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Sustainability Atlas of Texas Ecoregions

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Abstract

Since the introduction of the triple bottom line sustainability assessment accounting, a variety of approaches have been developed to quantify sustainability using the three axes of social, economic and environmental sustainability. The aim of this atlas is to assess the sustainability of Texas natural ecoregions: the Piney Woods, the Gulf Prairies and marshes, the Post Oak Savanah, the Blackland Prairies, the Cross Timbers, the South Texas Plains, the Edwards Plateau, the Rolling Plains, the High Plains and the Trans-Pecos, by identifying a set of indicators. These are unemployment, children in poverty, severity of housing problems, daily PM2.5 concentrations, population affected by drinking water violation, total water use, organic production, non-obesity and attainment of post-secondary education. Despite the limitations of inherent inaccuracies and temporal limitation, the assessment points to issues that negatively affect the environmental sustainability of Texas ecoregions. Continual assessment is recommended to optimize the atlas.

Keywords

Sustainability Assessment, Environmental Indicators, Economic Indicators, Social Indicators, Texas Ecoregions, Triple Bottom-Line, People Planet Profit

1. Introduction

"What we are doing to the forests of the world is but a mirror reflection of what we are doing to ourselves and to one another"—Mahatma Gandhi [1]. Sustainability definition progressed from measuring a corporate's financial performance to a new three-dimensional framework of the three Ps: people, planet and profit, or triple bottom line (TBL) [2] [3]. According to EPA (2015), sustainability "is to create and maintain the conditions under which humans and nature can exist in productive harmony to support present and future generations" [4]. Because of its significance to the quality of life in the present and the future, normative and scientific aspects of sustainability have evolved in an attempt to qualify and quantify sustainability. These measurements have been shaping policy on the three main scopes: environmental, economic, and social [5]. However, for sustainability to be scientifically operationalized, it needs to be measured using a holistic system's interdisciplinary approach [6].

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Triple Bottom Line (TBL) analysis has been the increasingly popular accounting management style because it assesses a system's success not by the financial bottom line only but by its social and environmental impacts. Although sustainability is a noble old concept, it brings more issues that producers, researchers, investors, consumers, and policy makers need to resolve in order to be able to implement it.

Texas is the second largest state after Alaska, covering 266,807 sq. miles, and having natural ecoregions: the Piney Woods, the Gulf Prairies and marshes, the Post Oak Savanah, the Blackland Prairies, the Cross Timbers, the South Texas Plains, the Edwards Plateau, the Rolling Plains, the High Plains and the Trans-Pecos [7]. Studying an ecoregion can provide insight on the sustainability baseline and potential for that ecoregion. But how can sustainability be quantified and measured for a Texas ecoregion? If it cannot be measured then how can they be qualified as being sustainable, or not? Also, how can two or more sustainable ecoregions be contrasted to each other in terms of sustainability? There has been some research that suggested developing indicators to measure the three bottom lines for ecoregions as indicators for sustainability [8], but it is still under development because of the complexity of studying the many variables that need to be accounted for.

"Defining an appropriate set of indicators for sustainable development is a difficult task" [9] because identifying too few indicators may ignore essential details whereas including too many indicators complicates data collection and analyses and result in non-feasible research. Hence, finding an optimal set of indicators is challenging [9] [10]. There are two categories for sustainability indicator identifying framework: system-based and content-based [11]. This research is based on holistic system-based framework. However, because the ecoregions represent the main trends given the available resources, this project presents a framework that is larger than the system, or more specifically it is at the sector level [12]. The systemic dimension plays an essential role when selecting and designing the indicators for sustainability assessment. In order to obtain an adequate system representation, three criteria should be met: parsimony, sufficiency and indicator interaction. In general, a system should be represented with as much simplicity as possible (parsimony) and as much complexity as necessary (sufficiency). This implies that, for obtaining an adequate system representation, the most relevant relations among the indicators have to be considered in the analysis [13]. The indicators and their relations have to represent the main structures, processes, and functions of the economic, ecological and social fields of the system studied and have to refer to the problems and targets to be tackled. In this context, the natural Texas ecoregion is the system of interest which is an economic, social and ecological entity that fulfills the previously-mentioned criteria.

