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A Sustainability Assessment of Utah's 29 Counties: Testing a Multivariate Graphical Method of Sustainability Assessment

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A SUSTAINABILITY ASSESSMENT OF UTAH'S 29 COUNTIES: TESTING A MULTIVARIATE GRAPHICAL METHOD OF SUSTAINABILITY ASSESSMENT

By

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ABSTRACT

A Sustainability Assessment of Utah's 29 Counties:

Testing a Multivariate Graphical Method of Sustainability Assessment

By

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Utah State University, 2016

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Sustainability provides a framework to help guide future planning, policy, investment, and development actions toward achieving multidimensional development goals. The goals of planning for sustainable development aim at a future with high quality of life in a healthy and protected environment.

This paper adopts, reviews, critically examines, and tests a previously-developed methodology for sustainability assessment. The tested approach applies an interactive evaluation model to combine existing data to explain sustainable development possibilities for each evaluated locale. The model's results, presented through a graphic interface, can build knowledge to improve planning decisions and implementation actions for sustainability. The assessment can help to connect data with actions by providing means to organize and combine existing information, and by turning stakeholders' views of development into an operational decision support system.

The model proves capable – given adequate data – of determining how well communities measure up to a given definition of sustainability. Thus, the methodology is a good tool for testing how our conceptions of sustainable development map to the world we live in.

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PUBLIC ABSTRACT

A Sustainability Assessment of Utah's 29 Counties:
Testing a Multivariate Graphical Method of Sustainability Analysis
Thomas Cluff

Sustainability provides a framework to help guide future planning, policy, investment, and development actions toward achieving a community's goals by attempting to understand the interactions between Environmental, Societal, and Economic conditions and circumstances – and then reducing conflicts between these three domains. The goals of planning for sustainable development aim at a future with high quality of life in a healthy and protected environment.

This paper adopts, reviews, critically examines, and tests a previously-developed methodology for sustainability assessment. The tested approach applies an interactive evaluation model to combine existing data to explain sustainable development possibilities for each evaluated locale. The model's results, presented through a graphic interface, can build knowledge to improve planning decisions and implementation actions for sustainability.

The assessment can help to connect data with actions by providing means to organize and combine existing information, and by turning stakeholders' views of development into an operational decision support system.

The model proves capable – given adequate data – of determining how well communities measure up to a given definition of sustainability. Thus, the methodology is a good tool for testing how our conceptions of sustainable development map to the world we live in.

ACKNOWLEDGMENTS

It is a strange thing indeed to arrive at the end of so wordy a process only to find oneself at a loss for words.

The least nod to decorum demands that I thank the members of my thesis committee, yet “thanks” is an astonishingly trite word in this circumstance – it lacks the necessary heft. Moreover, if that is true for the committee, it is a thousand-fold more true for my committee chair, my advisor, my mentor, my friend; Carlos Licón. Would that I could find the phrase sufficient to describe how much I appreciate his never-ending enthusiasm for discovery.

And, of course, wisdom requires the greatest devotion precisely where words are least likely to *ever* be adequate: Marla, my beloved, what would I be without you?

Thos. Cluff

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CHAPTER I

INTRODUCTION

For practicing planners, elected officials and other policy-makers, it can often be a challenge to determine which policies to pursue in order to create a more sustainable future for the communities they serve. Some of the reasons include:

- Complexity of the factors that affect sustainability.
- The interrelation of those factors, which greatly increases the difficulty in predicting results of policy changes.
- The time involved to try and understand these issues.

Nevertheless, enabling policy-makers to incorporate complex, multivariate analysis of sustainability efforts into policy-making decisions could give them valuable information about the possible outcomes of their actions. More importantly, the availability of a tool that can help them predict the outcomes of interactions between numerous complex factors affecting their community could help them integrate better information into their decision making processes.

A community's sustainable development is dependent on the interaction between three factors – the Social, Environmental and Economic aspects of life in that community. Sometimes these factors support each other and sometimes they conflict (Figure 1). To the extent they conflict, potential for sustainable development is reduced.

The three factors of sustainability are modeled, measured, and operationalized using a set of indicators. The indicators make use of publicly available data to represent conditions and interrelationships in the communities being assessed.

Figure 1. Interaction defines sustainable development. (Adapted from Campbell, 1996, p. 298.)

A sample graphic is displayed in Figure 2. The triangle in the center – the area left over after conflicts between the three sustainability factors are accounted for – represents the potential for sustainable development in the subject community. The areas in the corners of the large triangle represent conflicts between the different sustainability factors. Conflicts between the factors contributing to sustainability create restrictions or limitations on the community's ability to freely act in a sustainable fashion.

The graphic provides an informationally-dense display of the relationships between all three components of sustainability. This, in turn, allows the user of the graphic the ability to access and compare a very wide array of complex relationships in a single display of information. If further information is needed, the user can then return to the data from which the graphic is derived to discover more about the specific conditions that are causing the conflicts. Policies can then be crafted to address specific needs or build on identified strengths. This project takes an assessment tool that can graphically display the net result of complex interactions between many different factors, and tests its use for assessing sustainability at the county level, using the 29 counties of Utah. The tool evaluates the sustainable development potential of each county by graphically comparing the interaction of Social, Environmental and Economic factors within that community. It also allows for comparison between counties.

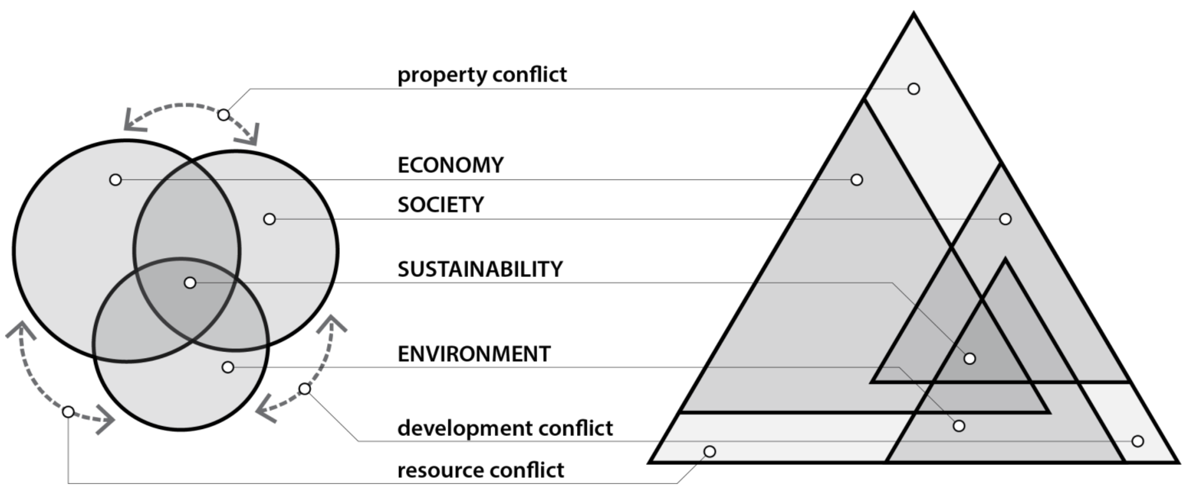


Figure 2. Graphic display of interactions between Society, Environment and Economy.

The project-specific purpose is to adapt a methodological approach developed in a previous study for the purposes of reviewing, testing and critically examining its usefulness for future application.

The larger purpose is to lay the groundwork for creating a tool that local-level decision makers can then adapt to their own needs, so that the tool can be used to support better policy formation. This last possibility exists because the many complex interactions that affect a community's well-being can be refined and displayed graphically through the use of this tool.

The 29 counties of the State of Utah (Figure 3) comprise the study area for this project. They range in population from Salt Lake County, with over a million residents, down to Daggett County, with scarcely more than 1,000 residents. The geography ranges from sparse, arid desert to high alpine forests. According to the U.S. Census Bureau (2012), Utah is among the 15 more extensive, and the 15 less populated states in United States. Utah ranks in the top 10 least densely populated of all the 50 states. Approximately 80% of Utah's residents live in an urban area that expands North and South of Salt Lake City (from Brigham City to Provo) making this state a dominantly urban state based on the portion of the population living in urban centers.

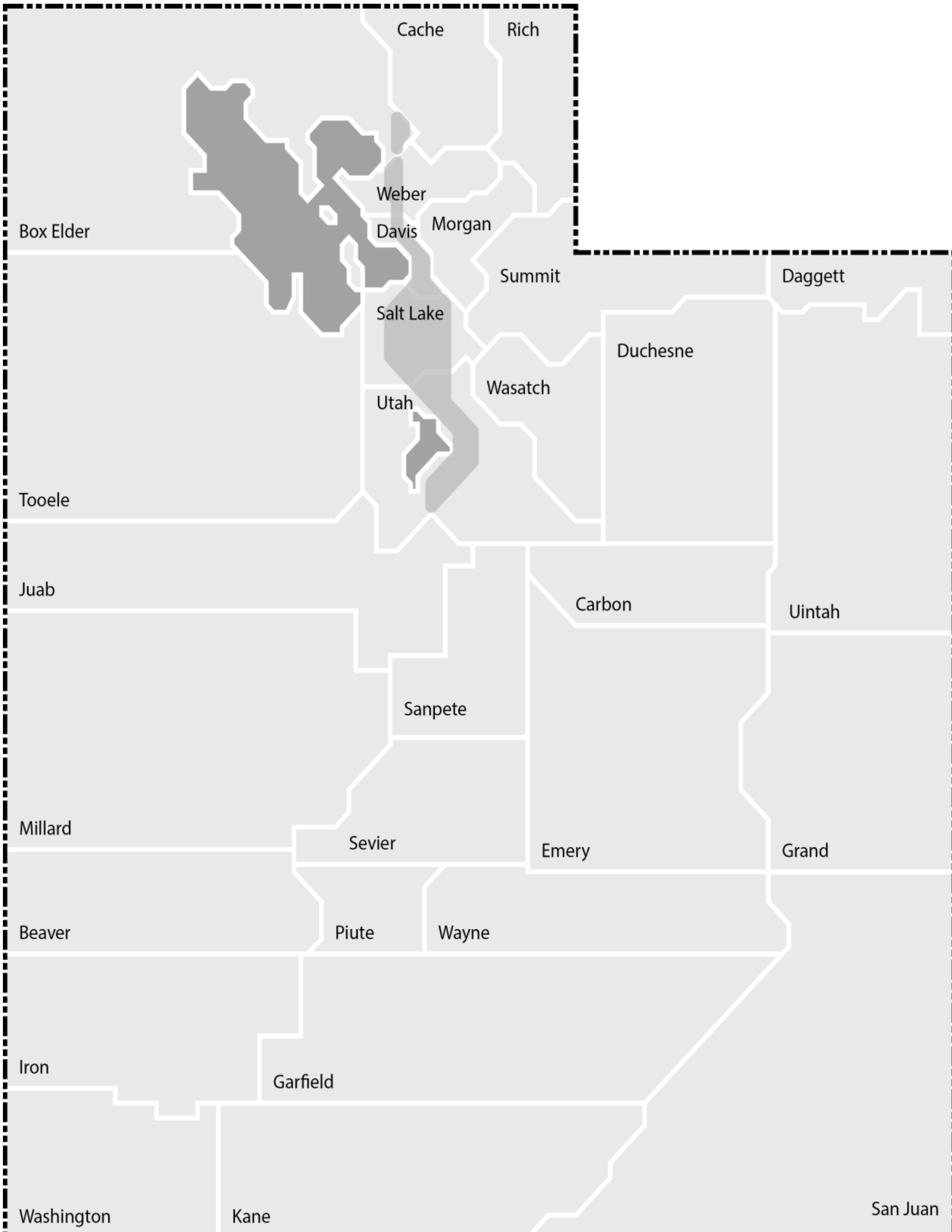


Figure 3. Map of Utah’s counties. The shaded area represents an urban corridor that contains most of the state's population.

