



Analyzing three pillars of sustainable development goals at sub-national scales within the USA

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ABSTRACT

America is a paradox: one of the world's economically leading countries, lagging in sustainable development (SD). Drawing on many studies, the problems caused by imbalances between the environment and economy often result in resource drains at the local level, leaving the state and local government officials to devise solutions to address such imbalances. While there are a few UN studies available analyzing this phenomenon at the state scale, no studies have observed SDGs across 3,142 localities (counties or county-equivalents) within the USA. The study categorized these SDGs into three pillars of SD: Social, Economic, and Environmental, to analyze the balance and imbalance between the pillars of SD across all states and localities within the USA. An indicator-based approach was used to measure SDGs for the years 2010 and 2015. Results confirmed the uniform distribution of overall SDG Index distribution across states, but some localities performed poorly, mainly in the Southern Region. Rank-wise, top scorers upheld balanced scores across three pillars and bottom ranks showed imbalances. Overall, the social pillar was less predominant, but the economic and environmental pillars predominated in the northern and southern parts of the nation, respectively. The outcome of the study can help collaborate and build networks, targeting clustered areas through collective actions and planning local strategies for the outliers and other localities. While localization is the key, balancing between three pillars is essential to make progress on the path of SD. Therefore, the present study can be used as a framework to prioritize SDG actions at sub-national scales.

1. Introduction

The United Nations (UN) has adopted Sustainable Development (SD) as a guiding principle to achieve economic, environmental, and social development. SD aspires “to meet the needs of the present without compromising the ability of future generations to meet their own needs and an equitable sharing of the environmental costs and benefits of economic development between and within countries.” [32].

The United Nations Millennium Declaration [73] committed world leaders to combat poverty, hunger, disease, illiteracy, environmental degradation, and discrimination against women. The UN Millennium Development Goals (MDGs) were adopted to fulfill these commitments with targets set to be achieved by 2015, but the progress was limited and uneven across countries [67,70,80]. In 2015, participating nations adopted the UN Sustainable Development Goals (SDGs) to continue the momentum generated through MDGs and guide the global SD framework further. Global 17 SDGs were implemented as a part of the 2030 Agenda with a 15-year plan to achieve these goals [71].

The annual SDG progress reports suggest that every wealthy country faces challenges to meet SDGs related to sustainable consumption, environment, and biodiversity [54–56,58]. In particular, indicators of progress for SDG 12 (Sustainable Consumption and Production), 13 (Climate Action), 14 (Life below Water), and 15 (Life on Land) suggest that OECD (Organization for Economic Co-operation and Development) countries are far from reaching these goals and that many are stagnating or retreating [52,53,55,56–59].

The top 20 national slots – ranked by the overall SDG Index scores, were secured by rich OCED countries. However, the USA – the world's seventh-highest per capita GDP (nominal) and the eighth-highest per capita GDP (PPP) as of 2022 [26], scored 74.6 percent on the SDG Index, ranking 41st among all 163 participating countries [53]. Moreover, the USA. Whereas Scandinavian countries (Finland, Denmark, and Sweden) won the honor of the top three ranks in progress, as measured by the SDG Index, with scores between 86.51 - 85.19, while ranked 21st, 12th and 17th by per capita GDP (PPP) [26].

The USA has one of the most powerful economies globally, at the forefront of technological advances, especially in computers, pharma-

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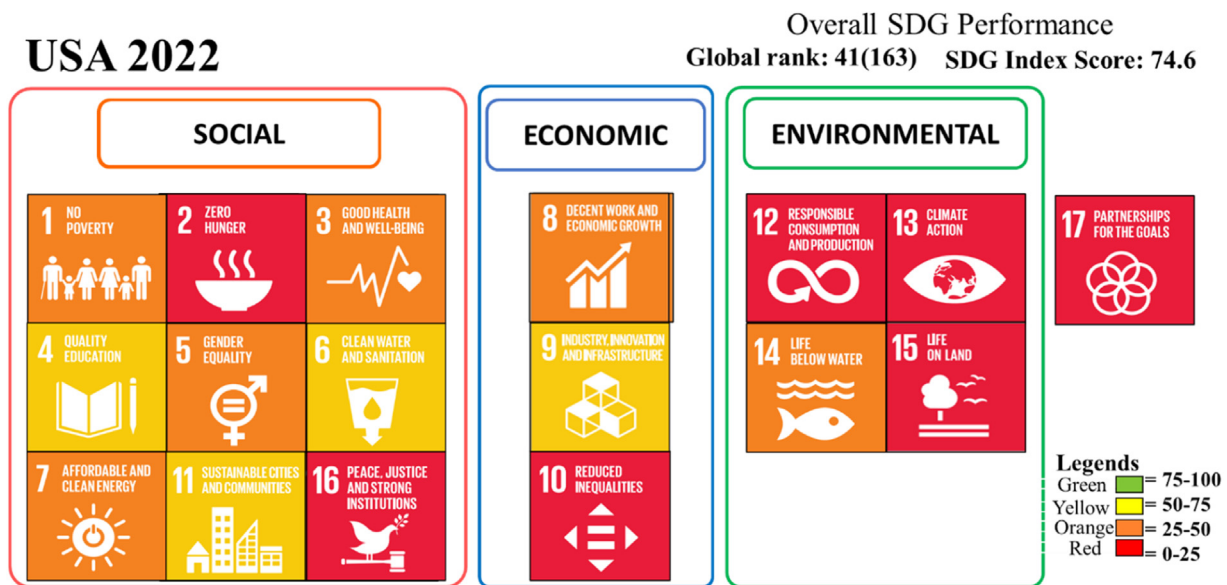


Fig. 1. Sustainable Development Goals Index Dashboard for the USA [53].

ceuticals, medical, aerospace, and military equipment [26]. Also, the financial sector appears resilient, with low leverage and limited funding risk [69]. However, the USA scored “red,” meaning 25% achievement, indicating seriously far from the 100% achievement for 6 out of 17 of the SDGs [53].

Fig. 1.¹ Most of the SDGs focus heavily on poverty, extending sustenance, and access to basic services and infrastructure (SDGs 1–9), but the USA did not score green (75–100% achievement of the targets) for any of the SDGs. The economic goals not only include the GDP increase, but other goals such as distribution of wealth, innovation, and infrastructure are also essential to move towards SD. The USA scored over the 50% mark for SDG9 but lagged on SDG8 and SDG10 [53].

While national and international studies on SD are important, the “rubber hits the road” at the local level. Problems caused by imbalances between the environment and the economy often result in resource drains at the local level, leaving the state and local government officials to devise solutions to address such imbalances [35,60]. While national governments have adopted SDGs, sub-national governments are the key to achieving them. In a federal system, the state governments enjoy extensive authority. Each state has its written constitution. Also, under the Tenth Amendment to the U.S. Constitution, all powers not granted to the federal government are reserved for the states and the people.

Each state establishes local governments to assist it in conducting its constitutional powers. Local governments often provide local services and are responsible for law enforcement and keeping vital records. Cities throughout the world are learning from each other as they integrate the SDGs into existing planning processes, address data and communication gaps created by administrations, and provide leadership in understanding and addressing local needs toward long-term, large-scale change [35].

The state and local governments often have a greater impact on people’s lives than the federal government. State governments have a wide array of functions, encompassing conservation, highway, and motor vehicle supervision, public safety, corrections, professional licensing, regulations of agriculture, intrastate business, industry, certain aspects of education, public health, and welfare. Moreover, the state government is flexible enough to address local circumstances. For example, the federal government has established minimum requirements and standards

in areas such as pollution control, but active state and local governments have tailored those regulations to broaden the scope of their activities. Finally, in terms of addressing political change, Americans rate local government more favorably than federal and state governments (Pew Research Center, 2009, 2015).

Lynch et al. suggested that localization is key when comparing results from the city, state, and global SDG indices, or looking at cities in the USA of similar sizes or geographies (2019). Localization is the process of considering sub-national contexts in the achievement of the 2030 Agenda. Localization relates both to how local and regional governments can support the achievement of the SDGs through action from the bottom up and to how the SDGs can provide a framework for local development policy [20].

The SDSN report in 2019 included 105 cities, up from 100 cities in previous reports. The latest report included 100 of the 101 most populous Metropolitan Statistical Areas (MSAs); San Juan, Puerto Rico, although the 32nd largest MSA, was not included in this or previous reports due to insufficient data coverage. Thus, SDGs across all localities within the USA are needed to identify and prioritize lagging SDGs at a local scale.

In the context of the SDGs, there is a risk of countries prioritizing certain goals, thereby creating trade-offs and threatening policy coherence [6,34,41,45,63]. To address these issues, studies have conceptualized prioritization in the context of the SDGs as the strategic ordering of the goals according to their relative perceived importance [19]. A government may for example choose to prioritize economic goals that are already in line with national strategic plans over environmental goals.

The SDGs are the most intriguing global initiative on the path of SD (Biermann, Kanie, and Kim, 2017). The SDGs promote a sophisticated and innovative message: the combination of SD aspects into a three pillars approach to human well-being combining the environment (environmental sustainability), economy (economic development), and society (social inclusion) [71]. The three-pillars model of SD employs three interconnected “pillars” [7], “dimensions” [40], “aspects” (Tanguay et al. 2010), etc. encompassing economic, social, and environmental (or ecological) factors or goals. As per the three-pillars model, SD requires all three pillars to work together in harmony.

Many studies have employed the three pillars of SD: to express SDGs through sustainability communicators [2,12,78] to develop a vision for education on SD [15,78] and in case studies that organize SDGs as concept maps or framework for modeling SD strategies [12,49]. The SDG

¹ Original dashboard [58] was rearranged to represent SDGs under three pillars of SD.

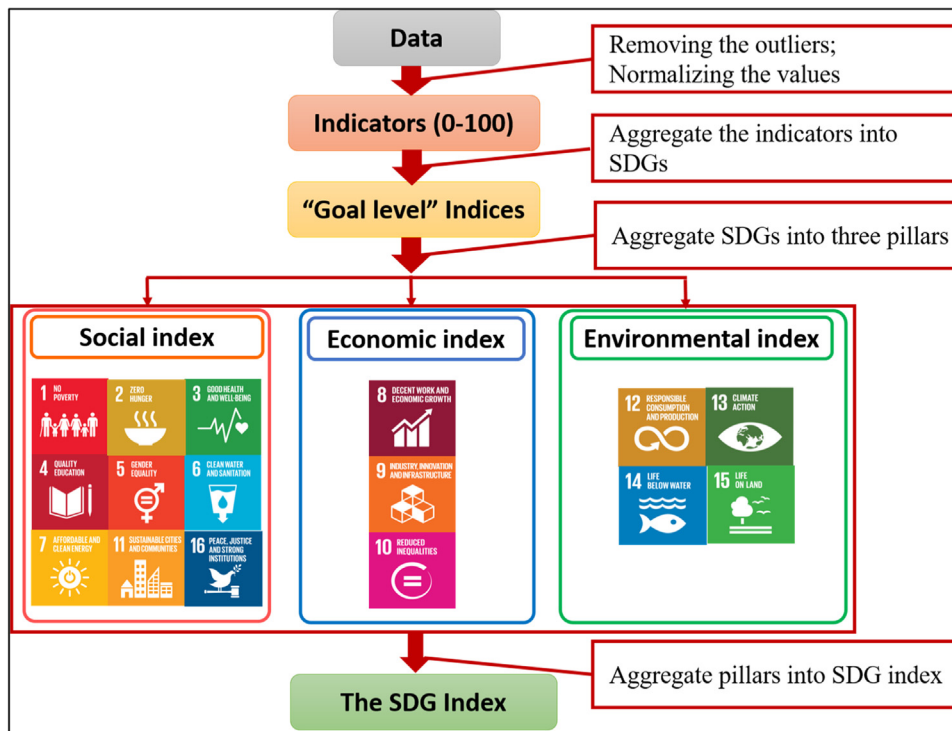


Fig. 2. Methodological framework.

Index reports [54–56,58] provide an overview of the world's SDG net implementation progress to date² but did not consider using the three pillars concept of SD. Therefore, the present study will further categorize localized SDGs under three pillars of SD. Tackling the complex web of challenges facing American states and localities require that their government leaders take a holistic approach, considering social, economic, and environmental pillars concurrently while setting ambitious long-term goals that provide a roadmap for the future. [5].

The present study intended to analyze the SD within the USA at a sub-national scale: across all states and localities (counties and county equivalents). The SD was estimated using 51 indicators representing the first 16 SDGs categorized under three pillars of SD. This study aimed to identify areas where the three pillars of SD are pursued simultaneously to assess whether the harmonious pursuit of the three pillars of SD is the key to progress. Detailed information on the indicator selection criteria, a list of indicators with data sources, and SDGs categorization under three pillars of SD are provided in the following methodology section.

2. Methodology

2.1. Study area and period

The present study focuses on SD progress in terms of UN SDGs at two sub-national scales within the USA: 1. across 50 states and Washington DC; 2. Across 3142 localities (counties and county-equivalents). The present study evaluated SDGs for baseline years 2010 and 2015.

2.2. Methodological framework

The present study used the three pillars framework of SD to categorize the first 16 SDGs into three pillars: Social, Economic, and Environmental (Fig. 2). SDG17 was not included due to its distinctly inter-

national scope and unavailability of such data at sub-national scales. SDG17 mainly focuses on global partnerships and has been considered an institutional goal [51]. Some of the SDGs could be placed under multiple pillars, for example –SDG7 could be placed under the social pillar for access to and affordability of energy, but the clean energy aspect could also be considered under the environmental pillar. Thus, the SDGs were categorized using the Rockström and Sukhdev [51] approach³ and Sachs, et al., [54] as well as using the main objectives of each goal (Table 1).

As portrayed in Fig. 2, selected indicators data were processed to calculate individual SDG goal-level indices and then aggregated into Social (SOCI), Environmental (ENVI), and Economic (ECONI) pillar-level indices. The three pillar-level indices were aggregated into the overall SDG Index (SDGI).

2.2.1. Selection of indicator data

Existing literature and published data available in the environmental, economic, and social dimensions of SD were integrated to estimate SDGs. The economic (ECONI), social (SOCI), and environmental (ENVI) indices were derived from 51 indicators representing 16 SDGs at the locality and state scales. The following selection criteria were used to screen prospects for the selected indicators; each must:

- Represent an issue that is important or contributes to one of the 16 examined sustainable development goals.
- Be meaningful and understandable to a general audience, even if the methodology behind the indicator is complicated.
- Be quantifiable.
- Be based on available data.
- Be scalable to regional, state, and local levels, where appropriate for the issue under consideration

Further, indicators were selected based on the best available measure to represent the specific SDG, and where possible, indicators were se-

² Since the indicators, data, and methodology have been revised for the SDG 2018 Index [54], the rankings and scores are not comparable with the 2017 and 2016 editions. Therefore, a change in a country's ranking does not necessarily signify a change in its SDG performance.

³ According to the cake model of SDGs [51], SDG 6 was categorized under environment, but it has been considered under social dimension based on its objective which is to provide safe drinking water and sanitation to all.

Table 1
Description of 17 SDGs [54].

Goals	Name	Objective
SDG1	No Poverty	Eradicate extreme poverty for all people everywhere
SDG2	Zero Hunger	End hunger, achieve food security, improve nutrition, and promote sustainable agriculture
SDG3	Good Health and Wellbeing	Ensure healthy lives and promote well-being for all at all ages
SDG4	Quality Education	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
SDG5	Gender Equality	Achieve gender equality and empower all women and girls
SDG6	Clean Water and Sanitation	Ensure availability and sustainable management of water and sanitation for all
SDG7	Affordable and Clean Energy	Ensure access to affordable, reliable, sustainable, and modern energy for all
SDG8	Decent Work and Economic Growth	Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all
SDG9	Industry, Innovation, and Infrastructure	Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation
SDG10	Reduced Inequality	Reduce income inequality within and among countries
SDG11	Sustainable Cities and Communities	Make cities and human settlements inclusive, safe, resilient, and sustainable
SDG12	Responsible Consumption and Production	Ensure sustainable consumption and production patterns
SDG13	Climate Action	Take urgent action to combat climate change and its impacts by regulating emissions and promoting developments in renewable energy
SDG14	Life below Water	Conserve and sustainably use the oceans, seas, and marine resources for sustainable development
SDG15	Life on Land	Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
SDG16	Promote Justice, Peaceful and Inclusive Societies	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels
SDG17	Revitalize the Global Partnership for Sustainable Development	Strengthen the means of implementation and revitalize the global partnership for sustainable development

lected from the published lists of indicators in Sachs et al., [55–58] and Agenda 21 [14]. Data sources of indicators selected are provided in the appendix – used for the indices Table 1.

2.2.2. Data

Indicator data were collected for the baseline years, 2010 and 2015. It was difficult to collect all the data from the same period due to certain data unavailability and as most of the indicator data were from the 5-year and 3-year surveys. Survey data provided a multi-year average value for the indicator. Therefore, the indicator data for the year 2010 were collected using the conditions listed in Table 2, and it was the same

applied for the year 2015 (2010–2015). Also, where 3-year and 5-year datasets were available, the "5-year" average dataset was preferred.

2.2.3. Construction of the indices

Indices were estimated particularly on the methodology used by Sachs et al., in the SDG Index and Dashboards (2017), and the methodology proposed by Swaminathan [68].

i Outliers

The arithmetic aggregation method is sensitive to extreme values; the estimated SDGs could also be seriously affected by extreme values

The overall SDG Index (SDGI) by states, USA

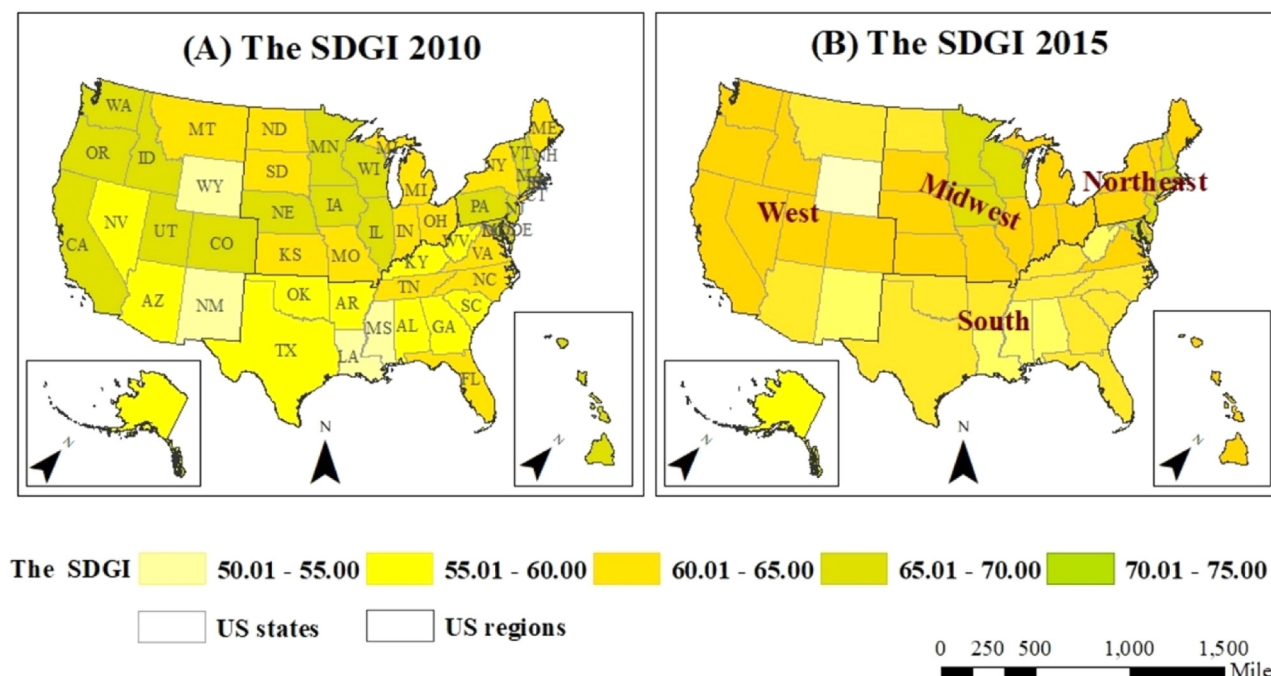


Fig. 3. The overall SDG Index (SDGI) by states, USA.