A list of major sustainability projects in the United States are inventoried by Sustainable Measures (2010) [14]. Two standout as they are projects specific to Texas: Central Texas Sustainability Indicators Project and Austin Sustainable Community Initiative. Both are focused on the social aspect of sustainability. The former is designed to assess community indicators for five counties whereas the latter does that same for Austin area. Schader *et al*. (2014) [12] thoroughly assess thirty-five major sustainability assessment approaches pertinent to ecoregions all over the world. Two approaches stand out from the U.S. Fieldprint Calculator and IFSC. The first is focused on six crops: corn, cotton, rice, wheat, potatoes, and soybean; whereas the second is for Illinois farms. Neither of them takes into account the social nor the economic aspects of sustainability. For an indicator-based sustainability assessment to comprehensively and reliably reflect the significant features of the ecoregion, the research and results must be pursued in a society- and policy-conscious framework. Trans-disciplinary research perspectives are considered herewith as essential to accomplishing this task. Parameterizing and thus quantifying sustainable operations can be used to guide sustainable management. Furthermore, this study highlights the usually skipped important aspect of sustainability: people and the society. The purpose of this study is to develop a sustainability assessment tool for Texas ecoregions that can lead to informed decisions based on a holistic approach. Moreover, the proposed sustainability indicators can provide early warning to avoid social, economic, and environmental setbacks. Finally, they can drive new sustainability policies, innovations and measures.

2. Methods

The social aspect of any society is the most transformational because unlike environmental or economic aspects, it is the only aspect we have control over. The literature points to plethora of social indicators. Nevertheless, representative social indicators should reflect the "nature, meaning, pace, and course of social change" [15] in the US. As such the percentage of adults who are not obese (with body mass index BMI less than 30) and percentage of adults aged 25 to 44 with some post-secondary education, were selected as representative social indicators. As for environmental indicators, they should represent the quality of the environment in Texas ecoregions including air, water, and soil. In this study average daily particulate matter that are smaller than 2.5 micrometer (PM2.5) (μg/m^3), percentage of population affected by water violation, total water Use (million gal/day) and organic production will be the four environmental indicators. The achievement of economic feasibility is vital to an ecoregion. Unemployment, children in poverty and severe housing problems were selected to represent the economic status. List of the nine proposed indicators are presented in **Table 1**. Pairwise associations were calculated. The selected indicators were summarized for the natural ecoregions for one year.

3. Results

Texas ecoregions are given in **Figure 1**. Pairwise associations between the indicators show strong positive correlation between the number of organic producers and total water use (**Table 2**). Non-obesity is negatively

Table 1. Proposed indicators, their scopes and descriptions.

Scope	Indicator	Description
Economic	Percent unemployed	Percentage of population ages 16+ unemployed and looking for work [16] [17].
Economic	Percent children in poverty	Percentage of children (under age 18) living in poverty [18].
Economic	Percent severe housing problems	Percentage of households with at least 1 of 4 housing problems: overcrowding, high housing costs, or lack of kitchen or plumbing facilities [19].
Environmental	Average daily PM2.5 (μg/m^3)	Average daily amount of fine particulate matter in micrograms per cubic meter [20].
Environmental	Percent in drinking water violation	Population affected by a water violation/Total population with public water [21].
Environmental	Water use (million gal/day)	Water use (fresh and saline), in million gal/day [22].
Environmental	Organic production	Number of organic producers [23].
Social	Percent non-obese	Percentage of adults that report BMI < 30 [24].
Social	Percent some college	Percentage of adults age 25 - 44 with some post-secondary education [25].

Table 2. Pairwise correlations between the proposed indicators.

