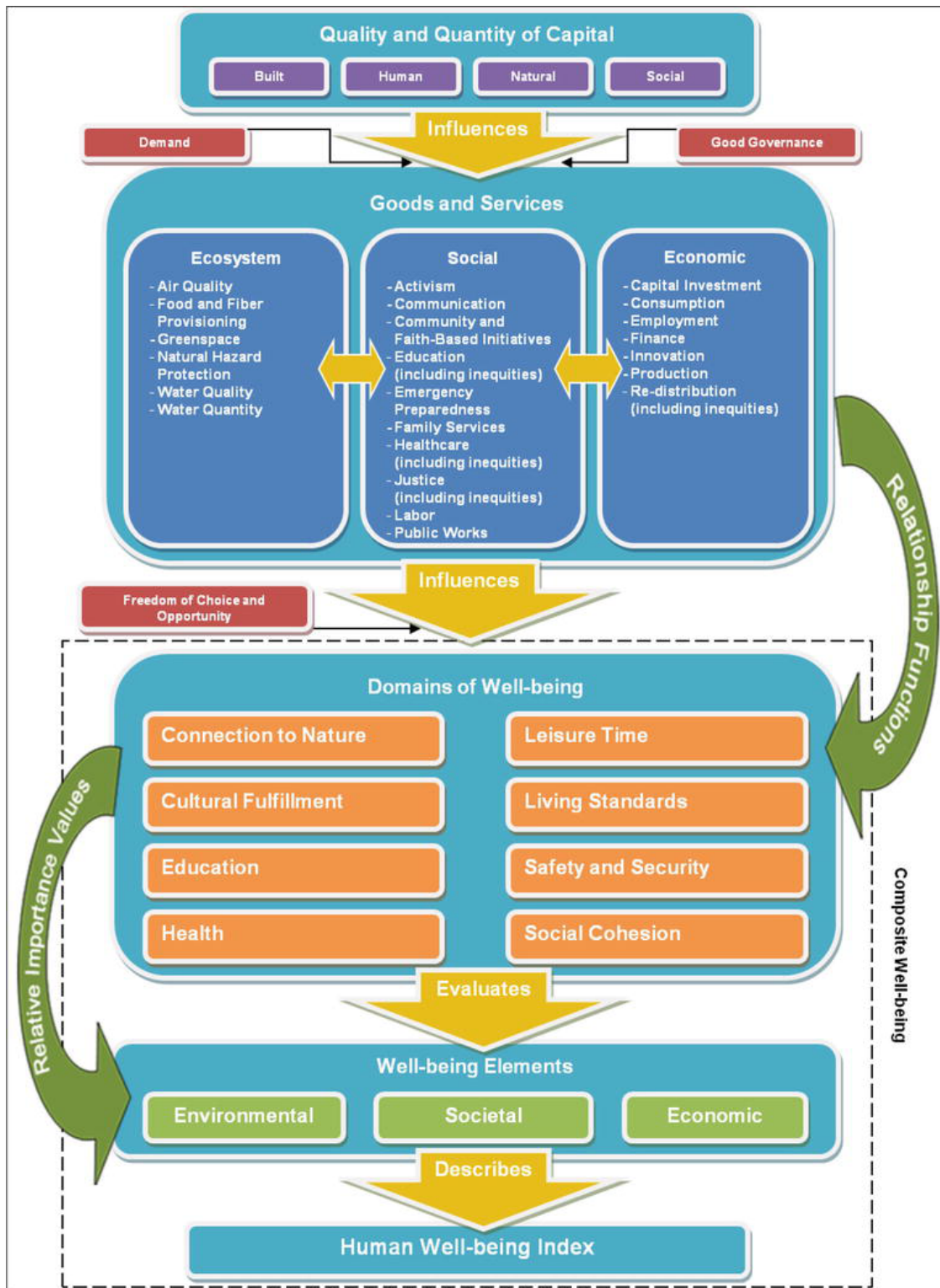
8. Appendices

A. Depiction of an SES (Virapongse et al. 2016)⁶⁵



⁶⁵ Virapongse, Arika, Samantha Brooks, Elizabeth Covelli Metcalf, Morgan Zedalis, Jim Gosz, Andrew Kliskey, and Lilian Alessa. "A social-ecological systems approach for environmental management." *Journal of Environmental Management* 178 (2016): 83-91. <https://doi.org/10.1016/j.jenvman.2016.02.028>