Social index clustering across states, USA

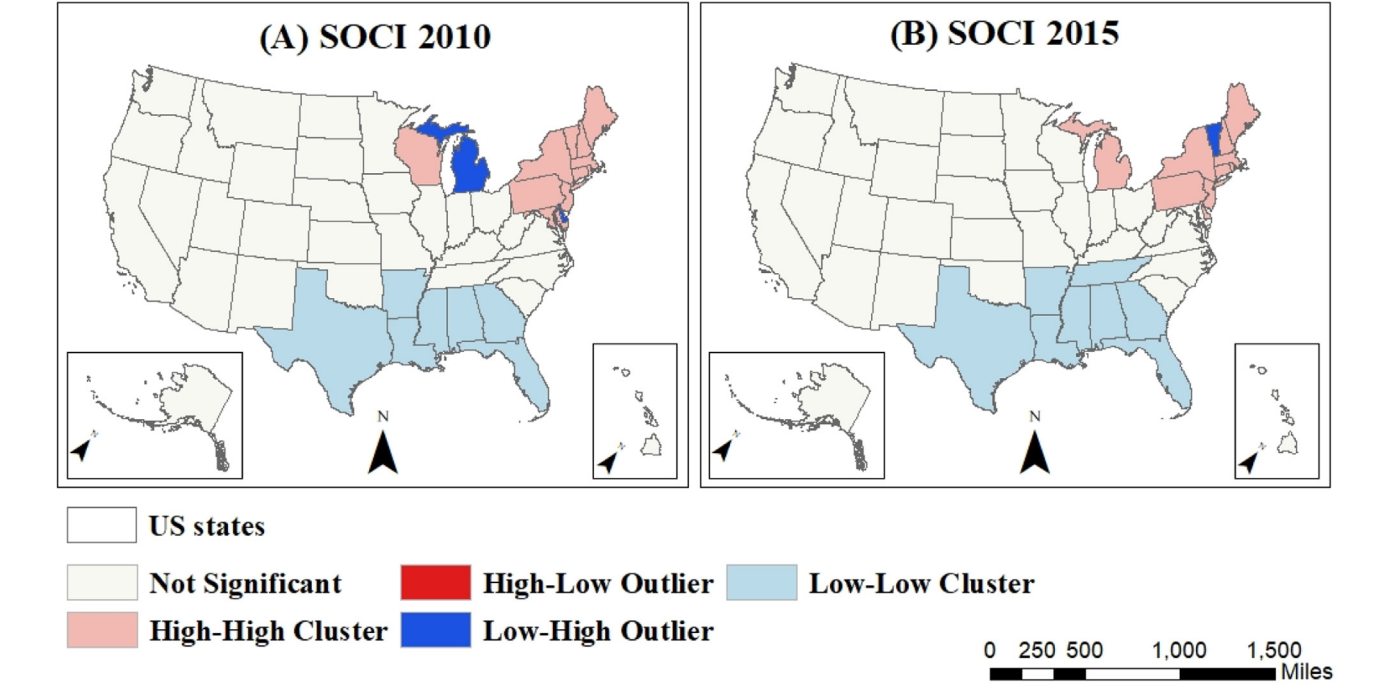


Fig. 4. The SDG Index clusters across states, USA.

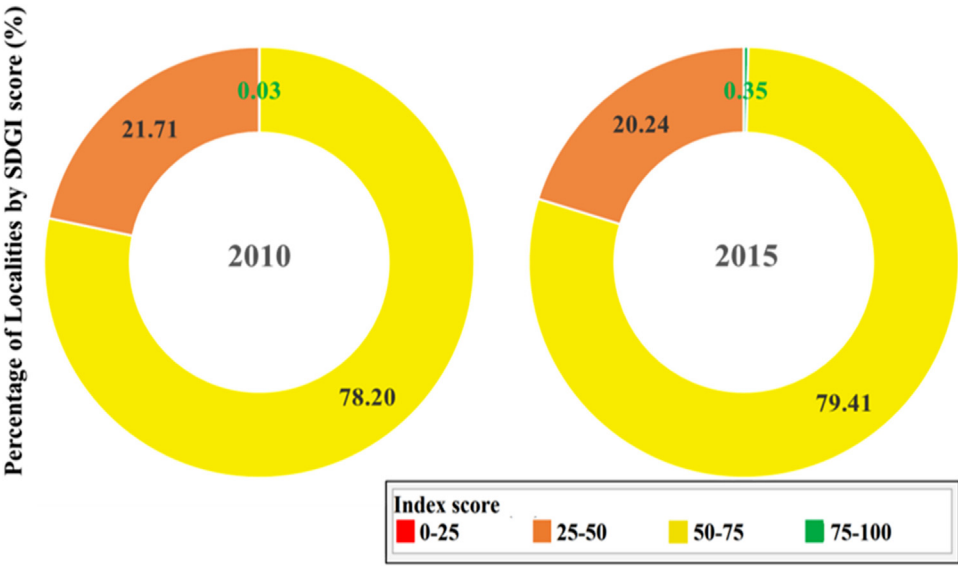


Fig. 5. Percentage of localities by their SDGI score in the years 2010 and 2015, USA.

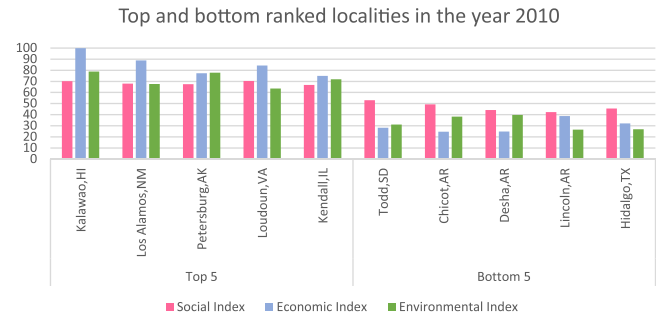


Fig. 6. Localities ranked by the overall SDGI scores, 2010.

Table 2	
Conditions for the data timelines.	
If the data for indicator “x” is available for	Then USE
2005 to 2010 (not including 3-year or 5-year survey data)	Data for the year 2010
3-year OR 5-year survey data	The average value over 3 or 5 years: 2008–10 or 2006–10
3-year AND 5-year survey data	The average value over 5 years: 2006–10 and 2011–2015
2006 and 2010	Data for the year 2010
For only one year from the 2006–2010 period	Available data
Example: Only 2007 data is available.	

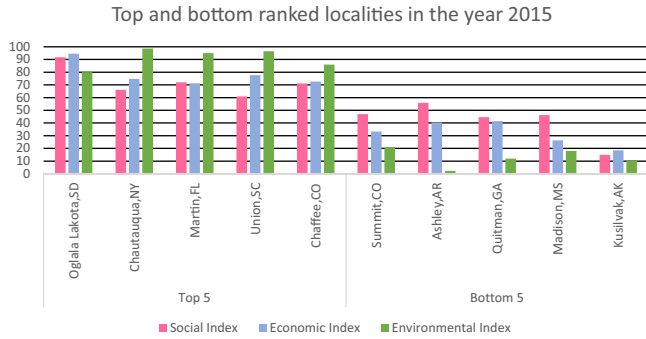


Fig. 7. Localities ranked by the overall SDGI scores, 2015.

or outlier indicators. This situation worsens as highly correlated indicators (or SDGs) are combined because that way double counting is introduced into the index [21,42]. Moreover, the choice of upper and lower bounds with which to rescale the data is a sensitive one and can introduce unintended effects into datasets due to extreme values and outliers [54]. To account for these considerations, the study used science-based thresholds, but the Interquartile Range (IQR) to remove outliers where needed.

No extreme values needed to be addressed at the state scale, but outliers were removed using the Interquartile Range (IQR) at the county scale to eliminate the confounding effect of extreme values, which can skew the results of a composite index. An outlier was defined as any point of data that lies over 1.5 IQRs (Interquartile range) below the first quartile (Q1) or above the third quartile (Q3) in a data set.

i Rescaling and addressing extreme values

Each variable was rescaled between 0 – 100 to make the data comparable across indicators where 0 means the worst and 100 indicates the best performance among all states/localities. The associated rescaling

equation had been adapted from the methodology used by Swaminathan and Saleth, described below in detail [61].

Let X'_{ijk_y} denote the value of the i^{th} variable, the j^{th} goal of the k^{th} location in y^{th} year, and X' is the normalized value after rescaling:

Eq. (1): Rescaling for positive variables

$$X'_{ijk_y} = \frac{X_{ijk_y} - \text{Lower bound}(X_{ijk_y})}{\text{Upper bound}(X_{ijk_y}) - \text{Lower bound}(X_{ijk_y})} \times 100 \quad (1)$$

Eq. (2): Rescaling for negative variables

$$X'_{ijk_y} = \frac{\text{Upper bound}(X_{ijk_y}) - X_{ijk_y}}{\text{Upper bound}(X_{ijk_y}) - \text{Lower bound}(X_{ijk_y})} \times 100 \quad (2)$$

In Eq. (1) and [Eq. (2)], “Lower bound X_{ijk_y} ” denotes the worst value of the i^{th} variable, the j^{th} goal of the total number of observations – combining the data for both years at state and local scales. Likewise, “Upper bound X_{ijk_y} ” denotes the best value.

Eq. (1) was applied to variables having positive implications toward SDGs and Eq. (2) was applied to variables having negative implications. The numerators in both equations measured the extent by which the k^{th} area did better in the i^{th} variable representing the j^{th} goal as compared to the area(s) showing the worst performance. The denominator is the total range, i.e., the difference between the maximum and minimum values of a given variable across the states or localities. The denominator served as a scale or measuring stick by which the performance of each location was evaluated for a given variable. Where possible, upper, and lower bounds were derived from technically feasible maxima or thresholds that must be met to achieve sustainable development and to leave no one behind. For example, the upper boundary for the female education rate is set at 100%. For some variables, no absolute upper bounds or lower bounds could be identified as it might be practically impossible to achieve certain absolute limits, for example, zero infant mortality rate. In such cases, the best performer at the local scale was considered as an upper threshold. The threshold values used for rescaling are provided in the appendix – used for the indices Table 1.

i Aggregate the indicators within and across SDGs

The overall SDG Index across localities, USA

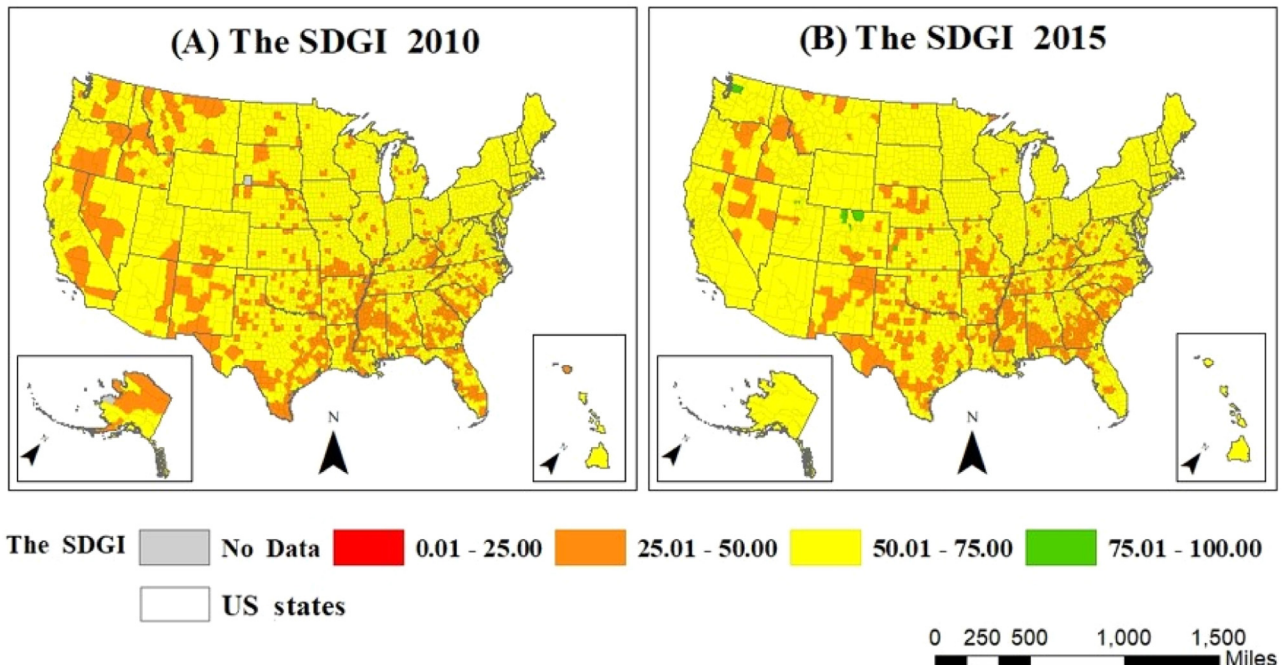


Fig. 8. The overall SDG Index (SDGI) across localities, USA.

The SDG Index clustering across localities, USA

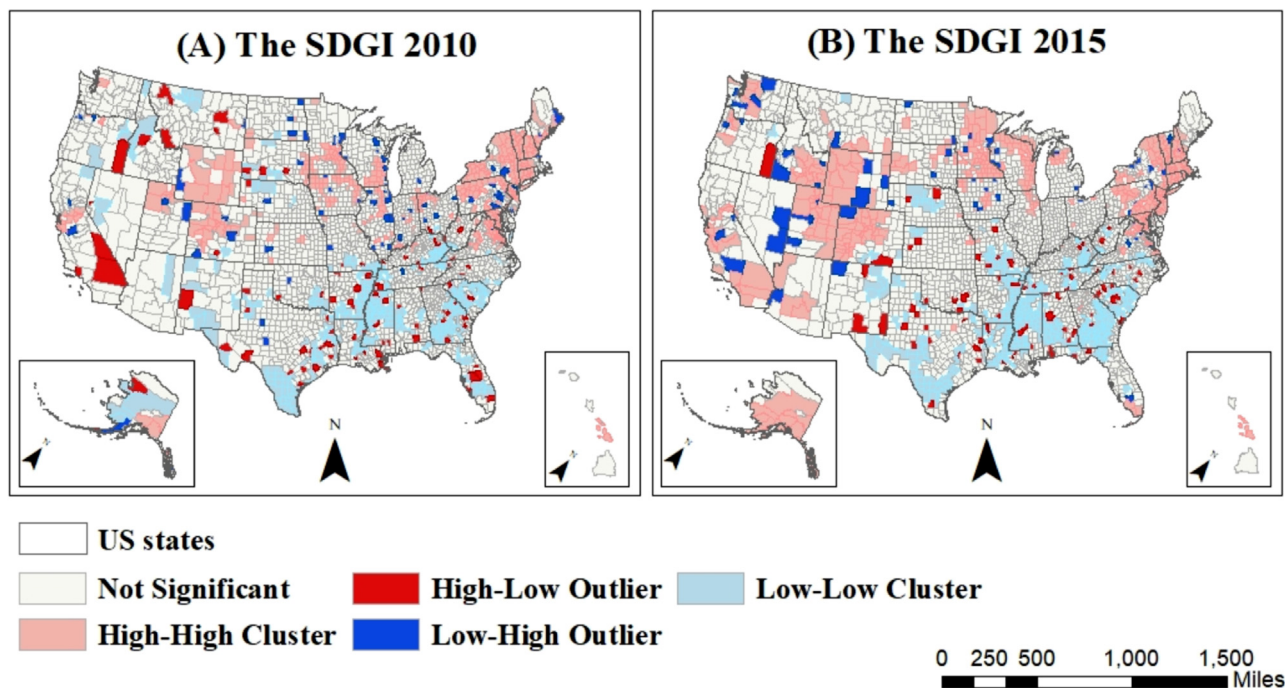


Fig. 9. The SDGI clustering across localities, USA.

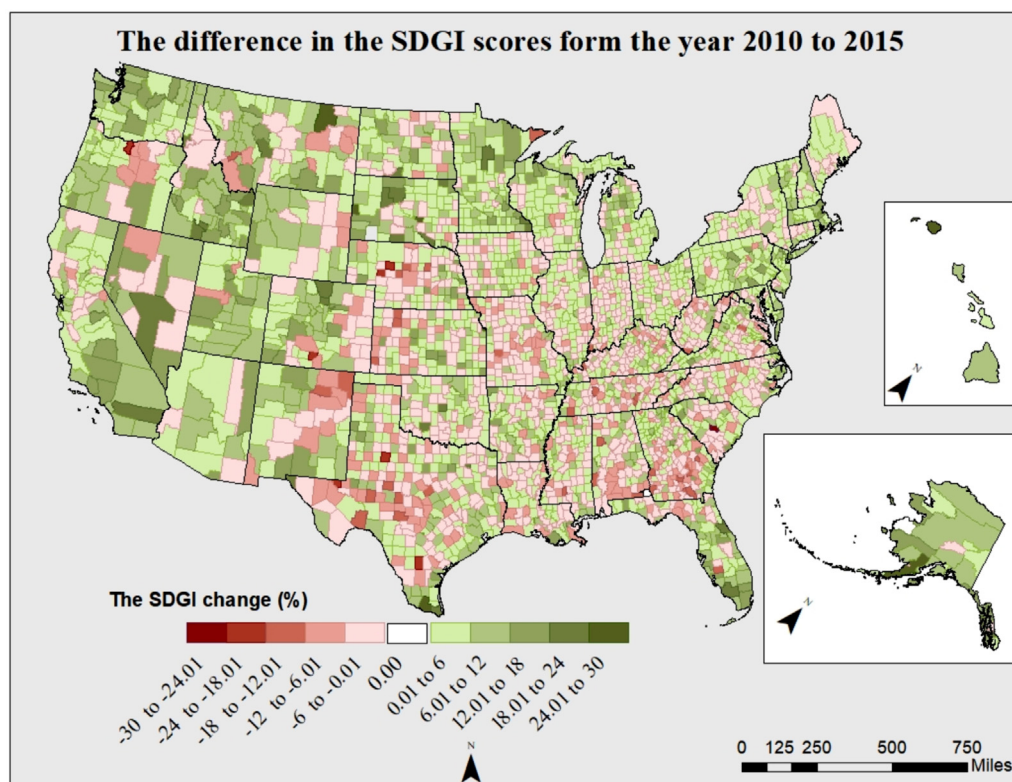


Fig. 10. The difference in the SDGI scores from 2010 to 2015, localities, USA.

