Chapter 6

The Development of a Human Well-Being Index for the United States

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Abstract

The US Environmental Protection Agency (EPA) has developed a human well-being index (HWBI) that assesses the over-all well-being of its population at the county level. The HWBI contains eight domains representing social, economic and environmental well-being. These domains include 25 indicators comprised of 80 metrics and 22 social, economic and environmental services. The application of the HWBI has been made for the nation as a whole at the county level and two alternative applications have been made to represent key populations within the overall US population—Native Americans and children. A number of advances have been made to estimate the values of metrics for counties where no data is available and one such estimator—MERLIN—is discussed. Finally, efforts to make the index into an interactive web site are described.

Keywords: index, well-being, indicators, Merlin

1. Introduction

An integrated approach for characterizing human well-being has been developed by the U.S. Environmental Protection Agency (USEPA). This approach has been developed at multiple scales and is called A Human Well-being Index (HWBI). The HWBI uses a suite of measures to examine the influence of social, economic and environmental service flows on the eight domains of human well-being in a holistic fashion (**Figure 1**). The index is applicable to communities of all scales whether national, regional or local. **Figure 1** represents the index conceptualization mode of the HWBI. The conceptualization depicts the relationships among natural and built capital, goods and services, the domains of well-being and their sub-elements, and the value system of the entity being examined (*i.e.*, relative importance values associated with specific communities).

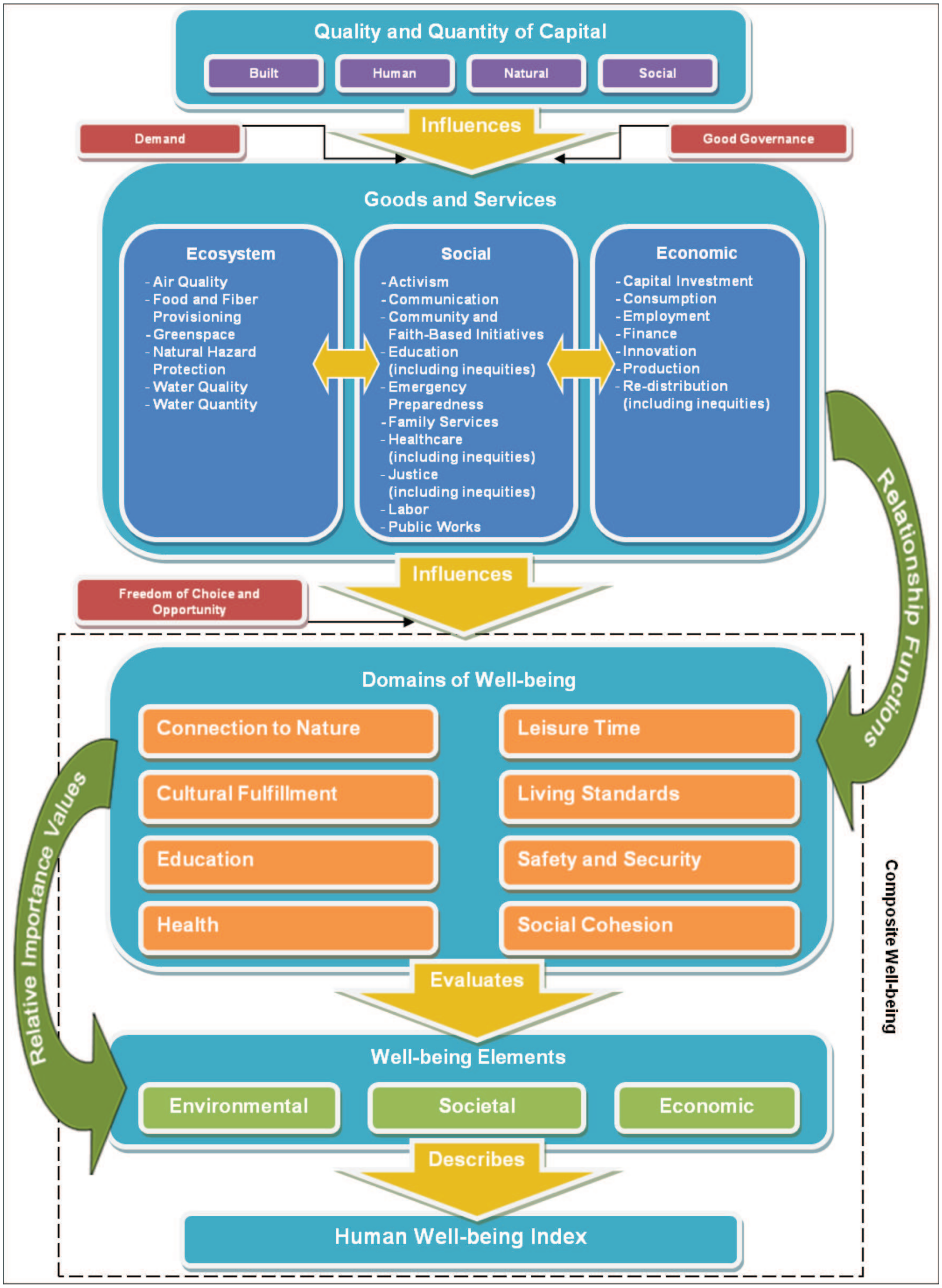

Figure 1. Conceptual framework for evaluating the influence of service flows on well-being endpoints for the construction of a Human Well-Being Index.

When tracked over time, the index has the potential to serve as a measure of sustainability and could be linked to alternative decisions that change the ecological, economic, and social well beings of defined populations. The metrics and methodologies for assembling multiple-scale measures have been developed [1–3] and, using this approach, a U.S. HWBI (for all counties) was calculated. Further, the functional relationships among domains and indicators of well-being and selected economic, societal and environmental services flows were determined. The HWBI is distinct from other well-being indices because the approach is scalable and domain and HWBI values are responsive to changes in services (e.g., economic, social and ecological), allowing it to be used as an informative endpoint in the sustainability decision-making process.

The HWBI is designed to empower and inform decision makers to proportionally weigh, in an equitable manner, the human health, socio-economic, environmental, and ecological factors that foster sustainability in a community. This would include the built and natural environments; and would help local decision makers understand the effects of alternative policies and actions on local sustainability. The HWBI can be used to identify: (a) current environmental, economic, and social trends that signal sustainability shifts; (b) the thresholds of sustainability for such indicators; and (c) performance metrics that signal that approaches designed to foster increasing sustainability are working as intended. This would include any indications of unintended consequences.

In 2011, the Sustainable and Healthy Communities Research program (SHC) in EPA's Office of Research and Development (ORD) coined the term TRIO for Total Resource Impacts and Outcomes [4]. TRIO encompasses integrated community decision-making approaches that address all three pillars of sustainability—economic, societal and environmental—in a holistic manner. While TRIO is similar to triple-bottom line accounting [5–7], many feel that the term triple-bottom line accounting conveys too much of an economic focus. SHC desired a term that would clearly demonstrate integration of all three pillars of sustainability. In the literature, methods that consider the three pillars of sustainability have included many different specific approaches—The Green Scorecard [8], Triple Bottom-Line Accounting [5–7], Happy Planet Index [9], and Millennium Ecosystem Assessment [10]. Others (e.g., Ecological Footprint) [11] have addressed one specific aspect of sustainability. All of these approaches contribute to the improvement of human well-being as a measure. As well-being is often an endpoint of concern regarding sustainability, SHC determined the need to develop an index of human well-being that fully embraced the integrated TRIO aspects of the developing SHC research program.

In an extensive review, Smith et al. [12]. examined 20 approaches to assessing human well-being (e.g., Gallup-Healthways Well-Being Index, Gross National Happiness Index) in order to determine if true TRIO-like approaches were included in these pre-existing indices. A brief summary describing the indices considered and their inclusiveness of well-being domains and indicators is shown in **Table 1**. While their findings suggested that several indices approached a full-TRIO assessment (*i.e.*, addressing all three pillars of well-being and sustainability), most approaches did not focus on the integration of all three pillars. As an example, the Gallup-Healthways Well-Being Index (Gallup) contained significant information pertaining to social drivers like health but had little or no information concerning the economic and environmental

Index	Scale	Economic well-being	Basic needs	Environmental well-being	Subjective well-being
The Economic Intelligence Unit's Quality of Life [13]	N	X	X		
Australian Unity Wellbeing Index [14]	N	X	X	X	
Human Development Index [15]	N	X	X		
Quality of Life Index for Developing Countries [16]	N	X	X	(X)	X
The Well-being of Nations [17]	N	X	X	X	
Sustainable Society Index [18]	N	X	X	X	
Hong Kong Quality of Life [19]	R	X	X	X	X
Well-being in EU Countries—Multidimensional Index of Sustainability [20]	N	X	X	X	
National Well-being Index—Life Satisfaction [21]	N	X	X	X	(X)
Child and Youth Well-being Index [22]	N	X	X		
Canadian Index of Well-being [23]	N	X	X	X	
Happy Planet Index [9]	N		X	X	X
Index of Child Well-Being in Europe [24]	N	X	X		X
Index of Social Health [25]	N	X	X		
Gallup-Healthways Well-Being Index [26]	M		X		X
The State of the Commonwealth Index [27]	S	X	X	X	X
QOL 2007 in Twelve of New Zealand's Cities [28]	L	X	X	X	X
Nova Scotia 2008 GPI [29]	R	X	X	X	
Gross National Happiness [30]	N	X	X	X	X
Human Well-Being Index [this manuscript]	M	X	X	X	X

X denotes the element was directly represented and addressed in the index; (X) denotes that element was indirectly represented but not directly addressed in the description of the indicators and domains. N denotes national scale, R denotes regional scale, S denotes state scale, L denotes local scale, and M denotes multiple scales.

Table 1. Well-being elements represented in reviewed indices [9].

pillars of well-being. Many of these reviewed approaches did not use substantial amounts of objective data, rather they relied on subjective perceived information from surveys. As shown in **Table 1**, HWBI addresses all three pillars of well-being with a clear combination of objective and subjective indicators and metrics relating to each pillar. Particularly, when linked to environmental, economic and social services flows, the HWBI epitomizes a holistic, integrated approach.

This chapter describes the approaches used to develop the HWBI and to assess services provisioning. The integrated concept of the interactions among social, economic and environmental drivers linked to well-being endpoints is demonstrated at the county level in the United States.

2. Index development, application and discussion

2.1. Characterizing Well-Being

2.1.1. Index description

The mathematical structure of HWBI is fully described in Summers et al. [44] and is reiterated here for completeness. The HWBI is an index based on a combination of objective data, subjective data collected through surveys, available data from other well-being surveys, and combined at the smallest spatial scale generally available (most often county level data). The conceptual model depicted in **Figure 1** shows the interplay of goods and services and their influence on the eight domains of well-being used in HWBI, the use of relative importance values to describe the community value structures, and the combination of all information into the three well-being elements and their subsequent combination into a single value representing well-being. The index utilizes eight domains, 25 indicators and 80 metrics (**Table 2**). First, metrics are combined to create an indicator (k) score for a spatial area $(\overline{x}_k)$ using the following equation:

$$\overline{x}_k = \frac{\sum_{m=1}^{n_m} \sum_{i=1}^{n_c} w_i x_{mi}}{n_m} \tag{1}$$

where n_c represents the number of locations (county by year) in an area (e.g., a region, state), n_m refers to the number of metrics, w_i equals the population weight for location i, and x_{mi} is the metric value for location i and metric m combination.

A domain (d) is scored for a given area $(\overline{x}_d)$ as follows:

$$\overline{x}_d = \frac{\sum_{k=1}^{n_k} \overline{x}_k}{n_k} \tag{2}$$

where k represents an indicator, $(\overline{x}_k)$ refers to the indicator score and n_k total number of indicators.

Economic, environmental, and social well-being element values (e) are derived from the geometric mean of all domains factored by a relative importance value specific to each element. The overall element scoring $(\overline{x}_e)$ for an area is given by the following equation:

$$\overline{x}_e = \prod_{d=1}^{8} \overline{x}_d^{\,RIV(d,e)} \tag{3}$$

where $RIV(d, e)$ is the Relative Importance Value between domain d and element e.

Finally, the HWBI is calculated using a relative importance factor for each element-to-overall well-being relationship as shown below:

$$HWBI = RIV_{eco}\overline{x}_{eco} + RIV_{env}\overline{x}_{env} + RIV_{soc}\overline{x}_{soc} \tag{4}$$

where RIV_{eco}, RIV_{env}, RIV_{soc}, and $\overline{x}_{eco}$, $\overline{x}_{env}$, $\overline{x}_{soc}$ are the Relative Importance Values and scores for the economic, environmental, and social elements, respectively.