B. EPA's Human Well-Being Index (Summers et al., 2017).



C. Table of EPA's HWBI Domains, Indicators and Metrics

Domain	Indicator	Metrics
Connection to Nature	Biophilia	Connection to Life
		Spiritual Fulfillment
Cultural Fulfillment	Activity Participation	Performing Arts Attendance
		Rate of Congregational Adherence
Education	Basic Educational Knowledge and Skills of Youth	Mathematics Skills
		Reading Skills
		Science Skills
	Participation and Attainment	Adult Literacy
		High School Completion
		Participation
		Post-Secondary Attainment
	Social, Emotional and Developmental Aspects	Bullying
		Contextual Factors
		Physical Health
		Social Relationships and Emotional Wellbeing
Health	Healthcare	Population with a Regular Family Doctor
		Satisfaction with Healthcare
	Life Expectancy and Mortality	Asthma Mortality
		Cancer Mortality
		Diabetes Mortality
		Heart Disease Mortality
		Infant Mortality
		Life Expectancy
		Suicide Mortality
	Lifestyle and Behavior	Alcohol Consumption
		Healthy Behaviors Index
		Teen Pregnancy
		Teen Smoking Rate
	Personal Wellbeing	Happiness
		Life Satisfaction
		Perceived Health
	Physical and Mental Health Conditions	Adult Asthma Prevalence
		Cancer Prevalence
		Childhood Asthma Prevalence
		Coronary Heart Disease Prevalence
		Depression Prevalence
		Diabetes Prevalence
		Heart Attack Prevalence
		Obesity Prevalence
		Stroke Prevalence
Leisure Time	Activity Participation	Average Nights on Vacation
		Physical Activity
	Time Spent	Leisure Activities
		Adults who Provide Care to Seniors
	Working Age Adults	Adults Working Long Hours

Domain	Indicator	Metrics
		Adults Working Standard Hours
Living Standards	Basic Necessities	Food Security
		Housing Affordability
	Income	Incidence of Low Income
		Median Household Income
		Persistence of Low Income
	Wealth	Median Home Value
		Mortgage Debt
	Work	Job Quality
		Job Satisfaction
Safety and Security	Actual Safety	Accidental Morbidity and Mortality
		Loss of Human Life
		Property Crime
		Violent Crime
	Perceived Safety	Community Safety
	Risk	Social Vulnerability Index
Social Cohesion	Attitude toward Others and the Community	Belonging to Community
		City Satisfaction
		Discrimination
		Helping Others
		Trust
	Democratic Engagement	Interest in Politics
		Registered Voters
		Satisfaction with Democracy
		Trust in Government
		Voice in Government Decisions
	Family Bonding	Exceeded Screen Time Guidelines
		Frequency of Meals at Home
		Parent-child Reading Activities
	Social Engagement	Participation in Group Activities
		Participation in Organized, Extracurricular Activities
		Volunteering
	Social Support	Close Friends and Family
		Emotional Support