Having rescaled all variables, the indices for various goals were calculated as arithmetic means of all the indicators under the same goal. The arithmetic mean aggregation method has been widely applied in the calculation of composite indices as compared to the other methods for its ease of application and communication [27,31,53,62]. Other functional forms usually used for aggregation in calculating compos-

ite indices are the geometric mean and Leontief production function [21,23].

The arithmetic average assumes equal weighting for all indicators corresponding to each SDG, and equal weighting for all computed SDGs in the construction of the index, which justifies as a reflection of the commitment by policymakers to treat all SDGs as equally important [21,53].

US localities presenting all three sub-indices in the same range

Localities with SDGI score are representing all three sub-indices in the same range.

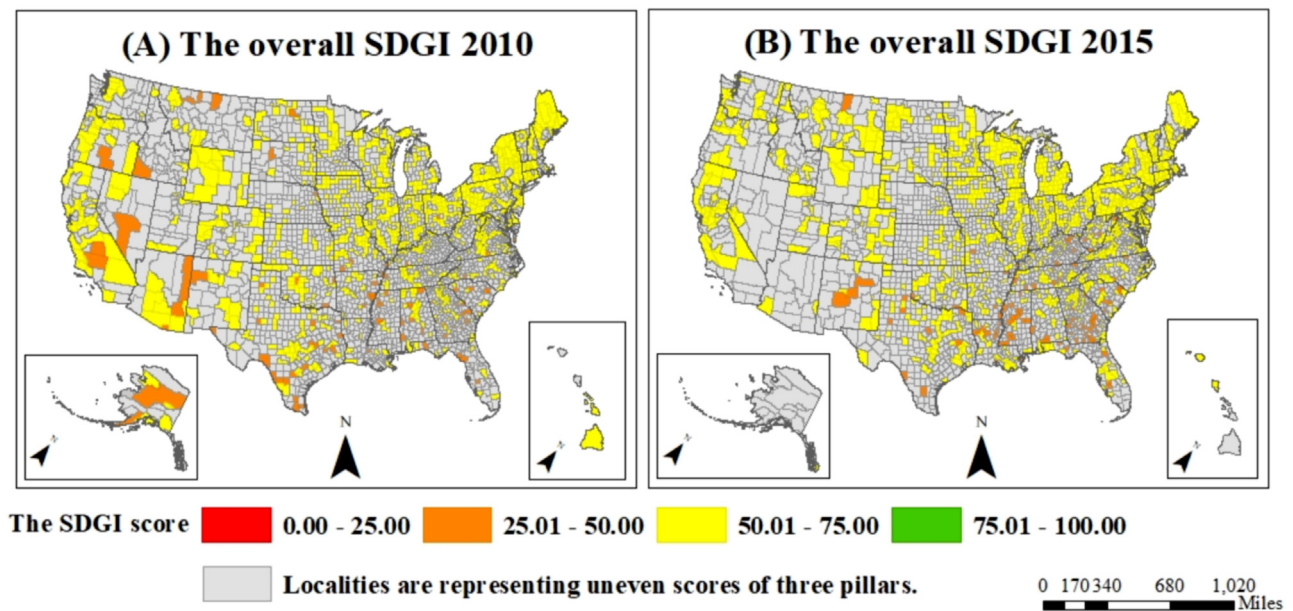


Fig. 11. Mapping three pillars of SD by localities, USA.

Predominance of Sustainability pillars by localities, USA

(Environmental index - ENVI; Social index - SOCI; Economic index - ECONI)

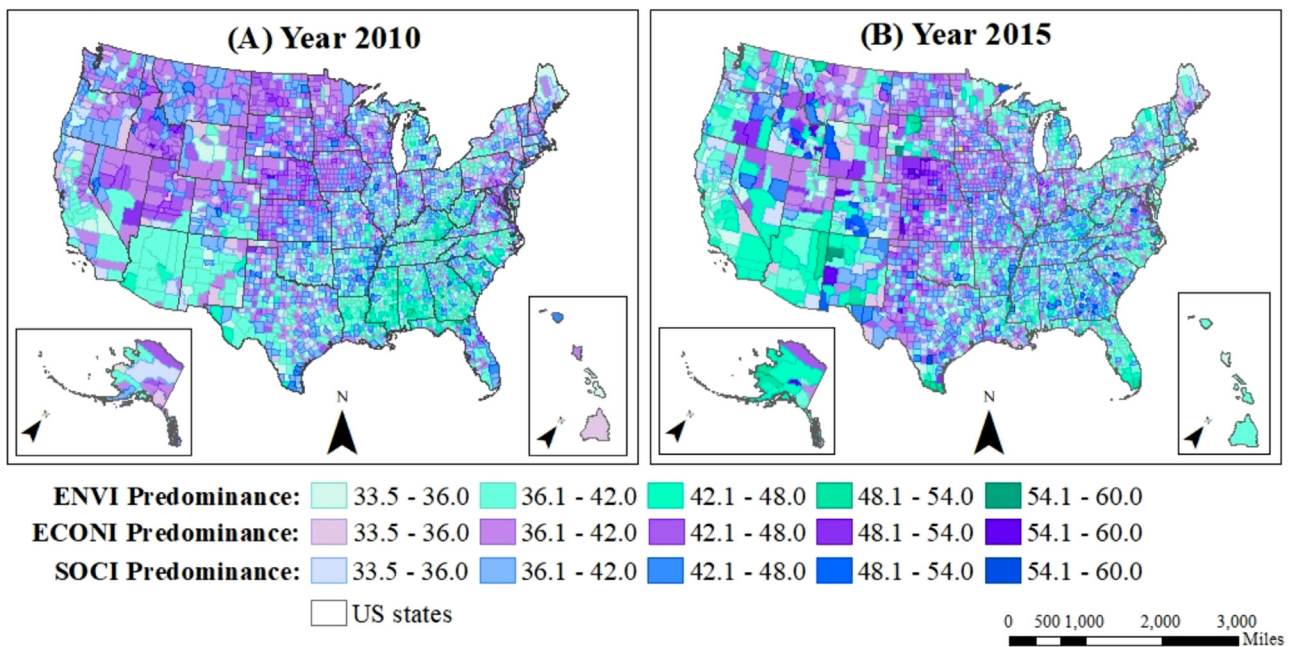


Fig. 12. Predominance of sustainability pillars by localities, USA.

The geometric mean follows the economic concept of “limited substitutability” [42], which states that being strong on one goal does not fully substitute for being weak on another. Progress on one goal cannot offset the lack of progress on another, which translates into the necessity of countries to progress toward every goal [36,54]. Despite the geometric mean being mostly preferred by academics, recent evidence suggests that differences in results are negligible [54]. As per Guijarro & Poyatos,

[21], the Leontief production function over-weights the worst-case elements. Such a pessimistic approach has the disadvantage of focusing on a single attribute, thus discarding the remaining elements of sustainable development.

Thus, the limitations of traditional aggregation methods are related to the weighting process of indicators and goals. The arithmetic mean assumes equal weighting. The geometric and Leontief aggregation meth-

Economic index clustering across states, USA

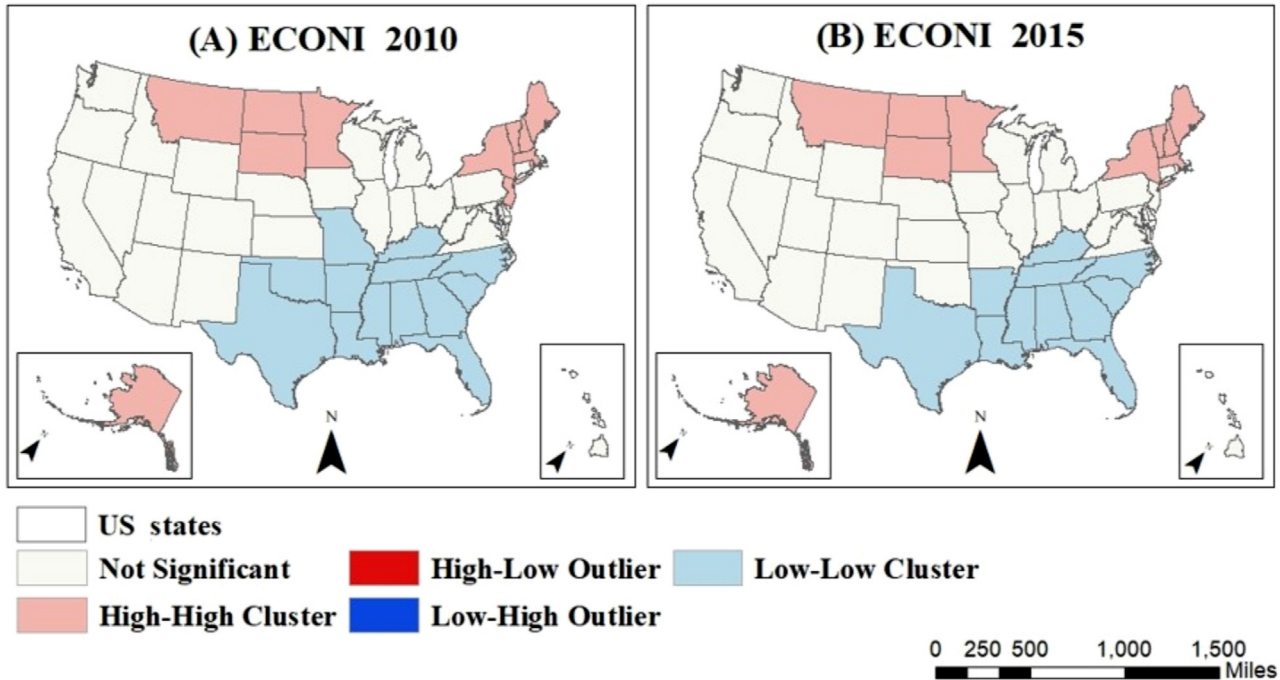


Fig. 13. The Economic index (ECONI) clustering across states, USA.

ods over-weight the worst performer indicators and goals, which, can cause some places to remain as the worst SDG performers regardless of how well they perform in other indicators [21].

Eq. (3): SDG “Goal” indices

$$Y_{jky} = \frac{\sum_{i=1}^J X'_{ijk y}}{I_j} \quad (3)$$

Where, i = indicators representing goal j (1, 2, 3, ..., I_j);

j = sustainable development goals ($J = 16$);

k = state or locality (1, 2, 3, ..., 51 states and 3142 localities);

y = years (2010 and 2015)

Then, the social, environmental, and economic indices and overall SDG Index for each region were calculated as weighted arithmetic means of the goal indices.

Eq. (4): The overall SDGI/Social/Environmental/Economic Index

$$\text{SDGI/Social/Environmental/Economic index} = \frac{\sum_{j=1}^J W_{jky} Y_{jky}}{J} \quad (4)$$

The W_{jk} in Equation [4] denotes the weight assigned to the j th Goal in the K th region and has the property that: $W_{1k} + \dots + W_{Jk} = 1$, which means that a system of equal weights was assumed. As a normative assumption, equal weights were assigned to every SDG to reflect policymakers' commitment to treating all SDGs equally and as an “integrated and indivisible” set of goals [71]. This approach also allows for the later addition of new variables for an SDG without affecting the relative weight of each SDG in the overall score.

2.3. Comparing indices across states and localities

To compare indices scores across states and localities, the SDGI scores and sub-indices values were presented using four color ranges: 0–25 (red), 25–50 (orange), 50–75 (yellow), and 75–100 (green). The green band is bounded by the maximum that can be achieved for each variable (i.e. the upper bound) and the threshold for achieving the SDG.

Table 3

Moran's Index for SDGI values across states, USA.

Input Feature	Moran's Index	z-score	p-value
State SDGI (51 indicators) _2010	0.119	4.04	0.000054
State SDGI (51 indicators) _2015	0.145	4.83	0.000001

Three color bands ranging from yellow to orange and red denote an increasing distance from SDG achievement. The red band is the lower bound meaning the farthest from the best threshold for achieving SDG. The upper and lower bounds are the same as for the SDG Index. When all states scored in the yellow range, sub-divisions within that yellow range were used to visualize the variations across states (example: Fig. 3).

2.4. Distribution of indices across states and localities

The overall distribution of the indices across the states and localities was studied using spatial autocorrelation. When a clustered pattern appeared, Anselin Local Moran's I was performed to identify the areas that are similar or different to their neighborhood.

3. Results

3.1. The overall SDG index (SDGI)

All states scored in the range of 54–73 on the overall SDGI, meaning states were at the 50–75 (yellow) mark towards the possible upper thresholds (green: 75–100) to achieve all 16 SDGs (Fig. 3). However, the spatial distribution of SDGI values across states was clustered, given the z-scores 4.04 and 4.83 (Table 3), there is a less than 0.1% likelihood that this clustered pattern could be the result of random chance.

As per Fig. 4, low-low (LL) values are clustered in the Southern region meaning a state with a low SDGI score is surrounded by neighboring states with similar low SDGI values. Likewise, high-high (HH) values are clustered in the Northeastern region for both years 2010 and 2015 (Fig. 4).

Economic SDGs across states, USA

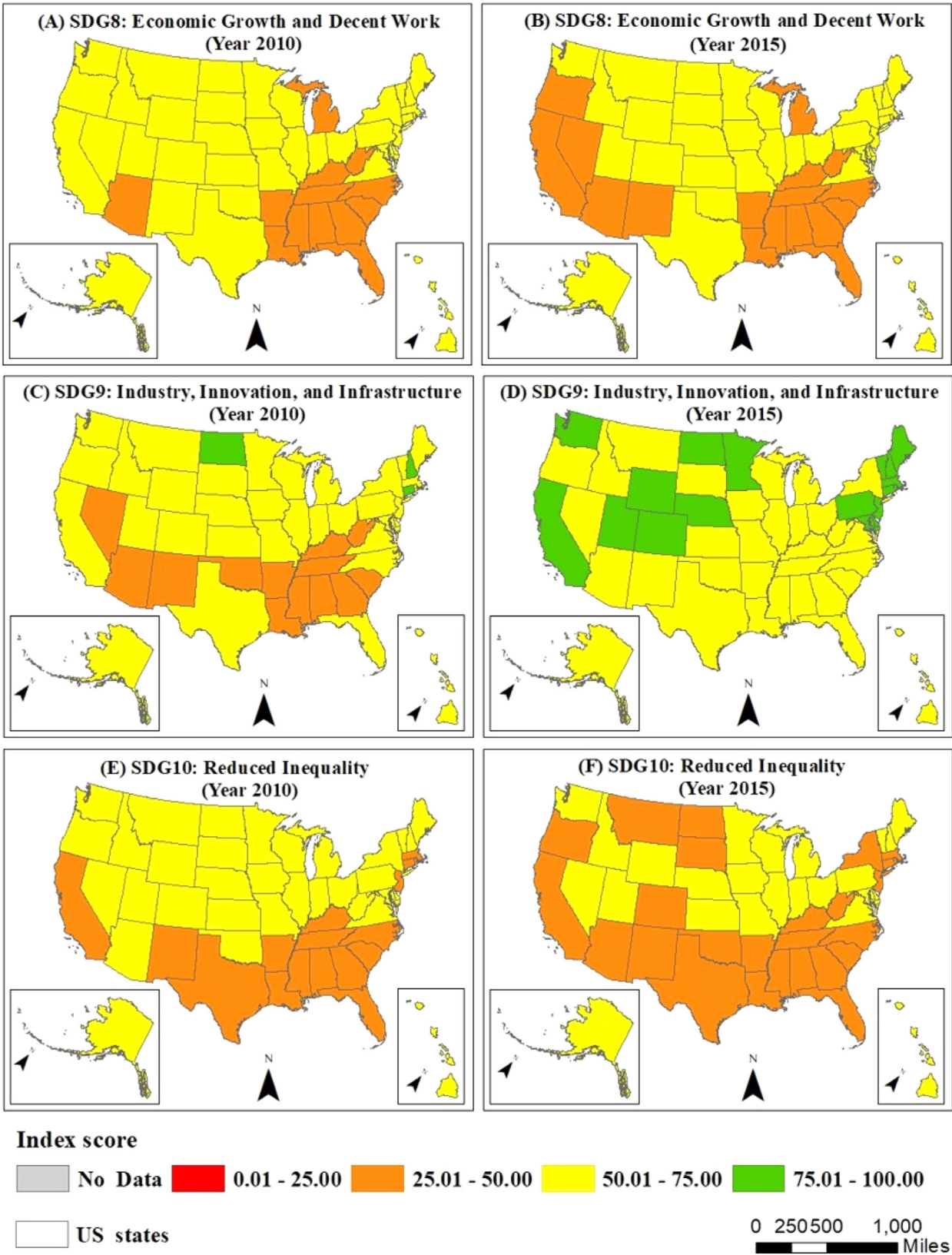


Fig. 14. Economic SDGs (SDG 8, 9, and 10) by states, USA.