CHAPTER II

SIGNIFICANCE

The work of this thesis was supported through a Utah Agricultural Experiment Station Grant. The grant-funded study (hereafter referred to as the "Utah Study"), "Evaluates sustainable development possibilities of Utah counties using a graphic interactive evaluation template" (Licón, 2011, p. 1). Beyond merely measuring the comparative sustainability of Utah's 29 counties at this moment in time, this project produces a tool that can be used as the basis for ongoing sustainability assessment, monitoring, and comparison of those counties.

The grant proposal also explains the importance of the work undertaken by the Utah Study:

> Planning for sustainability needs an operational framework. Efforts in this direction will benefit communities with better references and a better sense of direction. Even though there are many studies on different aspects related to sustainability, there is not a state-wide assessment of sustainable development possibilities. A related issue is the challenge of translating assumptions and assessments of sustainability into operational strategies. Establishing an operational path to sustainability and understanding the hierarchy of issues in a sustainable development goal context is critical for effective planning efforts. An integrated index of sustainability provides the overall understanding, which then needs to be turned into specific plans, policies, and actions.
>
> Sustainability operates at multiple scales and in complex socio-physical arrangements. It is important to develop common measures and make decisions at local levels while keeping the large scale (regional, state, nation, etc.) connection. Sustainability assessments appear more often at larger scales, but implementation has to operate at local levels. Missing the scale link fragments the efforts and distorts the goals. This proposal offers a performance based assessment of sustainability at the county scale for the state of Utah. This assessment addresses the interdisciplinary nature of sustainability and its

> graphic output provides guidance to operational implementation of sustainable development strategies at local levels (Licón, 2011, p. 4-5).

In short, the Utah Study is doing two important things: it is laying the groundwork for using sustainability assessment tools to inform policy-making (“operationalization”), and it is doing so at a scale that is useful to local-level officials and stakeholders. In the process, the Utah Study does a state-wide comparison of county-level sustainability, something that has never been done before.

The second of those ‘two important things’ – working at a scale useful to local-level decision-makers – is important because many of the policies and actions that have to be implemented in order to improve sustainability must be done at the local level (Licón, 2011, p. 4). So many critical decisions regarding resource regulation and consumption are made at the local level – and the ecological, social and economic realities that make up sustainability are most clearly felt at the local level – that local communities truly are, “the key to our sustainability” (Hubert, 2007, p. 10).

Of course, local-level sustainability is not easy. In their study of local assessments in Romania, authors Cornel and Mirela (2008) pointed out that the complexity inherent in the concept of sustainability made local efforts to grasp it quite difficult:

> Communities are multidimensional, reflecting diverse realities and consisting of complex interactions and networks. . . . analysis at the local level may be achieved only on the basis of a well-structured and sized statistical indicator system, reflecting, as much as the existent information allows it, the economic and social evolution from the sustainable development perspective. (p. 312)

The authors then address the lack of quality local-level indicators and (after some discussion of criteria for indicator selection and the various data sources available to

Romanian localities) they reiterate the importance of local-level sustainability indicators with the practical observation that "you can only manage what you can measure" (p. 318).

In an earlier study on local-level assessment methods, Force and Machlis (1997), give a very good explanation of some of the issues surrounding good data sources and analysis at the local-level – particularly the county-level. They also connect assessment to policy-making when defining good indicators as, "An integrated set of social, economic and ecological measures available to be collected over time and primarily derived from available data sources, grounded in theory and useful to . . . decision making" (p. 371). It is important that local indicators, "allow for systematic comparison across spatial units and over time" (p. 371).

A key part of this project's work is producing the Utah-specific (and county-level specific) indicator set that can be used with the assessment framework to measure and compare sustainability. In the spirit of 'you can only manage what you can measure,' the assessment framework used in this thesis makes use of data available to the decision-makers in the communities being assessed because, in describing how "Planning decisions are made with available knowledge," Licón explains, "This tool is designed to process the information you have access to into actionable knowledge" (Licón, 2012).

Using accessible data to build the indicator set makes the product relevant to Utah communities and establishes it as a useful tool for future work in Utah using the assessment. By doing so, the project creates a useful baseline for the use of the tool by local officials, USU Extension, or other interested parties – it uses available knowledge to lay the groundwork upon which local actors can then manage what they can measure.

Of course, assessing sustainability and addressing deficiencies shown by an assessment are two different things, which brings us back to the first of the important things accomplished by the Utah Study – describing how the results of the assessment can inform and improve decision-making at the local level. In the literature, this is known as *operationalizing* sustainability assessment; turning measurement into management as it were.

Operationalization, or the lack of means to readily do so, is often reported as one of the major limitations of sustainability assessment and reporting tools (Buselich, 2002; Khandokar et al., 2009; Rorarius, 2007). Indeed, as one researcher notes, "there is no settled doctrine on how to combine different and sometimes contradictory indicators and indexes in a way immediately useful for policy" (Munda, 2005, p. 119).

One conceptual path for translating this project's assessment into policies as well as to show how it can inform the day-to-day understanding (regarding sustainability of their communities) of decision-makers at the local level is outlined below.

Planners, elected officials, or other local-level decision-makers cannot afford to spend even a fraction of the time necessary to fully understand all of the issues that affect sustainability in their communities, let alone even begin to understand how those factors interact with one another. This assessment framework compiles available knowledge (in the form of data that describes conditions and relationships at the scale of the communities being assessed) and computes relationships between the various pieces of data. The graphic, by collapsing that very complex set of facts into an easily understandable display, allows one to see "the forest" of sustainability in a community without having to identify and understand every "tree" of which it is composed.

A decision-maker who receives a copy of the graphic assessment and wants to know how to move toward greater sustainability can look at the triangles, identify which of the factors is most restricted, and then dig into the data that underlie the indicators to see which relationships are most contributing to the limitations. Once the problem areas are identified, policies that affect the relationship or factor can be formulated and put into place (see Figure 4).

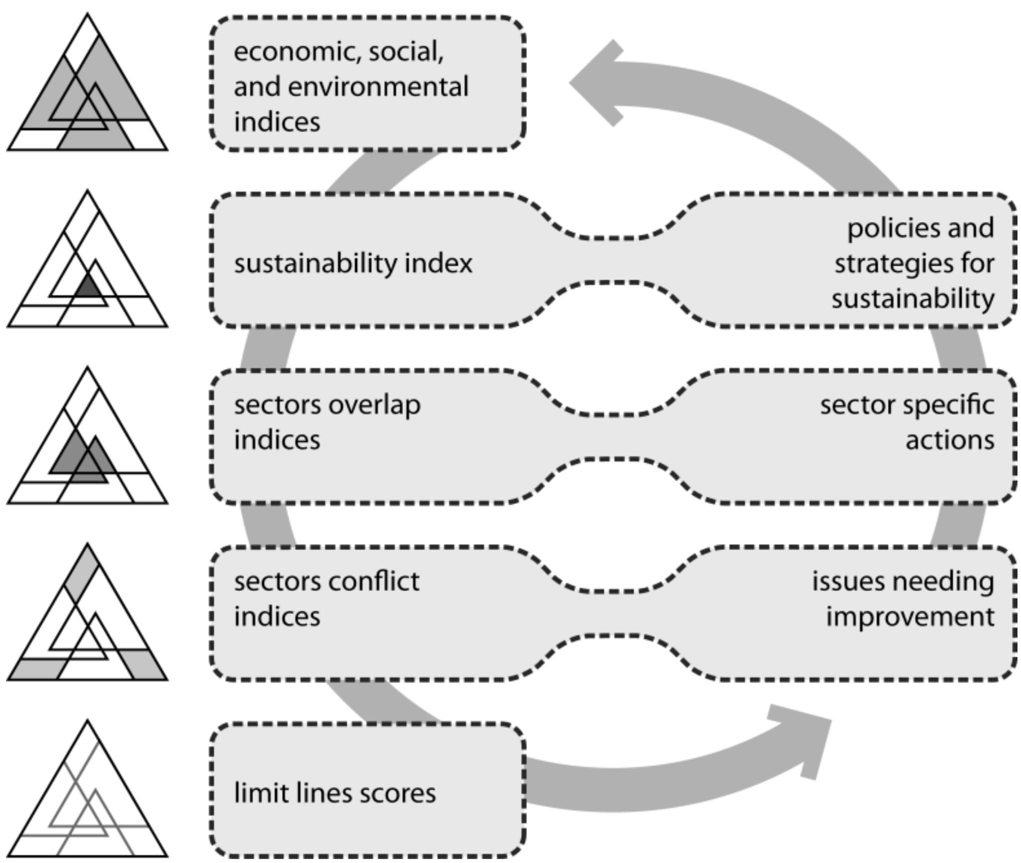


Figure 4. Flow chart for operationalizing assessment results.

Furthermore, the assessment tool can be used to test likely outcomes between alternative policies in order to forecast likely results and help policy-makers decide between options available. This can be done by formulating predicted changes in data (decreased Vehicle Miles Traveled or solid waste production, for example) resulting from proposed policies, entering the data and observing the potential or predicted changes in overall sustainability and in the relationship between the three factors of sustainability as forecasted by the assessment tool.

Thus, local actors can look at the assessment tool's results to determine where the major limitations to sustainability are occurring in their community and then seek to develop policies to address the identified limitations. By exploring the data used to produce the assessment, they can identify which areas of action those policies can best address. Finally, by making predictions about the outcome of their policies, translating those predictions into projected "data" and then entering the data into the assessment framework, interested parties can model the comparative differences between policy options.

CHAPTER III

APPROACH AND METHODOLOGY

Project History

The methodology tested in this thesis project is designed to apply the same research method and tools as used in two earlier sustainability assessments of communities in the US-Mexico border region. The first of these, (hereafter referred to as the "Mexico Study") measured sustainability in Mexican municipalities (equivalent to US counties) along the border (Licón & Balarezo, 2009). The Mexico Study was then followed by a study looking at counties and municipalities on both sides of the border (hereafter referred to as the "Border Study") (Licón & Li, 2011).

The common thread running through all of these studies is that they apply a graphic evaluation framework (the methodology that this thesis is evaluating) in order to assess the sustainable development potential of the communities being studied. Further explanation of this tool is found in the "Framework" section of this chapter.