	Water use (million gallon/day)	Number of organic producers	% No obese	% Some college	% Unemployed	% Children in poverty	Average daily PM25	% In drinking water viol	% Severe housing problems
Water use (million gallon/day)	1.00								
Number of organic producers	0.81	1.00							
% Obese	0.55	0.28	1.00						
% Some college	0.17	0.24	−0.05	1.00					
% Unemployed	0.40	0.19	−0.46	−0.50	1.00				
% Children in poverty	−0.13	−0.26	−0.20	−0.73	0.75	1.00			
Average daily PM25	−0.27	−0.38	0.48	−0.32	−0.32	−0.28	1.00		
% In drinking water viol	−0.41	−0.20	0.06	0.26	−0.72	−0.33	−0.03	1.00	
% Severe housing problems	0.25	0.34	−0.29	−0.21	0.75	0.61	−0.68	−0.59	1.00

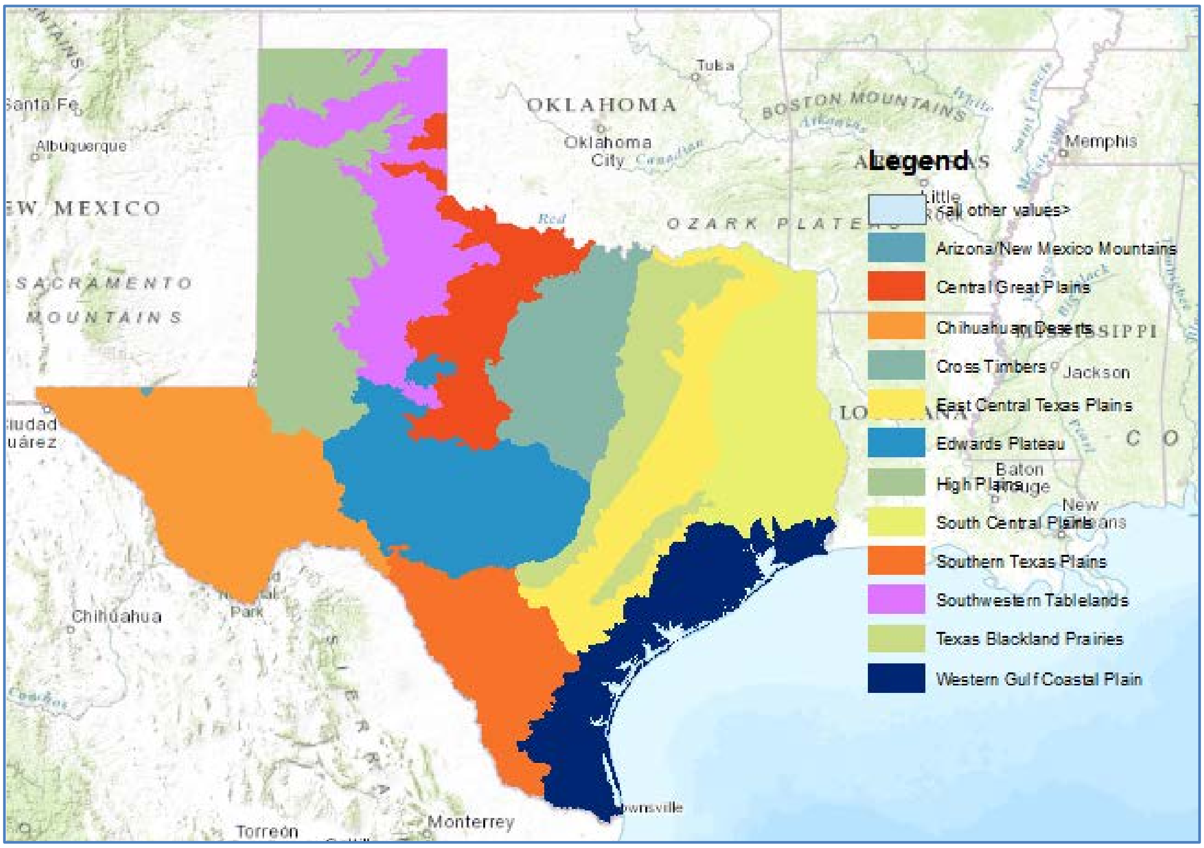

Figure 1. Texas ecoregions [26].

correlated with unemployment and positively correlated with daily PM2.5 concentrations. Moreover, unemployment is strongly positively associated with percentage of children in poverty and severe housing problems. However, it is strongly negatively associated with percentage of population in areas with drinking water violation. Severe housing problems is strongly positively associated with percentage of children in poverty and negatively associated with daily PM2.5 concentrations. Severe housing problems are negatively associated with percentage of population affected by drinking water violation. Percentages of harvested acres in each ecoregion are given in **Figure 2**. Southwestern Tablelands are mostly agricultural whereas only two percent of Chihuahuan Deserts are. Economic sustainability is the average of the three economic indicators of unemployment, children in poverty and severity of housing problems (**Figure 3**).