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 Well-being
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 Well-being	Happiness
		Life Satisfaction
		Perceived Health
	Physical and Mental Health Conditions	Adult Asthma Prevalence
		Cancer Prevalence
		Childhood Asthma Prevalence
		Coronary Heart Disease Prevalence
		Depression Prevalence

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Domain	Indicator	Metrics
		Diabetes Prevalence
		Heart Attack Prevalence
		Obesity Prevalence
		Stroke Prevalence
Leisure Time	Activity Participation	Average Nights on Vacation
		Physical Activity
	Time Spent	Leisure Activities
	Working Age Adults	Adults who Provide Care to Seniors
		Adults Working Long Hours
		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
		Voter Turnout

Domain	Indicator	Metrics
	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

Table 2. Indicators and metrics associated with each of the eight domains used to characterize human well-being and calculate the index.

2.1.2. Indicators and data source selection

The domains, indicators and metrics included in the HWBI and its service drivers are shown in **Tables 2** and **3**. Subjective and objective data were collected from a number of publically accessible sources. In order to populate the metrics for the years 2000–2010, these data were organized in a hierarchical manner based on spatial and temporal resolution (e.g., national, regional, state, and county by year). When multiple spatial scales existed for a metric, the lowest spatial scale (e.g., county *versus* state) was selected for processing. To the extent possible, factors such as historic data continuity, data credibility and reliability, and future data accessibility were considered in the data selection process.

2.1.3. Data imputation, outliers and standardization

Data gaps caused by spatial and temporal disparities found among data sources needed to be filled. These gaps were filled using a carry-forward substitution imputation technique [31] using cross-year county or within year state or regional data. Using the carry-forward method allowed for more robust data analyses. An additional imputation was conducted to calculate imputed values for counties exhibiting similar demographic and economic characteristics. From the spatially and temporally complete data set, county groupings were created using a combination of the Rural-Urban Continuum Code (RUCC) classifications [32] and the Gini Index for Household Income Inequality (HII) quintiles [33]. The RUCC-HII combinations generated county data groupings that usually reflected the relative spatial relationship of a county to the nearest large urban center with their measured income dispersion. Within-year median values were calculated for each RUCC-HII banding. Missing values in the original aggregate of metric data were substituted with the resulting RUCC-HII values.

Box-and-whisker analyses were completed for each fully enumerated HWBI metric. Extreme lower and upper outlier measures were set to minimum and maximum values, respectively. The maximum values were calculated to be three times the 75% percentile for each metric and

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Service type	Service	Indicator	Number of metrics
Economic	Capital Investment	Capital Formation	1
		Commercial Durables	1
		New Housing Starts	1
		New Infrastructure Investments	4
	Consumption	Cost of Living	1
		Discretionary Spending	1
		Goods and Services	3
		Sustainable Consumption	1
	Employment	Employment	3
		Employment Diversity	1
		Underemployment	1
		Unemployment	1
	Finance	Governance	2
		Loans	4
		Savings	1
	Innovation	Investment	2
		Patents and Products	1
	Production	Exports	1
		Household Services	1
		Market goods and services	2
		Sustainable Production	1
	Redistribution	Inequality	1
		Public Support	5
Ecosystem	Air Quality	Usable Air	1
	Food and Fiber Provisioning	Energy	4
		Food and Fiber	3
		Raw Materials	5
	Green Space	Natural Areas	4
		Recreation and Aesthetics	3
	Natural Hazard Protection	Natural Hazard Exposure	4
	Water Quality	Usable Water	2
	Water Quantity	Available Water	2
Social	Activism	Participation	4
	Communication	Accessibility	3
		Industry Infrastructure	3
		Providers	1

Service type	Service	Indicator	Number of metrics
		Public Service Communication	1
		Quality	2
	Community and Faith-based Initiatives	Investment	1
		Providers	1
	Education (services)	Accessibility	3
		Confidence	1
		Investment	2
		Providers	2
	Emergency Preparedness	Post-Disaster Response	1
		Pre-Disaster Planning	1
		Responders	1
	Family Services	Accessibility	2
		Effectiveness	3
		Investment	1
		Providers	1
	Healthcare	Accessibility	5
		Investment	3
		Providers	1
		Quality	1
	Justice	Accessibility	2
		Confidence	1
		Environmental	4
		Investment	2
		Providers	1
		Quality	1
	Labor	Confidence	1
		Effectiveness	1
		Employee Rights	2
	Public Works	Accessibility	2
		Investment	4
		Providers	1
		Quality	5
		Quantity	5

Table 3. Indicators and number of metrics associated with each of the three service types used to generally characterize the provisioning of goods and services that influence the human well-being index.

the minimum values were calculated as minus three times the 25% percentile. Any outliers of this three times maximization technique were set to the metric value closest to the fence. All data were standardized on a scale from 0.1 to 0.9 following the Organization for Economic Co-Operation and Development's (OECD) Better Life Index approach [34] with minor modification to account for the difference in scale. The resulting HWBI metric data set included both imputed and non-imputed standardized data for the 3143 counties of the U.S that represented approximately three million data points.

2.1.4. Calculating the HWBI

The HWBI was derived from the indicator scores and calculated as the population-weighted average of the standardized metric values. Indicator scores were averaged for each domain score. Finally, a scaled geometric mean was calculated across domain scores to produce the final the HWBI. The calculation process provided a means for examining well-being and its constituents at multiple spatial scales. For example, the mean decadal HWBI for the nation was 52.8 ± 0.1. At finer spatial scales, the New England region scored highest among the GSS regions and the West South Central region scored lowest in the decadal HWBI assessments. Similarly, New Hampshire had the highest decadal score (55.8 ± 1.0) for a state and Louisiana the lowest (49.9 ± 0.4) (**Figure 2**). Higher HWBI scores indicate greater levels of well-being.

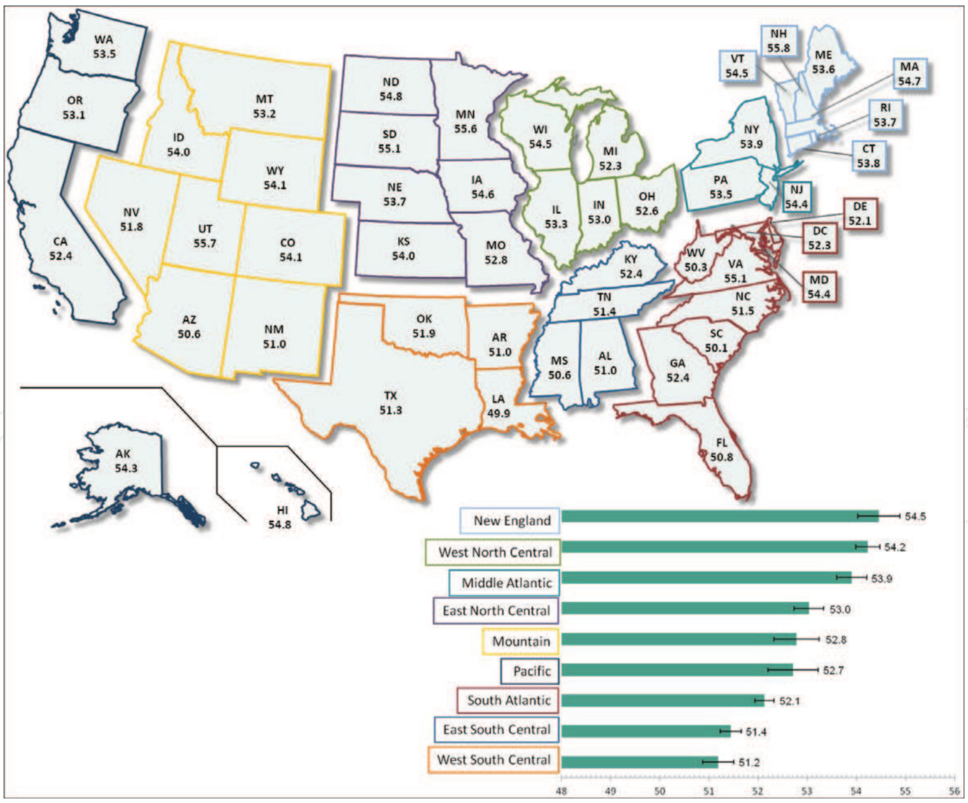

Figure 2. Mean decadal Human Well-Being Index (HWBI) for each state across the U.S.

At the finest spatial scale, chloropleth maps (**Figure 3**) show the mean decadal domain scores for all counties across the United States. This disassembled view of domain values shows observable patterns in the components that contribute to overall well-being. For example, the pattern for the domain of Leisure Time seems inversely related to Living Standards while Education may be linked to Health. Even though there is no specific indication of causality or directionality, the ability to make these types of observations may provide an initial point for identifying well-being related decision priorities.

HWBI data for metrics at spatial scales smaller than county were generally not available. To account for this limitation, an approach was developed to include the option of using relative

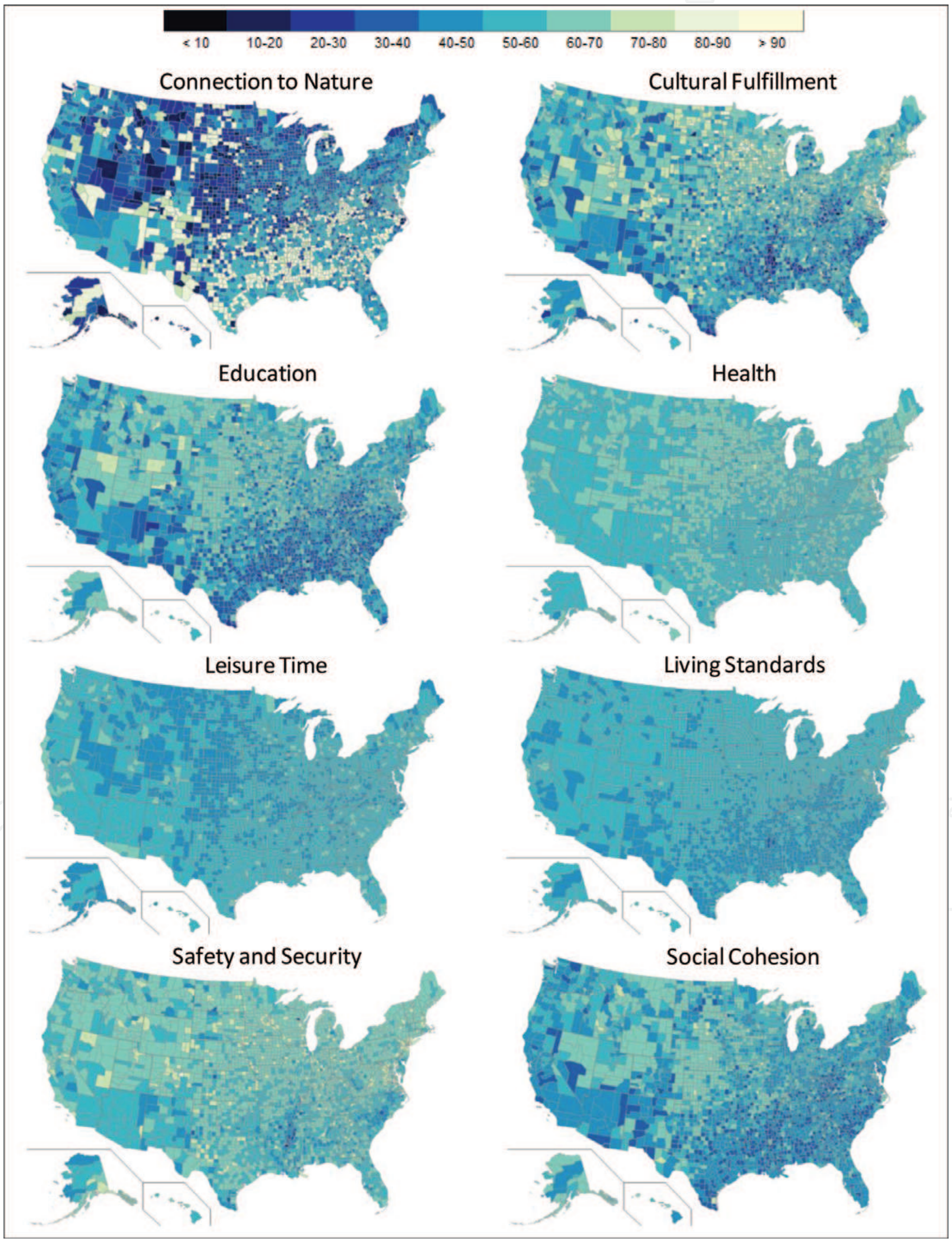

Figure 3. Spatial distribution of decadal county-level domain scores.

importance values (RIVs) derived following methods described in Smith et al. [35]. RIVs are externally supplied weighting factors that represent a set of priorities associated with local values structures that may be applied to the domain and element components prior to the final calculation of the HWBI to better represent a locality. An example application of the priority-based well-being index has been demonstrated for the Tampa Bay metropolitan area [36].