Background Concepts

This project deals with the topic of sustainability – a widely used idea with no clear agreement as to its meaning (Fahy & Ó Cinnéide, 2008, p. 366; Keirstead & Leach, 2008, p. 330; Tainter, 2006, p. 92). This study is not about trying to determine what sustainability *is*, but instead deals with sustainability by applying one definition of the term to existing, real-world localities to see how measuring things according to that definition works. In other words, trying to understand what a given possible meaning of sustainability says about a set of places.

The definition of sustainability used for this project is taken from the Border Study (because this project is applying the same methodology):

> [S]ustainable development can be defined by the combined attention to issues and concerns about the environment, the economy, and society together with Campbell's idea of conflicting goals between the domains (Licón, 2011, p. 5)

This definition is itself a restatement of Licón's (2004) earlier evaluation of the definition of sustainability in his doctoral dissertation. After noting that, "The panorama of definitions of the term and its components," is, "a large field" (Licón, 2004, p. 10), he then reviews that field, pointing out the relative strengths, weaknesses and deficiencies of many of the proffered definitions of sustainability (p. 10-14). Among the definitions he considers:

- The "Brundtland Commission" definition – perhaps the most commonly referred to definition in the literature and, thereby, the best candidate for a "consensus definition" of sustainability:

  > Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987, p. 43).

- The definition given by the United Nations Conference on the Environment and Development (UNCED) in Rio de Janeiro:

  > Sustainable development is defined as improving the quality of human life while living within the carrying capacity of supporting ecosystems (UNCED, 1993, p. 10).

- The definition given in the Vision Statement of the 1996 report of the President's Council on Sustainable Development (PCSD):

> A sustainable United States will have a growing economy that provides equitable opportunities for satisfying livelihoods and a safe, healthy, high quality of life for current and future generations. (PCSD, 1996.)

He then reviews a number of challenges and criticisms of these definitions, including the work of D. A. Munro (1995), who is bothered by the uncertainty in existing definitions of sustainability and therefore proposes to split the concept into three parallel branches; ecological, social and economic – which would then each operate as independent, specialized fields of study.

Munro is not alone in expressing concern about the definition of sustainability. Kierstead and Leach (2008) note that, as of 1998, there are more than 80 alternative definitions of sustainability in the literature (p. 330). The lack of agreement about a definition of sustainable development leads Fahy and Ó Cinnéide (2008) to observe that it is, "an attractive but vague and highly contested concept," and that, "there is no consensus over the societal goals that may be regarded as consistent with it and that contribute towards its achievement in practice" (p. 366).

To address this conceptual uncertainty, Licón does not go as far as Munro suggests. He still uses a unified definition of sustainability, but he does adopt some approaches designed to mitigate the concern over how comprehensive and messy the concept of sustainability is becoming. Taking Munro's observations about the variety of fields of expertise needed to properly conceptualize (let alone understand) sustainability into account, Licón then frames the study of sustainability as a multi-disciplinary field of work. Multi-disciplinarity becomes an important element of his conception of the issue and, therefore, to his model – both in purpose and application. He wraps up his discussion of the concept of sustainability with a definition that – while quite precise as to what sustainability, *per se*, means – also makes clear that the whole enterprise must be interdisciplinary in nature if it is to matter at all:

> Sustainability is understood as simultaneous considerations of the economic, environmental and social dimensions of development. Being specific areas of knowledge, each of these domains is also a discipline, with sometimes different views on what is important and with different theoretical frameworks. This is the challenge of sustainability as an interdisciplinary effort – promoting frameworks for interaction, understanding, and information flow so that knowledge conducive to sustainable actions and views can be produced (Licón, 2004, p. 14).

"Interdisciplinarity" is a critical aspect of sustainability assessment in the framework that guides this project. According to Licón:

> Even though sustainability is the combination of three "dimensions" of development, the proposals made from a sustainable development approach need to have a nature of their own (the holistic interdisciplinary nature of the topic). Interdisciplinary studies need to produce something that none of the disciplines would have produced by their own. Sustainable development is not something that has a part of economy, a part of ecology, and part social equity. The interrelationship of elements and the mutual influence among sectors defines development as sustainable (Licón, 2004, p. 36).

Sustainability studies – if they are to live up to the ambition of actually increasing our ability to live sustainably – need to do more than simply add up whatever the contributing disciplines make note of. The world we live in is an interconnected whole; hence, understanding sustainability requires some means of accessing that interconnectedness. Failing to do that is a failure to live up to the hope of studying sustainability.

Naturally, any attempt to cross disciplinary lines runs into the problem that gave rise to separate disciplines in the first place: complexity. Fields of expertise are differentiated precisely because the world is far too complex for any one mind to comprehend in totality. Specialization allows deeper grasp of some concepts at the expense of equivalent depth in others; and efforts to use specialized knowledge, tools, and concepts outside of their respective fields is fraught with risk.

To get the cross-disciplinary perspectives needed for properly understanding sustainability, Licón explores some of the research into complexity studies and concludes that the best approach, "is not to adapt methods to complex situations, but to understand the limitations of existing methods and the possibilities in helping to build maps to represent a [more holistic] view of reality" (2004, p. 47).

One excellent framework for addressing the complexity inherent in sustainability assessment and policy creation is soft-systems methodology. To introduce soft-systems methodology, Licón summarizes the work of Jackson and Keys (1984) in creating a "grid of problem contexts":

> The columns for this grid define the individual or the group solving the problem, and the rows identify the type of system considered under which the problem is focused. Columns define three types of participants. The left column starts with "unitary" participants, in agreement with objectives and shared values and beliefs. The second column groups "pluralist" participants, with different values and beliefs among individuals, and different interests and objectives but with some degree of compromise to reach agreement. The right column describes the "coercive" interaction, characterized by conflict and the use of power as the form of agreement possible. The vertical continuum of

> system types has, on one end, simple systems with well-defined laws of behavior, and complex systems at the top of the chart. (Licón, 2004, p. 53.)

He then adapts Jackson and Key's grid (as shown in Figure 5) and applies the grid to sustainability assessment and policy-making. He starts by explaining that most definitions of sustainability fit in the upper right of the grid while most assessment methodologies fit in the lower left (2004, p. 51-55). In other words, we tend to describe sustainability in terms of complex systems and controversial policies but measure it using much simpler techniques.

The practical outcome of this is that implementation efforts are going to naturally fall somewhere between these two portions of the grid (Licón, 2004, p. 54-55) and that, "Soft systems can help to bridge this need of connection between measurement and definition" (2011, p. 6). This approach is predicated on the idea that, "there are multiple perceptions of reality," and that, "The social world is seen as the creative construction of social beings," (2004, p. 55).

Other researchers have also noted the importance of context in sustainability assessment. Fahy and Ó Cinnéide (2008) found that, "A bottom-up approach to indicator development, involving a wide variety of local actors, is strongly advocated. . . . Indicators need to be socially constructed" (p. 371). Because sustainability is socially constructed, the meaning and import of any effort to put measuring it into practical effect will necessarily produce differing takes on how to do that *and* on how those efforts relate to whatever it is that you are measuring when you assess sustainability.

From a practical standpoint, this matters because assessment results cannot be translated into operational policies without some means of accounting for, and dealing with, multiple competing perceptions of reality. One of the key purposes of the assessment framework used in this project is to prepare the available information (data and indicators) so that the appropriate decision-makers can have the discussions needed in order to expose and reconcile the different subjective world views that form their understandings of sustainability as it pertains to their community.

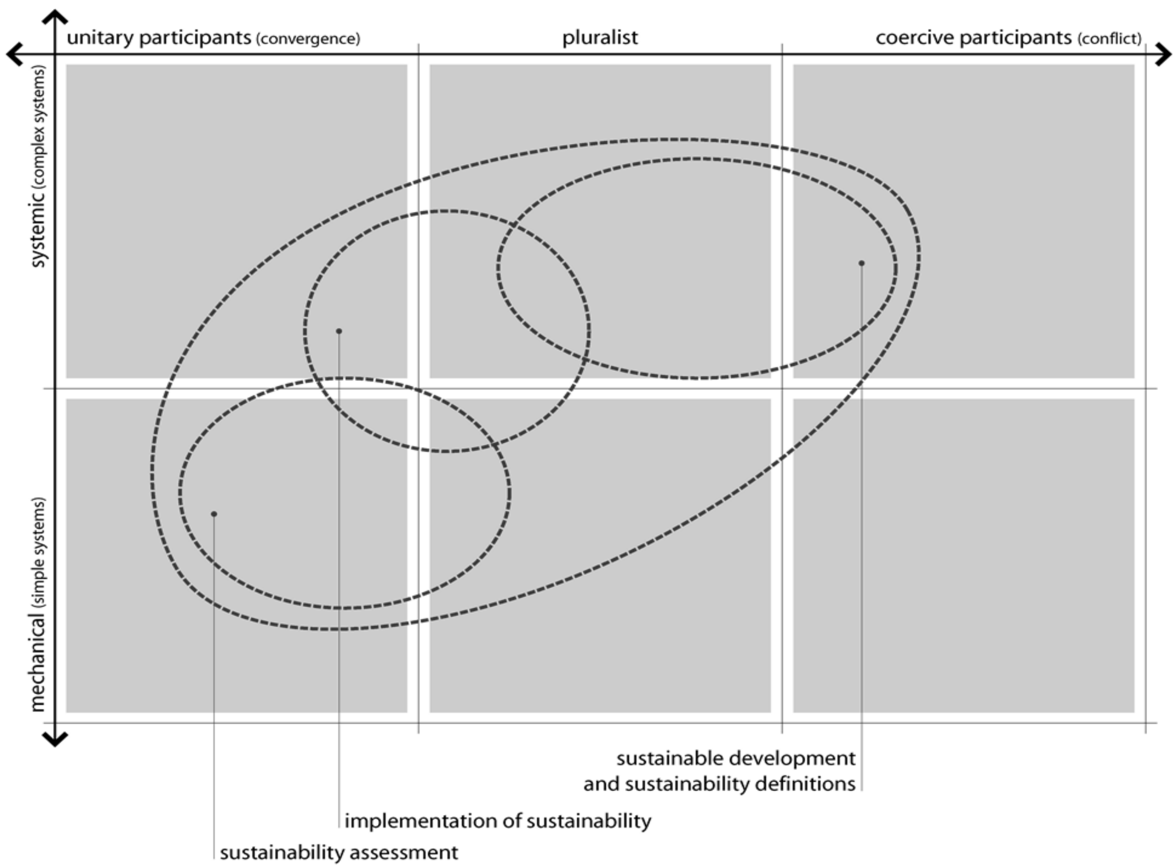


Figure 5. Grid of problem contexts. (Licón, 2004, p. 55.)

The Framework

The assessment framework used for this project "starts with a simple idea: an activity can be a restriction for other activities even of a different nature" (Licón & Balarezo, 2009, p. 103). In other words, when an environmental activity (irrigation, for example) takes place, it may restrict activities that fall under the other two components of sustainability (the water available for habitat or industrial needs, perhaps).