D. Comparative Overview of Peer Watersheds

Feature	Chesapeake Bay	Puget Sound	Lake Erie	Saginaw Bay
Geographic Location	East Coast, 6 US States—DE, MD, NY, PA, VA, WV, and DC.	Pacific Northwest—WA (U.S), and parts of British Columbia (CA)	Great Lakes Region, 4 US States—OH, PA, NY, MI—and Ontario (CA)	Michigan (U.S), Western side of Lake Huron
Population	~18.5 million	~7 million	~12.4 million	~1.4 million
Est. Area of Watershed	~64,000 square miles	~42,000 square miles	~30,000 square miles	~8,700 square miles
Key Program/ Initiative	Chesapeake Bay Program (1983)	Puget Sound Partnership (2007)	Great Lakes Restoration Initiative (GLRI, 2010)	Saginaw Bay Watershed Initiative Network (1998)
Recovery Focus/Goals	- Abundant life - Clean Water - Land Conservation - Community Engagement - Climate Change	- Healthy Human Population - Vibrant Quality of life - Thriving Species and Food Web - Protected and restored habitat - Abundant Water quantity - Healthy Water Quality	- Toxic Substances and Areas of Concern - Invasive Species - Nonpoint Source Pollution Impacts on Nearshore Health - Habitat and Species - Foundations for Future Actions	- Agricultural Pollution Prevention - Wildlife Stewardship - Water Resources - Land Use - Communication
Flagship Monitoring Program	Eco Health Report Cards	Puget Sounds Vital Signs	Lake Erie Quality Index	SMBC Water Quality Monitoring
Key Well-Being Domains	i. Ecological ii. Societal iii. Economic iv. Others	i. Healthy Human Population ii. Vibrant Human Quality of life iii. Thriving Species and Food Web iv. Functioning Habitat v. Healthy Water Quality	i. Environment Quality ii. Human Exposure Risks iii. Tourism and Redevelopment iv. Wildlife and Recreation v. Maritime Industry	i. Water Quality <i>(Our project aims to fill this gap: identify HWBI by building on the work of TNC, ODM Report and other watersheds)</i>
Est. Annual Economic Value	Over \$100b in jobs and recreation (US Geological Survey, 2021)	Up to \$83 billion in jobs and recreation (Earth Economics, 2010)	Over \$14 billion in tourism besides 124,000 jobs (IJC, 2018)	Over \$26.6 billion in outdoor recreation (2024)
Additional	Map	Map	Map	Map

E. Peer Watershed HWBI/Metrics.

Peer Watershed	HWBI/Metrics
Chesapeake Bay & Watershed Report Card	1. Protected lands 2. Stewardship 3. Social index 4. Walkability 5. Heat vulnerability index 6. Environmental justice index 7. Median income 8. Housing affordability 9. Income inequality 10. Jobs growth
Hood Canal Integrated Watershed Plan	1. Resident outdoor activity hours 2. Percentage of safe swimming beaches 3. Availability of commonly harvested species 4. Drinking water quality 5. Toxin levels in shellfish 6. Number of days annually of air quality (category) 7. Percent of residents with positive feelings/emotions from being in nature in the Hood Canal 8. Percent of residents expressing high life satisfaction, in part because of living in the Hood Canal 9. Percent of residents expressing positive connection to the region 10. Percent of publicly accessible or owned shoreline 11. Percent of residents satisfied with access to public shorelines 12. Percent of residents who have learned about resource management or recreation issues 13. Number of Hood Canal residents who trust in experts and local and state government 14. Percent of identified Pollution Correction & Identification (PIC) failures with corrective action 15. Percent of participants engaging in a natural resource stewardship 16. Percent of residents participating in natural---resource inspired cultural activities 17. Proportion of residents who want regular access to traditionally/commonly harvested natural resources 18. Land type/use distribution 19. Percentage of residents who trust their community 20. Average number of days/year participate in outdoor activities 21. Percent of residents who support resource management 22. Number of jobs and living wages per worker by resource 23. Number of new jobs in natural resource sector/year 24. Percent of economic activity from natural resource small businesses 25. Percent of revenue to local economy from natural-resource adjacent industries 26. Number of businesses supported by natural resource sector
Puget Sound Vital Signs	1. Exposure to impaired air quality 2. Participation in cultural practices 3. Nitrate concentration in source water 4. Percent of employment in natural resource industries 5. Employment in natural resource industries