2.2. Uncertainty and sensitivity

Uncertainty analyses determined the estimated errors associated with the HWBI scores. For each spatial and temporal scale, the standard error for each indicator was calculated from the standardized metric values. Additionally, estimated errors introduced by the imputation process were propagated to the indicator level and added to the standard error estimate. The total indicator error was set to the maximum value of 0.5 or 100% error when either the standard error or the imputation error could not be estimated, or where the total error exceeded 0.5. The indicator error estimates were propagated through the index calculation to estimate the uncertainty associated with domain, element and final index values (**Table 4**). As would be expected, the mean reported error was much greater for indices calculated at the lowest spatial unit (i.e., county-level). The HWBI calculations for counties relied on large numbers of imputed values because fewer measurement data were available.

Sensitivity analyses were conducted to identify index measures susceptible to bias caused by unknown random or systematic error. Sensitivity to random error was tested for each metric using a one-at-a-time Monte Carlo simulation method by introducing zero-mean centered normally treatment. The analyses were run to examine the effects of spatial, temporal, or combined spatial-temporal missing value imputation methods. For random error effects, 7 of 83 metrics used in calculating the HWBI showed consistently higher bias relative to the group average ($Z > 1.65$, $P < 0.05$) (**Table 5**). The Connection to Nature and Cultural Fulfillment domains were most sensitive to both temporal and spatial methodological bias. The domain of Social Cohesion exhibited spatial bias sensitivity while the Health domain was, spatially and temporally, the most robust.

Time period	Scale	Average error	Standard deviation	Minimum	Maximum
Annual	National	0.40	0.03	0.33	0.43
	GSS Region	1.09	0.36	0.54	1.83
	State	2.34	1.31	0.98	8.10
	County	9.51	2.99	5.93	24.09
2000–2010	National	0.122	N/A	N/A	N/A
	GSS Region	0.33	0.11	0.19	0.51
	State	0.70	0.38	0.33	2.09
	County	2.64	0.90	1.83	6.93

Table 4. Summary statistics for estimates of uncertainty at the various spatial and temporal scales.

2.3. Index performance

The performance of the HWBI was evaluated by comparing HWBI results with established indices of similar scope to confirm the rationale and soundness of indicator choices and development approach. The existing indices chosen for comparison (**Table 6**) [11, 18, 37, 38] shared a common theme—a "measure" of the U.S. for two or more years within the 2000–2010 timeframe using a composite value derived from varying economic, social and environmental indicators (**Figure 4**).

Two of four comparisons of well-being measures focused solely on the U.S. ranking within a global context. For these indices, the U.S. generally scored higher than the HWBI for well-being. Conversely, the HWBI tracked closely with Gallup [23] and Social Science Research

Domain	Indicator	Metric
Connection to Nature	Biophilia	Spiritual Fulfillment
		Connection to Life
Cultural Fulfillment	Activity Participation	Performance Arts Attendance
		Rate of Congregational Adherence
Safety and Security	Actual Safety	Loss from Natural Hazards
	Perceived Safety	Community Safety
Social Cohesion	Attitude Toward Others and the Community	City Satisfaction

Table 5. List of domains and indicators affected by metric bias.

Source	Index name
Gallup-Healthways	Well-Being Index
Social Science Research Council	American Human Development Index
Sustainable Society Foundation	Sustainable Society Index
United Nations Development Program	Human Development Index

Table 6. List of independent national scale indices used to test the fidelity of the HWBI.

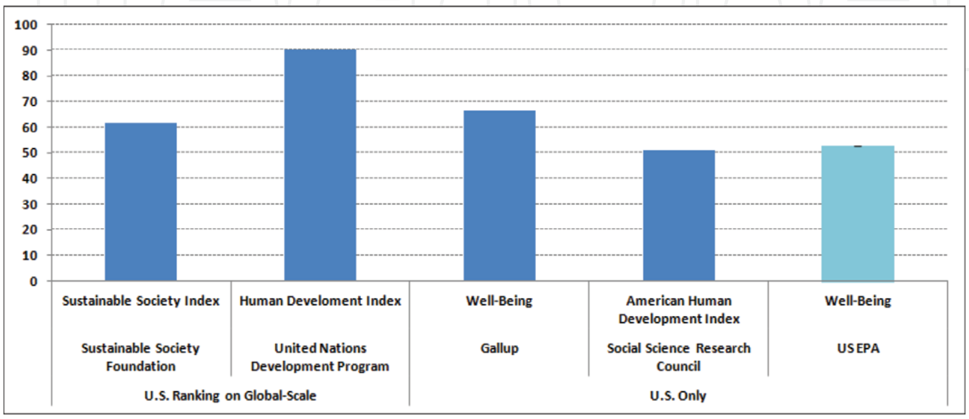

Figure 4. Average well-being type measures for four national indices and US EPA's HWBI—based on reported 2000–2010 results. The calculated error for the HWBI is <1.

Council's American Human Development Index (AHDI) [37], both indices which focused on the United States. HWBI calculations used both subjective and objective metrics, which did not extensively overlap with subjective measures used in Gallup or objective measures used in AHDI.

The HWBI performed most similarly to the Sustainable Society Foundation's Sustainable Society Index (SSI) [33], the only other composite index calculated using a more holistic TRIO-like approach (**Figure 5**). The average environmental well-being measures were almost identical between the two indices. The Gallup index is comprised of six indicators that were available for this review. Mean indicator scores from Gallup (2008–2010) and mean domain scores from the HWBI (2000–2010) were compared. The relative scoring assigned to each of the HWBI and Gallup components are depicted as a tree map (**Figure 6**). This disassembling of the indices focuses on the similarities and differences among the index's components that contribute to the respective well-being index.

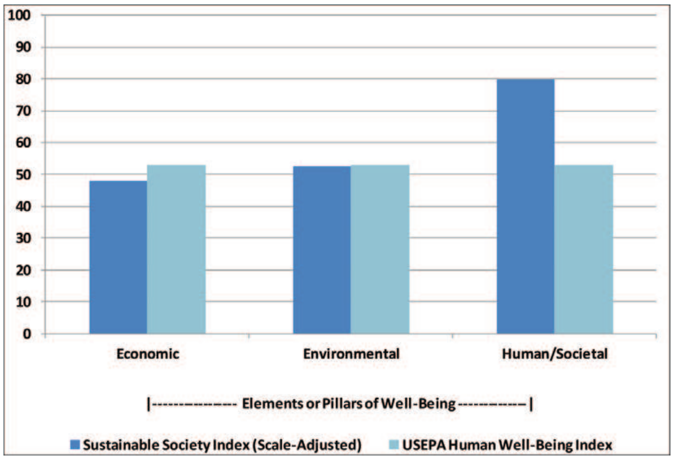

Figure 5. Total Resources Impact Outcome (TRIO)-like measures used in the Sustainable Society Index (SSI) and HWBI calculations.

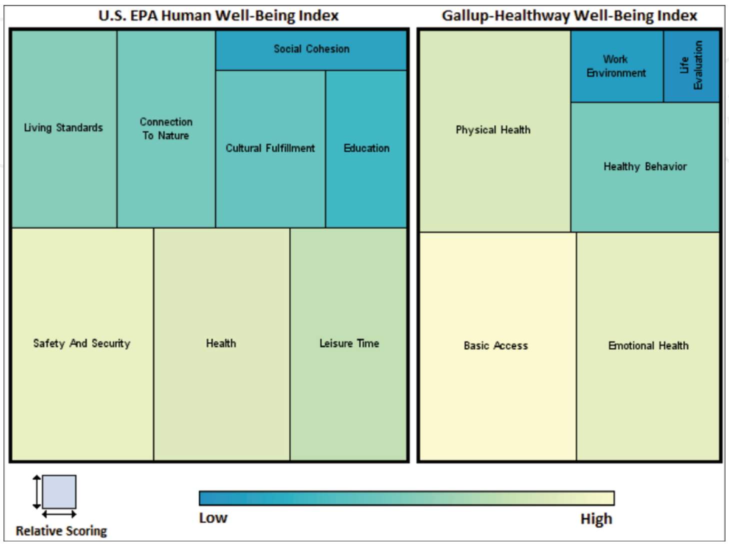

Figure 6. The relative scores (scale 0–100) of Gallup Healthways Well-Being indicators and the HWBI domains.

2.4. Well-Being in the context of TRIO

The HWBI approach generates a measure that characterizes the general state of well-being contextually based on the economic, environmental, and social drivers. Data quantifying social, natural and built capital provisioning were collected and summarized describe the relationships among service flows to overall well-being [28]. To construct well-being as a TRIO measure, service indicators for the states with the highest and lowest HWBI scores were visualized along with the county-level well-being gradient for each of the two states (**Figure 7**).

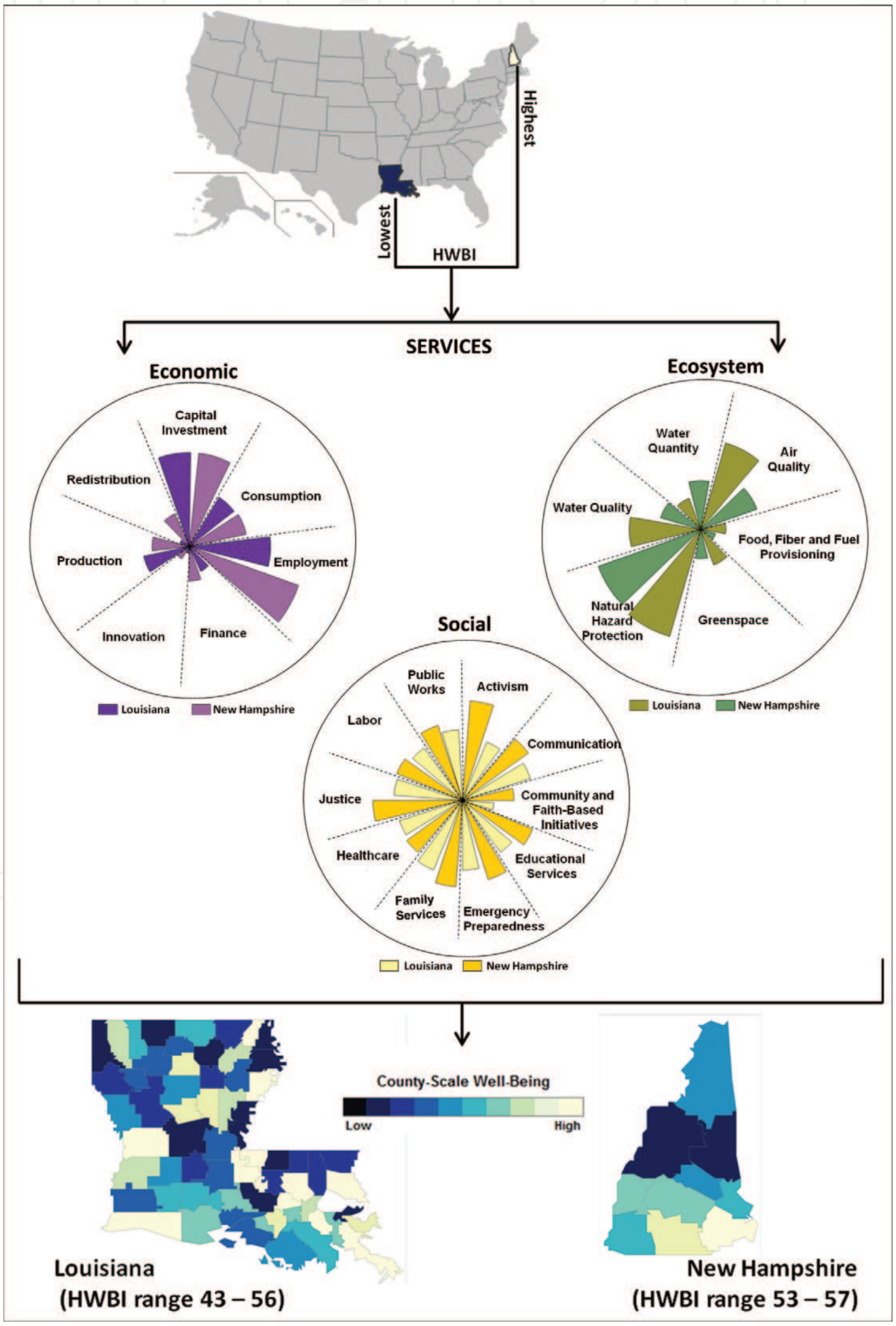

Figure 7. Hierarchical view showing the provisioning of state-level services and county HWBI gradients for states with the highest and the lowest HWBI.