When overlaid, the interactions between the three components create a single triangular graph that displays not only the interactions that restrict sustainability, but the areas of compatibility, and, ultimately, the area in which the subcomponents of sustainability do not conflict with each other and which represents the current potential for sustainable development in the subject community.

The fact that there are three interrelated components means that there are six relationships to be accounted for in a holistic assessment. Each relationship defines a set off possible development constraints as shown in the following descriptions (Figures 6-8) from the Border Study (Licón & Balarezo, 2009, p. 104.):

1. Environmental limitations to economic development refer to the availability or scarcity of resources, land productivity, and the environment's general carrying capacity for intended or existing economic activities. (Figure 6.)
2. Social limitations of economic activities. The contribution or restrictions the social conditions impose on the productive sector have to do with population skills and education, the availability of labor, the demand for jobs. Also has

to do with the demand for products and the potential consumer market the population represents together with their purchasing power. (Figure 6.)

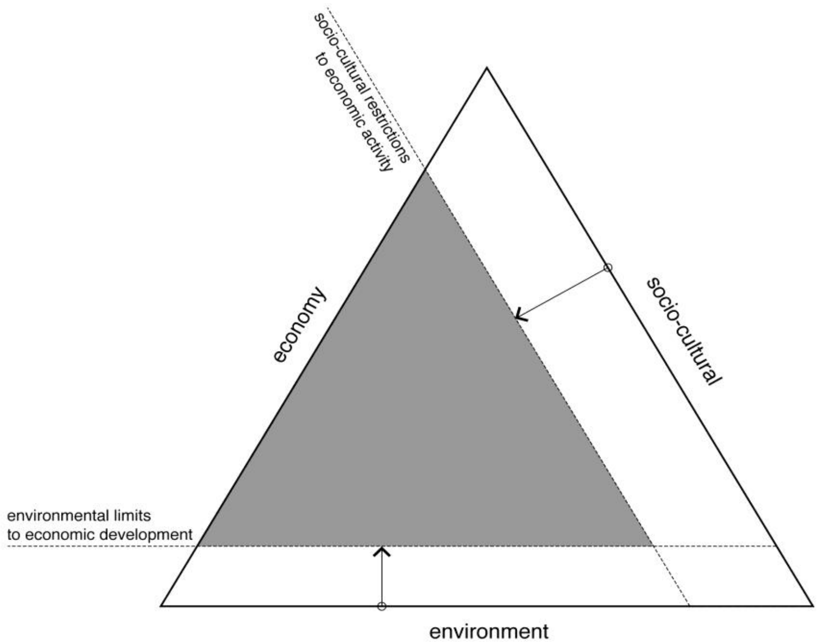


Figure 6. Restrictions on Economy.

3. Socio-cultural constraints to environmental activities include the impacts of population on the environment, such as waste generation, pollution, and land uses. Also included in this category are people's preferences for environmental appropriation such as settlement patterns, densities, outdoor activities, etc. (Figure 7.)

4. Economic restrictions of environmental action address how the productive sector affects the environment. Pollution, waste generation, energy consumption patterns are part of this set of indicators. (Figure 7.)

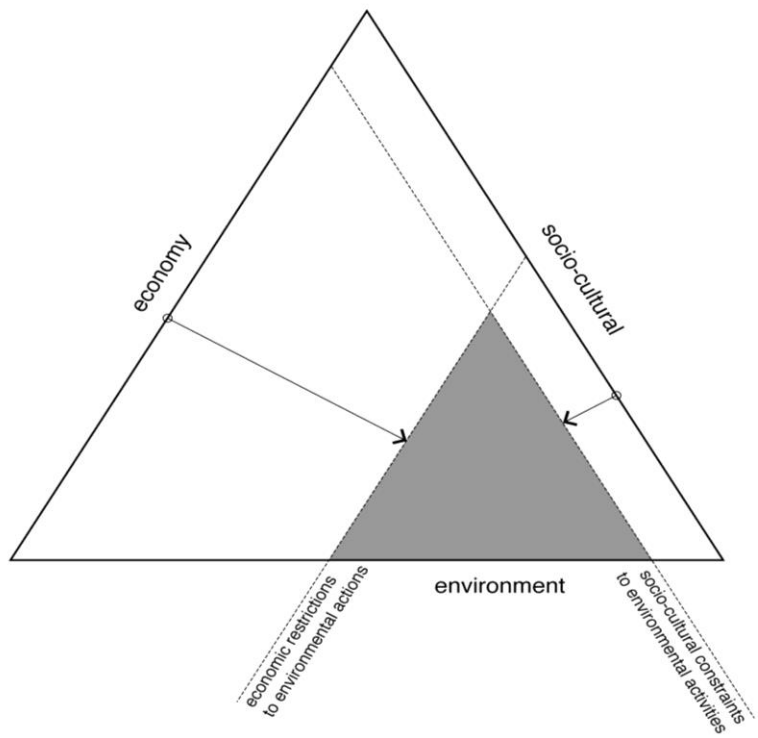


Figure 7. Restrictions on Environment.

5. Economic limitations to Society include income distribution, the supply of jobs, and the diversity of productive activities, among others. (Figure 8.)
6. Environmental limitations to social action are related to environmental conditions and their effect on population's health. These restrictions represent

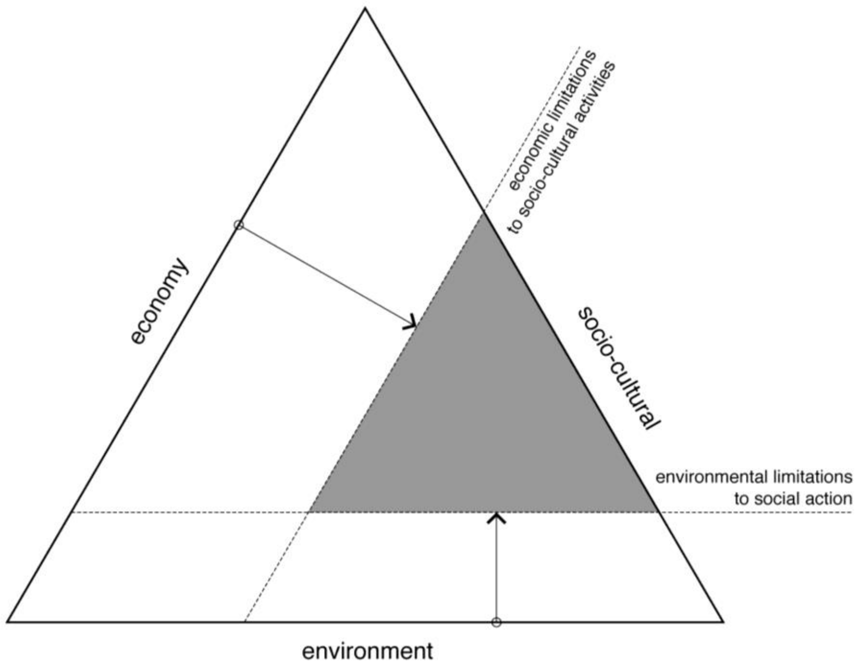


Figure 8. Restrictions on Society.

> the impact of the relationship humans-environment, and are related to the capacity to support a given population. (Figure 8.)

Results are displayed graphically because the graph shows, “in physical terms, the idea of limitations employed by this model” (Licón, 2004, p. 59). Thus, because even though there are six relationships to account for between the three factors, no one relationship constitutes sustainability – only the six interactions when taken all at once, as a whole (Figure 9).

The assessment tool used is appropriate for meeting the needs of the project for two reasons. First, it assesses not only the impacts on sustainability that the individual indicators are designed to measure, but it also assesses how the interactions between

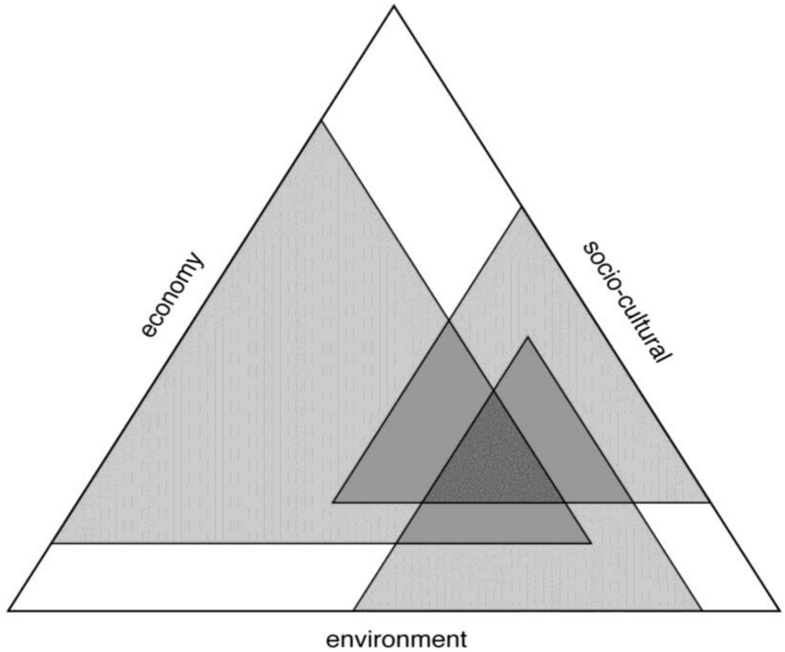


Figure 9. Combining restrictions.

those indicators are affecting sustainability. This is critical to accurately understanding sustainability because mere measurement of impacts does not speak to the whole problem of sustainability. Existing assessments generally tend to measure the effects of economic and social policies on the environmental conditions of a place, but they do not do a very good job of pointing out effects in the opposite direction – especially in the case of aggregate measurements of impacts such as the various “footprinting” tools (Fiala, 2008). Essentially, assessment tools that merely add up impacts usually only get at one or two of the six relationships assessed by the tool used in this study.

This is important because sustainability is holistic – hence the need to define it in terms of three components. Any measure of sustainability that fails to treat one of these components adequately will not be measuring *sustainability*, but something else instead (Fahy & Ó Cinnéide, 2008, p. 367).

In the case of “footprint” type aggregates, the tools may well be doing a great job of demonstrating cumulative impacts on the environment, but if all they are measuring is deviation from a “pristine” environment (or some approximation of one), then they are failing to take into account the need for economic productivity and positive social roles. In such circumstances, they are not truly assessing sustainability.

Second, the graphic comparison used to report the assessment tool’s results allows for an informationally-dense display of the relationships between all three components of sustainability. Through this graphic interface, users are able to more easily understand and compare the wide array of complex relationships involved in the concept of sustainability. From a practical standpoint, most people do not have the time or technical expertise to fully think about, let alone try to grasp, all of the factors and relationships that pertain to sustainability (realistically, the question of sustainability when applied to actual locales is too complicated to be thoroughly examined, let alone understood). This means that even the most conscientious observers will have, at best, a limited understanding of the sustainability of their communities. For the majority of any population, understandings of the issue will be even more constrained.