Peer Watershed	HWBI/Metrics
	6. Natural resource industry output 7. Good Governance Index 8. Locally harvestable foods 9. Bivalve harvest for personal use 10. Nature-based recreation 11. Nature-based work 12. Condition of swimming beaches 13. Overall life satisfaction 14. Psychological Wellbeing Index 15. Sense of Place Index 16. Area of harvestable shellfish beds 17. Engagement in stewardship activities 18. Sound Behavior Index 19. Dungeness crab catch for personal use 20. Index of Vulnerability for elevated nitrates in groundwater 21. Frequency of flood events 22. Regional index of the stock presence and health of forage fish species
Lake Erie Quality Index	1. Eating fish 2. Swimming 3. Drinking water 4. Tourism 5. Coastal recreation and beaches 6. Fishing participation 7. Angler success 8. Fishing satisfaction

F. TNC Scoring Rubric (Liberati et al., 2020)

CRITERIA	RELEVANT	RESONANT	RESPONSIVENESS	REALISTIC	DATA-RICHNESS	UNCERTAINTY/ CONFIDENCE
DESIRED ELEMENTS AND SCORE	- Connected to TNC strategy programs - Connected to the strategy themes (environmental challenges or focus areas)	- Accessible wording and terminology - People think it is important	- We can “move the needle” and see results - End of results chain (final > intermediate outcome) - Change occurs quickly and clearly (time-lag & noisy data)	- Likely to have ongoing monitoring - Low resource investment for data acquisition	- Data collected with good scientific practices - Data is produced frequent, at fine resolution, and is accessible (*repurposed = use differs from original purpose of collection)	- Low variable across team-member scores - High understanding of what communities’ care about
0	No connection to strategy programs or themes.	Unlikely to be familiar to community	Addressed by multiple, intersecting results chains/theory-of-changes	No existing program and prohibited by cost/logistics	No data available or data is >10 yr old	Limited to no confidence in the accuracy of my scores
1	Indirect connection to strategy themes, but no connection to existing programs.	Familiar but unlikely to influence decisions	Complex results chains/theory-of-changes (e.g., 15+ steps)	Monitoring program exists as part of short-term project with no dedicated funding source	Data is repurposed and collected infrequently (>2 yr time gaps)	Low confidence in the accuracy of my scores (e.g., topics has not come up in conversation but will guess based on experience with community)
2	Indirect or direct connection to strategy themes and limited connection to existing programs.	Occasionally thought of and will occasionally influence decisions	Long results chains and mid-complexity theory-of-change (e.g. 5-15 steps)	Existing monitoring program but data is privately held or pay-to-use	Data is repurposed but collected frequently (every 1-2 yr) High quality data and collected infrequently (>2 yr time gaps)	Fairly confident in the accuracy of my scores (e.g., anecdotal evidence or experience)
3	Direct connection to strategy themes and clear connection to existing programs.	Often thought of and frequently influences decisions	Short results chains and simple theory-of-change (e.g., <5 steps)	Existing monitoring program and data is publicly accessible	Data use aligns with collection and data is collected frequently (every 1-2 yr)	Confident in the accuracy of my scores (e.g., seen data or other studies; have worked in this space)

G. Indicator Ranks in TNC Report

Scenario A: Retro baseline	Scenario B: Baseline moving forward	Scenario C: Maximize impact/ROI	Scenario D: Community engagement
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Table 4. Indicator ranks based on overall scores from winnowing for each scenario (Rank 1 = highest overall score). For each scenario, ranks 1-3 are highlighted in dark green, ranks 4-5 are in medium green, and ranks 6-7 are highlighted in light green.