4. Discussion

Of the three bottom lines, environmental sustainability was the lowest compared to the social and economic scopes, ranging between 27% for Edwards Plateau and 34% for the High Plains (**Figure 3**). This means that Texas ecoregions environmental sustainability needs attention from policy makers in order to address the issues that negatively affect its degree of sustainability. The highest degrees of sustainability were observed in the economic indicators which averaged from 80% for Southern Texas Plains to 89% for the Central Great Plains (**Figure 4**). Social sustainability ranged from 57% for the Chihuahuan Deserts to 63% for Texas Blackland Prairies (**Figure 5**). Overall sustainability ranged from 55% for Southern Texas Plains to 60% for Texas Blackland Prairies (**Figure 6**).

Despite the simplicity of this assessment method, data accuracy might be an issue especially that most of the data collected has inherent accuracies and some being "best estimates" as opposed to field measurements. Spatiality is built in sustainability assessment. Hence, relevance and applicability to other locations depend on similarities to Texas ecoregions. TBL based sustainability assessment is flexible and easy to customize [8]. Achieving sustainability is like chasing a moving target because of the inherent subjectivity in selecting the indicators

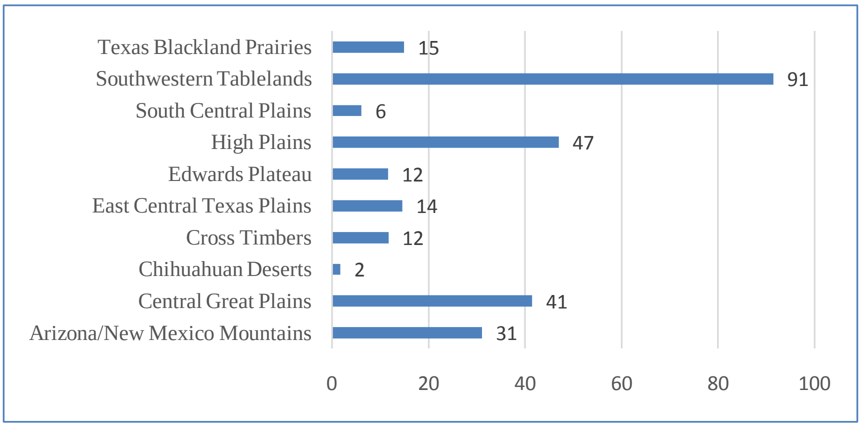

Figure 2. Percentage of harvested acres in Texas ecoregions.