This tool collects a variety of information about a community and processes it into a graphic representation of the overall sustainability potential of that community – i.e., to what extent the different coexistent needs of the community can be met without interfering with one another. The graph allows people to utilize information about how sustainability is affected without having to fully know and understand all of the base data and interactions that go into producing the graphic. At the same time, the base data and all of the measured interactions are still available for investigation should the observer be inclined; an option that is unavailable in other tools that aggregate multiple indicators into a single-score index.

The assessment tool is capable of accommodating and comparing a vast range of indicators and data. As long as the data entered is comparable at the desired scale, the framework's results will be useable at that scale.

Scale of Analysis

This thesis retains the county-level analysis for many reasons. First, because it is a straight-forward application of the analytical approach used in the Border Study and continuing to use it avoids unnecessary deviations from the methodology that was adapted for this project.

Next, county-level scale closely matches the scale at which ecosystem effects are most commonly studied and addressed. In concluding that county-level data is particularly useful for this sort of assessment, Jo Ellen Force and Gary Machlis (1997) explain that counties are:

> The sociopolitical unit closest to the landscape or mid-scale often discussed in ecosystem management—cities and towns are too small in area and states include too many landscape types. (p. 376)

County-level analysis is a good scale at which to evaluate interactions between the three components of sustainability because it contains enough landscape for meaningful analysis without including so much variety that it becomes difficult to understand how society and the economy are interacting with the environment.

Another reason, and most important from a planning perspective: county-level analysis is also extremely valuable for understanding and affecting the interaction between man and the environment. County policies have direct effects on all three aspects of sustainability (Force & Machlis, 1997, p. 375-376), and the ultimate goal of this assessment framework is to enable decision-makers to operationalize the assessment by influencing decision-making.

Finally, local-level assessment is valuable because it translates (comparatively) easily into policy initiatives – especially if the results of the analysis are accessible to local decision-makers. “Local orientation is not so much a preference for a geopolitical scale as it is a bias toward implementation and action” (Niraj, 2010, p. 399).

Among the users who might benefit from more easily assessing the complexity and interactions inherent in the concept of sustainable development are local-level decision-makers. Many, if not most, of the decisions that affect sustainability are made locally, while many, if not most, of the currently popular measures of sustainability are national-level indices. Placing usable information in the hands of local-level policymakers is important if the measurement of sustainability is to have a significant impact on actual development decisions (Fahy & Ó Cinnéide, 2008, p. 370).

Using the evaluation framework starts with assembling a list of indicators. The list needs to contain indicators that measure the conflict between the three domains of sustainability. The assessment framework is very flexible as far as which actual indicators are used so long as the set of selected indicators is the same for each county and there are enough indicators in each of the three broad categories that the relationships between the three are adequately captured. The categories are:

- Environmental – data might include things like air and water quality reports, fertilizer and pesticide use, area of preserved lands, agricultural lands converted for development, toxic releases, solid waste generation, resource extraction, and so on.
- Economic – data might include things like county-level GDP, largest employers, import/export, debt to savings ratios, home price data, housing starts, etc.
- Social – data might include infant mortality rates, deaths from infectious or respiratory diseases, crime rates, commute times, vehicle miles traveled, educational attainment, dropout rates, and more.

Once indicators are identified, the necessary data is gathered and entered into the spreadsheet. In order for the data to be adequate for the model's purposes, it needs to be available – and comparable – for each desired indicator and for each of the communities or areas being studied. The usefulness of the assessment tool is reduced without a complete set of comparable data.

After data is gathered, some statistical testing is done outside of the framework's spreadsheet. This step evaluates the set of data for "redundancies or relevant associations of variables" (Licón, 2004, p. 76). Avoiding redundancies is especially important with this tool, because two variables that are highly correlated could cause the evaluation to show more conflict between two sides of the triangle than is actually there if they are effectively double-counting the same functional relationship.

Once the data is tested and entered into the spreadsheet, the ranges that will be evaluated by the tool are examined and adjusted as needed. This allows the framework to be tweaked to give a more correct comparison of jurisdictions for each indicator by eliminating distortions from outlier scores or other statistical anomalies.

Next, the user attributes the indicators to the appropriate functional relationships (between sustainability components) so that the framework “knows” which data is measuring which relationship. The indicators were originally selected to describe relationships between social, environmental and economic aspects of sustainability. In this step, those relationships are marked in the spreadsheet so that the tool can evaluate the interrelationships and effects of the various indicators. This is done by selecting which aspects of sustainability each indicator is measuring and which aspects it is affecting. Direction of effect (i.e. – if the indicator score increases, is the effect positive or negative?) is noted.

At this point, the spreadsheet calculates the interactions and creates the graphs. Results are available in numerical scores, rankings and in a graphic display for each county. The results can be reviewed and the spreadsheet adjusted. If desired, indicators can be weighted for importance, or to reflect local conditions. The spreadsheet is designed to recalculate as changes are made, so once this step is reached new results are available for evaluation in real-time.

Known Limitations

The "Streetlight Scenario"

A common limitation inherent in this kind of study is the risk that the work will turn out to be an example of the "streetlight scenario." This happens when you look for data in the answers you have, rather than in the data needed to address the true issue, and is called the streetlight scenario in reference to the comic anecdote of someone looking for their keys – not where they dropped them – but under the streetlight, "because the light is better over here."

In the real world, data that perfectly measures the desired phenomena is not always available. Collecting custom data is rarely practical – especially for policy makers, who can seldom afford the time and expense of new data collection projects. Therefore, one must use the available data that fits best while keeping a watchful eye out that the results are as relevant as possible to the communities and circumstances at hand and not simply artifacts of the data that was available.

This tool makes use of existing, available data so that non-research users may utilize it to advantage. That there may be a hypothetically "better" measure does not serve the need of someone with an immediate need to see how a pending decision might improve conditions in a given community.

Happily, this tool is designed to help alleviate the streetlight scenario by using the soft-systems methods previously described to help test, and adjust, the data for proper "fitness." The flexibility and responsiveness of the evaluation framework are the best defense against concerns that data availability is leading one to look for answers in the wrong places.

Data Quality and Availability

Anytime one conducts a data-driven analysis, the quality of the results is dependent upon the quality of the data used to derive those results. One of the challenges of carrying out an assessment like this at smaller, local-government-level scales is that there are not always good sources of high-quality data available for all of the kinds of things you'd like to measure (McDonagh, Varley & Shortall, 2009, p. 242-243). The problem is compounded when you want to compare multiple jurisdictions, as not all data is collected uniformly across the various counties. This study dealt with some challenges related to data availability, as shown in the next chapter.

Another limitation related to data quality is that in any data-based assessment there is a risk that the results are merely artifacts of the data set, rather than true observations about the subject of the study. Taking care to gather and treat the data properly throughout the study is important for avoiding this possibility, but there is no perfect safeguard against this possibility. Fortunately, the use of this information is not over with when the model kicks out its results. The goal of using this tool to operationalize the analysis will give the end users an opportunity to test the framework's analysis against the real-world communities represented by the data. If the results are off, this can be addressed by the users of this tool so that no permanent misunderstandings need result

CHAPTER IV

DATA COLLECTION

Challenges of Local Assessment

Work on this project began with the assumption that the same set of indicators and the same data sources used in the Border Study would adequately describe the counties in Utah. In actual fact, before data for half of the indicators had been acquired, it became apparent that these same sources – and in some cases the indicators themselves – were not going to work as they had before.

For the Border Study, all of the counties selected for inclusion had populations of 100,000 or more. In Utah, very few of the counties are that large. This created a problem because some sources used in the previous study do not report data for counties that small. In some instances, the lack was because sampling methods used to collect the data do not allow reporting of reliable results (samples were too small). For other sources, privacy concerns prevent agencies from releasing the data because there were so few instances being reported that individual respondents could be identified. Regardless of the reasons, the lack of a complete set of data for all the counties would impede the ability to run the model.

This circumstance is an example of the data availability limitation described in the previous chapter. Moreover, this project isn't the first to struggle with this problem; other sustainability assessment efforts have found it difficult to gather the needed data when assessing local-level sustainability (Cartwright, 2000; Cornel & Mirela, 2008; Letsie, 2004; Velázquez et al., 2008). Kissler & Fore (1999), in particular, found problems with data availability for smaller populations (p. 5).

One significant challenge of assessing sustainability at local levels is how to select and use sustainability indicators. Often, sustainability studies – and their frameworks – are concerned with sustainability at the global, international or national level. These are able to make use of data sets that are collected at (or aggregated to) the national level, many of which are easily available through national agencies, international NGOs, or the UN. However, these national-level indicators frequently include data (such as GNP) which is not reported at the scale of local jurisdictions.

In fact, when it comes to the issue of the scale at which sustainability is to be assessed, literature regarding sustainability metrics and assessment methods that deals with the topic of scale (beyond just noting that it exists) is limited. Hopton et al., (2010), point out that data used for sustainability indicators must be appropriate to the scale at which the analysis is being conducted (p. 48), and they point up instances where they adjusted national, state, and county-level indicators to the regional scale at which they were working, but they do not address any of the potential data-quality pitfalls this could create. Briassoulis (2001) warns that the scale of sustainability assessment, "may not reflect the true spatial scope," of the underlying issues (p. 420), but offers no means of solving this dilemma; rather, she concludes that sustainability indicators "are still a long way from making a substantial contribution" (p. 424).

Studies that did address sustainability measures at the local level were often quite location-specific and sought to measure sustainability according to locally-selected priorities (Bell & Morse, 2004; Brugmann, 1997; Cass, 2008; Keirstead & Leach, 2008).

They tended to be unhelpful in identifying indicators that would work with this project's framework for three reasons. First, they were often conducted for a single jurisdiction, which meant that the indicators they used were not of a type that could be readily compared across multiple jurisdictions (City of Santa Monica, 1994; City of Seattle, 1996; Durham County Council, 1997; Sustainable Pittsburgh, 2008; Sustainable Somerset Group, 1997).

Second, the local-level efforts documented in the literature were often focused on narrowly-constructed concepts of sustainability rather than the full breadth of the Bruntland Commission's three-fold definition. This meant that the way they defined sustainability and the data they used to measure it were often not comprehensive enough to be generalizable for use in other jurisdictions or for a more comprehensive description of sustainable development (Bell & Morse, 2004; Cornel & Mirela, 2008; Herendeen & Wildermuth, 2002; Parkins, Steadman & Varghese, 2001; Sustainable Pittsburgh, 2008).

More importantly, the methodology being evaluated is at least as focused on the interactions between different sustainability factors as it is on the absolute measures of the factors themselves. The narrowly-tailored local definitions of sustainability referred to above often overlooked the relationships *between* the indicators they had chosen (Briassoulis, 2001; Cartwright, 2000; Herendeen & Wildermuth, 2002; Munda, 2005; Rorarius, 2007; Valentin & Spangenberg, 2000).

Third, for many of these studies, the primary local-jurisdiction priority was to support policy initiatives, not improving the understanding of sustainability as it related to their locale. These authors tended to look at how sustainability assessments were used in environmental reviews, in climate-change plans, in health studies, etc. In these cases, sustainability assessment often took the form of a few – sometimes as little as two or three – indicators that were then used to inform a particular type or category of decision making (Brugmann, 1997; McAlpline & Birnie, 2006; Rydin, Holman & Wolff, 2003; Rydin et al., 2003; Sustainable Pittsburgh, 2008).