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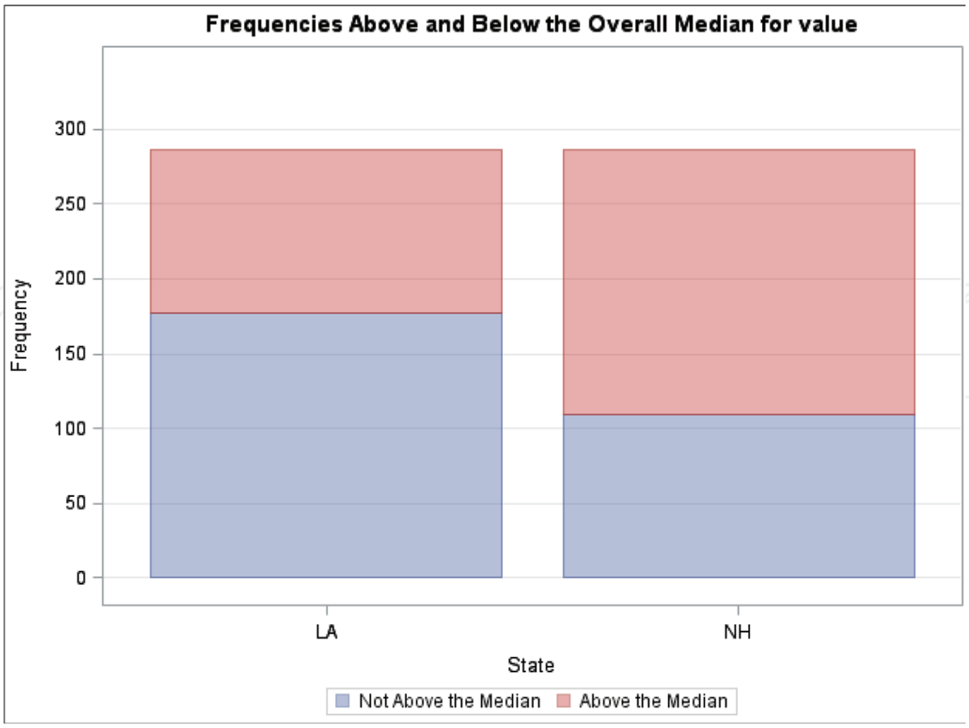

Figure 8. Median two-sample test showed a significant difference ($\chi^2(1, N = 253) = 20.6021$, $p < 0.0001$) for services provisioning between states with the lowest and highest HWBI.

Differences across annual HWBI values (2000–2010) for the states reported with the highest and lowest well-being were significant ($t = -14.96$, $p < 0.0001$) as were, the state-scale services provisioning values ($t = -2.43$, $p < 0.0015$). The overall difference in the number of service provisioning scores that fell either above or below the median value was significant between the states (**Figure 8**). Ongoing research will seek to develop service-to-domain relationship functions from which alternate HWBI outcomes may be forecasted based on changes in the provisioning of reported services and services interactions resulting from decisions.

3. Applications of HWBI to subsets of U.S. population

3.1. American Indian and Alaska Native (AIAN) Populations: Transferability of the HWBI framework

The transferability of the Human Well-being Index (HWBI) to a specific population group, inclusive of American Indian Alaska Native (AIAN) and large tribal populations, was evaluated based on the applicability and integrity of the HWBI framework and available population-specific metrics scaled to assess well-being [41]. HWBI values were calculated for the AIAN population and large tribal groups for the time period covering 2000–2010 following the identification of potential modifications needed to produce reasonably defensible well-being assessments. A review of data availability for AIAN HWBI assessments revealed that the majority (>80%) of the data available for a national AIAN assessment were specific to the target population, while the remaining data were derived from the general U.S. population. Despite the utilization of non-target data, The AIAN well-being signature was distinguishable from the U.S.

HWBI, despite the inclusion of non-target data, indicating that the HWBI approach is transferable. Although the HWBI framework, as designed, is intended to be used for a variety of spatial scales and demographic groups, the structural utilization is dependent upon the availability and quantity of quality data.

Evaluation of the transferability of the HWBI framework to AIAN population groups was based on the relevancy of domains used to describe well-being; the appropriateness of the metrics used to quantify and qualify the indicators; and the robustness of the metric data available. Alternative metrics were suggested to better capture aspects of Native American well-being where appropriate. As determined by the availability of data, metrics in the U.S. HWBI framework were categorized. Available data were used in an application of the existing HWBI for AIAN populations and large Tribal Groups for the time period covering 2000–2010.

Comparative analyses were performed to assess the integrity and relevancy of the HWBI construct for estimating the national well-being of the AIAN population. The domains, indicators and metrics underwent an additional review to ensure that the measures were relevant to the AIAN population and that the available data were adequate and comparable to U.S. values. Three primary criteria were used to review and accept metrics for inclusion: (1) metric was relevant to the AIAN population and data were available; (2) metric was relevant but no data were available; and (3) metric was not relevant to the AIAN population. Metrics were categorized based on results stemming from review of the related data (**Table 7**), and where appropriate, suggested alternative metrics were identified.

Approximately 65% of the HWBI metrics were classified as Category I, II and III with AIAN or AIAN-mixed population data available to assess measures at the annual scale (**Table 7**). Thirty-nine percent of the Category I metrics had tribal-specific identifiers. Decadal AIAN-mixed population data were available for 19% of the metrics in the HWBI framework (Category IV) [41]. With only 1 year of AIAN-mixed population data available for analysis or

Metric category	Category description	Number of metrics
I.	AIAN population data suitable for annual analysis	38
(TS)	Tribal-specific population data available (Cat I)	15
II.	AIAN population data suitable for decadal analysis and AIAN-mixed population data suitable for annual analysis	4
III.	AIAN-mixed population data suitable for annual analysis; AIAN population data unavailable or not suitable for analysis	9
IV.	AIAN-mixed population data suitable for decadal analysis with more than 1 year of data available; annual AIAN-mixed population data not suitable for analysis; AIAN population data unavailable or not suitable for analysis;	15
V.	AIAN-mixed population data suitable for decadal analysis with only 1 year of data available. Additional years may be supplemented with alternative data sources or measures	3
VI.	AIAN and AIAN-mixed population data unavailable for not suitable for analysis at any temporal scale	10

Table 7. Description of each of the six categories used to classify HWBI metrics based on available data for AIAN and AIAN-mixed populations.

insufficient data available for analysis, the remaining thirteen metrics were classified as Category V and Category VI. The distribution of categorized metrics across the HWBI domain indicators is represented in **Figure 9**. National AIAN and Tribal Group datasets were created by populating metric values from the most robust data available according to the metric categorization process and from existing U.S. HWBI metric data (**Figure 10**) [41].

Data gaps caused by temporal disparities across data sources were filled using a single imputation method carry-forward technique [42]. Imputed values were calculated based on existing data for the nearest year within a single population group. AIAN data were scored using the U.S. HWBI procedure [43], with minimum and maximum values being carried over from the HWBI dataset to allow for comparisons between HWBI and AIAN scores. The full suite of metrics and for those metrics (subset) for which AIAN specific data were available and U.S. general population data were not substituted were included in the calculation of HWBI scores for the U.S and AIAN populations. The AIAN and tribal-specific domain and HWBI scores were calculated according to the methods described for the U.S. HWBI [44]. Results from the U.S. domain and HWBI calculations were compared to results for AIAN populations.

Results from the analysis examining the differences between U.S. and AIAN HWBI and domains scores based only on metrics for which AIAN specific data were available are shown in **Figure 11**. The Connection to Nature Domain was not included in the analysis because no AIAN specific data were available. Both the Education and Social Cohesion domains scored

Domain	Indicator	Metrics								
Connection to Nature	Biophilia	VI	VI							
Cultural Fulfillment	Activity Participation	IV	V*							
Education	Basic Educational Knowledge and Skills of Youth	I	I	I						
	Participation and Attainment	I	I	I	V					
	Social, Emotional and Developmental Aspects	I	I	I	IV					
Health	Healthcare	I	VI							
	Life Expectancy and Mortality	III	III	III	III	III	III	III		
	Lifestyle and Behavior	I	I	I	III					
	Personal Well-being	I	I	IV						
	Physical and Mental Health Conditions	I	I	I	I	I	I	I	I	I
Leisure Time	Activity Participation	I	IV							
	Time Spent	II								
	Working Age Adults	I	II	IV						
Living Standards	Basic Necessities	I	I							
	Income	I	I	IV						
	Wealth	I	I							
	Work	IV	IV							
Safety and Security	Actual Safety	I	I	III	VI					
	Percieved Safety	V								
	Risk	VI								
Social Cohesion	Attitude Toward Others and the Community	II	IV	IV	VI	VI*				
	Democratic Engagement	I	II	IV	IV	IV	VI			
	Family Bonding	I	IV	IV						
	Social Engagement	I	I	VI						
	Social Support	I	V							

Figure 9. Distribution of metric categories within the HWBI framework for AIAN assessments. Category I metrics shaded lighter gray indicate tribal-specific data availability; *an alternative metric is suggested.

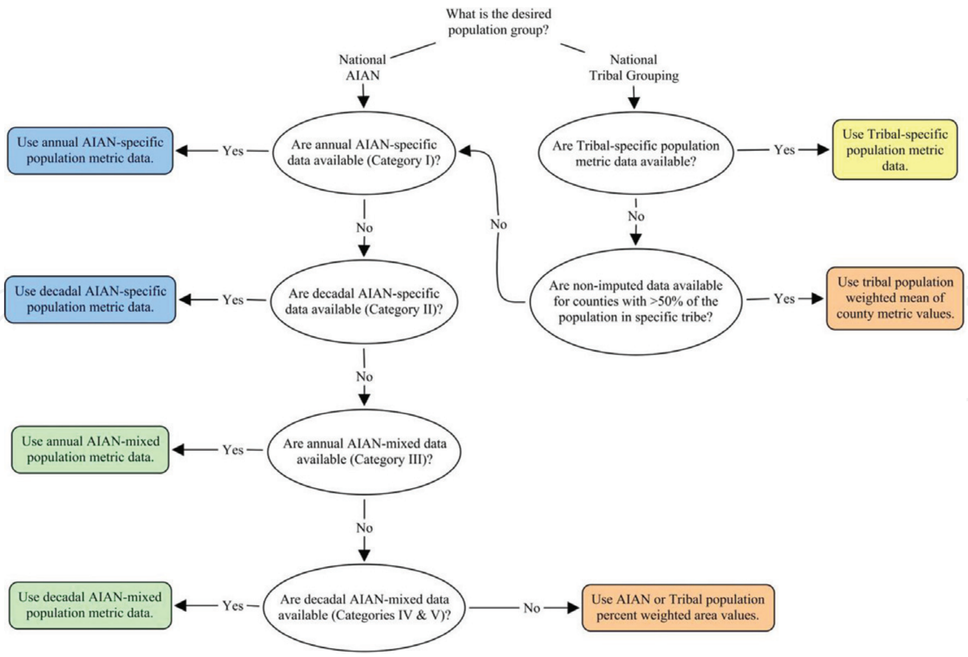

Figure 10. Process for selecting the most robust AIAN and Tribal Group data available for HWBI assessments.