Economic SDGs across localities, USA

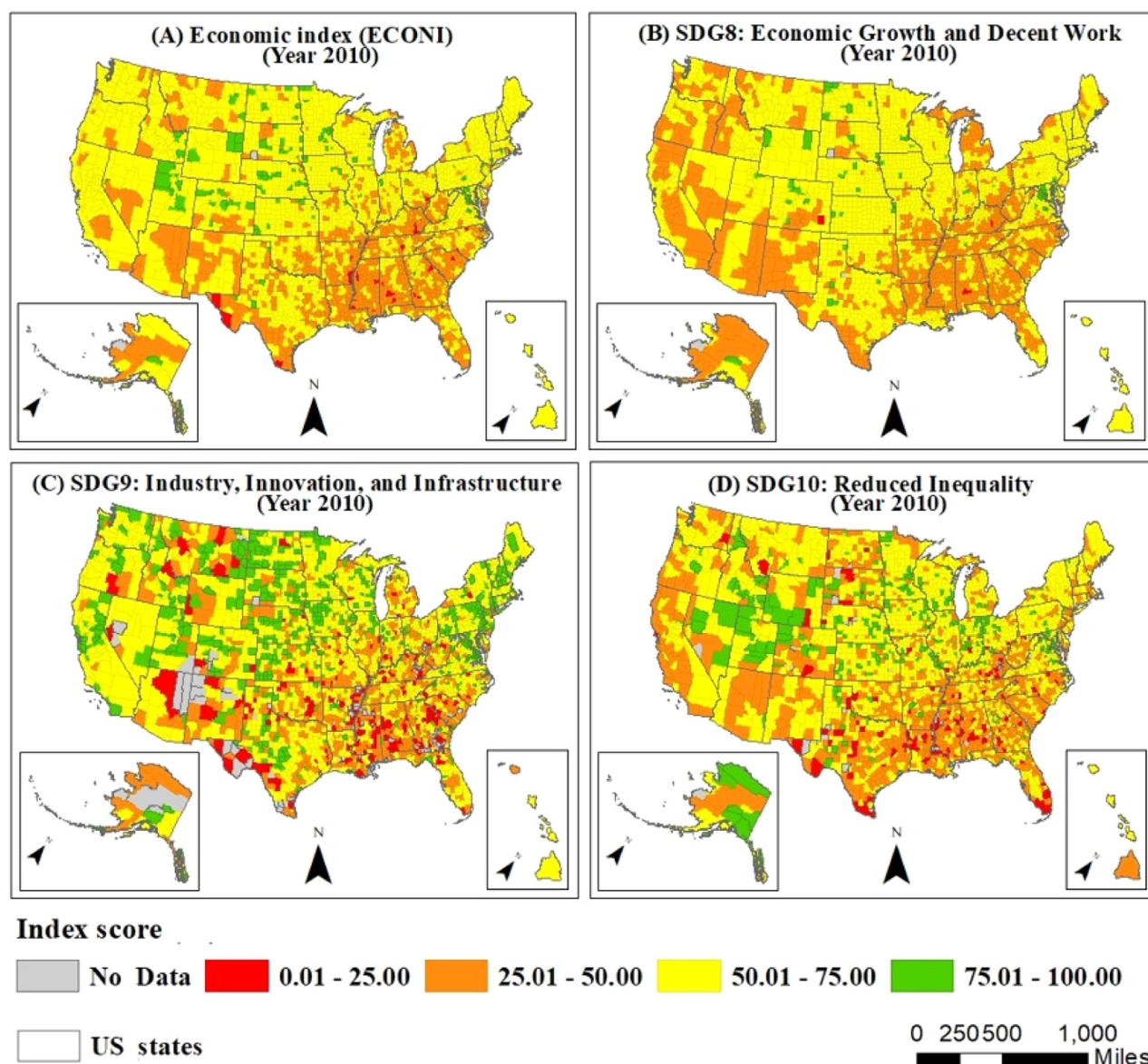


Fig. 15. Economic SDGs (SDG 8, 9, and 10) by localities, USA 2010.

At the local scale, 78% and 79% of all 3142 localities scored between 50 – 75 on SDGI for the years 2010 and 2015, respectively (Fig. 5). While none of the localities scored in red (below 25), 22% and 20% of the localities scored between 25 – 50 (orange) for the years 2010 and 2015, respectively. Only one locality (Kalawao, HI) in 2010 and 11 localities in 2015 scored between 75 – 100, meaning close to achieving the goal, with first rank out of 3142 localities (Fig. 6). While top 5 and bottom 5 ranking localities did not reveal enough information about distribution of these 3142 localities, but it highlights that southern localities are also in the top 5 ranks (Figs. 6 and 7).

Most of these 22% and 20% orange localities mentioned in Fig. 5 are geographically in the Midwestern (47%) and Southern (41%) regions (Fig. 8). Also, almost every locality in the northeast region scored in the yellow range for both years.

Corresponding to states, the SDGI distribution across localities was clustered (Table 4). A few local high-high (HH) clusters were observed in the Northeastern, Midwestern, and Western regions. Conversely, low-

Table 4

Moran's Index for SDGI values across localities, USA.

Input Feature	Moran's Index	z-score	p-value
Localities SDGI_2010	0.18	106.43	0
Localities SDGI_2015	0.06	36.32	0

low (LL) clusters were observed mainly in the Southern region of the country. However, high-low (HL) outliers in Southern regions, and low-high (LH) outliers in the remaining regions, were also noticeable. (Fig. 9).

Although temporal trends cannot be considered dependable as some of the underlying indicators were missing for either year, it was worth noticing that the percentages of localities with SDGI scores in the range of green and yellow increased by 0.32% and 5.23%, respectively, from the years 2010 to 2015 (Fig. 5). A total of 350 (51%) localities out of 682 (22% of a total of 3142 localities) observed an increase in the SDGI

Economic SDGs across localities, USA

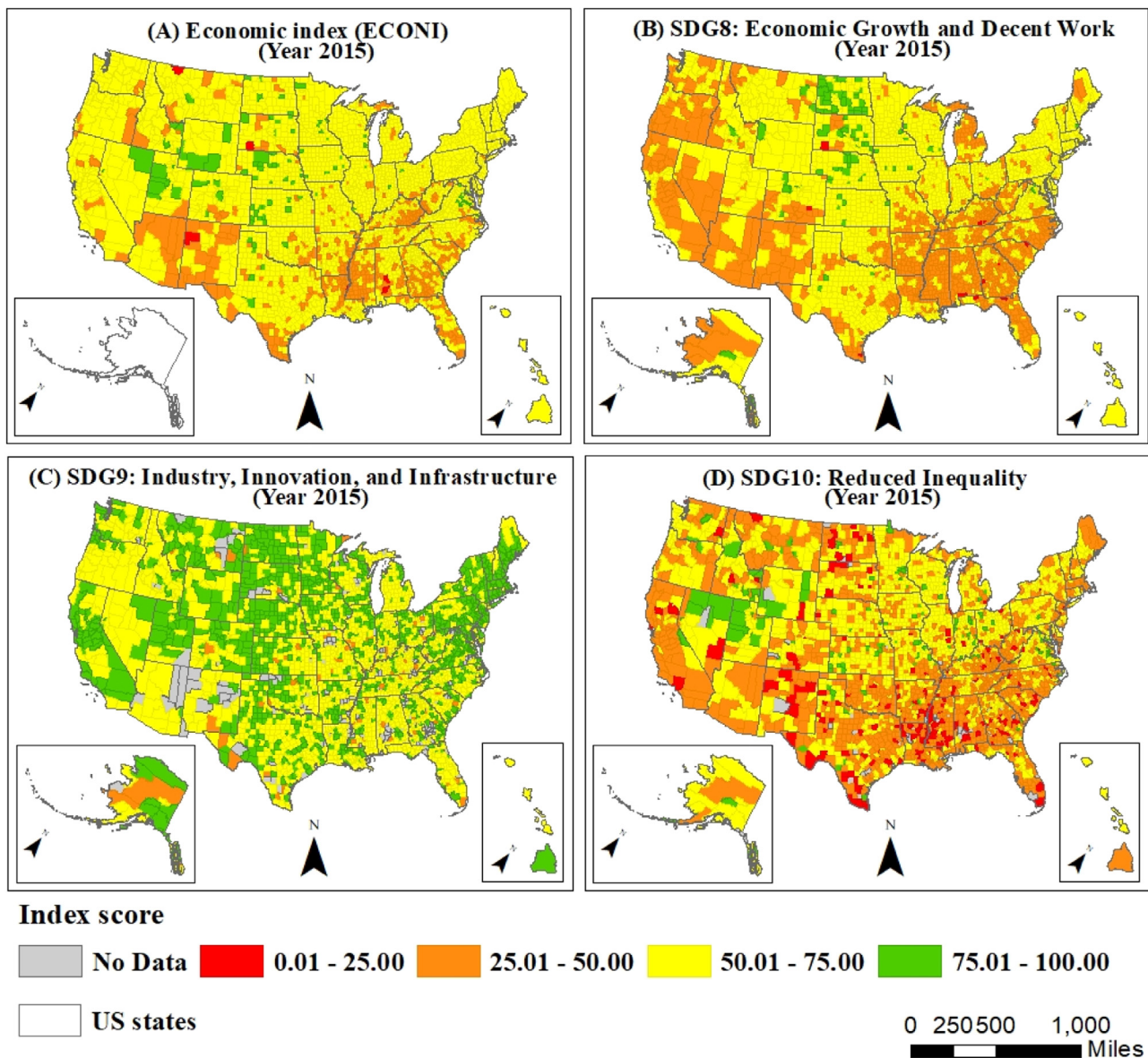


Fig. 16. Economic SDGs (SDG 8, 9, and 10) by localities, USA 2015.

scores from orange to yellow in the year 2015, the majority (194) localities were recorded in the Southern states (Fig. 8). The SDGI score for 12% (304) of localities out of 2457 (78% of the total 3142 localities) decreased from yellow in 2010 to the orange range in the year 2015. The majority (213) of these 304 localities are also in the Southern states (Fig. 8). Only one locality (Kalawao, HI) scored in green in the year 2010 and then maintained the score in the same range in 2015. Additionally, 10 localities in the Western region show an increase from the yellow to green range in the year 2015. The remaining localities displayed either a slight positive change or were able to maintain the same status in 2015. The difference map (Fig. 10) portrayed the relative improvement and a decrease in the SDGI scores in 5 years.

3.2. Sub-indices based on the three pillars of SD

While overall SDGI scores provide the SD status for every state and locality within the USA, sub-indices such as Environmental index

(ENVI), Economic index (ECONI), and Social index (SOCI) identified the states and localities pursuing all three pillars of SD concurrently.

In the year 2010, the top thirty states (except for HI, CO, OR, IL, and CA) by SDGI ranks, simultaneously scored in the yellow range for all three sub-indices, possibly presenting the three-pillars model approach to achieve SD (Table 5). In the case of exceptions, the environmental index was scored in green, relatively higher than the economic and social pillars of SD. It was quite different for the year 2015, except for Nebraska, where all three sub-indices were scored in the yellow range. The remaining states in the top 30 ranks recorded a higher score for the environmental index compared to social and economic aspects in the year 2015. The bottom (ranks 31–51) states scored green or yellow on ENVI (except for WY) and yellow on SOCI (except AK) in both years 2010 and 2015. However, 12 and 7 states lagged on ECONI with scores in the orange range for the years 2010 and 2015, respectively (Table 5).

Few states in the bottom ranks, such as DE, NC, ND, MT, TX, NV, and OK, also simultaneously scored in the yellow range for all three

Table 5

List of states by SDGi ranks, and sub-indices using 48 indicators.

Index scores: 0-25 25-50 50-75 75-100												
SDGI Rank	2010						2015					
	STATE	ST	The SDGI	ECONI	SOCI	ENVI	STATE	ST	The SDGI	ECONI	SOCI	ENVI
1	Connecticut	CT	68.04				New Hampshire	NH	73.21			
2	Hawaii	HI	67.39				Minnesota	MN	72.33			
3	New Hampshire	NH	67.31				Connecticut	CT	72.04			
4	Vermont	VT	67.23				Utah	UT	71.72			
5	Iowa	IA	66.73				New Jersey	NJ	71.55			
6	Colorado	CO	66.66				Massachusetts	MA	71.24			
7	New Jersey	NJ	66.28				Maryland	MD	70.51			
8	Utah	UT	66.26				Rhode Island	RI	70.14			
9	Minnesota	MN	66.19				New York	NY	69.99			
10	Wisconsin	WI	66.17				Wisconsin	WI	69.92			
11	Nebraska	NE	65.81				Washington	WA	69.86			
12	Oregon	OR	65.78				Idaho	ID	69.59			
13	Illinois	IL	65.69				Iowa	IA	69.58			
14	Washington	WA	65.66				Nevada	NV	69.53			
15	Pennsylvania	PA	65.62				Hawaii	HI	69.50			
16	Massachusetts	MA	65.40				Colorado	CO	69.17			
17	Idaho	ID	65.17				Pennsylvania	PA	68.65			
18	Maryland	MD	65.13				South Dakota	SD	68.58			
19	California	CA	65.06				California	CA	68.40			
20	New York	NY	64.94				Kansas	KS	68.30			
21	South Dakota	SD	64.86				Virginia	VA	68.30			
22	Virginia	VA	64.72				Oregon	OR	68.24			
23	Maine	ME	64.69				Nebraska	NE	68.05			
24	Kansas	KS	64.48				Maine	ME	67.97			
25	Indiana	IN	63.70				Delaware	DE	67.81			
26	Missouri	MO	62.87				Vermont	VT	67.81			
27	Rhode Island	RI	62.65				Illinois	IL	67.70			
28	District of Columbia	DC	61.87				Ohio	OH	67.14			
SDGI Rank	2010						2015					
	STATE	ST	The SDGI	ECONI	SOCI	ENVI	STATE	ST	The SDGI	ECONI	SOCI	ENVI
29	Michigan	MI	61.79				District of Columbia	DC	66.57			
30	Ohio	OH	61.53				Michigan	MI	66.44			
31	Florida	FL	61.25				Indiana	IN	65.58			
32	Delaware	DE	61.12				Montana	MT	65.29			
33	North Carolina	NC	60.89				North Carolina	NC	64.61			
34	North Dakota	ND	60.50				Missouri	MO	64.47			
35	Tennessee	TN	60.43				Alaska	AK	64.42			
36	Montana	MT	60.29				North Dakota	ND	63.51			
37	Texas	TX	59.74				Texas	TX	63.40			
38	Arizona	AZ	59.73				Florida	FL	63.36			
39	Georgia	GA	58.76				Arizona	AZ	63.22			
40	Alaska	AK	58.65				Oklahoma	OK	63.15			
41	Alabama	AL	58.50				Tennessee	TN	63.03			
42	Nevada	NV	58.50				Kentucky	KY	61.37			
43	Oklahoma	OK	58.26				Georgia	GA	61.35			
44	Kentucky	KY	57.04				Southern Carolina	SC	61.01			
45	Southern Carolina	SC	56.83				Arkansas	AR	60.22			
46	Arkansas	AR	56.62				New Mexico	NM	59.51			
47	West Virginia	WV	56.56				Mississippi	MS	59.38			
48	New Mexico	NM	54.85				Alabama	AL	58.78			
49	Mississippi	MS	54.80				West Virginia	WV	58.05			
50	Louisiana	LA	54.33				Louisiana	LA	57.72			
51	Wyoming	WY	53.95				Wyoming	WY	56.03			

Economic index clustering across localities, USA

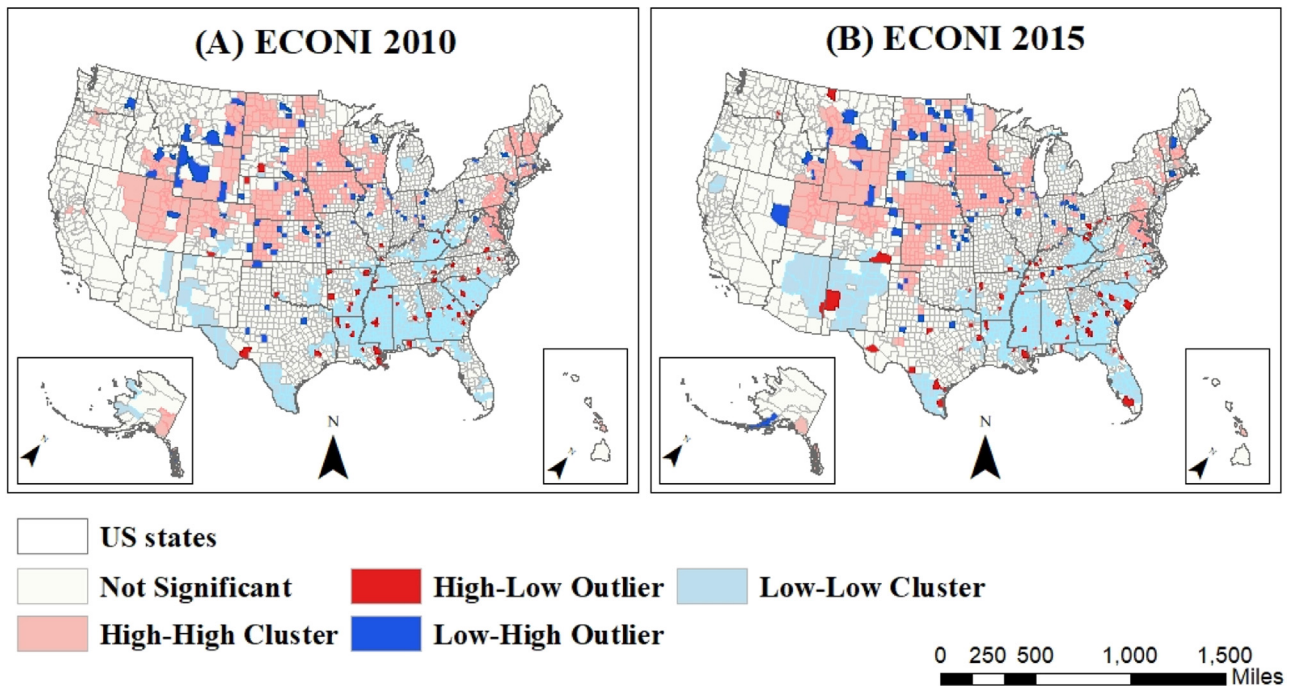


Fig. 17. The Economic index (ECONI) clustering across localities, USA.

sub-indices in 2010. Nevada's outstanding performance was evident as it moved from the rank of 42nd to 14th in the year 2015. Amongst the bottom-ranking states, ND, MT, TX, and OK maintained balanced scores across the three sub-indices, while making the progress in terms of overall SDGI in the year 2015. Also, the bottom-ranked states such as IN, KY, AR, and WV appeared to be pursuing all three pillars concurrently in the year 2015.

In Fig. 11, localities presented with SDGI scores, recorded all three sub-indices (ECONI, ENVI, and SOCI) in the same color range, meaning possibly presenting the three-pillars concept of SD. The remaining, gray-colored localities presented the imbalance between the three pillars of SD. About 50% of the localities in the Northeastern and Midwestern regions, 40% of the Western localities, and about 30% of the Southern localities scored parallelly high in all three pillars of SD.

Fig. 12 shows the predominance of the SD pillars by localities while indicating the need for prioritizing the other two sub-indices to work in unison and progress towards SD. In terms of the predominance of SD pillars across localities (Fig. 12), lighter shades (33.5–42) mean nearly balanced pillar indices, meaning no significant predominance and the darker color shows increasing predominance. Accordingly, the Northeastern localities are showing lower strengths of predominance, the economic pillar is predominating in the northern part and the environmental pillar is predominating in the southern part of the country. Most Southern localities (44%) observed higher scores for ENVI as compared to the other two in the year 2010. In 2015, about 27% and 21% of Southern localities recorded a higher score in the environmental and economic dimensions, respectively. Whereas 30% of Midwestern localities represented high economic status as compared to the social and environmental dimensions of SD for both years. The economic dimension was also relatively high among the three dimensions of SD in the northeastern (18%) and Western (20%) localities for both years. The least share of localities in each region represented the higher score for social dimension compared to economic and environmental dimensions.