Indicator, full name	Indicator, shorthand	Domain	Scenario A: Retro Baseline	Scenario B: Baseline moving forward	Scenario C: Maximize impact/ROI	Scenario D: Community engagement
Cost of flood- or storm- related property damage	Property damage from floods and storms	Living standards	1	1	1	2
Proportion of waterbodies classified as "impaired"	Waterbodies are "impaired"	Work & Leisure	2	2	1	9
Number of days that nutrient/chemical levels in nearby waterbodies exceed thresholds for human health	Waterbodies exceed human-health thresholds	Health	3	3	2	7
Number of public beach/water-access closures	Beach/water closures	Work & Leisure	4	4	3	6
Average number of days per house with drinking water warnings/advisories	Drinking water warnings	Health	5	5	3	6
Number of days with air quality alerts/warnings	Air quality warnings	Health	6	8	6	8
Number of buildings impacted by flooding annually	Property flooding	Living standards	7	6	4	5
Proportion of families needing support from financial assistance programs (e.g., SNAP, EBT)	Financial assistance programs	Living standards	8	7	11	1
Number of properties at risk for flooding/storm damage	Property flooding risk	Security	9	8	5	6
Average household income	Household income	Living standards	10	9	14	3
Per capita doctors/hospital visits due to water-related illnesses	Hospital visits, water-related illness	Health	11	10	7	16
Unemployment rate	Unemployment rate	Work & Leisure	14	12	19	6
Crime rates by type of offense (break-in, non-violent, violent, hate, etc.)	Crime	Security	16	12	22	4

Appendix H: Metric Scoring and Recommended Data Sources

EPA Domain	Indicator	Metric	Description	Overall Tier		Recommended Data Source(s)*
				Applicability	Data	
Social Cohesion	Social Engagement	Engagement in natural resource stewardship	The percentage of citizens engaging in a natural resource stewardship activity in the Saginaw Bay Watershed area per year.	2	3	No Data Available
		Community support for resource management	Number of community organizations that participate in natural resource management or stewardship in the Saginaw Bay Watershed.	2	3	No Data Available
		Attitudes of citizens regarding social engagement	The attitudes of citizens regarding how their actions matter, their desire to do more, and beliefs about the impact of pollution and quality of water in the Saginaw Bay Watershed on their wellbeing	2	3	No Data Available
Connection to Nature	Public Access	Walkability	The number of citizens that can walk to a park within the Saginaw Bay Watershed in 10 minutes.	1	1	Trust for Public Land
		Land use and distribution	Measures the distribution of land within the Saginaw Bay Watershed (federal, state, private, indigenous) and land use (urban, rural, agriculture, forest, conservation, etc.)	1	1	Michigan DNR , NLCD by GIS
		Citizen satisfaction with accessible shorelines	Percent of residents who are satisfied with their access to public shorelines in the Saginaw Bay Watershed.	2	3	No Data Available
		Publicly accessible shoreline	Percent of shoreline that is publicly accessible or owned.	1	1	USGS PAD Public Access Areas
Leisure Time	Time Spent	Nature-based recreation days/year	The average number of days/year citizens participate in nature-based recreation in the Saginaw Bay Watershed area during all seasons including passive and active recreational activities.	1	3	No Data Available
		Fishing participation	The total number of fishing boat trips taken on an annual basis and the total number of hours annually citizens spent fishing within the Saginaw Bay Watershed.	1	1	Michigan DNR

EPA Domain	Indicator	Metric	Description	Overall Tier		Recommended Data Source(s)*
				Applicability	Data	
		Fishing satisfaction	Measures the degree to which fishers self-report their fishing experience within the Saginaw Bay Watershed as "successful" or "unsuccessful".	1	1	Michigan DNR
		State park camping	The number of stays in state park campgrounds within the Saginaw Bay Watershed annually.	1	1	MI Park System
Health	Beach Safety	Percentage of safe beaches	Percent of beaches that meet safe swimming standards at all times during the summer.	1	1	EGLE: BeachGuard
		Annual beach closures (TNC)	The number of annual beach closures/water access closures due to water not meeting water quality standards that risk human health.	1	1	EGLE: BeachGuard , NOAA: National Marine Ecosystem Status
Living Standards	Harvestable Foods	Frequency of collecting commonly harvested foods	Frequency of private collection of commonly harvested species including walleye, yellow perch, lake trout, whitefish, animal meat, mushrooms, and plants.	1	3	No Data Available
		Fisheries Health	Measures the health and quality of Saginaw bay's fisheries in terms of the health of game fish and other species that sustain recreational fishing in the watershed.	1	1	MI DNR Status of Fishery Resource Reports
		Fish advisories	Number of annual fish advisory warnings within the Saginaw Bay Watershed.	1	1	MDHHS Eat Safe Fish Guides
		Citizen desire for access to commonly harvested natural resources	Percent of citizens that desire regular access to traditionally/commonly harvested natural resources from the Saginaw Bay Watershed.	2	3	No Data Available
Health	Drinking Water Quality	Source water nitrate concentration	The concentration of nitrate in ground water prior to treatment.	1	1	EGLE Water Chemistry Monitoring Program
		Drinking water warnings/advisories (TNC)	Number of drinking water warnings/advisories annually in the Saginaw Bay Watershed.	1	1	SDWA & NPDWR , EPA ECHO , MDHHS MI Tracking
		Cyanobacterial microcystin toxins	Detection of microcystin toxins in raw, untreated water	1	1	MI Harmful Algal Bloom Maps