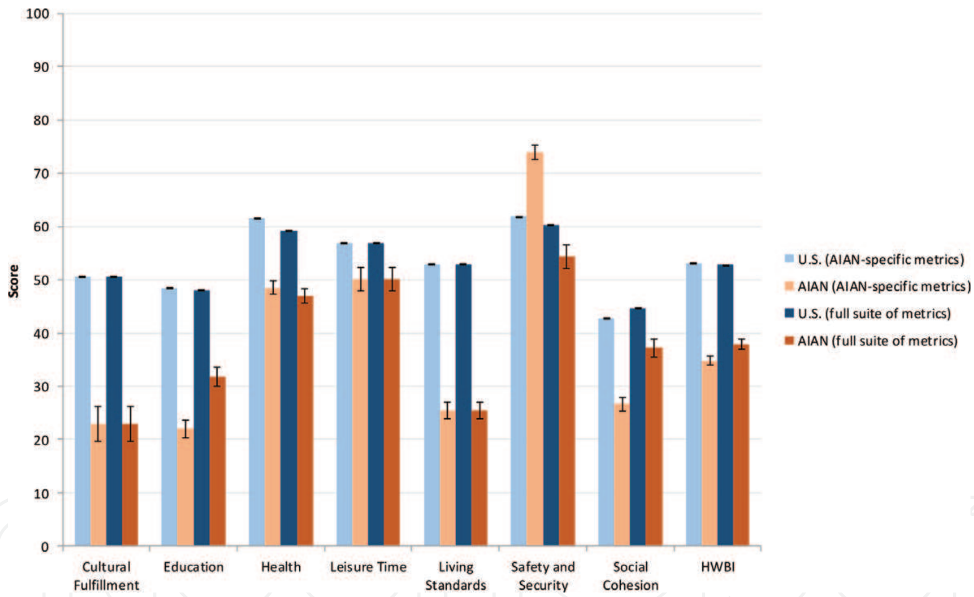

Figure 11. Comparison of U.S. and AIAN domain and HWBI scores based on full suite of framework metrics and those specific to AIAN populations only.

significantly lower for the AIAN populations when only AIAN specific metrics were used. The AIAN population overall HWBI score was also slightly, but significantly lower than the HWBI score calculated using U.S. general population data substitutions. However, Safety and Security domain scores based on AIAN specific data were significantly higher than all other calculations for this domain.

The number of metrics with tribal specific data for the 38 Tribal Groups was examined and the seven Tribal Groups with the greatest percentage of tribal-specific (TS) data (>40% of the metrics) were selected for HWBI score comparison. Included in the analysis were the following

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Tribal Groups: Alaskan Athabascan, Blackfeet, Chippewa, Eskimo, Menominee, Navajo and Sioux. Each of the seven Tribal groups was compared to the county HWBI scores for which the counties had greater than 50% of the population identified as tribal-specific.

The Tribal group HWBI scores were all significantly lower than their corresponding county-level HWBI scores, with the exception of the Eskimo Tribal group and Wade Hampton County, AK (**Figure 12**). For values with >50% TS populations, Tribal HWBI assessments differed from county HWBI values. Since the signature was unclear, the county level values could not be deemed as an appropriate replacement for tribal level values where the tribes represented the majority of the county population. Hence the need for more publicly available TS was reinforced. Similarities between the Eskimo Tribal group and Wade Hampton, AK HWBI scores are based on a large degree of imputed data at the county level; however, the characteristics of this county could be more similar to the Eskimo group since the largest population of Eskimos reside in Wade Hampton, AK. This distinction cannot be verified because of the lack of TS data [41].

The Cultural Fulfillment domain score was recalculated using a suggested alternative metric. The Performing Arts Attendance metric was replaced with the previously suggested measure, Ceremonial Attendance and a new Cultural Fulfillment domain score for the AIAN population was calculated. This resulted in a dramatic increase in the Cultural Fulfillment domain and Activity Participation indicator scores. When calculated using the existing metrics in the framework, scores for AIAN Cultural Fulfillment were low compared to the U.S.; however, when a more culturally specific metric (for the Activity Participation indicator) was substituted, the

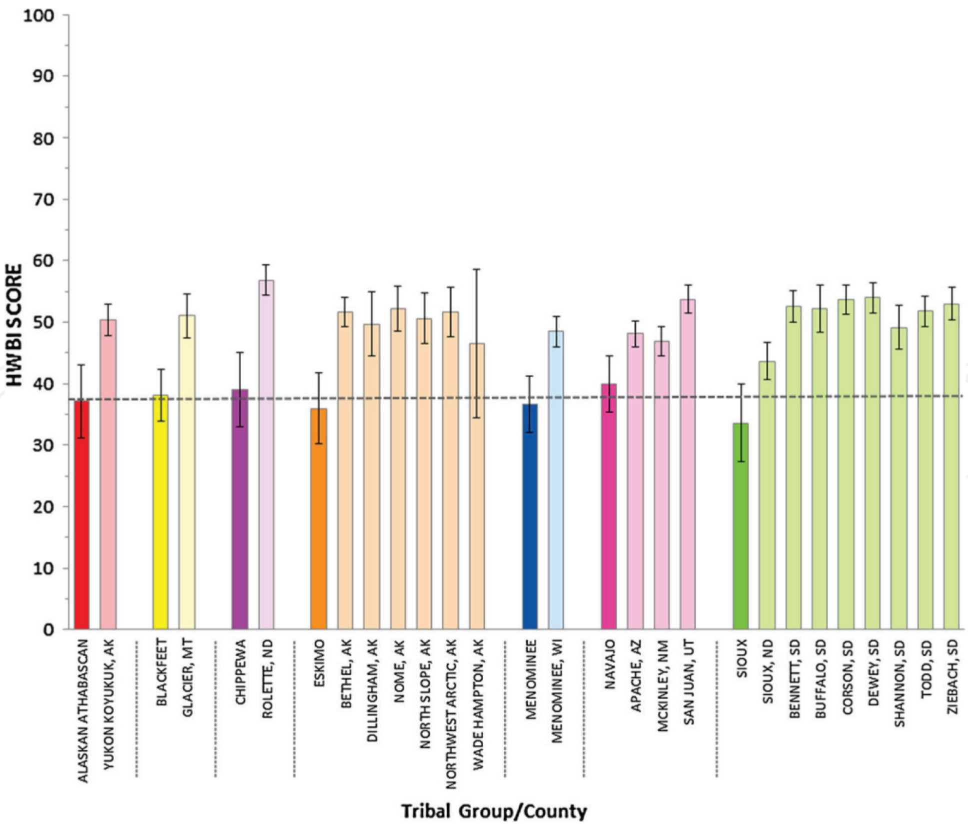

Figure 12. Comparison of HWBI scores for each of the Group C tribes compared to the scores for the counties with >50% of the population specific to the Tribal group (2000–2010). The AIAN HWBI is indicated by the dashed line.

AIAN domain score was much higher than national values [41]. This dramatic increase is the result of two factors. Only two metrics are used to describe the Cultural Fulfillment domain; therefore, this domain's scores are heavily influenced by changes in metrics. Secondly, both the original and alternative metrics in the Cultural Fulfillment domain had AIAN values that fell outside of the range of U.S. HWBI values.

The HWBI may be less sensitive at TS scales as a result of non-specific data substitutions based on the general lack of publically available data for some key areas, limited spatial and temporal resolution of available data available and inconsistent ethnic-specific identifiers in the data; however, the approach can be used to estimate well-being for Native Americans collectively with a reasonable level of confidence [41]. While the data substitution methodology utilized may the most robust method for scaling the HWBI, the limited availability of comparable metrics at smaller spatial scales and for specific demographics may prove to be problematic [12].

The results presented are descriptive in nature and are intended to characterize representative populations for which data are available; therefore, the transferability of the HWBI approach is determined by the representativeness of the data itself [45]. HWBI data are both subjective and objective and mostly generated from probabilistic and complete surveys. The transferability of the HWBI approach was determined based on the reliability of the data rather than the target populations themselves. Demonstration of the transferability of the approach was demonstrated on data acceptance criteria and data specificity; however, the approach could be better demonstrated with a full suite of data specific to the target population. Metric level flexibility in the index structure could potentially accommodate transferability issues as determined by the end users [41].

3.2. Children's Well-Being

Well-being on a community scale is both an important and nuanced topic. In contrast to personal well-being, community assessment is very much a generalized amalgamation of various groups across space that represents the average of all individuals. While providing a workable approximation of the community, there will inevitably be populations within the community that are at the extremes. Similarly, there will be populations at greater risk of loss in the event of perturbations. Groups such as these, referred to as sensitive populations, are of significant value to a community if the attempt is to raise overall well-being. The old adage, "a chain is only as strong as its weakest link," describes well the importance of identifying these "weakest links" for the betterment of the community as a whole.

Among the populations generally regarded as sensitive; elderly, children, minorities, poor, etc., children are the most unique due to their dependence. By law, people under 18 years old do not have legal rights and are, in most cases, completely dependent on the decisions made by their parents. By itself, this dependence makes them a sensitive population, but this is increased further due to both their physical and emotional development during childhood. Impacts of trauma and exposures are potentially more extreme and long lasting in children [46–48]. Behaviors of their parents as well as exposures to views and sentiments within the community will drive the development of future behaviors. On the same token, environmental exposures will impact future health. In both aspects, the present well-being of the community is shaping the future well-being.

Both age and level of autonomy are initial considerations in children's well-being. When it comes to assessment of well-being distinct from the parental influence, there is, of course the question of how much influence the parents exert based on age of the child and the general status of the family. When community level measures are used, such as average household income, it becomes theoretically necessary to identify alternative measures that may capture the premise of income as a total community measure versus one specifically related to a dependent child. If the concept does not fit children in a similar fashion, alternatives must be developed. Confounding the theoretical shift from total community to children further is age-range. Younger children are far more reliant on their parents and likely to mimic views and attitudes conveyed to them through their parents [49]. Older children, beginning around age 11, will begin to push back against their parent's views and ultimately begin to establish their own views and identity as they approach independence.

In order to adapt the HWBI to children, it is necessary to identify the appropriate measures while maintaining the theoretical intent of the index. In other words, metrics in the adaptation should measure the same concept as the original. To accomplish this, a decision flow chart was created (**Figure 13**) to guide metric decisions. In the assessment of metrics for retention, the dependency of children on their parents creates a major theoretical hurdle. Since children are reliant on their parents for support across all well-being domains, it is easy to assume that measures of adult well-being will translate down to children. The problem with this assumption is that children are a unique group with unique vulnerabilities often not aligning with those of adults. These vulnerabilities are considered in the construction of this index adaptation within each domain of well-being.

The end result of the adaptation is a set of eight domains matching those of the original HWBI, three changes of indicator terminology, and the adjustment of 42 metrics to accommodate data availability and theoretical differences between an index meant to represent an entire population and one specific to children. While many of the metrics are altered, they are all able to

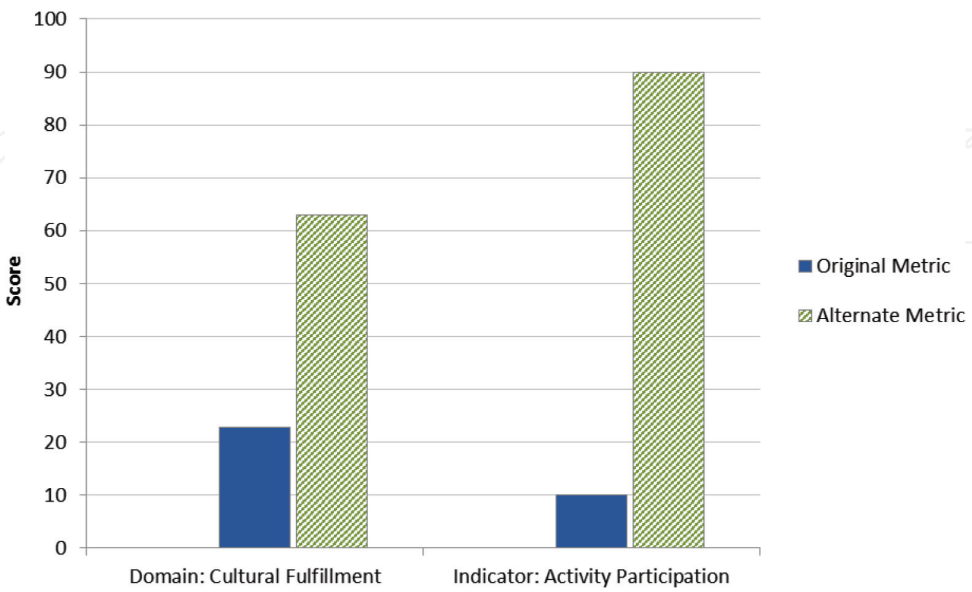

Figure 13. Comparison of the results of using an alternative metric for the activity participation indicator in the cultural fulfillment domain for AIAN populations.

maintain a structure and premise closely resembling the original HWBI [50]. All of these changes are made based on data availability and the extent to which the original metrics assess children or family specific characteristics.