While there was no significant clustering was observed in terms of localities presenting balanced scores of sub-indices, the overall percentage

of localities increased from 39% to 44% in the year 2015. The individual sub-indices were studied further to provide more insights in terms of the spatial distribution of these indices and to identify and prioritize localities by SD dimensions and by SDGs when needed.

3.2.1. Economic index (ECONI)

Lower ECONI scores (25 – 50) are clustered in the Southern part of the country for both years (Fig. 13). This could be the result of lower scores of underlying SDGs 8, 9, and 10 in the year 2010 (Fig. 14- A, C, and E). Likewise, SDGs 8 and 10 could be held accountable for the lower ECONI in southern states in the year 2015 (Fig. 14- B, D, and F). High-value clustering in the Northeastern and in between the Western (MT) and Midwestern (ND, SD) regions was consistent for both years (Fig. 13).

Likewise, the underlying SDGs 8, 9, and 10 were scored lower in the Southern localities in the year 2010 (Fig. 15), but only SDGs 8 and 10 are accountable for the lower values in the southern region in the year 2015 (Fig. 16).

Overall, the ECONI distribution across localities upheld a weak clustering of low values in the Southern region and high values clustering in the Midwestern region for both years 2010 and 2015 (Fig. 17). Localities in the Northeastern and Western regions also scored relatively higher, but no significant clustering is observed, except for states such as Montana, Wyoming, Colorado, and Utah.

3.2.2. Environmental index (ENVI)

Although there was no statistically significant clustering observed in the distribution of ENVI across states, states such, as HI, CO, OR, IL, CA, FL, TN, AZ, GA, AL, and SC scored in the green range in 2015 (Table 5). Also, WY was consistently laggard on ENVI by scoring in orange for both years (Table 5).

In the year 2010, almost every state recorded the SDG12 index in the yellow range, except for MO and ME (scored in orange); WY (red); and NY, NJ, and MA (scored in green) from the Northeastern region

Environmental SDGs by states, USA

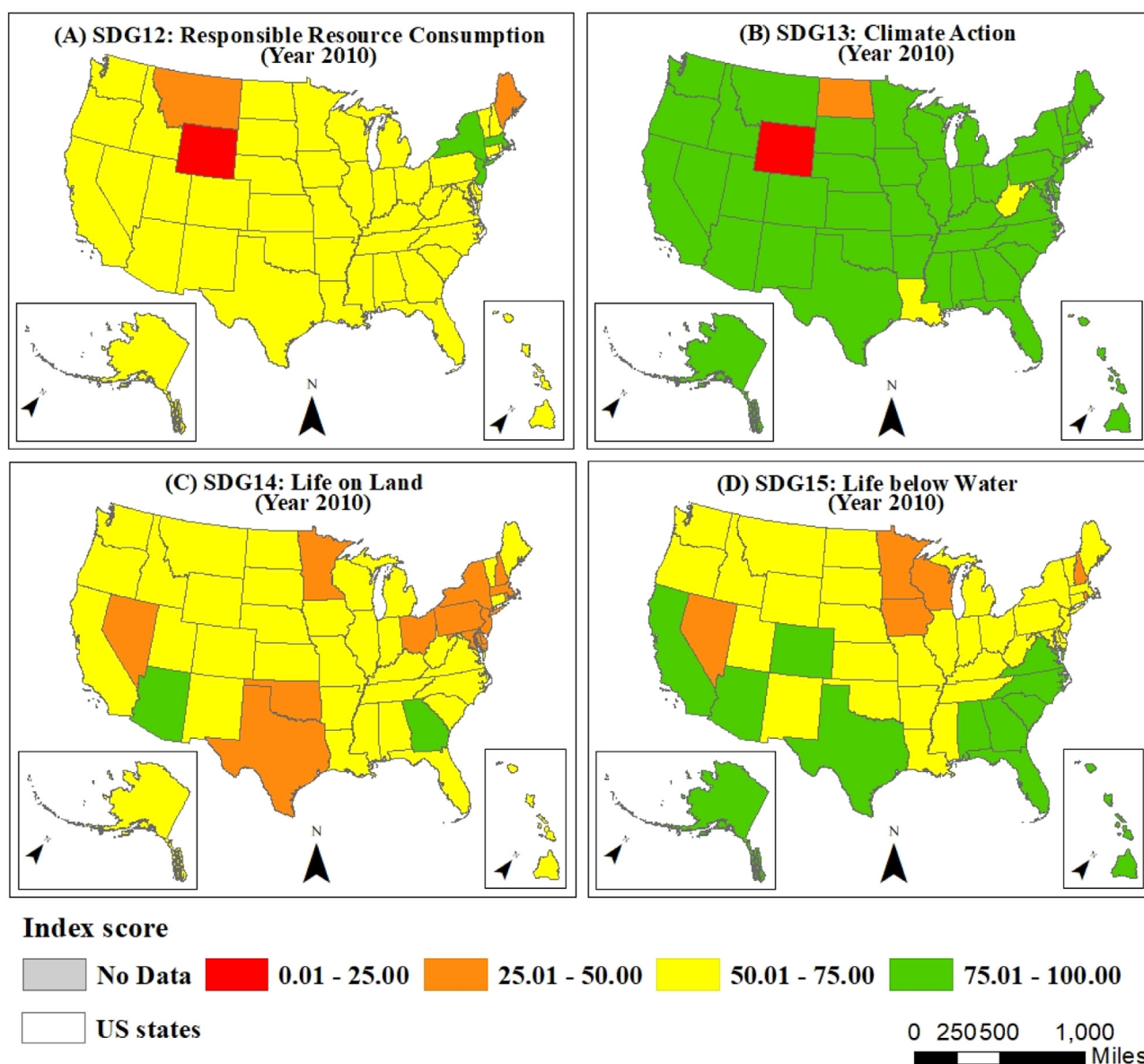


Fig. 18. Environmental SDGs (12, 13, 14, and 15) by states, USA 2010.

(Fig. 18- A). Similarly, SDG14 scores⁴ were in the yellow range for a majority of the states, but TX, OK, MD, and DE in the Southern; NV in the Western; MN and OH in the Midwestern; and PA, NY, NJ, MA, and NH in the Northeastern region, scored in orange (Fig. 18- C). Only two states, NV and GA scored in the green range on SDG14 for the year 2010.

As per SDG13 (Figs. 18- B and 19- B), there was no difference between 2010 and 2015, in terms of spatial distribution as almost every state scored in green except for, WY, LA, ND, and WV. Nevertheless, the underlying indicators are GHG and CO₂ emissions reported by facilities and summarized by states to estimate the emissions for each state. The drawback of these indicators includes that more extensive are likely to emit more GHGs, and probably provide the services to a larger population, but they were normalized with location state population. The

reason for using this facility scale data was that county scale emissions are not being recorded, and for comparison purposes, the same list of indicators was maintained at both scales. For SDG15⁵ indicators (Birds, Mammals, Amphibians, and Trees richness) in 2010, green scores are observed in the Southern and Western parts of the country (Fig. 18- D). Also, the lowest performance (25–50) was observed in the states such as North- Hampshire, Iowa, Nevada, Wisconsin, and Minnesota (Fig. 18- D). SDG15 (indicator-protected area for biodiversity) for the year 2015, was recorded in the green range for most (35) states (Fig. 19- C).

While there was no significant clustering was observed, the majority of the lower ENVI scores were observed in the Midwestern and Western regions in the year 2010 (Fig. 20- A). Based on distinct environmental

⁴ The SDG14 data were not available for the year 2015, hence it was excluded from the ENVI evaluation for the year 2015.

⁵ Data for five out of six indicators relevant to SDG15 were not available in the year 2015, and the only available SDG 15 indicator data for 2015 was not available for the year 2010.

Environmental SDGs by states, USA

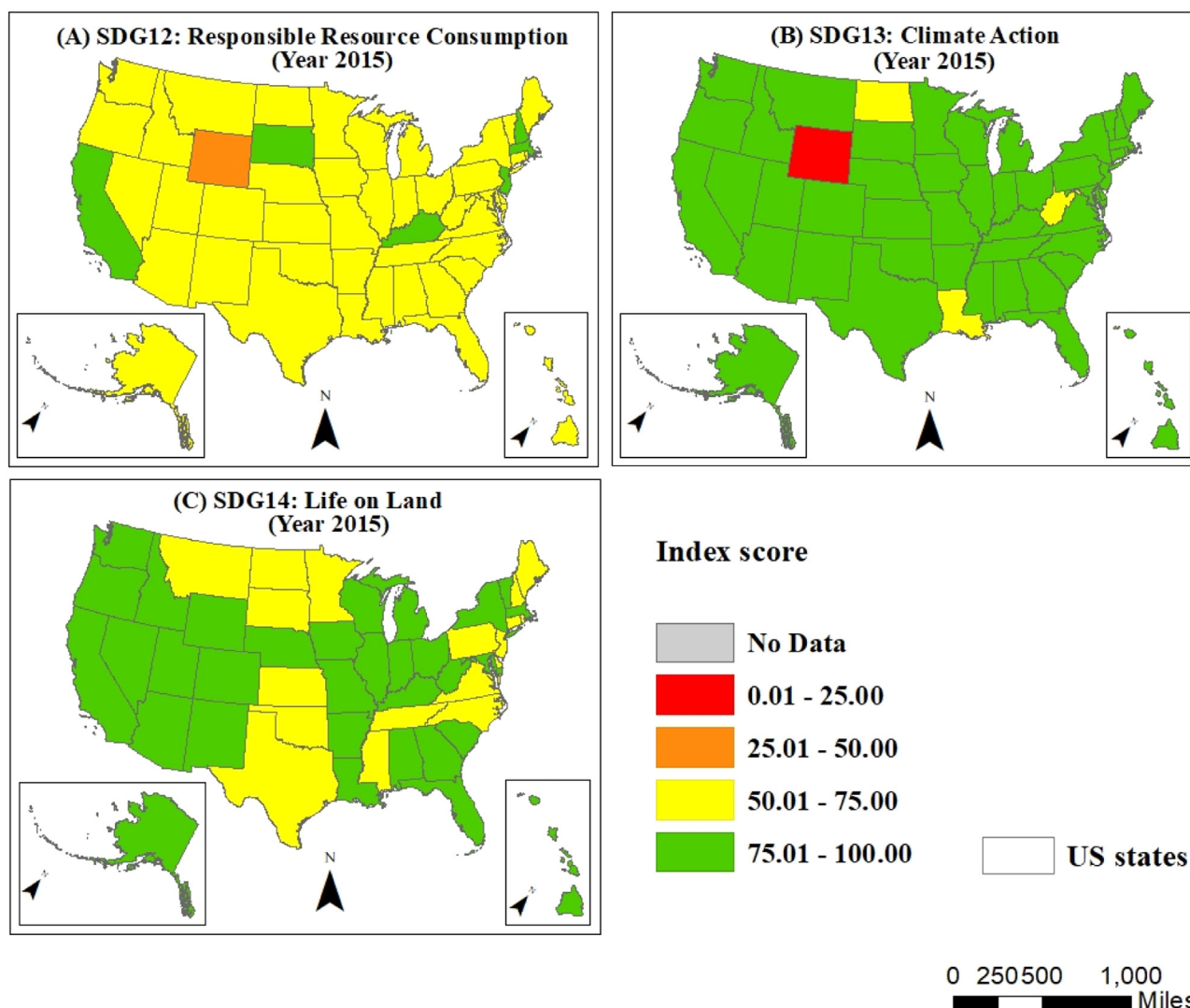


Fig. 19. Environmental SDGs (12, 13, and 15) by states, USA 2015.

indicators available for the year 2015, most of the lower scores (0–50) were observed in Midwestern and Southern states (Fig. 20- B).

Underlying SDGs at the local scale revealed the poor performance (0 – 50) of localities in terms of SDG12 in the Western (48%) and Midwestern (34%) regions in the year 2010 (Fig. 21- A). Outstandingly, most localities recorded in green and yellow on SDG 12 in the year 2015, but 30% of localities in the Western region still presented scores below 50. (Fig. 22- A). Likewise, poor performance on SDG 14 was observed for most localities in the Western (61%) and Midwestern (54%) regions (Fig. 21- C). Also, SDG15 was recorded in red or orange for most localities for both years (Figs. 21- D and 22- C), except for the Western region in 2015 (Fig. 22- C).

3.2.3. Social index (SOI)

Though all the states scored in the same range (yellow) for both years, it appeared like there is a parallel line somewhat in the middle of the country, dividing it into two parts (Fig. 23). Though this divide does not start at the Mason-Dixon line which is a boundary between Pennsylvania and Maryland at 39° 43' N, it is similarly dividing the country into Southern states with poor performance and the Upper part as Northern states with high scores.

Likewise, 38% and 31% of the localities in the Southern region recorded SOI in the orange range for the years 2010 and 2015, respectively (Fig. 24). Furthermore, Fig. 25 confirmed the state-wise low-low clustering in the Southern region, and high values clustering in the Northeast region mainly.

A weak clustering was observed at the local scale (Fig. 26), with a few high-values (HH) clusters in the Northeast and Midwest regions. A few low-values (LL) clusters were also observed in the Southern region (Fig. 26).

The social SDGs at the local scale are presented priority-wise in Figs. 27–29. Approximately 60 – 70% of localities out of the total 3142, consistently scored below 50 for SDGs – SDG2, SDG4, and SDG5 in both years (Fig. 27). Also, over 35% of localities scored in either red or orange on SDG1 and SDG3 for both years and were located mostly in Southern states. (Fig. 28).

Most of the localities consistently scored in the yellow range for SDG11 (Sustainable Cities and Communities) in both years, and approximately 10% of the localities, majorly in the Southern region, lagged on SDG11 with scores under 50 (Fig. 29). While most localities scored in green for SDG6 (Clean Water and Sanitation) for both years, SDG6 can be prioritized at the local level, to improve

Environmental index by localities, USA

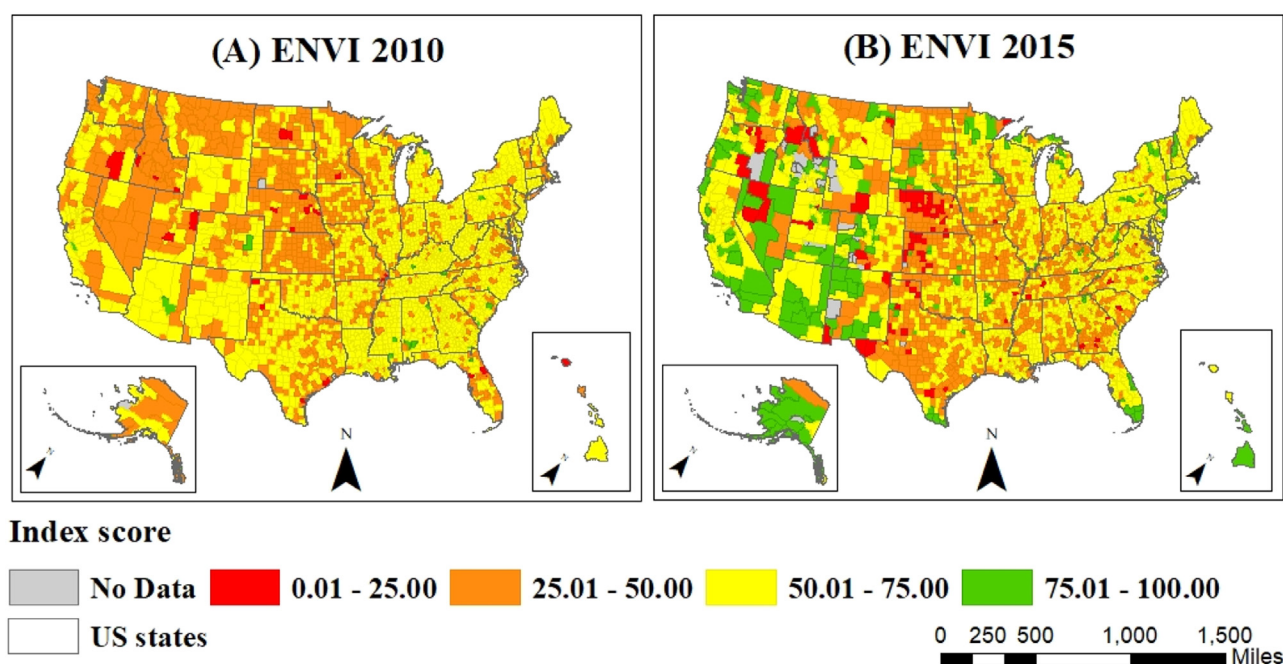


Fig. 20. The Environmental index (ENVI) by localities, USA, 2010, and 2015.

the scores for around 6% of localities that are in the yellow range (Fig. 29C-D).

The social SDGs 7 and 16 are presented state-wise for the years 2010 and 2015 in Fig. 30. Local-scale data for SDGs 7 and 16 are lacking over 50% of the localities, available locality data presented scores in either the green or yellow range for both years. Per Fig. 30 (A, B), most states scored high on SDG16, but states in the yellow range were also noticeable in the Southern and Western regions. Also, almost every state (except WY, ND, VT, and WV) states consistently scored in green for SDG7 (Fig. 30). WY lagged on SDG7 with scores below 50 in both years. Others such as ND, WV scored in the yellow range for the years 2010 and 2015, and VT scored in orange in 2015.

4. Discussion

4.1. The overall SDGI and three pillars of SD

The overall SDGI scores observed at the state scale for both years 2010 and 2015, probably haven't changed much considering the USA scored (72.7 – 74.6) in the yellow range for the Overall SDGI for the years 2016–2022 [53–59]. From the national to state scale, all states scored in the yellow range looked perfect in terms of uniform progress across all states. However, there is quite a bit of variation across all US Census regions, the entire Southern region performed poorly, none of the Southern states were ranked in the top 20 and high performers were clustered in the Northeastern region. Moreover, UN studies reported a similar geographic clustering in the index scores, with American states in the Northeastern and Pacific Northwest near the top of the index and states in the three southern regions performing poorly, despite using different indicators [36,54].

Corresponding to states, a few of the low-performing localities are clustered in the Southern region, and high-performing localities are in the Northeastern region. Nevertheless, most of the localities did not present a significant clustering. Subsequently, Sachs et al. [58] recorded San Francisco Oakland-Hayward, California (Western region) as the

best-performing city, and Baton Rouge, Louisiana (Southern region) as the worst. The geography of discontent is a symptom of an underlying policy failure. A focus on aggregate performance at the national level has obscured that struggling regions require distinct solutions. Only if policymakers address this fundamental issue will they be able to deal with the cause behind the geography of discontent [46].

Many countries have taken steps to address geographical inequalities. For example, Namibia is committed to ensuring both urban and rural electrification, including through solar and wind systems [22]. Colombia focuses on malnutrition in the regions most affected to ensure people from these areas are not left behind [8]. Egypt started an initiative to improve living conditions in their poorest villages. Madagascar demonstrates regional action especially by strengthening efforts to combat food insecurity in the south of the country [72].