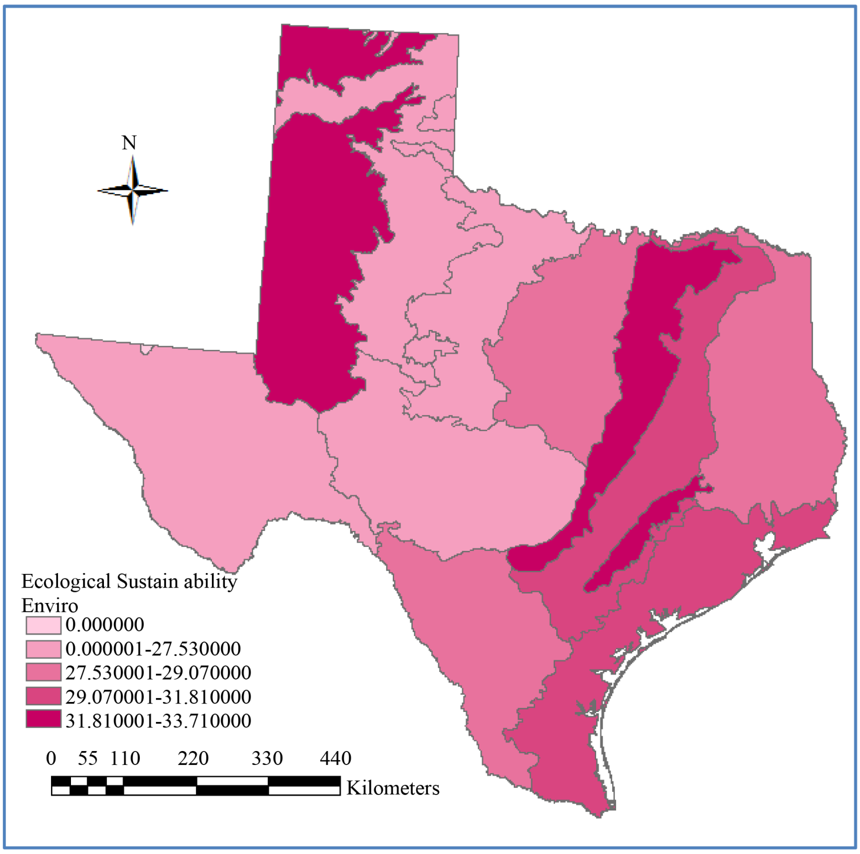

Figure 3. Ecological sustainability of Texas ecoregions.

due to reasons related to ease of access or ease of calculation. Moreover, the investigated indicators were for one year. That is, the results' applicability is limited and this calls for continuous assessment in order to ensure temporal suitability, accuracy of data and selection of the most representative indicators.

5. Conclusion

This research is an example of quantifying sustainability for Texas ecoregions using the three bottom lines of people, planet and profit. The assessment quantifies the social, economic and environmental aspects using nine indicators: unemployment, children in poverty, severity of housing problems, daily PM2.5 concentrations,

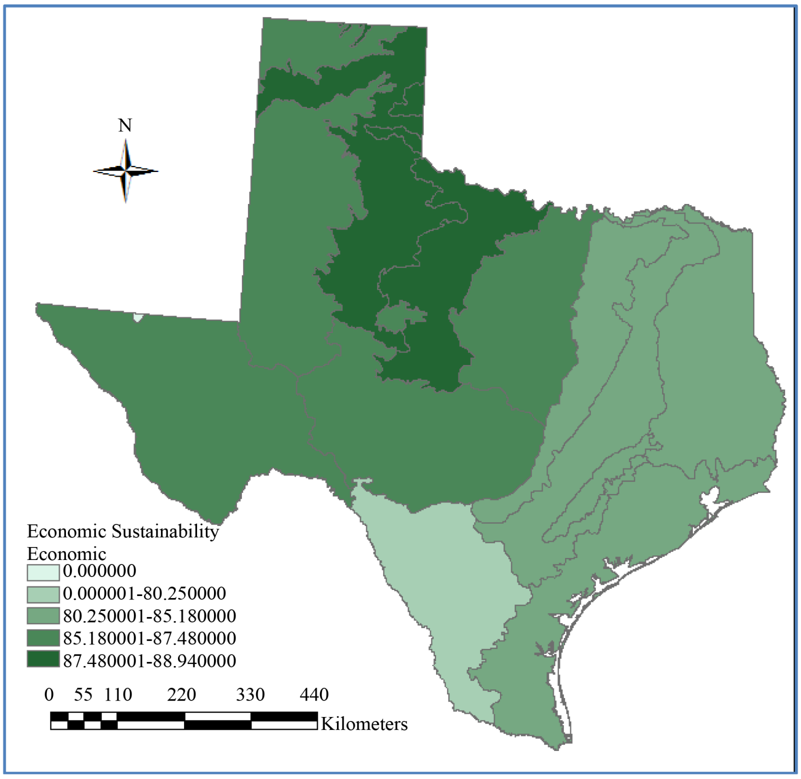

Figure 4. Economic sustainability of Texas ecoregions.