The national domain scores, shown in **Figure 14**, highlight the disparity that exists between the domains in children's well-being. There is an obvious discrepancy in scores, with Cultural Fulfillment and Connection to Nature falling well below the median of other domains. To be fair, these two domains also have the least number of measures contributing to their score, with a collective four metrics and two indicators between them, whereas no other domain has less than three indicators and seven metrics. This lack of data points to two likely scenarios, however. On one hand, there is a serious lack of data collected within these domains of well-being, which points to an area of necessary development in the future of well-being assessment if it is to be considered truly a holistic concept. On the other, even given data constraints, this index can be used as a comparative tool for assessing childhood well-being between counties and through time. As interest continues to increase, hopefully enhanced collection tools and techniques will aid in providing additional data in areas where they are currently lacking.

Spatial patterns in Children's Well-Being are another important consideration in the development of an index. Looking at both overall scores (**Figure 15**) and domain scores (**Figure 16**), regional patterns are evident. The highest well-being values exist in the much of the upper Midwest and in the Southeast. The lowest scores are in parts of the deep South, the Southwest, and along areas of the East Coast. Domain scores also display a similar clustering pattern with much of the higher scoring counties in the Northern states. Again, worth noting, is that economics do not dominate this index. Evidence for this can be seen when comparing the Living Standards domain, where all of the economic metrics are held, to the overall CWBI. In the Northeast, the Living Standard domain is higher, whereas the overall CWBI for that same region is relatively low, likely driven by lower values in the Connection to Nature, Leisure Time, and Safety and Security domains (**Figure 17**).

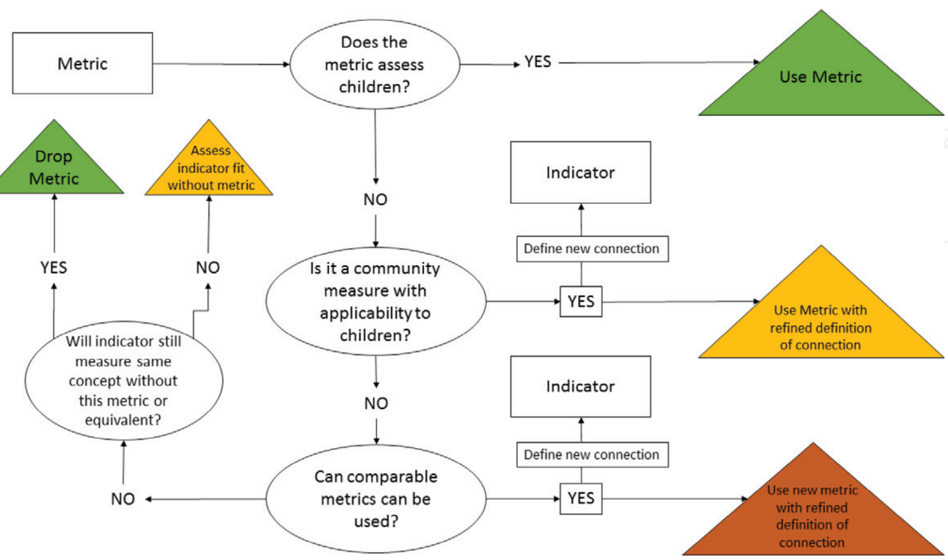

Figure 14. Decision flow chart for metric adaptation in children's well-being index creation for the original HWBI. Start with metric in order to minimize changes at indicator or domain level. Move to right indicates metric retention, while move to left indicates dropping of metric.

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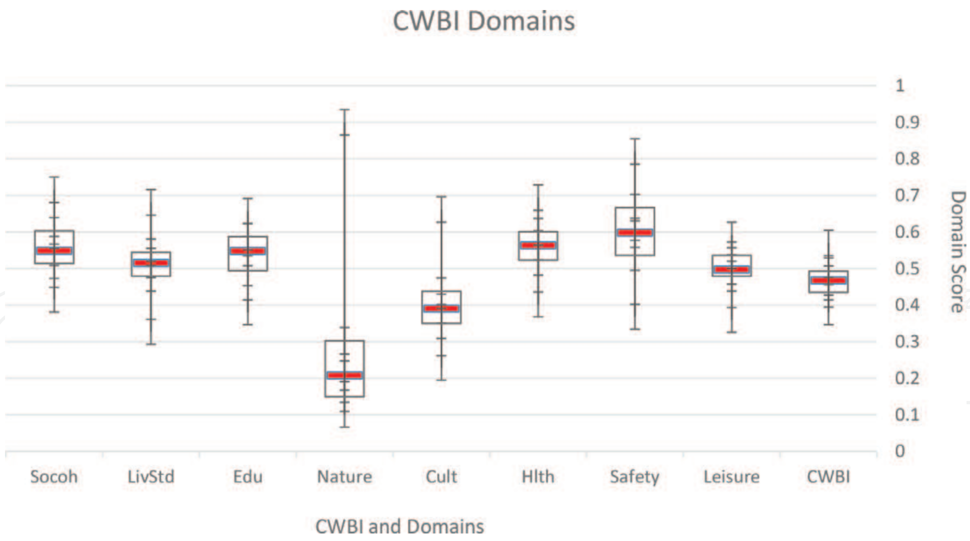

Figure 15. Children's Well-Being Domains box plot. Center lines represent the median of each domain, while the boxes bound the 1 st and 3rd quartiles. Lines extend to the minimum and maximum values for each domain as well as the overall CWBI.

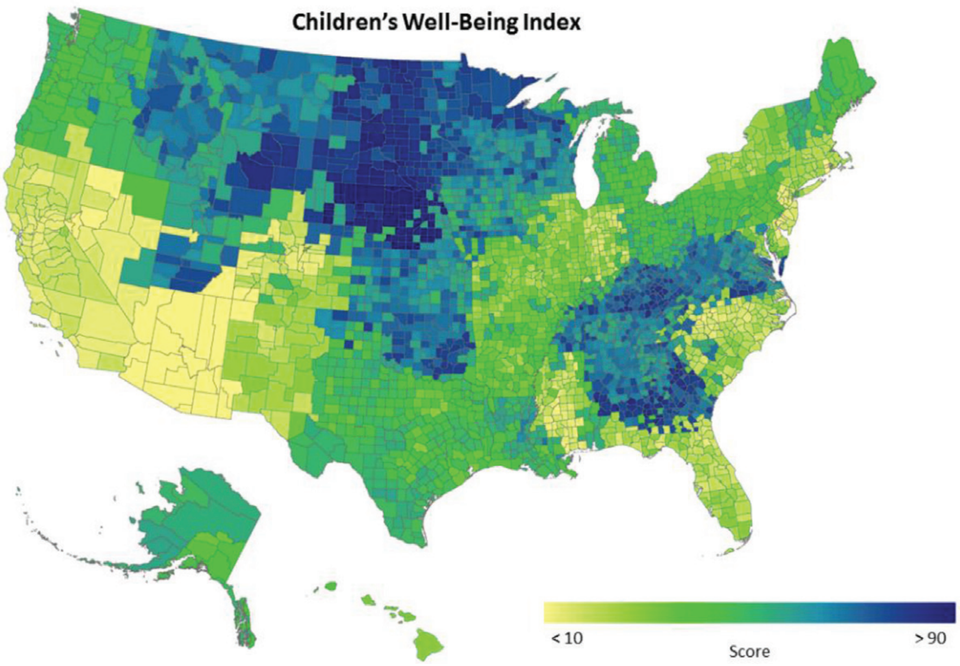

Figure 16. Children's Well-Being Index scores for all US Counties in 2010.

While there are challenges and likely shortcomings in any adaptation of a well-being index, the task is still necessary as a means to identify how sensitive populations are faring in comparison to the general population. In the case of children, not only is this important for current assessments of a sensitive population, but it may also serve as a good predictor of future trends. Investing in children's well-being is akin to investing in the future of a community and carries significant weight.

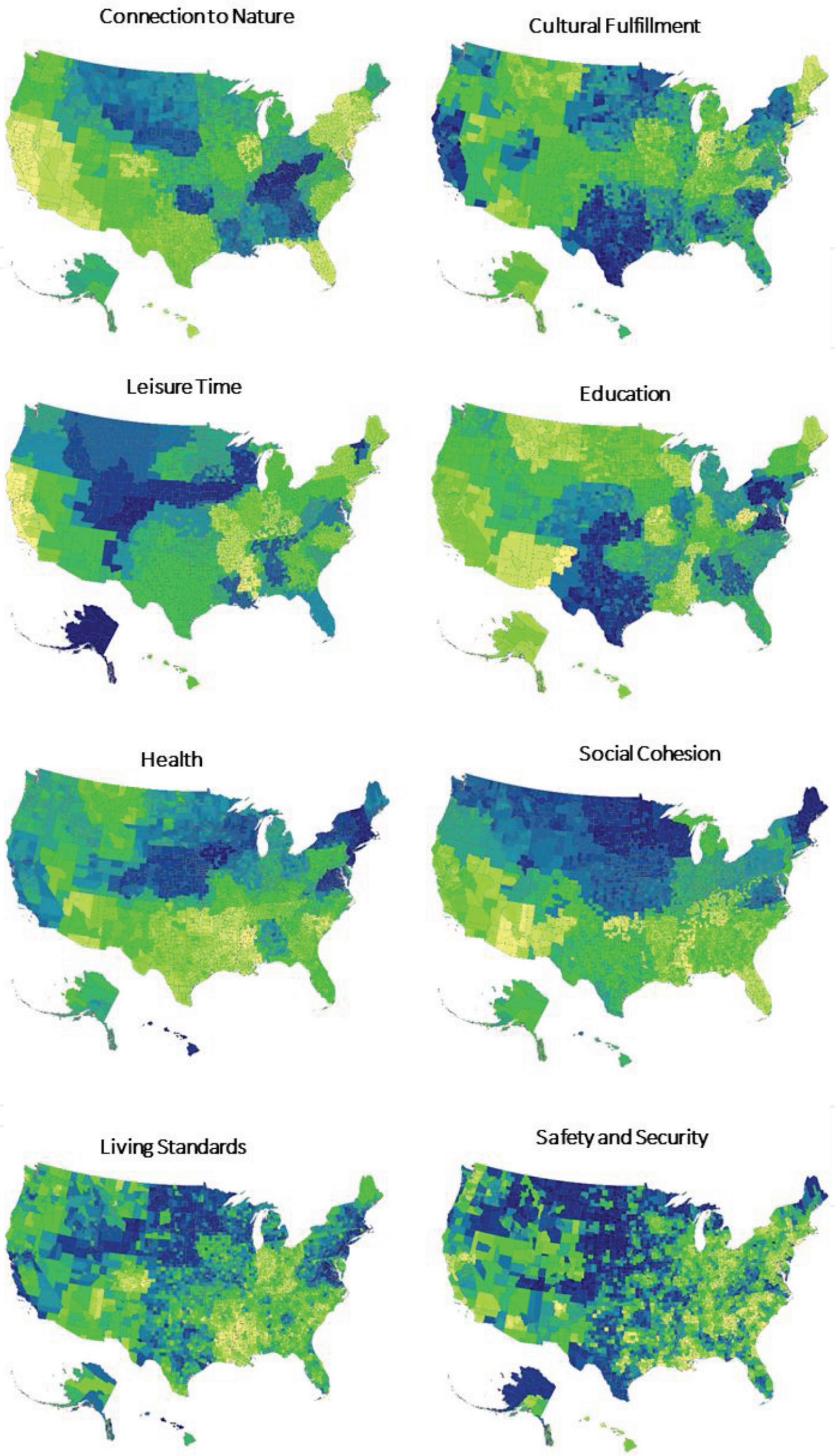

Figure 17. Eight domains of Children's Well-Being shown for all US Counties in 2010. Blue represents areas of higher well-being (darker = better) and yellow represents lower well-being (lighter = worse).

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4. Community HWBI—A matter of scale

As discussed previously, the scale at which well-being is assessed makes a difference in its interpretation as an outcome measure. Individual measures of well-being, while the gold-standard, are not really useful from a policy standpoint. Just as the elements leading to well-being are distinct to the individual, so too are the community features that contribute to each person's perspective of their environment. Simply put, what makes one person happy may not make another happy. Because of the unique perspectives contributing to overall well-being, a community approximation is required to provide feedback to decision makers.

Assuming personal well-being is both unrealistic to measure and aggregate in a meaningful way for community leaders, the question then becomes how to attain data that represents needed metrics and scale to be translated into policy. This begs the question, what constitutes an ideal representation of community from a well-being perspective? The answer to this question is that it depends on the needs of the community and additional information will always be helpful. To make sense of this spatial question, it is helpful to look at human communities in a manner similar to natural communities in that none exist in isolation. The attributes of one community will be dependent on both the internal structure of the community in addition to the attributes of surrounding communities. This does not mean that a community's well-being will be high just because a neighboring community is doing well. With the highly fragmented social landscape of the US, the opposite is more likely to hold true.