Spatial and location-specific coalitions that bring together companies, investors, governments, civil society, and citizens to agree on shared priorities and develop common plans for action offer high potential to achieve scale and systemic impact [43]. The SDGs at sub-national scales provide a unique opportunity to rethink drastically the design and implementation of public policies, in a shared responsibility across levels of government and stakeholders to foster greater accountability, equity, inclusion, and cohesion now and in the future. This will contribute to addressing some of the root causes of the geography of discontent in a place-based manner. For example, in Southern Denmark, the SDGs are used to shape regional policy dialog. The overall concept of well-being and quality of life, the specific regional goals, and as well as the action of the region are linked to specific SDGs and are designed to contribute to their achievement. In particular, the Southern Denmark region has prioritized 11 SDGs that are most relevant for its work: SDG 3 on health, SDG 4 on education, SDG 5 on gender, SDG 6 on water, SDG 7 on clean energy, SDG 9 on industry and infrastructure, SDG 10 on inequalities, SDG 11 on sustainable cities and communities, SDG 12 on sustainable consumption, SDG 13 on climate and SDG 14 on life below water [47].

However, this prioritization comes with the risk of unbalanced attention being given to the SDGs. Excessive and prejudicial goal prioritiza-

Environmental SDGs by localities, USA

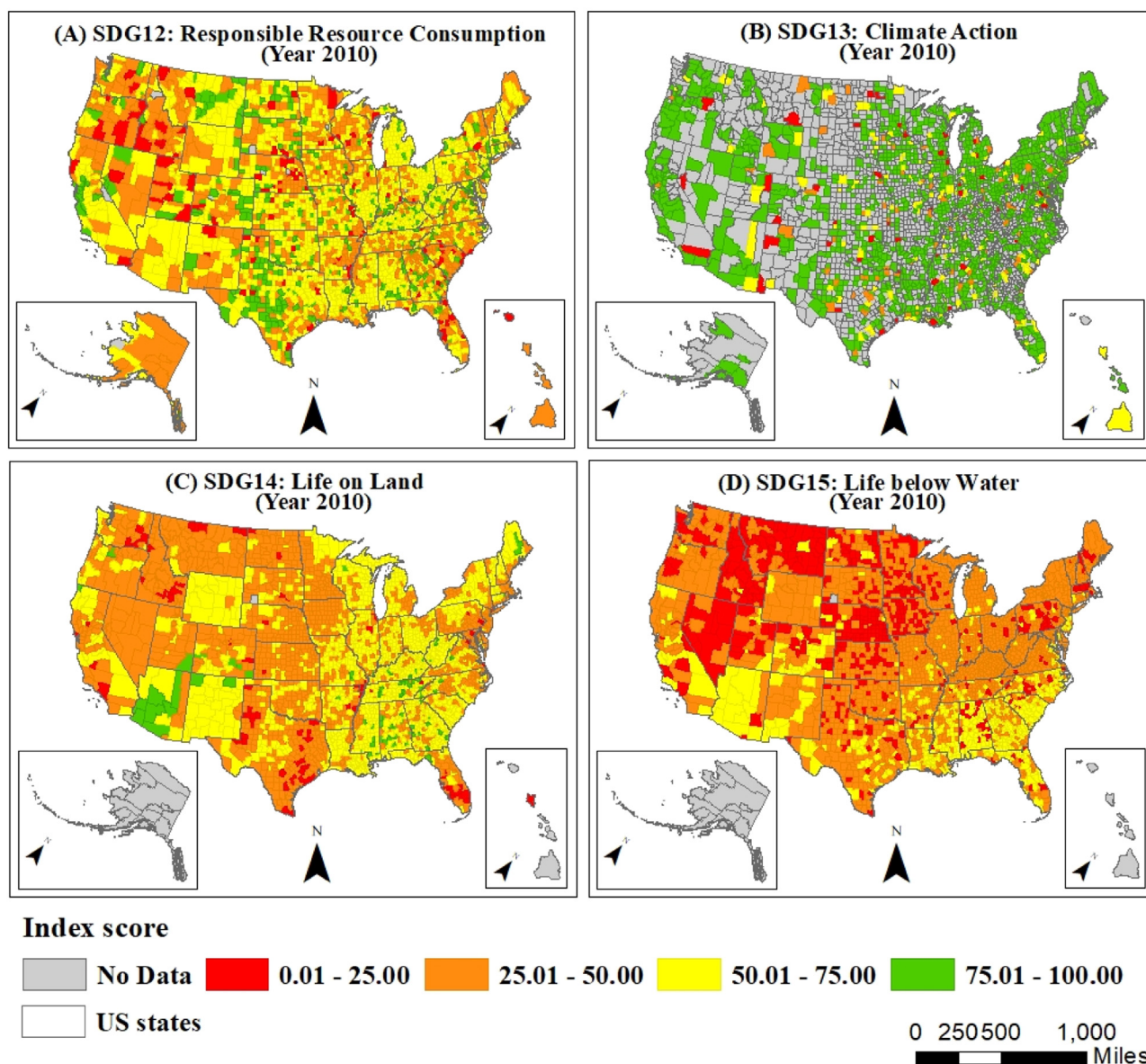


Fig. 21. Environmental SDGs (12, 13, 14, and 15) by localities, USA 2010.

tion goes against the intent of the 2030 Agenda for Sustainable Development and could pose a significant threat to the integrity and coherence of the supposedly “integrated and indivisible” SDGs [19].

To be fair, prioritization is not entirely avoidable especially to address geographic inequalities as mentioned earlier in the discussion. Some researchers argue that certain goals are, or should be recognized as, more important than others [11,24]. To identify the prioritization and associated risks, Forestier & Kim, [19] grouped the SDGs according to the three pillars of sustainable development as defined by Waage et al., [79], the results confirmed the conventional understanding that as a country develops, it transitions from selective prioritizing socioeconomic objectives towards a more balanced consideration of all three pillars of sustainable development. Comparably, the present study observed that most of the high-performing states in the Northeastern, Midwestern, and Western regions, also upheld a balance between three (economic, social, and environmental) pillars of SD for the year 2010.

Though, it was not the same in 2015 as most states scored higher on the environmental dimension. Contrary, poor-performing Southern states, with Wyoming (the bottom-most state) in the Western region, presented an uneven SD performance across three pillars. States showing imbalance across of three pillars of SD, recorded higher scores for the environmental pillar, in the Western region (AZ and NM), Northeastern region (VT), and the Southern (LA, MS, AL, GA, and SC) regions. Whereas Wyoming, North Dakota, and Alaska portrayed higher scores for the economic pillar. Sachs et al. [54] also noted that the Northeastern and Pacific Northwest regions with the best overall SDG are also doing the best across social, environmental, and economically grouped SDGs, the environmental dimension was leading across all states.

When drilled down to the local scale, not all the high-performing localities presented a three pillars approach to SD, there is a significant variation across localities. However, the overall pattern is sustained as over 40% of localities in the Northeastern, Midwestern, and Western lo-

Environmental SDGs by localities, USA

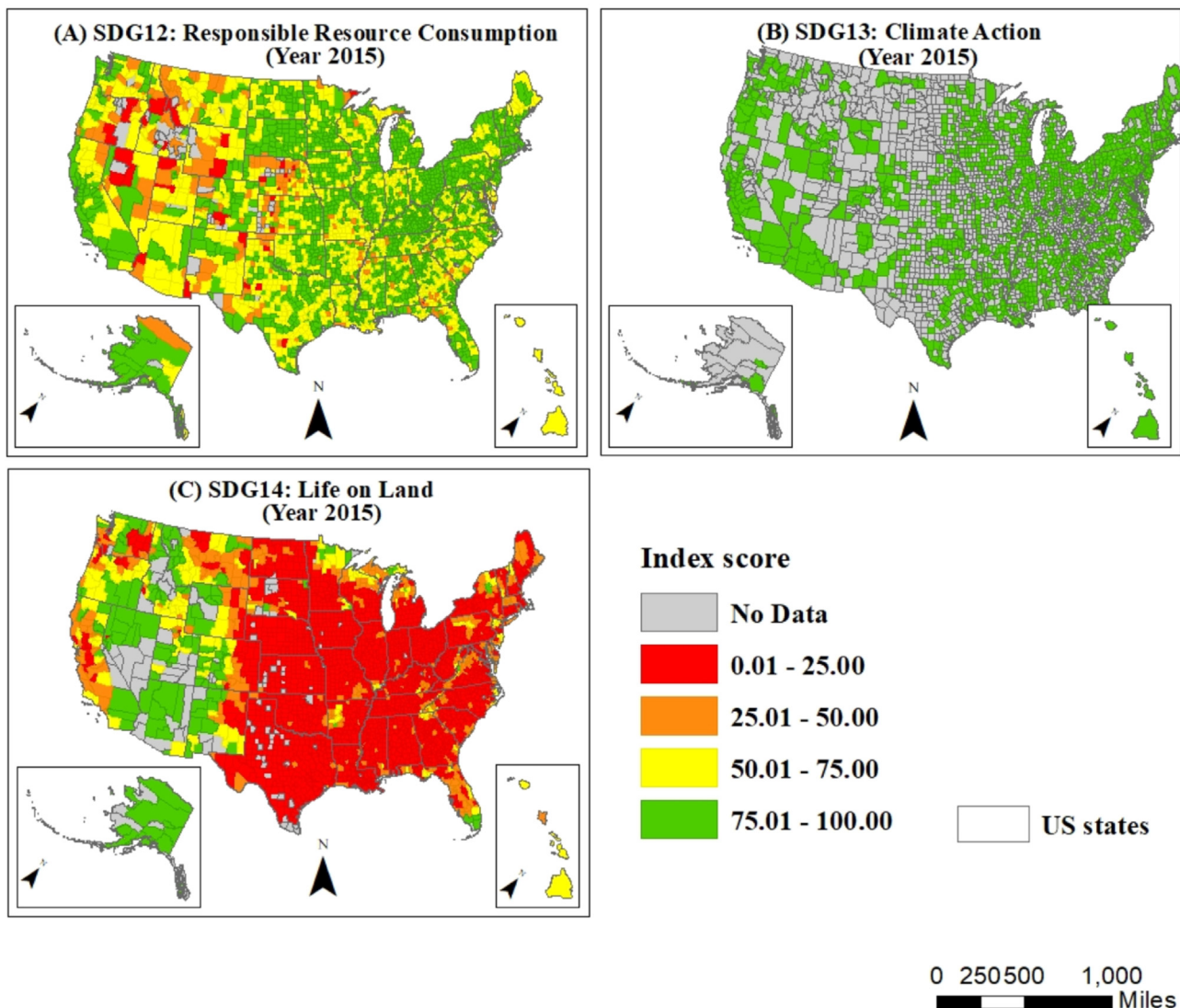


Fig. 22. Environmental SDGs (12, 13, and 15) by localities, USA 2015.

calities presented the balance scores across sub-indices. In the Southern region, most localities (about 70%) did not show the balance across the three pillars of SD. This suggests that to achieve all SDGs, balancing between or harmoniously pursuing these three pillars of SD is essential. The economic pillar predominated in most parts of the Midwestern region, with about 20% of the localities in the Northeastern, and Southern states such as Texas. Whereas most of the Southern localities represented environmental predominance in both years.

Although temporal variation is a bit ambiguous in the present study due to the unavailability of the underlying data, it was worth noticing that the best five localities in the year 2015, were scored lower in the year 2010, with balanced scores of sub-indices for two out of 5 localities in 2010. Conversely, the worst five localities in the year 2015 are at the bottom due to a decrease in the SDGI scores with an increased imbalance between sub-indices in the year 2015 as compared to 2010. This potentially indicates that success towards sustainable development is achieved when three dimensions of SD are pursued concurrently. Therefore, balancing between the three pillars of SD should be considered crucial and incorporated into a decision-making process to prioritize actions towards SDGs at the sub-national scales.

4.2. Economic, environmental, and social SDGs across states and localities

Social and economic pillars are distributed concurrently across states and localities, with minimal variation between the distribution patterns of these two pillar indices. The southern states have performed poorly in the economic dimension mainly due to underperformance related to specific underlying SDGs. The per capita income (one of the indicators under SDG8), did increase between the years 2010 and 2015, but the unemployment rate (SDG8 indicator) was high in most parts (MS, SC, AL, FL, GA, DC, TN, KY, LA, AR, and WV) of Southern region. This indicated the growing inequality with a growing economy, which was again evident with SDG10 distribution across states and localities. The entire Southern region was recorded with high-income inequality as compared to other states. This is a reminder of the famous Mason-Dixon line between Pennsylvania and Maryland, during the Civil Wars. The original intention of this line was to simply put a constitutional boundary, which ultimately becomes a divide of the country into parts, bottom Southern states, and upper Northern states. Initially, it was limited to Southern slaves and Northern free land divisions, later it became a cultural boundary, and the shadow of this divide still exists even after centuries. How-

Social index (SOCI) by states, USA

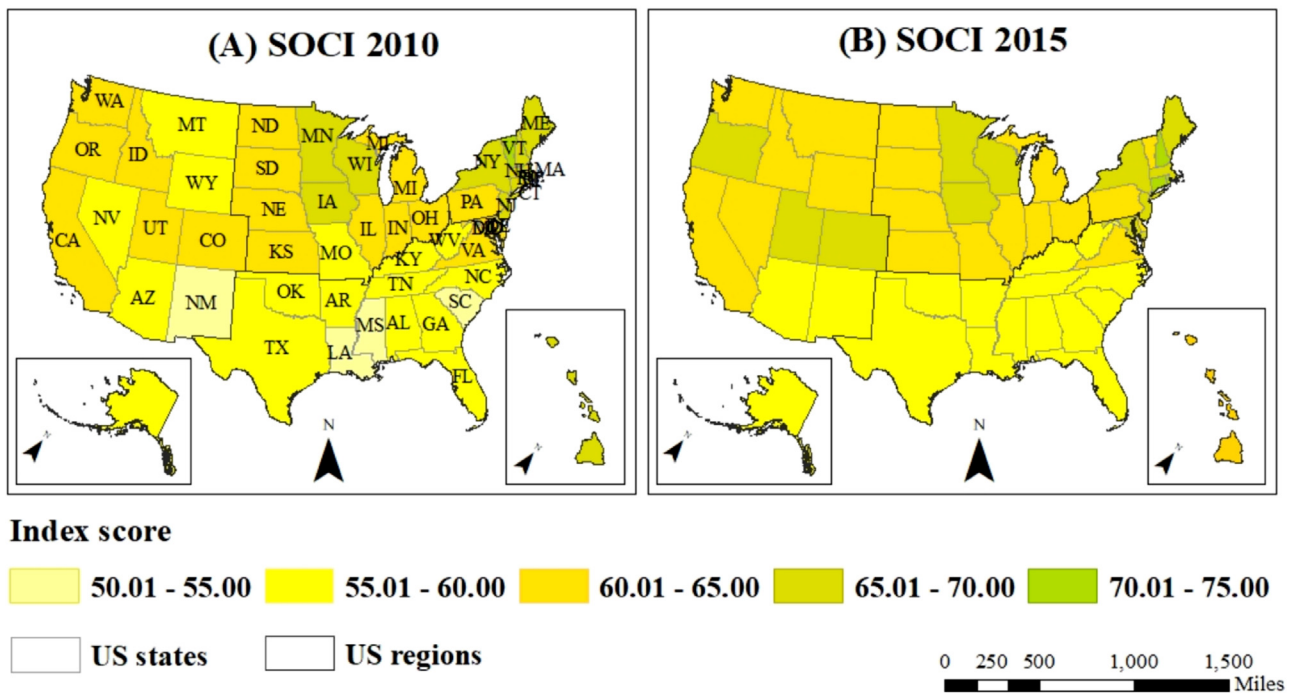


Fig. 23. The Social index (SOCI) by states, USA.

Social index by localities, USA

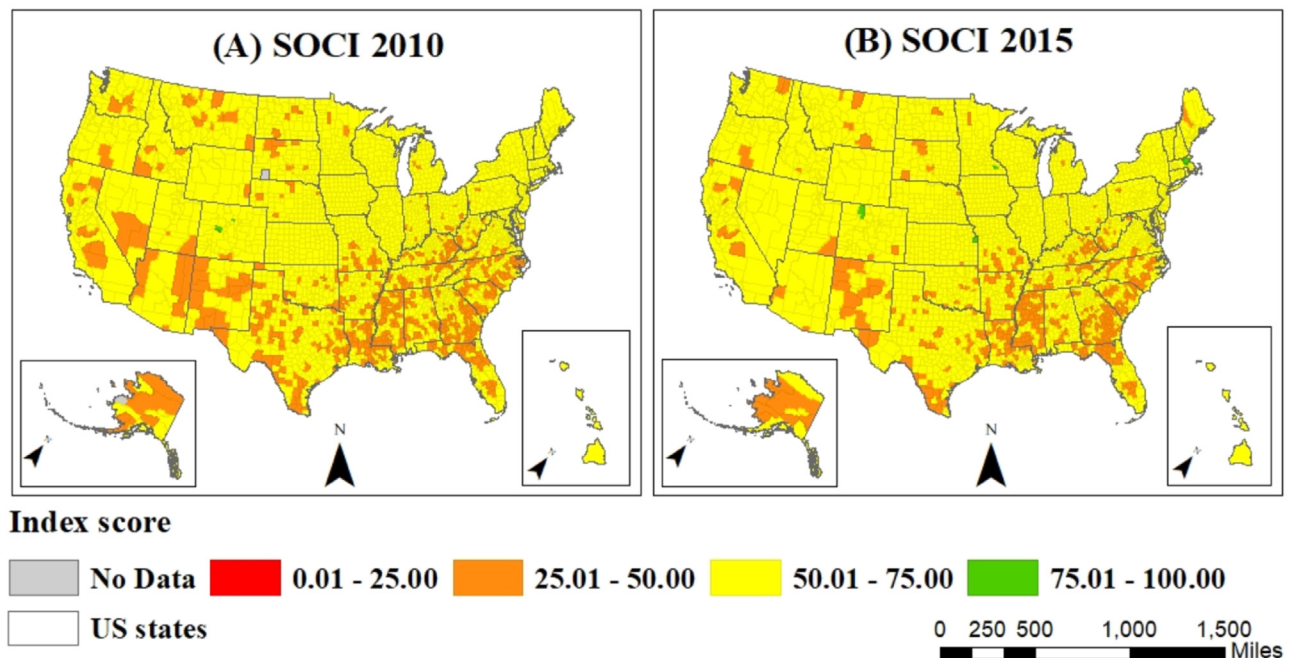


Fig. 24. The Social index (SOCI) by localities, USA.

ever, it is worth noting that the employment-to-population ratio under SDG8 rated well (scores above 50) across all states, including Southern states. Also, these economic distribution patterns can help to prioritize the SD pillars, underlying SDGs, and even economic indicators if needed.