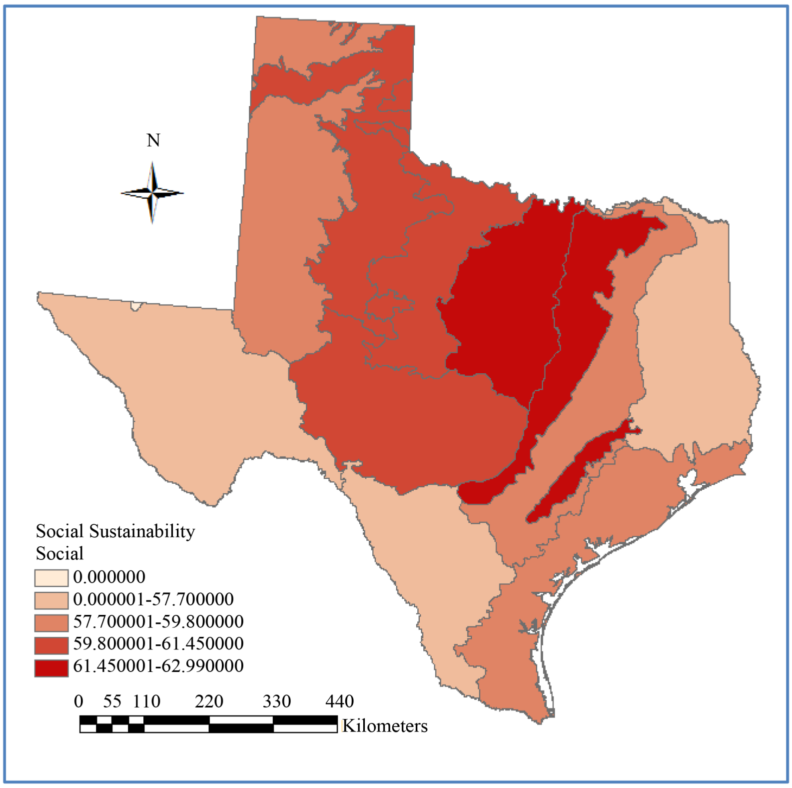

Figure 5. Social sustainability of Texas ecoregions.

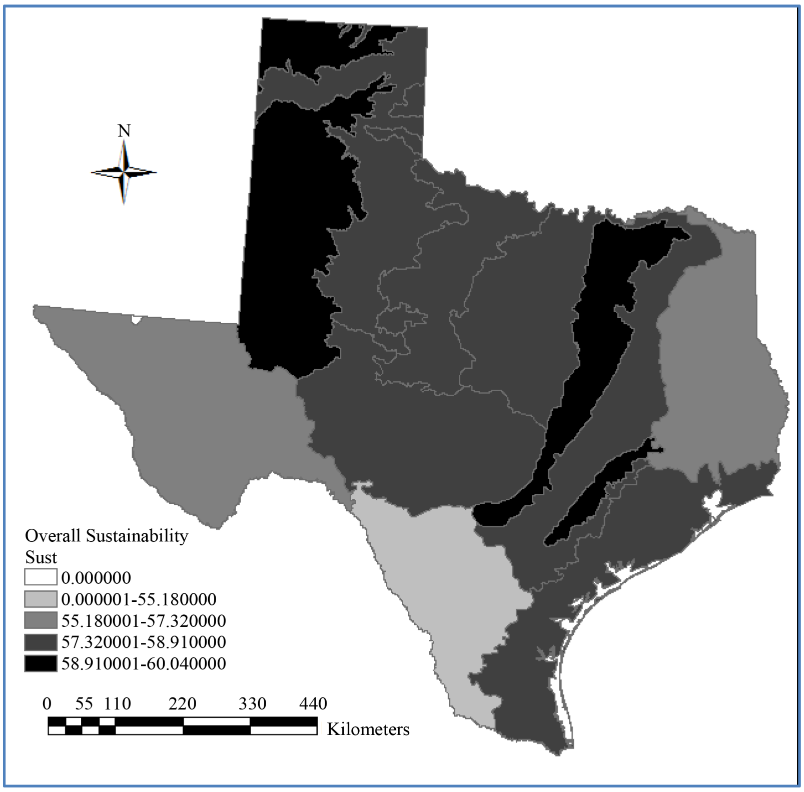

Figure 6. Overall sustainability of Texas ecoregions.

population affected by drinking water violation, total water use, organic production, non-obesity and attainment of post-secondary education. The results point to certain needs in the different ecoregions especially on the environmental aspect. Further analyses are required to test and validate the atlas in terms of time, data accuracy and identification of the best set of representative indicators.

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