In order to assess well-being at a variable scale, it is necessary to interpolate data using relationships both within and outside of defined community boundaries of interest. This allows for local patterns to be independent, yet reflect the trends occurring at the larger scales. The Model for External Reliance of Localities IN Regional Contexts (MERLIN-RC) accounts for both data lacking in smaller geographies as well as the challenge of aligning these geographies in a way that enhances specific analyses [50]. The model uses inductive statistical methods to assemble measures at multiple spatial scales and ascribe these estimated values to a smaller geography according to both same-scale and between-scale associations amongst the measures. These correlations, or deviations, between the measures ultimately become conversion factors that allow for scaling and interpolation. Distinct from other methods of imputation, no assumptions based on number of neighbors or distance are made using this model. The data produced by the model is created from a combination the deviation function and the existing data in the smaller geography.

The concept driving MERLINs development is that correlations between variables at a specific location and level of geography can be tested and applied to other scales for interpolations [51, 52].The statistical model, based on the use of a principal components analysis (PCA), has proven to have stability at multiple scales and to be adaptable in instances where factor loadings are different at these multiple scales. [52–54]. Moreover, the relationship between variable sets at various scales can provide important details pertaining to local distributions of these characteristics. For the model to perform as intended, the smaller spatial units, or nested geographies, must exist completely within the larger spatial unit. **Figure 18** provides an

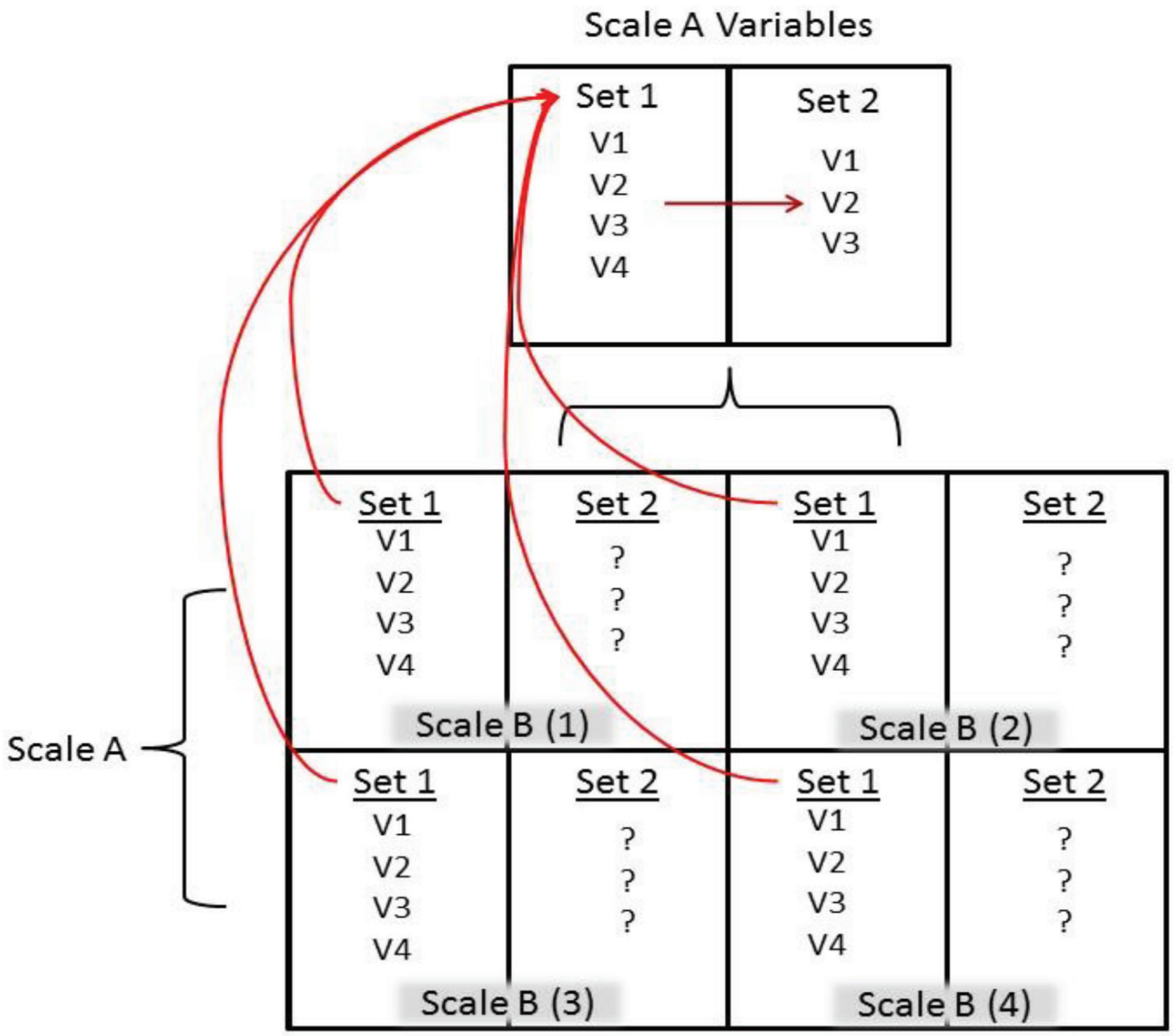

Figure 18. Diagram representing the methods for scaling variable sets at multiple levels of geography.

example of how the distribution of data would work between a larger geography (scale A) and a smaller, nested geography (scale B). The model will only work if census tracts falling exclusively within a county are used or block groups within a census tract, and so on.

In the context of well-being, MERLIN offers an alternative to kriging or other forms of spatial or temporal imputation. Instead of using only neighboring years or geographies to estimate community measures of well-being, the data are allowed to reflect directly the composition of the population and how this plays out on a larger scale. As mentioned previously, sharp divides in the social and economic landscape are normal and many spatial estimators do not fully represent this patchwork accurately. Dealing with the issue of scale is a critical step in shifting the research focus of well-being from a personal and purely subjective concept to something more widely recognized as a community-level concept. Making this shift will require a model that allows data gaps to be filled in a way that represents the composition of the community.

5. Community HWBI—utilities and tools

5.1. Community-specific HWBI

In many cases, indicator tools supply information related to a specific place. This spatial specificity often makes it necessary for stakeholders to supply data to make indicator results more relevant at spatial scales of interest (e.g. town, neighborhood, community). By their very nature, indicators and indices can be labor intensive to generate—the amount of effort needed to acquire and prepare data to quantify an index can present a barrier not easy to overcome. Therefore, it is important to offer potential users a way to easily introduce information that is locally relevant while maintaining the integrity of the index framework.

A desktop tool has been developed to accept locally-held data so stakeholders may investigate various aspects of the HWBI and calculate a "custom" index (**Figure 19**). Using Microsoft® Excel as the platform, users are offered a familiar interface in which to work and an intuitive form-based input feature to accept individual data values to quantify the HWBI metric foundation. Average 2000–2010 U.S. county-level HWBI indicators serve as baseline information. Users have the option to supply all or a portion of the metric data needed to re-calculate the index and related indicator and domain scores. Based on introduced data, the results represent either an integrated suite of HWBI measures or wholly new ones. Since the HWBI is designed to respond to changes in economic, ecosystem and social environments, an interactive dashboard is provided, populated with calculated index, domains and indicators based on new and existing data. Users can investigate how the indicators perform under increasing or decreasing scenarios applied to the availability or flow of select community service categories. The dashboard also allows users to prioritize importance of one or more of the HWBI domains to reflect community values. The HWBI data tool and companion dashboard is intended to help stakeholders increase their understanding about the relationships between social, economic, and environmental conditions and changes in those conditions that may influence well-being in their community.

5.2. Interoperability and reuse—"The Plug-N-Play" factor

To better assist communities and other stakeholders in addressing sustainability issues, it is necessary to create utilities that integrate data, structures and models to build holistic decision-platforms. However, most software applications and tools are created as unique, stand-alone products that are limited in scope and specific data requirements. As a result, many sustainability tools designed for public use go underutilized or unrecognized. The HWBI is designed specifically for use in the development of decision-support tools. Its framework can absorb the variety of adaptions or modifications that may be necessary to prove useful in a wide-range of applications. Casting the HWBI into an interoperable framework creates a highly flexible integration solution for using the index and component indicators in decision-support tool development.

The concept of interoperability is a software development paradigm that embraces the creation of self-contained software modules that communicate, execute program processes and transfer data among each other in a fashion requiring the user to have minimal knowledge of the

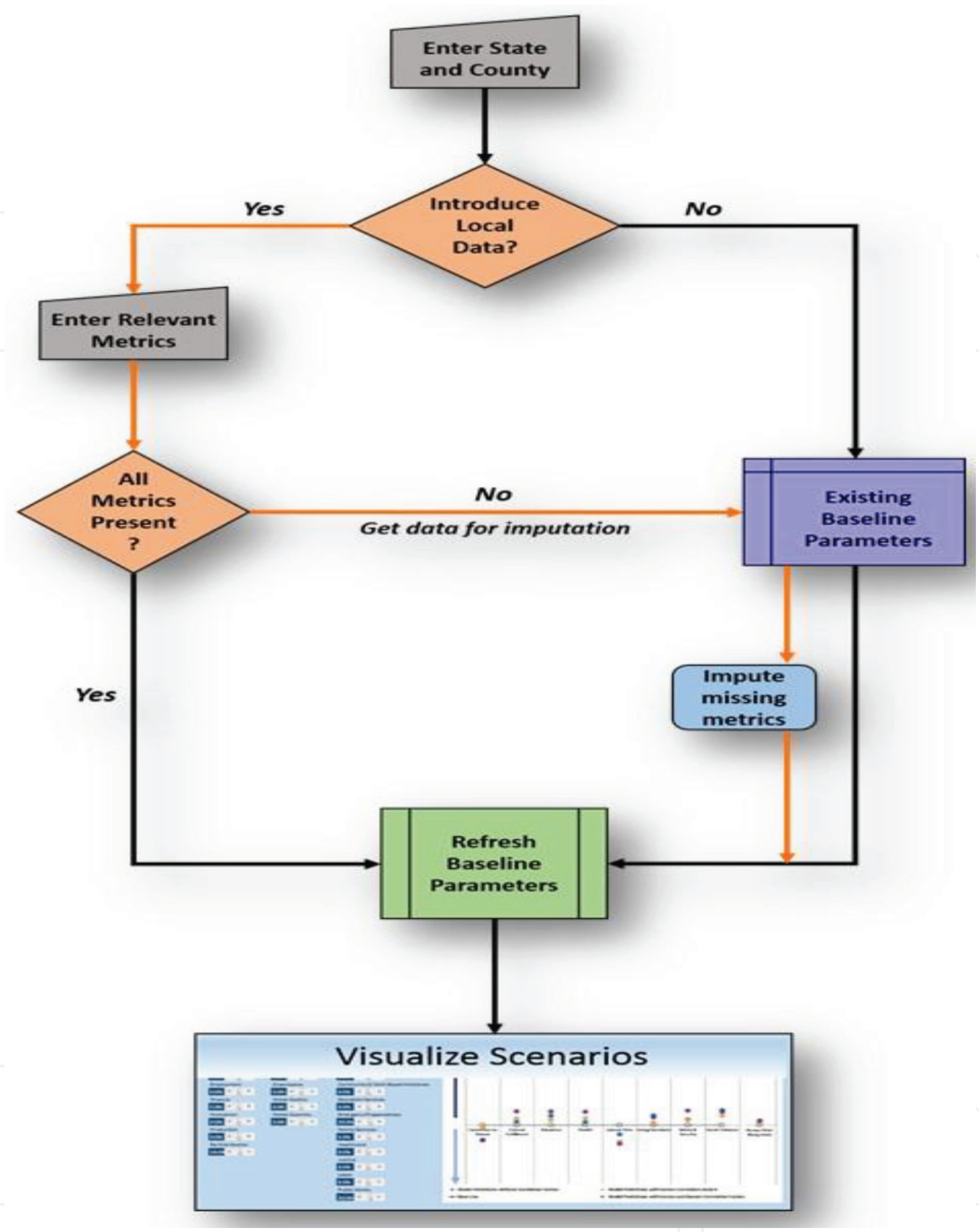

Figure 19. Decision pathway diagram governing the flow of information in the local-scale Human Well-Being Index (HWBI) calculation tool.

unique properties of each module [55]. Interoperability is an emerging set of software development best practices that leverages web technologies to promote access and transparency. Considering interoperability in the development of end-user tools adds value by creating a utility that is reusable in a variety of applications. However, the availability of flexible, modular, component-based software is largely lacking in environmental sciences, particularly in model development and data access. This gap inhibits wide-scale use of developed tools by decreasing information discovery, transparency and accessibility [56].