Corresponding to the economic dimension in Southern states, high ECONI values in the Northeastern region resulted from SDGs 8, 9, and 10, with SDG10 being the major concern as it portrayed the lowest scores of the region (representing high-income inequality) in the states such as MA, RI, NJ, and NY. Also, SDG9 recorded higher scores in com-

Social index clustering across states, USA

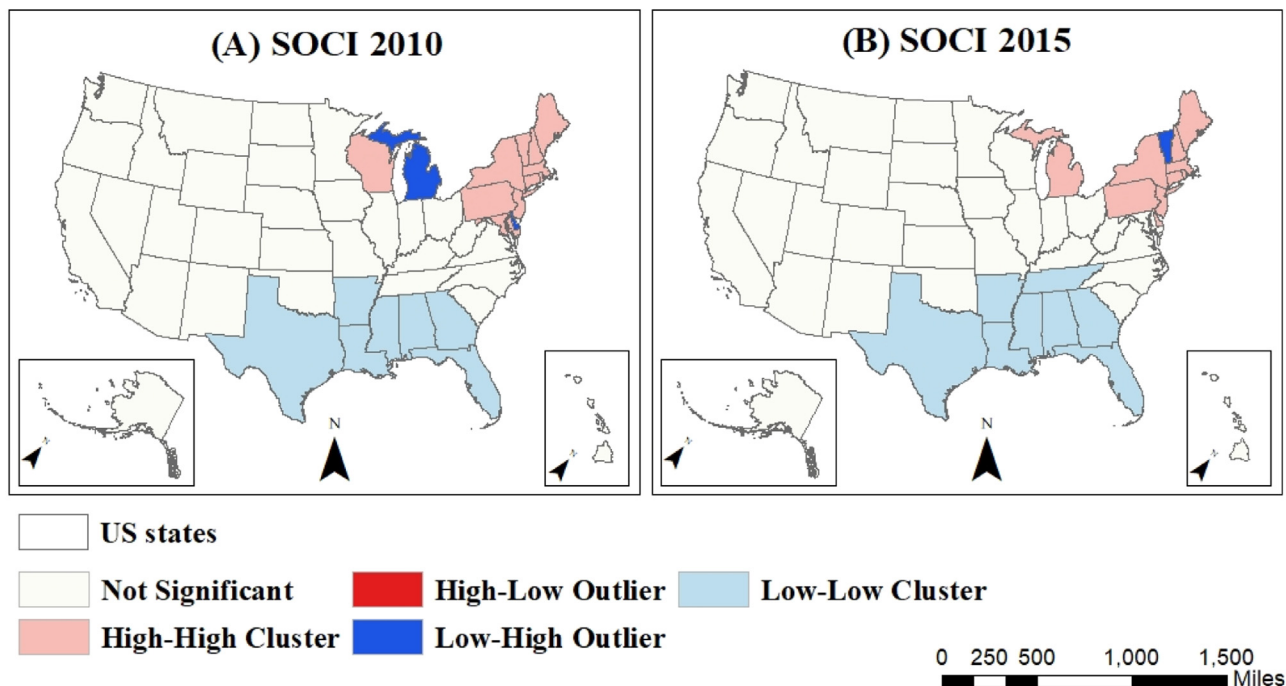


Fig. 25. The Social index clustering across states, USA.

Social index clustering across localities, USA

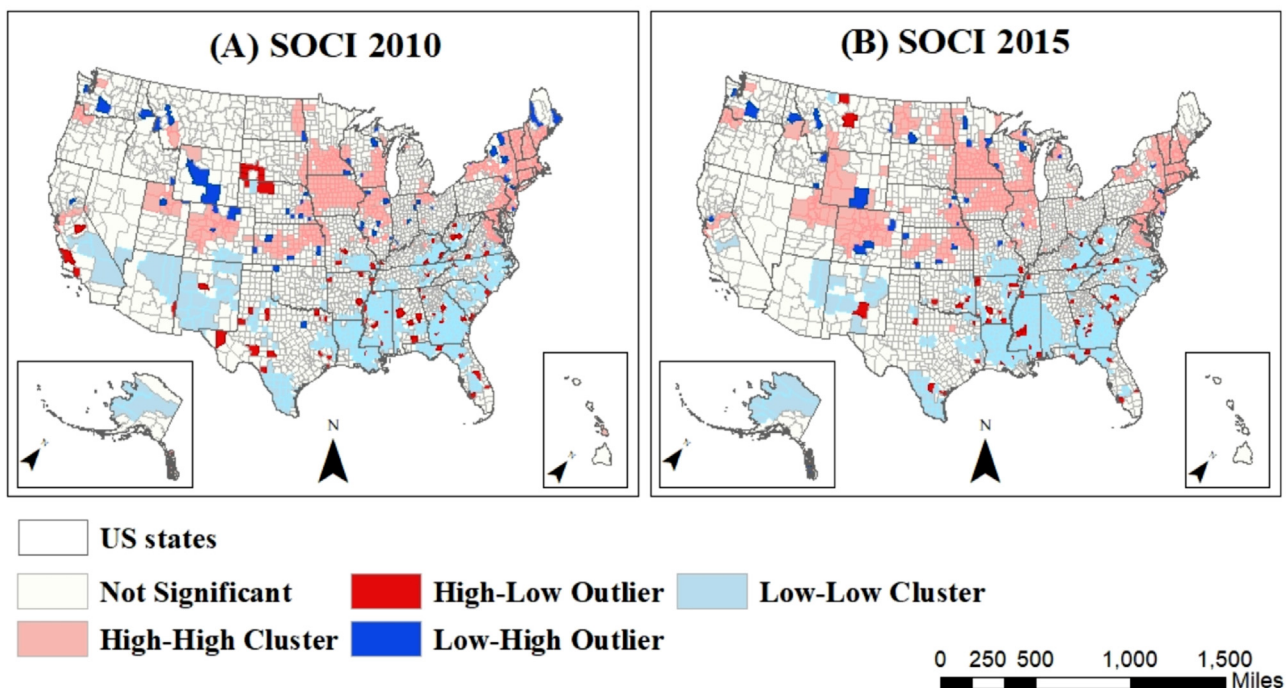


Fig. 26. The Social index (SOCI) clustering across localities, USA.

parison to SDG8 and SDG10 for most of the Northeastern states, indicating that SDG8 should be the next priority. Likewise, economic performance at the local scale can help prioritize local actions based on SDGs and underlying indicators.

In the social pillar, SDGs such as Quality Education (SDG4), Zero Hunger (SDG2), Gender Inequality (SDG5), No Poverty (SDG1), and

Good Health and well-being (SDG3), contributed to the lower performance of the states and localities and need to be prioritized, respectively over other social SDGs such as sustainable cities and communities (SDG11) and clean water and sanitation (SDG6). Most of the Southern states and localities performed poorly in terms of the social index (SOCI). This suggests that a certain minimum economic status is a pre-

Social SDGs by localities, USA

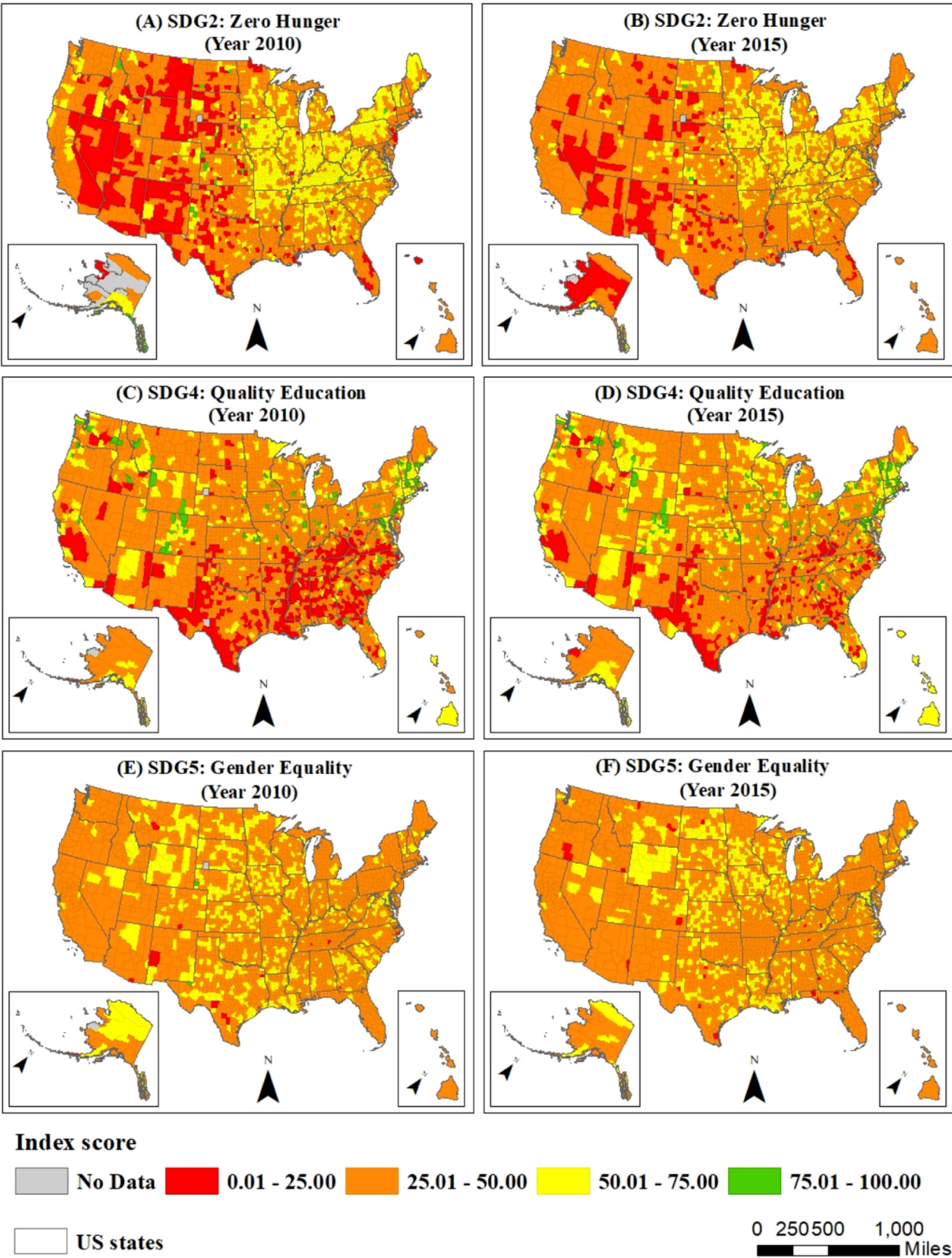


Fig. 27. Social SDGs (2, 4, and 5) by localities, USA.

Social SDGs by localities, USA

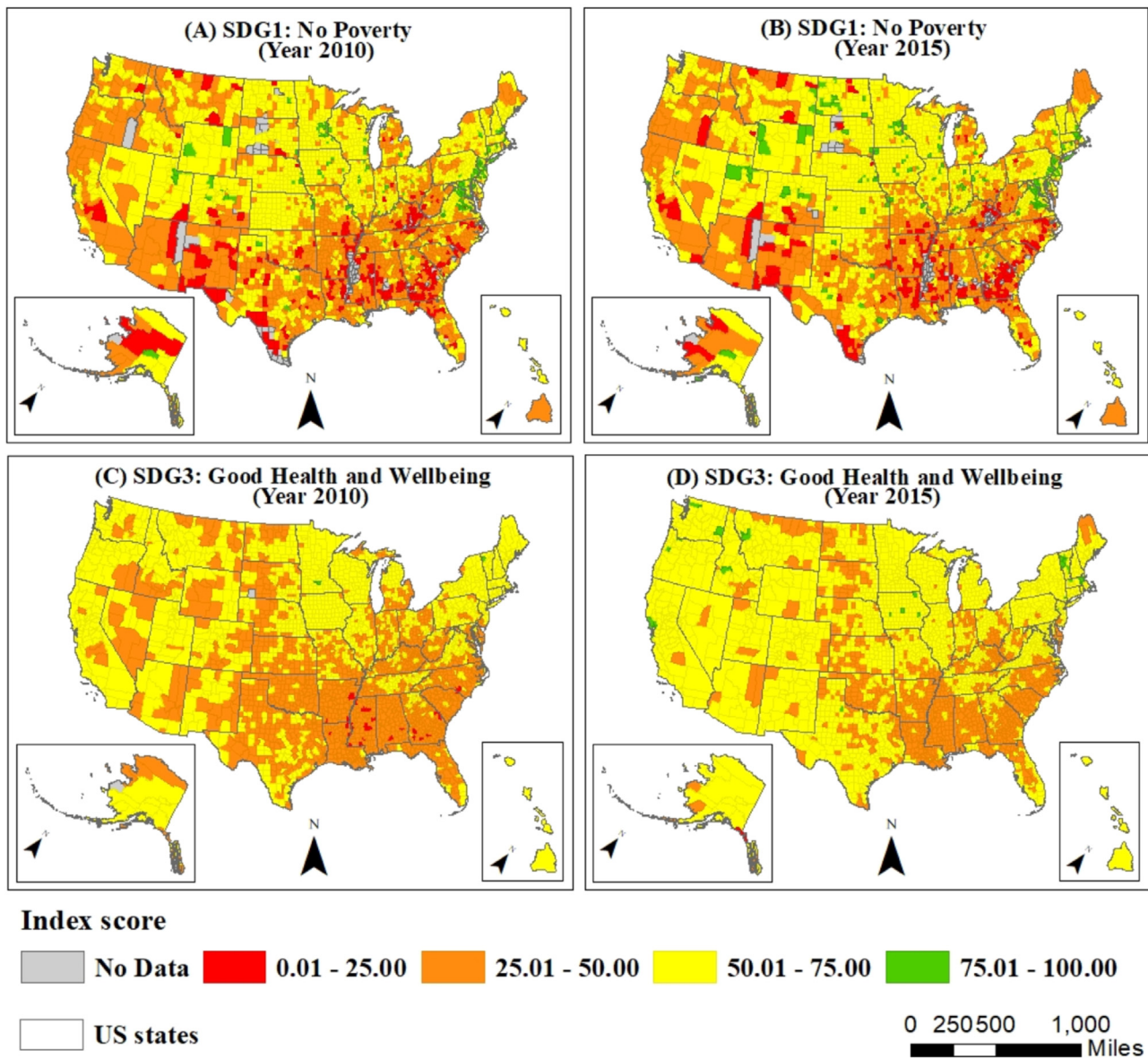


Fig. 28. Social SDGs (1 and 3) by localities, USA.

requisite to getting access to all social needs. Sachs et al. also recorded that, poverty hinders progress toward other development targets and prevents access to services for those who need them most (2018). For example, considering access, at best there are 51 affordable and available rental units per 100 low-income renters (Alabama), indicating that for low-income families across the US, there is little to no choice about where to live [54]. Another example is the prevalence of food insecurity, which is also affected by income and employment, as well as state-level characteristics such as average wages, cost of housing, unemployment, and State-level policies that affect access to unemployment insurance, the State Earned Income Tax Credit, and nutrition assistance programs [4]. As per the State and U.S. estimates for the 3 years of 2019–21, the prevalence of food insecurity was higher (i.e., statistically significantly higher) than the national average in 9 States (AL, AR, KY, LA, MS, OK, SC, TX, and WV) and lower than the national average in the District of Columbia and 14 States (CA, IA, MA, MD, MN, ND, NH, NJ, PA, RI, SD, VA, VT, and WA) [10].

The present study recorded SDG6 mostly in green across states and localities using indicators such as the percentage of occupied households with complete plumbing facilities, the percentage population served with public water supply, and the percentage population that has access to water supply (public/private). Contrary, Sachs et al. [54] observed extreme differences in access to safe drinking water within the US. Accordingly, in Minnesota, the best performer in avoiding water violations, 1.3% of communities were served by a community water system with a Safe Drinking Water Act (SDWA) violation. In contrast, over 61% of communities in Delaware had violations, and those are only the violations that are reported [54].

The green SDGs such as SDG7 (Affordable and clean energy), SDG13 (climate action), and SDG16 (Peace, Justice, and Strong Institution) were recorded mostly in green for all states, but over 60% of data were missing at the local scale. However, the results of a similar study show that low-income households are extremely energy burdened in all 50 states [16]. Spending 11% of income on energy is considered a high

Social SDGs by localities, USA

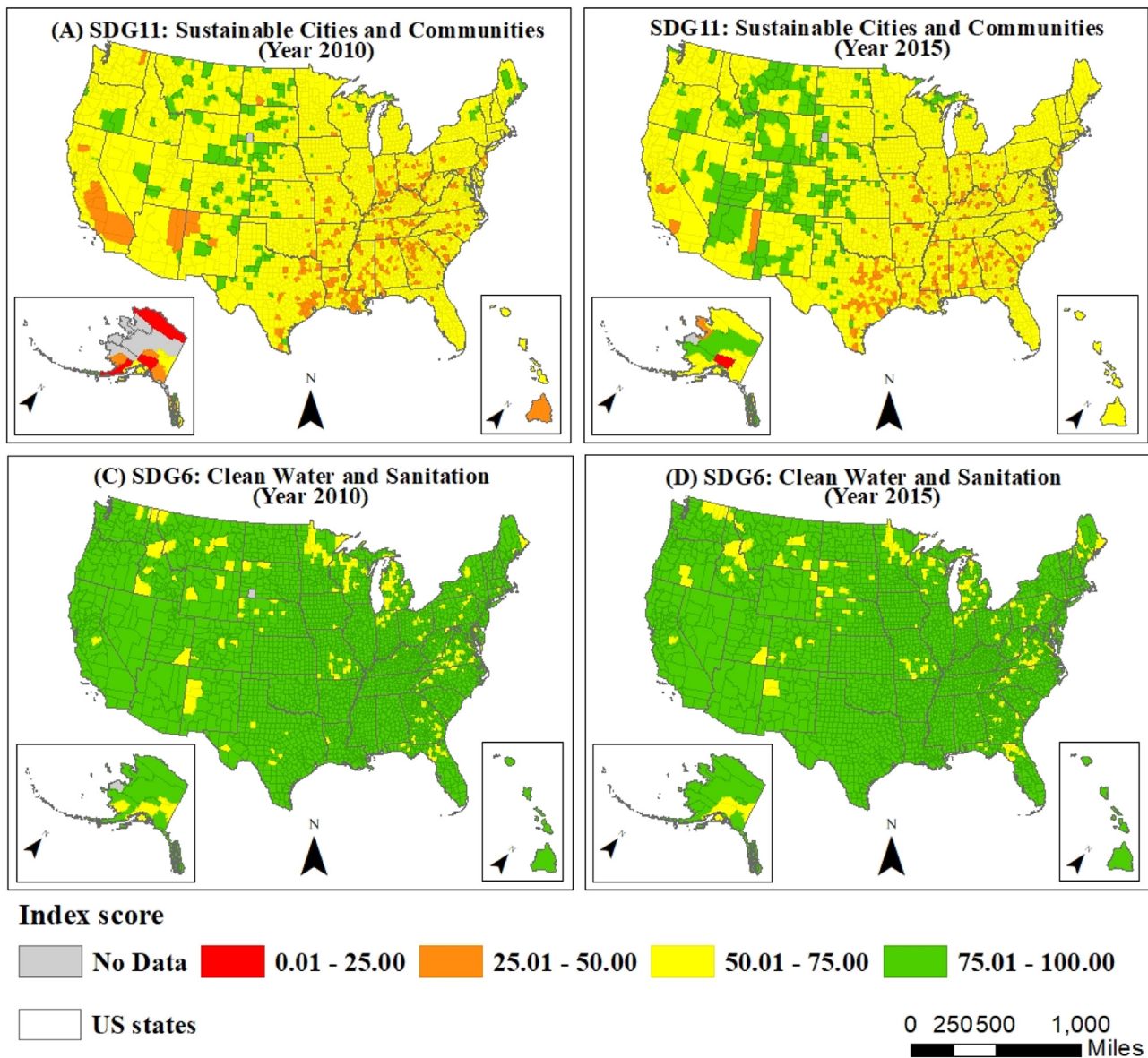


Fig. 29. Social SDGs (6 and 11) by localities, USA 2010 and 2015.

burden [16]; in every state except Hawaii, households below 50% of the poverty line are spending upwards of 20% of their income on energy – with Hawaii performing only marginally better at 19% [54].