EPA Domain	Indicator	Metric	Description	Overall Tier		Recommended Data Source(s)*
				Applicability	Data	
			within the Saginaw Bay Watershed.			
Health	Air Quality	Air quality warnings (TNC)	Number of air quality warnings/advisories annually in the Saginaw Bay Watershed.	1	1	EPA Air Now , MiAir , National Air Quality Standards , EGLE Air Quality Division
		PM 2.5 exposure	Percent of the Saginaw Bay Watershed population exposed to PM 2.5 concentrations that do not meet the state of Michigan's standard of 9.0 ug/m ³ annually.	1	1	EPA Air Now , MiAir , National Air Quality Standards , EGLE Air Quality Division
Connection to Nature	Biophilia	Psychological wellbeing while in nature	The percent of citizens who experience inspiration and/or stress reduction while in nature.	1	3	No Data Available
Social Cohesion	Life Satisfaction	Overall life satisfaction	The percent of citizens that express varying levels of overall life satisfaction.	2	3	No Data Available
		Life satisfaction due to living in the Saginaw Bay Watershed area.	The percent of citizens that express life satisfaction in part due to residence within the Saginaw Bay Watershed area.	2	3	No Data Available
Social Cohesion	Attitude Toward the Community	Citizen connection to the region	Percent of citizens that feel a positive connection to the region.	2	3	No Data Available
		Citizen trust in community	Percent of citizens who trust people in their surrounding community.	2	3	No Data Available
		Sense of place	Percent of residents that feel a sense of pride belonging to the Saginaw Bay Watershed area.	2	3	No Data Available
Social Cohesion	Democratic Engagement and Governance	Trust in government	Number of Saginaw Bay Watershed citizens who report trust in experts and local and state government and collaborative government efforts	1	2	MSU SOSS Data
		Good environmental governance	Citizen perception of the way decisions are made regarding management of the natural environment.	1	2	MSU SOSS Data
		Pollution correction and identification failures with	Percent of identified pollution correction and identification failures with corrective action	1	1	EGLE

EPA Domain	Indicator	Metric	Description	Overall Tier		Recommended Data Source(s)*
				Applicability	Data	
		corrective action	taken in a timely manner.			
Cultural Fulfillment	Cultural Activity Participation	Natural resource-based cultural activities participation	Percent of citizens who participate in natural resource-inspired cultural activities.	1	2	MI DNR Statewide Comprehensive Outdoor Recreation Plan Survey
		Satisfaction with participation in natural resource-based cultural activities	This indicator describes citizens' satisfaction in regards to their participation in cultural practices such as those linked to the natural environment, including recreational, civic, and social activities, as well as tribal cultural practices related to natural resources.	1	2	MI DNR Statewide Comprehensive Outdoor Recreation Plan Survey
Living Standards	Economic Factors	Job growth	Measures the percentage of jobs gained or lost (net) per capita from the past 4 years.	2	1	Michigan Department of Technology, Management and Labor, 2023 Michigan Annual Economic Analysis Report, MI Labor Market, MI Senate Fiscal Agency (SFA), Bureau of Labor Statistics (BLS), US Census Bureau (American Community Survey), University of Michigan (Michigan Economic Outlook), The Michigan Economic Outlook for 2024–2026, USA Facts
		Housing affordability	Measures the percentage of households that spend 30 percent or more of their income on housing costs.	2	1	MI State Housing Development Authority (MSHDA), MI Housing Data Portal, HUD, HUD User, MI State Housing Development Authority, US Census Bureau (American Community Survey), Zillow Housing Data, DataUSA
		Income inequality	Use of the Gini Coefficient to measures the inequality in income distribution to citizens in the Saginaw Bay Watershed.	2	2	US Census Bureau, Federal Reserve Economic Data (FRED), Current Population Survey (CPS), American Community Survey (ACS), Survey of Income and Program Participation (SIPP), MI Senate Fiscal Agency, DataUSA, World Inequality Database (WID)