With so few variables, these efforts do not adequately measure or describe the whole sustainability picture for a community. That they may have been helpful in making certain specific, targeted decisions does not mean that they are sufficient to help that community achieve a better understanding of the wide array of complicated interactions that affect its overall sustainability (Briassoulis, 2001; Bohringer & Jochem, 2007; Brugmann, 1997; Cass, 2008; Herendeen & Wildermuth, 2002; Hopton et al., 2010; Poveda & Lipsett, 2011; Rydin, Holman & Wolff, 2003).

Finding New Indicators

The strategy for building a new indicator set was twofold:

- First, we looked for state level analogues to data sources that we had used in the Border study.
- Second, we looked for data to populate new indicators selected for the framework based on the research into community-level sustainability assessment described in the lit review.

In either case, a properly functioning framework requires that the additional indicators (and sources for the accompanying data) be:

- Effective at measuring sustainable development potential as described by the evaluation framework.
- Complete for the whole set of indicators needed to do so.
- Complete for all of the counties examined.

Between these strategies and the information learned about local-level assessment from the preceding literature review, a new set of indicators was selected that would allow this project to move forward. These indicators are shown in Table 1.

Table 1
Selected indicators

Category of indicator:	Social (SOC)		Environmental (ENV)		Economy (ECN)	
Categories affected:	ENV	ECN	ECN	SOC	ENV	SOC
Commute time		x		x		
% workers carpooling	x					
% workers commuting via alternative	x					
Household size	x					
Single-parent household		x				
Single-person household	x	x				
Owner-occupied household		x				x
Literacy		x				
College educated pop., age 25+ (%)		x				x
Population w/o HS diploma, age 16+ (%)	x	x			x	
Solid waste (daily pounds per person)	x		x	x		
Dependency (ratio of dependents to jobs)		x				x
Obesity (%)		x				
Income per capita		x				
Wages per job	x				x	x
% population below poverty	x	x			x	x
Violent & property crime rate (per 1000		x				x
Uninsured (% pop. 65+ w/o health		x				x
Water use (daily gallons per capita)	x		x	x		
Cancer risk (inhalation-related cases)			x	x		
Natural amenities scale (USDA)			x	x		
Irrigation (% of agricultural land)			x		x	
CO2 per acre			x			
CO2 per capita				x		

Category of indicator:	Social (SOC)		Environmental (ENV)		Economy (ECN)	
Categories affected:	ENV	ECN	ECN	SOC	ENV	SOC
Total pollution per acre			x	x	x	
% of workers with no car						x
Labor productivity (gross taxable sales per						x
Land productivity			x			
Unemployment						x
Labor force utilization (% pop. 18-64 with						x
Primary sector jobs			x		x	x
Secondary sector jobs					x	x
Tertiary sector jobs					x	x
% of households receiving food stamps						x
Economic hardship index					x	x
Cost of living index					x	x
Inequality (GINI coefficient)						x
Population growth 2000-2010	x	x				
% non-public land	x	x	x		x	x
Population density	x	x	x	x	x	
% state population		x				
% population living in unincorporated	x		x	x		
Automobile ownership (persons per auto)	x					
Daily vehicle miles traveled per capita	x			x		
VMT per acre						x
% commuters driving alone	x	x				

Correlation Matrix

Having identified the indicators and populated them with data, a correlation test was run to test the significance of the relationship between each variable. Correlation is a comparison of two variables to determine how strongly they are related to each other. The degree to which the correlations are significant allows us to find dominant variables – those relationships which are influencing the results of the model the most.

Testing a set of variables is done by comparing each variable against all the other variables in the set and displaying the results in a correlation matrix. This is done to assess how strongly they relate to one another. We want to know which relationships are strongest because we ultimately want to be able to see how changes in one variable affect overall sustainability so that we can be confident the model is assessing adjustments correctly (strength does not imply causality, but knowing the strong relationships helps us determine if the data is representing the desired interactivity between the three factors of sustainability).

Table 2 contains a list of the most significant correlations (0.8 or more) from the matrix. These are the relationships that will most clearly affect each other using the base data in the model. Some of the key relationships revealed by this correlation test:

- Per capita measures naturally correlate with population density. We saw a significant correlation on three of these, in particular:
    1. CO per capita.
    2. Particulates per capita.
    3. VOCs (Volatile Organic Compounds) per capita.

  This correlation is not surprising, given that these are pollution-related indicators and one would expect more pollution in more populated areas.
- The percentage of total state population correlated strongly with one parent and one person households.
- So did the percentage of people living in unincorporated areas.
- Home ownership correlates strongly with the percentage of owner occupied households – an obvious relationship.
- Daily VMT (Vehicle Miles Traveled) per acre correlates strongly with:
    1. Cancer risk.
    2. Land productivity.

- Household size correlates with the percentage of the population under 18.

Having identified the strongest relationships, we can immediately see that two factors are driving the majority of these relationships: population (both total size, and density) and economic activity. This means that the data set we have should be good at showing us relationships between Economic and Social components of sustainability.

Table 2

Significant correlations between individual variables

Indicator	**Correlates with:**
acres per people	CO per capita, Particulates per capita, and VOCs per capita
% state pop	One-parent households and One-person households
% pop in unincorporated areas	One-parent households and One-person households
Daily VMT per private acre	Cancer risk (Inhalation) and Land productivity
Home ownership	% Owner Occupied
Household size	% pop younger than 18
One-parent households	% state pop, % pop in unincorporated areas, and One-person households
One-person households	% state pop, % pop in unincorporated areas, and One-parent households
% Owner Occupied	Home ownership
% pop younger than 18	Household size
Cancer risk (Inhalation)	Daily VMT per private acre and Land productivity
Land productivity	Daily VMT per private acre and Cancer risk (Inhalation)
CO2 per capita	NOx per capita and SOx per capita
CO2 per private acre	SOx per capita
CO per capita	Acres per people, Particulates per capita, and VOCs per capita
NOx per capita	CO2 per capita and SOx per capita
Particulates per capita	Acres per people and CO per capita
SOx per capita	CO2 per capita, CO2 per private acre, and NOx per capita
VOCs per capita	Acres per people and CO per capita

Running the Model

In order to test the indicator set as required for the thesis project, data was entered for each of the indicators and the assessment tool was run three times. Each run served to help develop the tool and refine its ability to use the indicators to produce a useful assessment. The runs are described below.

First Run

The first run was an initial dry run using the indicators selected for the project – no weighting of the indicators was used. This step is designed to test the spreadsheet and see if the model is running properly. Also to test the data set for any serious errors.

Even though the first run is really a preliminary step, we were able to confirm that the Environmental triangles were less sensitive than the others, as predicted.

Second Run

The second run involved soliciting input from a selection of faculty members and graduate students at Utah State University. The survey consisted of six lists of potential sustainability indicators. Respondents were asked to rate the importance of that indicator (on a scale ranging from “most important” to “not important”). Responses were used to select which indicators were used for the second run and to test-weight the selected indicators.

On reviewing responses to the survey, a few issues affecting the overall quality and usefulness of the responses were noted. First, there were very few respondents over

Table 3

Indicators for the first run

social indicators affecting the economy:
Population Growth
% non-public land
Population Density (private)
% State Pop
Unincorporated Population
Car Ownership
Solo Commuters
Carpoolers
Alt Modes
No Car
Commute Time
Household Size
Single-Parent Households
Single-Person Households
Vacancy Rate
Owner Occupied
literacy
College Educated
Undereducated
Youth
Seniors
Dependent
Dependency Ratio
Obesity
Labor Force Utilization
Income
Wages
Poverty
Food Stamps
Crime
Police

social indicators affecting the environment:
Population Growth
% non-public land
Population Density (private)
Unincorporated Population
Car Ownership
VMT per Capita
VMT per Acre
Solo Commuters
Carpoolers
Alt Modes
No Car
Commute Time
Single-Person Households
Vacancy Rate
College Educated
Undereducated
Solid Waste
Land productivity
Poverty
Water Use

environmental indicators affecting the economy:
% non-public land
Alt Modes
Solid Waste
Primary Sector Jobs
Secondary Sector Jobs
Land productivity
Natural Amenities Scale
Water Use
Irrigation
CO2 per private acre
Total Air Pollution

environmental indicators affecting society:
VMT per Acre
Commute Time
Cancer risk (Inhalation)
Solid Waste
Land productivity
Natural Amenities Scale
Water Use
CO2 per private acre
Total Air Pollution

economic indicators affecting the environment:
% non-public land
Population Density (private)
Unincorporated Population
Car Ownership
VMT per Capita
VMT per Acre
Undereducated
Dependency Ratio
Labor Productivity
Unemployment
Labor Force Utilization
Primary Sector Jobs
Secondary Sector Jobs
Tertiary Sector Jobs
Land productivity
Cost of living
Irrigation
Total Air Pollution

economic indicators affecting society:
% non-public land
Population Density (private)
VMT per Capita
VMT per Acre
Single-Parent Households
Owner Occupied
College Educated
Dependent
Dependency Ratio
Labor Productivity
Unemployment
Labor Force Utilization
Primary Sector Jobs
Secondary Sector Jobs
Tertiary Sector Jobs
Income
Wages
Land productivity
Poverty
Food Stamps
Hardship Index
Crime
Police
Cost of living
Total Air Pollution

all. Only four faculty members and six students answered the full set of survey questions. This gave a very small pool of responses with which to work. In order to normalize the results between the groups, each faculty response was counted three times and each student response was counted twice (total of 24 responses).

Next, the survey process itself produced problematic results. Each of the six lists of potential indicators was presented, one at a time, in the same order for each respondent. Problems arose because respondents were more engaged in the earlier moments of responding to the survey than towards the end (they appeared to experience ‘fatigue’ that affected how carefully they evaluated the indicators in the later sets of lists). Across the board, respondents considered many of the indicators important in the early sets of indicators that they evaluated and fewer of them important in the later sets.

Unfortunately, since the survey instrument presented all of the indicators for consideration to each respondent in the same order, there is no way to determine how much of this phenomenon is due to instrument error and how much might be due to actual valuation of the indicators by respondents.

This affected both the total number of indicators that were selected to measure each relationship *and* the weights that the indicators were assigned. In the initial categories (Social), there were many indicators and they tended to be weighted higher in importance. In the later categories (Economic) there were few indicators selected and they tended to be weighted lower in importance.