Contrary to economic and social dimensions, the environmental dimension did not represent significant clustering at the state scale with almost every state scoring in the yellow range, leaving ND (orange) and WY (red) behind. Also, almost every state scored relatively higher on the environmental dimension in the year 2015, with a distinct set of indicators. The difference between the years 2010 and 2015 in terms of ENVI, cannot be interpreted as a change in the environmental dimension during 5 years period, as SDG15 for the year, 2010 used mainly biodiversity indicators whereas SDG15 for the year 2015 used protected area indicators. Also, SDG14 data was not available for the year 2015.⁶

⁶ In the year 2010, SDG 14 was represented by fish richness, stream habitat condition index, and coastal habitat condition index in the year 2010, data products from the 2010 national assessment of fish habitat, conducted in sup-

port of the National Fish Habitat Action Plan (NFHAP). However, oceans at the sub-national level in the US presents difficulties and oceans are managed at the interstate, national, and international scales. However, efforts could and should be made to better understand state-level impacts on the oceans to include Goal 14 in future editions of the index [54].

However, the underlying goal indices for SDG12 and SDG13 for both years 2010 and 2015 did not show much of a change. Hence, not showing any significant changes in 5 years could also be interpreted as there was no progress towards the SDGs, which can be argued by considering the timeline of the new 17 SDGs started in the year 2015 with targets to be achieved by 2030 and/or the inconsistent period of the data used underneath.

Considering the spatial distribution of environmental index scores across localities in the year 2015, lower scores of ENVI resulted from lower values of SDG15 (Life on land –% protected area). But lower values in the year 2010 were represented by SDG 14, and higher values

Social SDGs by states, USA

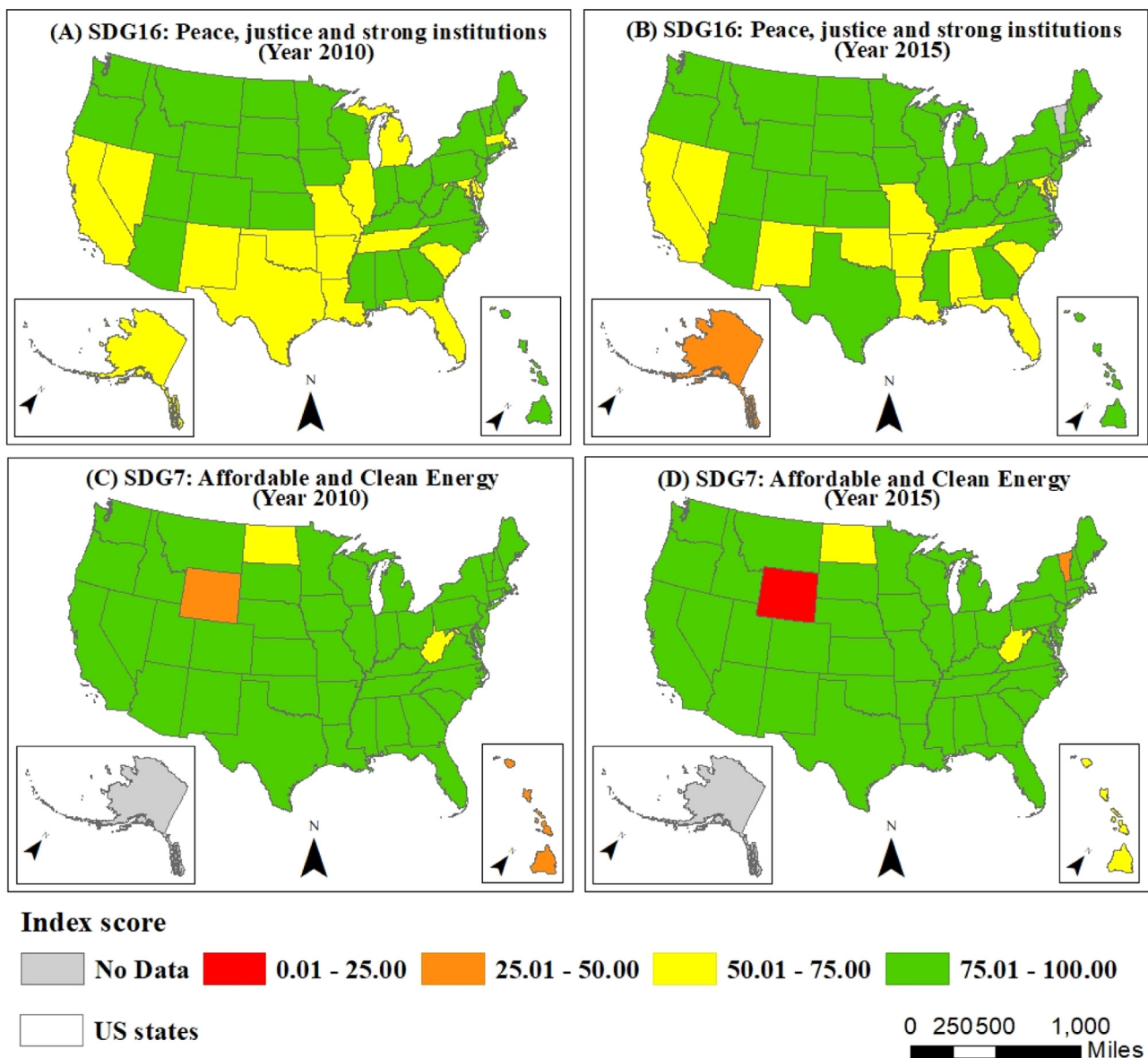


Fig. 30. Social SDGs (SDG 7 and 16) by states, USA 2010 and 2015.

in the southern region were due to underlying biodiversity indicators (SDG15) and climate change indicators (SDG13). However, SDG13 was represented by total GHG emissions and CO₂ emissions equivalent to CO₂ metric tons, by facilities, which was converted into per-capita emissions, and every state scored in green leaving WY, ND, WV, and LA behind in the year 2015. Historically the US has been one of the largest annual per capita and total emitters in the world [1]. This disproportionate contribution to global emissions impacts international efforts to mitigate and adapt to climate change and hampers the achievement of SDG13 (Climate Action). According to Sachs et al. [54], the US performs poorly on Goal 13, with significant variation between states, and the worst performer, Wyoming, has emissions thirteen times higher than New York, the best performer.

Overall, sub-indices across both scales seemed to express a possibility of a positive association between social and economic dimensions but had a bit confusing, as in negative or decoupling, association with the environmental dimension. Likewise, overlaying the SDGs within and

across the three pillars of SD, appeared to be interconnected. For example, the economic SDGs (8, 9, and 10) were observed lowest in the Southern region, SDGs 1 to 5 from the social dimension also performed poorly in this region. Contrary, SDG12 was recorded higher in the southern region. Also, SDG14 and SDG15 represented the same possibility of a negative or decoupling with economic and social goals in the year 2010. Just as poor outcomes in one SDG can hinder the achievement of others, progress on one goal can create benefits and opportunities in other aspects of development [33].

The SDGs are integrated and interdisciplinary development agendas and the results of the index in their study strengthen the claim that no SDG can be achieved alone – solutions and progress must be pursued in cross-cutting ways which acknowledge that outcomes are inherently connected across environmental, social, and economic development [3,54]. However, these interactions need to be studied further to confirm the association between the three pillars of SD as well as between the 17 SDGs.

The indicator-based approach is imperative for monitoring and assessing sustainable development, as it provides a basis on which to judge whether sustainable development is being achieved, to analyze the problems, and to understand their complexity while providing a reference for policymaking [37]. However, these indices are sensitive to the selection of indicators [50,81]. To observe and compare SDGs from local, state, and national scales, a consolidated list of indicators representing targets set under 17 SDGs, should also be recorded and tracked at sub-national scales. In collaboration with the US Office of Management and Budget, Office of Information and Regulatory Affairs; the US Department of State, Office of International Organizations; the US General Services Administration; and the US Office of Science and Technology Policy, the USA has already started working on providing information on the U.S. National Statistics for the U.N. Sustainable Development Goals. Subsequently, states and localities also should take reporting initiatives following the same framework as the national scale.

5. Conclusion

The present study provided the consolidated list of local indicators and SDGI measures across all states and localities (3142 counties and county-equivalent) to identify the local needs and prioritize the pillars and SDGs accordingly. The present study also supports the need for localization in planning and prioritizing the SDGs and highlighted the need for identifying and monitoring the same set of SDG indicators as created for national SDGI at sub-national scales. While the national performance provided the standing of the USA among 167 participating countries in this global collective action [58], the underlying state-scale analysis helped highlight the clusters of relatively well and poor-performing states. Though all states were recorded in the yellow (50–75) range for overall performance, underlying localities revealed an uneven distribution, emphasizing the need for locality-specific actions to resolve issues at a local level. Also, states can incorporate local scale customization in the planning and decision-making process to make sure that planned actions are precisely targeting the area(s) in need, whether it is a state's collaborative action with other states facing a similar issue or a state-specific action.

Analyzing the first 16 SDGs using the three pillars framework of SD demonstrated that most high SDGI scorer states and localities showed a balance between the three pillars (economic, social, and environmental) of SD. Additionally, findings indicated a possibility of a positive association between economic and social dimensions as distribution patterns across states and localities varied parallel to each other. Conversely, the environmental dimension is associated negatively with the other two dimensions, though it was not consistent spatially. The interactions between the three pillars of SD require further theoretically and empirically compelling research to confirm the associations and causality between the three dimensions of SD. Further, indices can be evaluated and monitored to study and track these patterns more accurately, using the same list of indicators that are being tracked at the national scale, to make it more consistent across the scales.

While localization is the key to moving forward toward sustainable development, balancing between the three pillars (economic, social, and environmental) of SD is essential to make progress on the path of SD. Therefore, the present study can be used as a framework to replicate country-specific domestic analysis and prioritize local actions.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

[Table A1.](#)

Table A1

List of indicators and the data sources and the thresholds used for the indices.

SDG	Name	Indicators	Locality		State		Source	Best (value = 100)	Worst (value = 0)	
			T1 (2006–2010)	T2 (2011–2015)	T1 (2006–2010)	T2 (2011–2015)				
Goal 1	No Poverty	1.1	Population living below the national poverty line (%)	2010	2015	2010	2015	[[65],[66]]	0	32
Goal 2	Zero Hunger	2.1	Households with food insecurity (%)	NA	2015	NA	2014	[38]	4.1	22.7
		2.2	Population with low access to grocery stores (%)	2010	2015	2010	2015	[77]	0	55.93
Goal 3	Good health and wellbeing	2.3	Forest area (%)	2006	2011	2006	2011	[25] Multi-Resolution Land Characteristics Consortium (MRLC) (Centers for Disease Control and Prevention [[9], n.d.]	93.5	0.1
		2.4	Agriculture area (%)	2006	2011	2006	2011		93.3	0.1
		3.1	Average annual neonatal (<28 days of age) mortality rate per 1000 live births over 5 years	2006–10	2011–15	2006–10	2011–15		1.52	7.18
		3.2	Total fertility rate per 1000 women	2006–10	2011–15	2006–10	2011–15		1163.6	2942.1
		3.3	Population without health insurance (%)	2010	2015	2010	2015	U.S. Census Bureau, Small Area Health Insurance Estimates [64] (Centers for Disease Control and Prevention [[9], n.d.]	0	33.3
		3.4	Low Birth Weight Babies (less than 2500 grams) (%)	2010	2015	2010	2015		2.6	10.4
		3.5	Average annual perinatal mortality per 1000 live births over 5 years	2006–10	2011–15	2006–10	2011–15		2.84	9.86
		3.6	Adult population obese Body Mass Index (BMI) ≥ 30 (%)	2008	2013	2010	2015		20.1	42
Goal 4	Quality education	4.1	Age 25 and older not completing high school (% high school dropouts)	2006–10	2011–15	2006–10	2011–15	U.S. Census Bureau (ACS): DP02	0.7	36.5
		4.2	Population (age 25 and over) with higher (Master, professional, doctorate) education (%)	2006–10	2011–15	2006–10	2011–15	U.S. Census Bureau (ACS): DP02	0.35	31.25
Goal 5	Gender equality	5.1	Gender wage gap (%)	2006–10	2011–15	2006–10	2011–15	U.S. Census Bureau (ACS): DP03	4.38	45.55
		5.2	Female population (age 25 and over) with higher education (%)	2006–10	2011–15	2006–10	2011–15	U.S. Census Bureau (ACS): B15002	31.01	0.48
		5.3	Female employees in local government (%)	2006–10	2011–15	2006–10	2011–15	U.S. Census Bureau (ACS): S2409	77.1	30.8
		5.4	Female employees in state government (%)	2006–10	2011–15	2006–10	2011–15		88.4	21.7
		5.5	Female employees in federal government (%)	2006–10	2011–15	2006–10	2011–15		87.9	1.8
		5.6	Female labor force participation rate (%)	2010	2015	2006–10	2011–15	U.S. Census Bureau (ACS): S2301	90.9	48.6
Goal 6	Clean water and sanitation	6.1	Households with complete plumbing facilities (%)	2006–10	2011–15	2006–10	2011–15	U.S. Census Bureau (ACS): S2504	100	0
		6.2	Total population served with public water supply (%)	2010	2015	2010	2015	The U.S. Geological Survey [[13],[39]]	100	10.18
		6.3	Total population served with water (public supplied + self-supplied) (%)	2010	2015	2010	2015		100	0
Goal 7	Affordable and clean energy	7.1	Per capita GHG emission from electricity generation (MT CO ₂), as reported by facilities	2010	2015	2010	2015	The United States Environmental Protection Agency [74]	0	349

(continued on next page)

Table A1 (continued)

SDG	Name	Indicators	Locality		State		Source	Best (value = 100)	Worst (value = 0)	
			T1 (2006–2010)	T2 (2011–2015)	T1 (2006–2010)	T2 (2011–2015)				
Goal 8	Decent work and economic growth	8.1	Per capita income in the past 12 months (dollars)	2006–10	2011–15	2006–10	2011–15	U.S. Census Bureau (ACS): B19301	47,675	5426.5
		8.2	Average Annual Unemployment rate (population 16 years and over) (%)	2006–10	2011–15	2006–10	2011–15	U.S. Census Bureau (ACS): S2301	0.2	16
		8.3	Employment to population ratio (%)	2006–10	2011–15	2006–10	2011–15		77.6	10.62
Goal 9	Industry, innovation, and infrastructure	9.1	Occupied housing unit with telephone service (%)	2006–10	2011–15	2006–10	2011–15	U.S. Census Bureau (ACS): S2504	100	90.8
Goal 10	Reduced inequality	10.1	Gini Index of Income Inequality (0–1)	2006–10	2011–15	2006–10	2011–15	U.S. Census Bureau (ACS): B19083	0.34	0.54
Goal 11	Sustainable cities and communities	11.1	Occupied housing units with complete kitchen facilities (%)	2006–10	2011–15	2006–10	2011–15	U.S. Census Bureau (ACS): S2504	100	92.2
		11.2	Annual average ambient concentrations of PM2.5 (µg/m3)	2010	2014	2010	2014	(Centers for Disease Control and Prevention [[9], n.d.])	3.7	15.3
		11.3	Average one-way commuting time (minutes)	2006–10	2011–15	2006–10	2011–15	U.S. Census Bureau (ACS): DP03	7	39
		11.4	Households with more people than rooms (%)	2006–10	2011–15	2006–10	2011–15	U.S. Census Bureau (ACS): S2501	0.1	10.48
		11.5	The population has access to parks/recreational spaces (%)	2010	2015	2010	2015	Centers for Disease Control and Prevention (CDC)	96	1
Goal 12	Responsible consumption and protection	12.1	Annual gross withdrawals of crude oil (numbers of barrels)	2010	2011	2010	2011	[76]	0	105
		12.2	Annual gross withdrawals of natural gas (1000 cubic feet)	2010	2011	2010	2011		0	1675.43
		12.3	Per capita total water withdrawal (ground + surface) (gal/day)	2010	2015	2010	2015	The U.S. Geological Survey [[13],[39]]	0.074	7763.07
		12.4	The working population uses public transport to work (%)	2006–10	2011–15	2006–10	2011–15	U.S. Census Bureau (ACS): DP03	37.58	0.01
		12.5	Per capita domestic water use (gal/day)	2010	2015	2010	2015	The U.S. Geological Survey [[13],[39]]	26.06	245.3
Goal 13	Climate Action	13.1	Per capita, GHG emission reported by facilities (MT CO ₂)	2010	2015	2010	2015	The United States Environmental Protection Agency [74]	0	107.7
		13.2	Per capita, CO2 emission reported by facilities (MT CO ₂)	2010	2015	2010	2015		0	107
Goal 14	Life below Water	14.1	Fish richness	2010	NA	2010	NA	[[28–30],[48]]	238	9
		14.2	Stream Habitat Condition Index (HCI) scores	2010	NA	2010	NA	(<i>NFHAP</i> , n.d.-a; [44])	4.69	0.04
		14.3	Coastal Habitat Condition Index Scores	2010	NA	2010	NA		0.95	0.02
Goal 15	Life on Land	15.1	Birds richness	2010	NA	2010	NA	[[28–30],[48]]	249	126
		15.2	Mammals richness	2010	NA	2010	NA		88	36
		15.3	Amphibians richness	2010	NA	2010	NA		46	3
		15.4	Reptiles richness	2010	NA	2010	NA		69	1
		15.5	Trees richness	2010	NA	2010	NA		138	2
		15.6	Protected areas for biodiversity (GAP 1 and 2) (%)	NA	2016	NA	2016	(U.S. Geological Survey [75] , 2016)	86.96	0
Goal 16	Promote justice, peaceful and inclusive societies	16.1	The total annual number of violent crimes reported (per 1000 individuals)	2010	2015	2010	2015	[[17],[18]]	1	162

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