EPA Domain	Indicator	Metric	Description	Overall Tier		Recommended Data Source(s)*
				Applicability	Data	
		Tourism	Tracking the overall sales, employment, wages, state taxes, and local taxes generated through tourism in the Saginaw Bay Watershed communities.	1	1	Pure Michigan, MI Tourism Economic Impact Report, 200sMichigan, Connolly Cove
		Unemployment Rate (TNC)	The unemployment rate within Saginaw Bay Watershed communities.	1	1	Bureau of Labor Statistics, US Census Bureau (American Community Survey), Michigan Department of Technology, Management and Labor, MI Labor Market
		Financial Assistance Programs (TNC)	Proportion of families needing support from financial assistance programs (e.g., SNAP, EBT)	2	1	MI Department of Health and Human Services: Annual State Summary, Administration for Children & Families, USDA Food and Nutrition Services, USDA Economic Research Services
		Median income (TNC)	The median income of citizens living in the Saginaw Bay Watershed annually.	2	2	US Census Bureau, US Census Bureau 2, Federal Reserve Economic Data (FRED), Census Reporter, Statista, DataUSA, Statistical Atlas
Safety and Security	Natural Disasters	Social vulnerability index	Social Vulnerability refers to the demographic and socioeconomic factors (such as poverty, lack of access to transportation, and crowded housing) that adversely affect communities that encounter hazards and other community-level stressors.(CDC)	2	1	CDC/ATSDR SVI
		Property damage from floods/storms (TNC)	Annual cost of flood or storm damage, both public and private, in the Saginaw Bay Watershed.	1	1	FEMA Preliminary Damage Assessment Tool
		Property flooding risk (TNC)	Number of properties at risk for flooding/storm-related damages.	1	1	FEMA: Federal Flood Risk Management Standard, USGS, EGLE
		Flooding events	Number of annual flooding events in the Saginaw Bay Watershed.	1	1	National Centers for Environmental Information

EPA Domain	Indicator	Metric	Description	Overall Tier		Recommended Data Source(s)*
				Applicability	Data	
Living Standards	Natural Resources Economic Factors	Employment in natural resource industries	Number of jobs supported by natural resource industries in the Saginaw Bay Watershed, including aquaculture, timber, fishing, agriculture, and recreation and tourism.	1	2	US Census Bureau, BLS
		Number of new jobs in natural resource sector/year	Number of new jobs created by natural resource employment sector/year.	1	2	US Census Bureau, BLS
		Percent of economic activity from natural resource small businesses	Percent of economic activity that is from natural resource--based small business.	2	3	No Data Available
		Percent of revenue to local economy from natural-resource adjacent industries	Percent of revenue to local economy from agriculture, commercial fishing, timber, non---timber products and tourism.	2	3	No Data Available
		Number of businesses supported by natural resource sector	Number of local supporting businesses to industry, by natural resource sector.	2	3	No Data Available
		Natural resource industry output	The output of natural resource industries, such as fishing, agriculture, timber, and tourism and recreation.	1	3	No Data Available

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