Respondents also weren’t familiar with the complete list of indicators, so they tended to select (and rate more highly) those indicators that they were familiar with to

Table 4

Indicators for the second run

social indicators affecting the economy:
Population Growth
% non-public land
Population Density (private)
Car Ownership
VMT per Capita
VMT per Acre
Solo Commuters
Carpoolers
Alt Modes
No Car
Commute Time
Household Size
Single-Parent Households
Single-Person Households
Vacancy Rate
Owner Occupied
literacy
College Educated
Undereducated
Youth
Seniors
Dependent
Dependency Ratio
Obesity
Solid Waste
Labor Productivity
Income
Wages
Land productivity
Water Use
Uninsured

social indicators affecting the environment:
Population Growth
Population Density (private)
VMT per Capita
VMT per Acre
Solo Commuters
Alt Modes
No Car
Commute Time
Household Size
Single-Person Households
Youth
Seniors
Dependent
Solid Waste
Income
Wages
Poverty
Water Use

environmental indicators affecting the economy:
% non-public land
Population Density (private)
Unincorporated Population
VMT per Capita
VMT per Acre
Alt Modes
Commute Time
Household Size
Cancer risk (Inhalation)
Solid Waste
Land productivity
Natural Amenities Scale
Water Use

environmental indicators affecting society:
% non-public land
Population Density (private)
VMT per Capita
VMT per Acre
Alt Modes
Commute Time
Household Size
Cancer risk (Inhalation)
Solid Waste
Land productivity
Natural Amenities Scale
Water Use
Irrigation
CO2 per capita
CO2 per private acre
Total Air Pollution

economic indicators affecting the environment:
% non-public land
Population Density (private)
Unincorporated Population
VMT per Capita
VMT per Acre
Owner Occupied
Seniors
Labor Productivity
Unemployment
Income
Wages
Land productivity
Irrigation
Total Air Pollution

economic indicators affecting society:
% non-public land
Population Density (private)
Owner Occupied
College Educated
Dependency Ratio
Labor Productivity
Unemployment
Primary Sector Jobs
Secondary Sector Jobs
Tertiary Sector Jobs
Income
Wages
Land productivity
Poverty
Food Stamps
Hardship Index
Crime
Police

describe all of the possible relationships – even if those indicators weren't the best measures of the relationship at hand. For example, things like Commute Time and Vehicle Miles Traveled were frequently selected as important indicators even of relationships that had little to do with these indicators (such as "Environmental indicators affecting the Economy").

The survey tool used to weight the indicators introduced a potentially troubling wrinkle in the use of this methodology. On the one hand, the soft systems approach is needed to better deal with complexity – and better achieve the aims for which this type of assessment is carried out. On the other, there is no guarantee that popular understanding of the concepts of sustainability will rest on solid, research-tested grounds; the prejudices and errors of respondents' thinking may cloud the function of this model more than they tune it.

However troubling this may seem, it is important to understand that this is an expected concern when using soft systems approaches to make adjustments to the analysis produced by this methodology. Inviting respondents to help adjust the model has the potential to muddle the clarity with which a well-designed indicator set performs. On the other hand, this sort of input is necessary to achieve the flexibility and local sensitivity necessary to adapt the assessment tool to the wide variety of complex circumstances that it is intended to help with.

For the purposes of this evaluation, survey responses were sought from informed participants in order to create an expert-based response that could be used to demonstrate adjustment of the model (and to help evaluate whether those adjustments result in outputs that reflect the kinds of adjustments made). Since the purpose of all three runs was to iteratively establish a benchmark assessment that could be shared with local communities in order to gauge their responses, the survey used here reached out to informed experts rather than attempting to aggregate the random opinions of community members. Future efforts (outside the scope of this thesis) will allow for broader public input.

Third Run

Following the evaluation of results from the second run, we refined the selection and weighting of the indicators and completed a third run. This last run takes into account the survey results used in the second run, but keeps in mind that survey respondents had very limited knowledge of the project or of the framework being used, therefore those results should be modified somewhat.

The third run's purpose is to serve as a viable baseline for future use of the assessment by Utah counties and other interested parties. It establishes a good "starting point" for the discussions and debates needed in order to make the soft-systems approach function as designed.

Table 5

Indicators for the third run

social indicators affecting the economy:
Population Growth
% non-public land
Population Density (private)
% State Pop
Solo Commuters
Commute Time
Single-Parent Households
Single-Person Households
Owner Occupied
literacy
College Educated
Undereducated
Dependency Ratio
Obesity
Income
Poverty
Crime
Uninsured

social indicators affecting the environment:
Population Growth
% non-public land
Population Density (private)
Unincorporated Population
Car Ownership
VMT per Capita
Solo Commuters
Carpoolers
Alt Modes
Household Size
Single-Person Households
Undereducated
Solid Waste
Wages
Poverty
Water Use

environmental indicators affecting the economy:
% non-public land
Population Density (private)
Unincorporated Population
Cancer risk (Inhalation)
Solid Waste
Primary Sector Jobs
Land productivity
Natural Amenities Scale
Water Use
Irrigation
CO_2 per private acre
Total Air Pollution

environmental indicators affecting society:
Population Density (private)
Unincorporated Population
VMT per Capita
Commute Time
Cancer risk (Inhalation)
Solid Waste
Natural Amenities Scale
Water Use
CO_2 per capita
Total Air Pollution

economic indicators affecting the environment:
% non-public land
Population Density (private)
Undereducated
Primary Sector Jobs
Secondary Sector Jobs
Tertiary Sector Jobs
Wages
Poverty
Hardship Index
Cost of living
Irrigation
Total Air Pollution

economic indicators affecting society:
% non-public land
VMT per Acre
No Car
Owner Occupied
College Educated
Dependency Ratio
Labor Productivity
Unemployment
Labor Force Utilization
Primary Sector Jobs
Secondary Sector Jobs
Tertiary Sector Jobs
Wages
Poverty
Food Stamps
Hardship Index
Cost of living

Early Analysis of the Dataset

Second Correlation Test

Following the third run of the model, a second correlation test was run to test the relationships between the scores that are calculated by the assessment tool for the various relationships between the sustainability factors. We want to know which relationships among the three sustainability factors are strongest. In other words, this level of analysis tells us the main message of the model – how much each factor is restricting the others. Consequently, analyzing these results is critical to understanding the message conveyed by the graphic analysis. When the resulting sustainability triangle is small, these relationships are the restrictions we need to see to understand why.

What the Matrices Tell Us About How the Indicators Are Working

A sample of the second correlation matrix, showing the relationship between these scores, is found in Table 6. This sample shows the correlations between the restrictions of one sustainability factor on another. For example, Environmental (ENV) restrictions on Society (SOC) are shown as a correlation score. But this table also compares the degree to which the restrictions themselves are correlated, so that Environmental restrictions on Society (RNS) are shown correlated with Economic restrictions on Society (RES). Overlaps (OvSN, for example) and Conflicts (CNE, etc.) are also shown; as is the degree to which each one of these correlations interacts with the overall sustainability score (SUST).

Table 6

Excerpt from the correlation matrix

	RSE	RES	RNS	RSN	REN	RNE	ECON	SOC	ENV	OvES	OvSN	OvNE	SUST	CES	CSN	CNE
RSE																
RES	0.61															
RNS	0.34	-0.01														
RSN	0.39	0.26	0.42													
REN	0.55	0.18	0.22	0.66												
RNE	0.50	0.18	0.73	0.71	0.45											
ECON	-0.86	-0.43	-0.59	-0.63	-0.58	-0.86										
SOC	-0.69	-0.79	-0.59	-0.46	-0.26	-0.57	0.70									
ENV	-0.53	-0.24	-0.36	-0.90	-0.918	-0.65	0.69	0.40								
OvES	-0.9	-0.67	-0.39	-0.57	-0.50	-0.66	0.91	0.79	0.61							
OvSN	-0.62	-0.52	-0.54	-0.88	-0.70	-0.71	0.76	0.74	0.87	0.74						
OvNE	-0.79	-0.32	-0.47	-0.71	-0.83	-0.78	0.92	0.53	0.87	0.83	0.80					
SUST	-0.88	-0.59	-0.36	-0.66	-0.68	-0.68	0.92	0.69	0.75	0.96	0.82	0.92				
CES	0.88	0.91	0.19	0.36	0.40	0.39	-0.72	-0.84	-0.43	-0.84	-0.64	-0.61	-0.80			
CSN	0.44	0.20	0.76	0.90	0.56	0.83	-0.72	-0.62	-0.79	-0.59	-0.86	-0.71	-0.63	0.36		
CNE	0.63	0.24	0.54	0.81	0.88	0.80	-0.83	-0.51	-0.932	-0.68	-0.83	-0.93	-0.79	0.49	0.82	

There are a few key observations worthy of note here:

1. The final sustainability score was most closely correlated with three things:
   a. The overlap between Economy and Society (OvES).
   b. The overlap between Environment and Economy (OvNE)
   c. And by the basic Economy score itself (ECON).

   (These points confirm the earlier observation that this data would be good at showing us these relationships.)

2. The next most significant correlation is the restriction by Society on the Economy (RSE). Here again, the Economy plays a major role in influencing the final sustainability score.

3. The Economy has the highest correlation with the overall Sustainability score.
4. Restrictions that Society imposes on the Economy are the second largest influence on the Sustainability score.
5. The Environment has very little to do with the conflict between the Economy and Society (CES).

From analyzing these results, we can conclude that the data we have is able to show the relationships between the Economy and the other factors. We can also conclude that the data is less able to show us the interactions between the Environment and the other factors. And, from this last point, we can predict that the model will be less sensitive to Environmental factors and less able to measure the impacts of changes that affect them.

CHAPTER V

DISCUSSION

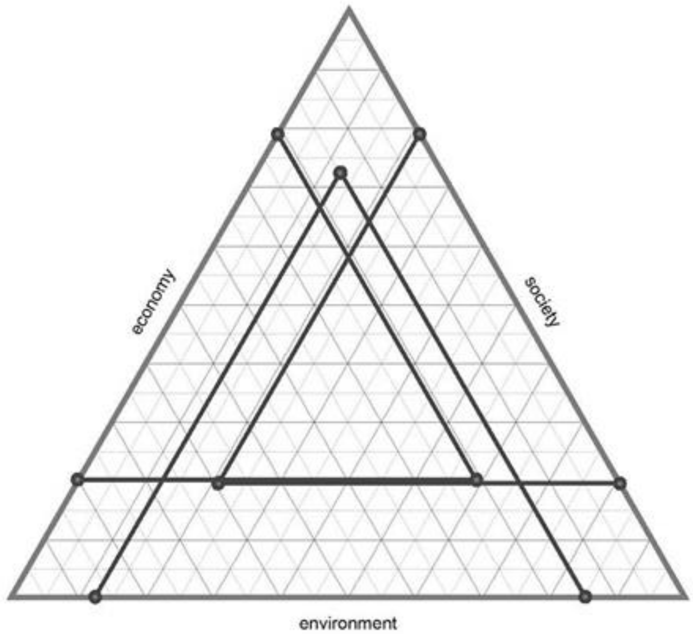
From the analysis of the different individual scores and graphs, a series of general findings and patterns describe the sustainable development opportunities for Utah counties. Over all, only 3 out of 29 counties had a sustainability score greater than 10%. This small score is useful as an initial benchmark, but can change as new indicators are incorporated into future assessments.

The county with the highest sustainability score, 14.4%, is Davis County (see Figure 10). This means that less than 15% of the development activities do not exceed the limitations that define sustainability.