A reuse and interoperability demonstration project was created using the HWBI [56]. Representational State Transfer Application Programming Interface (REST API) standards provide the basis for developing on-demand information delivery tools. For the HWBI, two REST API endpoint services are available. The *"locations"* REST endpoint supplies base-line HWBI and related indicator result for each U.S. county. The *"calculators"* endpoint provides calculation information to accept user-supplied inputs for displaying HWBI scenarios. Both REST API endpoints return metadata information, as well as a complete list of input data and output values. **Figure 20** depicts the intended use of the HWBI REST API tools.

5.2.1. Demonstration tools

Envision is a GIS-based desktop tool that fosters integrated planning and environmental assessment [57]. The model uses spatially explicit environmental data and local policy rules to drive a agent-based simulation model [58]. The US EPA has demonstrated the utility of this model in place-based case study areas (Oregon, Puerto Rico, and Florida) [59, 60] to model the effects of changing land cover patterns on the provisioning of ecosystem goods and services. A more recent decision extended the model to include well-beingas a different endpoint influenced by changes land cover.

Since the Envision model framework encourages the creation of plug-in tools [61], a software plug-in was developed based on HWBI REST API inputs to replicate the services-to-well-being relationship function model described in Summers et al. [62]. This HWBI plug-in module

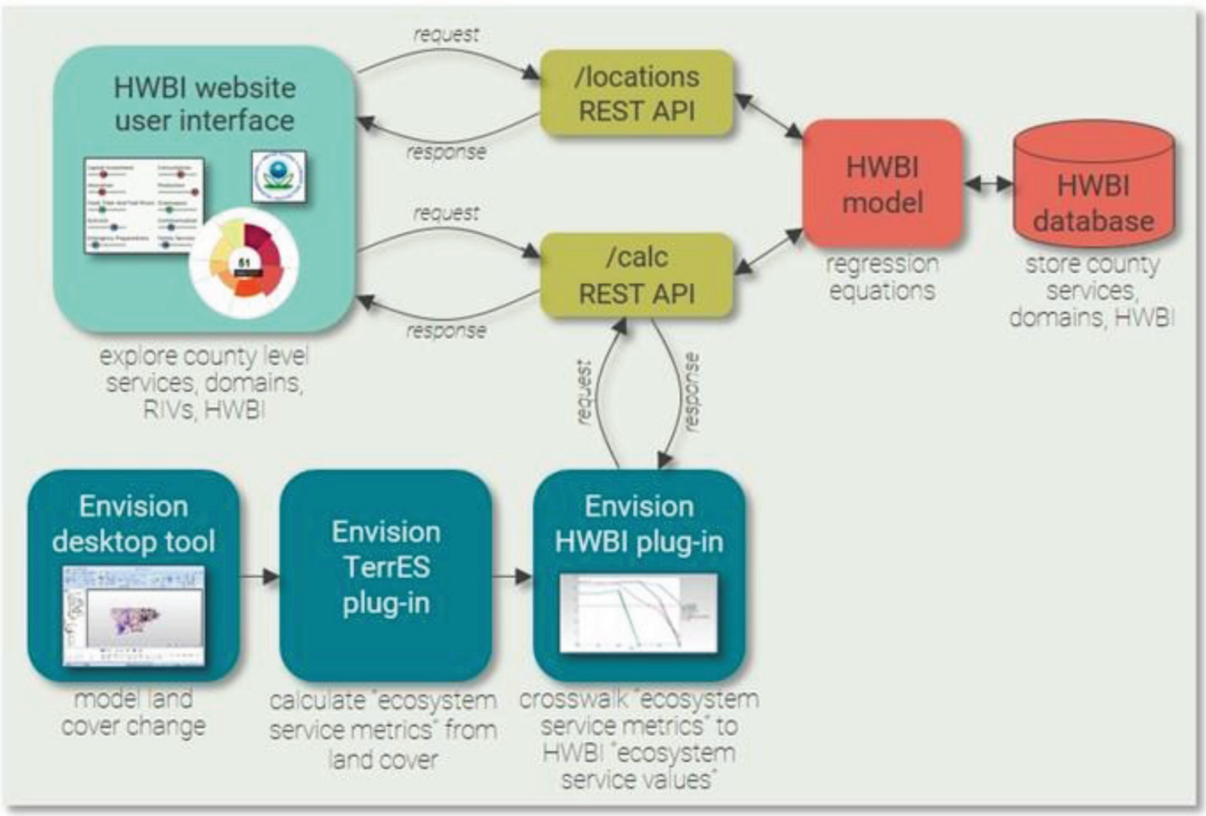

Figure 20. Overview depicting the operational framework showing the use of the HWBI REST API in web-based and desktop application development.

serves as the final endpoint in the Envision place-based demonstration. Driving the ENVISION model with REST API inputs extends model functionality and demonstrates the value of interoperability [63] (**Figure 21**). Creating HWBI REST API modules further supports the use of interoperable software design strategies and increases the utility of the HWBI as a tool.

A web application has also been created using the HWBI web services and relationship function model. This web presentation uses intuitive, interactive elements and data visualizations to encourage people to interact with the model by engaging in decision-based scenarios (**Figure 22**).

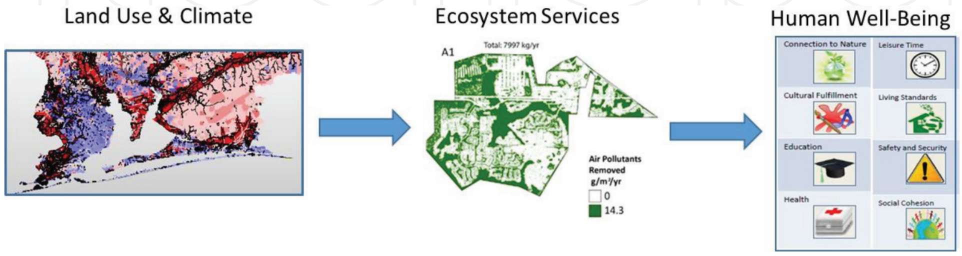

Figure 21. Simplified Envision desktop application flow diagram showing the relationship between climate and land use changes that influence human well-being through the provisioning of ecosystem services.

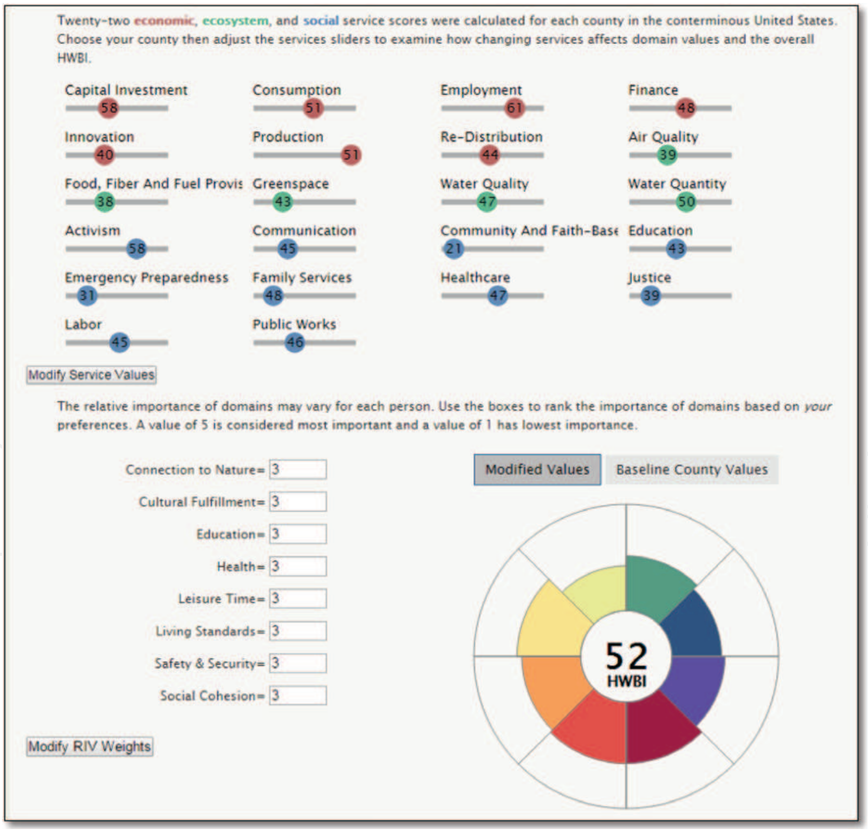

Figure 22. A snap-shot of the HWBI decision scenario demonstration application housed on EPA's Quantitative Environmental Domain (QED). The QED brings EPA scientific models to the web to promote application development transparency and application consistency.

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The application is designed to increase awareness and encourage use of interoperability software standards for tool development as well as offering a practical application of the HWBI.

An HWBI focused website houses the application (http://qed.epa.gov). As an HWBI information hub, it provides background information about the index, its development, and documentation related to the model and REST APIs to promote access and transparency. By utilizing responsive data visualizations, the website seeks to increase community engagement with the HWBI and its intended uses, introduce users to interoperability and reuse software design in context of real use cases and encourages users to explore ways the HWBI can be used to inform sustainability discussions.

6. Conclusions

The index presented here presents a measure of the influence of policies and services (environmental, economic and social) on aspects of overall human well-being [39]. These holistic interactions of social, economic and environmental drivers allow a better integration of the human condition and its relationship to service flows. This approach will allow decision makers to understand the potential impact of specific decision alternatives on the well-being of their constituencies. Coupling this type of decision scenario testing with social equity and intergenerational equity could permit the selected decisions to create more sustainable conditions for communities [40].

As stated in earlier publications, the main reason for the construction of the HWBI is to include explicit connections between human well-being and environmental drivers and services [9]. Earlier versions of well-being indices (e.g. [6, 10–27]) addressed only two of the three pillars of well-being well and either ignored the third pillar or inadequately addressed it [9]. The present HWBI described in this chapter includes important aspects of all three pillars of well-being in a balanced manner. Furthermore, the index is adjusted to the specific spatial level of the community (nation, state, county, community) based on information regarding the value structure of the community using representations of the relative importance of elements of the value structure [9].

Communities across the U.S. are examining the management of growth through sustainable development. The HWBI approach allows the U.S., states, counties and communities to assess the potential result of decisions on the long-term well-being of their constituencies. The HWBI allows decision makers to assess not only the direct impacts of their decisions (e.g., effects of economic decisions on jobs) but also to assess their indirect impacts (unintended consequences). Many earlier indices focused on the intersection of human well-being and environmental conditions rather than how they related. The HWBI represents an important advancement in this area by emphasizing the symbiotic relationships between nature, humans and economies. Rather than vilifying all human activity as being detrimental to the natural environment, the HWBI embraces that natural ecosystems provide goods and services that are essential for human well-being. Since people are the beneficiaries of sustainable solutions, it is essential that metrics reflect the dependence of humans on ecosystems.

Many problems exist in continuing to develop comparable measures of human well-being at multiple spatial scales. Primarily these obstacles include a lack of consistently available data, transparency of performance indicators and domains and cultural differences. In the construction of the HWBI, we have focused on an index that is based on indicators and domains that can be shown to clearly impact well-being. While the data necessary for the HWBI implementation are not always available at the smallest spatial scales, they can be collected and applied in a meaningful way at any scale in a meaningful way. Similarly, the value-based weighting factors (RIVs) can be collected at these smaller scales to represent a community and its demographic population structure (e.g., socio-economic groups, cultural entities). Additionally, in the construction of the HWBI, we have provided transparent information regarding the selection and performance of indicators [28–30] and the uncertainty levels associated with these values. With the exception of the connection to nature domain, some of the domains included in the HWBI and their associated indicators and metrics are those used in similar indices developed prior to the HWBI. The HWBI described here sets itself apart from other existing measures, in that: (1) it openly includes metrics associated with all three pillars of sustainability; (2) it provides clear measures of the uncertainty associated with the index; and (3) the approach is easily transferable to any spatial scale for which the appropriate information is available. Our development of the HWBI provides a significant step forward in a community's (or larger spatial entity's) ability to assess its well-being.

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