Strong Environmental Triangles

In all three runs, there was a very strong pattern of the Environmental triangle being larger than either the Social or Economic. In other words, in the vast majority of counties, Environmental factors of sustainability tended to be less restricted than Social or Economic.

It may be that the comparative strength of the Environment triangles is an artifact of the indicator set that has been selected. As was noted in the discussion of the correlation matrix, there is a strong correlation between population-dependent indicators and economy-dependent indicators. That is, larger population numbers or densities underlie many of the stronger correlations, as does the amount of economic activity. Therefore, finding a data set that is comparable across multiple counties may tend to rank counties by the size of their population and the strength of their economy.



inner triangles area [percent of total]:

ECONOMY	34.8%
economy-society OVERLAP	14.4%
economy-society CONFLICT	8.8%
SOCIETY	35.3%
society-environment OVERLAP	20.2%
society-environment CONFLICT	5.7%
ENVIRONMENT	53.2%
environment-economy OVERLAP	21.6%
environment-economy CONFLICT	5.0%
SUSTAINABLE DEVELOPMENT POSSIBILITIES	14.4%

percentages do not add 100 due to multiple area overlap

Figure 10. The triangles and scores for Davis County, showing the overall graph and the values for each

One basic reason that this is likely the case is that demographic and economic data are far more accessible than environmental data; especially in forms that can easily be tied to comparable indicators that *also* match up with given jurisdictions. As a result, the framework produces more accurate results for impacts to Social and Economic factors of sustainability than for Environmental – it is simply part and parcel of an assessment tool that is designed to use available data.

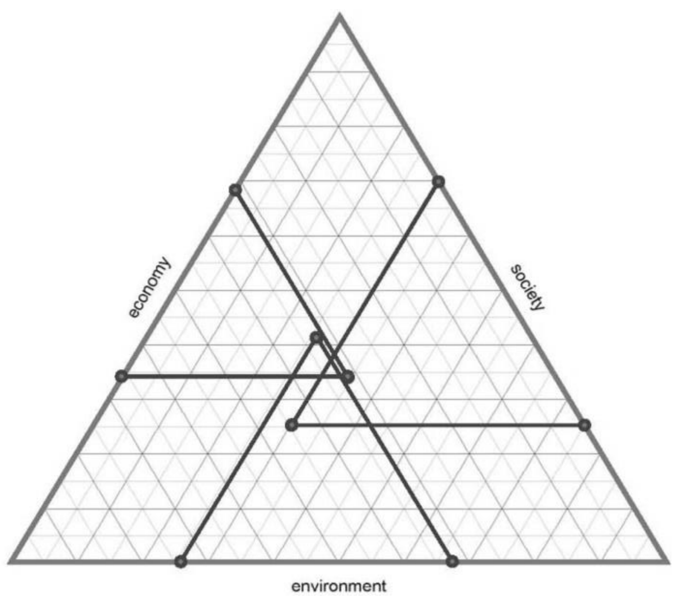
Another possibility is that the measurements of environmental restriction are muddled because it is possible that issues of environmental quality “push both ways.” For example, a large share of public lands in a county could be a positive impact on economic activity because of travel-and-tourism related business activities, while at the same time being either an additional positive because of the availability of resources and the associated primary sector jobs, or an economic restriction because public land management regimes limit access to those resources. While this thesis does not attempt to answer the question of whether public lands are a net economic benefit, the fact that the question can be asked points to a measure of uncertainty about how to assess environmental restrictions in some cases.

Fortunately, the evaluation tool is designed to be able to address this problem. Because it can be adjusted, the tool can be “fitted” to particular local circumstances. In this case, input from local experts, economists, resource specialists, and so on, could be sought to adjust the way the tool is accounting for the effect of public lands, and produce an improved result on a future run.

Not all of the results support the theory that the strong Environmental triangles are an artifact of the dataset, however. As described in the next section, a few of the counties did not fit this trend. One important conclusion to draw from this is that these exceptions show that the evaluation methodology is effective when assessing and comparing sustainable development potential.

Exceptions to the Trend for Strong Environmental Triangles.

In a few counties – some of those in the middle and lower rankings – the Environmental triangle was not the largest (see Figure 11). It is not clear from an initial investigation of the data how these counties are experiencing relatively elevated restrictions on the Environment, but the methodology does enable identification of some avenues for further analysis.



inner triangles area [percent of total]:

ECONOMY	11.8%
economy-society OVERLAP	0.2%
economy-society CONFLICT	19.1%
SOCIETY	19.8%
society-environment OVERLAP	1.5%
society-environment CONFLICT	16.4%
ENVIRONMENT	17.2%
environment-economy OVERLAP	0.6%
environment-economy CONFLICT	17.7%
SUSTAINABLE DEVELOPMENT POSSIBILITIES	0.1%

percentages do not add 100 due to multiple area overlap

Figure 11. The triangles and scores for Rich County.

When the population growth rate is compared with the percentage of non-public lands available, these counties appear to be among the more stressed by the new growth. Factor in that these counties have some economic challenges, such as inequality and a generally smaller share of primary sector jobs, and the affected communities may lack the capacity to mitigate environmental restrictions that other communities enjoy.

Definitively explaining the causes of the greater restrictions on the Environment is beyond the scope of this thesis. That the data was able to show that these counties have special challenges, however, shows that the methodology is capable of producing valuable analysis when it comes to understanding the complex relationships that make up sustainable development.

Shift in Order Between Scenarios.

Notwithstanding the strong pattern noted above, there were very apparent changes in the ranking of counties between the different runs (see Table 7). In the first run, the rankings showed a mix of urban and rural counties through at least the upper half of the rankings. This was an interesting result, as the Border Study tended to show urban counties outperforming rural counties on overall sustainability.

With the second run, however, we began to see the urban counties rise to the top of the rankings; and with the third run, the shift was essentially complete. Generally, those counties with larger, more urbanized populations – and the larger, more productive economies that went with them – did better than more rural counties. Conversely, the most rural counties in the state had largely shifted all the way to the bottom half of the rankings.

Table 7

County ranks (Shaded cells are top-5 ranks).

County	Rank		
	1st Run	2nd Run	3rd Run
Beaver	25	23	26
Box Elder	19	17	11
Cache	3	2	6
Carbon	26	22	22
Daggett	28	27	28
Davis	4	1	1
Duchesne	21	24	15
Emery	22	15	18
Garfield	8	13	14
Grand	14	14	25
Iron	23	20	23
Juab	24	26	21
Kane	13	19	20
Millard	27	25	27
Morgan	5	11	3
Piute	12	28	24
Rich	1	9	16
Salt Lake	10	5	4
San Juan	29	29	29
Sanpete	17	21	19
Sevier	16	16	12
Summit	2	3	2
Tooele	15	12	8
Uintah	20	18	17
Utah	6	4	5
Wasatch	9	10	10
Washington	18	7	9
Wayne	7	8	13
Weber	11	6	7

The better performance by urban counties is both an expected and a frustrating result. Frustrating because it seems to call into question the need for such an elaborate tool to assess sustainability. If population ends up being a strong correlate to sustainable development, then is it really necessary to work so hard to measure other things? The answer of course is that the methodology is intended to get at *more* than one contributing factor when it comes to assessing sustainable development possibilities. If the tool or the data are strongly sensitive to population-related data, the answer is to find ways to increase the sensitivity to other, non-population, measures.

The result is also expected because much of the “conventional wisdom” in the sustainability field holds that urban living is more sustainable than rural because of the greater efficiencies in energy use, land consumption, etc., that can be had in urban environments. This urbanism bias is problematic for two reasons. First, it tends to be blind to the question of how sustainable a city can be if it depends on an ‘unsustainable’ rural area for support.

Second, and more critically, future assessments need a model (and associated data for the necessary indicators) that can describe a “sustainable rurality.” A quality description of how a sustainable rural economy or community would look and function is difficult to find in the literature. Being able to define rural sustainability is important for improving sustainability assessment tools such as this, but it is even more important for the communities themselves to have a definition of sustainability that does not essentially say, “you should be a big city.”

Using the Results

Local stakeholders and decision-makers will need to examine the results and discuss desired changes to the indicator selection and weighting. These discussions can be done by survey, by discussion in workshops and open houses, by social media, or any of the other public involvement tools that are commonly utilized in the local planning process. As localities elucidate their understandings of what sustainability means and how that definition can be expressed in the assessment tool, they will be creating an assessment that acknowledges and incorporates their socially-constructed reality *and* their socially-constructed definition of sustainability into a tool that helps those shared understandings inform future policies affecting sustainability.

CHAPTER VI

FINDINGS AND CONCLUSIONS

The results of the analysis form the first benchmark of what will hopefully be many more rounds of assessment and calibration that will help communities understand where they are and move in a more sustainable direction. While this was not an all-inclusive examination of all relevant dimensions of development possibilities, this thesis did critically examine the methodology used to arrive at the present benchmark.

The tested tool was found to be capable of integrating a wide variety of indicators in order to perform useful sustainability assessments across multiple scenarios. This allows it to be useful in addressing the multiple, interdisciplinary factors that make up sustainability. It also allows it to be useful in an area where complexity often overwhelms efforts to create simple tools.

At the same time, the tool demonstrated that it was flexible enough to accommodate input from experts or potential users in order to adjust the analysis as may be needed – an important consideration when dealing with varying local circumstances and priorities.

The range of adjustability in the framework is very broad. Users will discover new data sources. Understanding of how to apply existing indicators will improve. The soft-systems approach will constantly inform the selection and weighting of indicators used. New scenarios will present themselves for analysis. Encountering limitations in the use/applicability/accuracy of the assessment tool at any one point should not deter from using it for subsequent inquiry. The model can be constantly refined and improved if the user is willing.

The adjustability of the tool enables users to link data with knowledge (from subject matter experts, local experts, decision-makers, etc.) to help bridge theoretical understandings of sustainability with on-the-ground understanding of a community; all in order to pave the way for more effective implementation of whichever strategies are adopted to improve sustainability.

By using available data to create the indicators needed for measuring a community's sustainable development potential, the tool assess current conditions without the need to invest time and expense in gathering new data. This makes the tool easier for local communities to use. As a result, this methodology should be capable of informing decision makers about the potential results of their actions. This will need to be tested in future studies (see section on "Future Work," below).

This evaluation did show that the methodology is sensitive to the data used to run the analysis. In particular, more and better environmental indicators are needed in order to increase the tool's sensitivity to restrictions on the environment and produce a more balanced evaluation. However, the results did show enough sensitivity to environmental measures to mitigate concerns that the tool's sensitivity to economic factors was too high.

Discovered Limitations

In the process of critically examining this methodology, some limitations became apparent that were not known beforehand. This section describes these limitations and offers some initial analysis of them.

Uncertain validity for indicators

One challenge with using indicators is that, while there are many studies that identify potential indicators and discuss their use, very few indicators have ever been rigorously tested to see if they legitimately measure the effect they purport to indicate. Some relationships (such as that between VMT and cancer risk) are obvious, but others (such as that between the % of total population and the share of 1 person and 1 parent households) are not. We ran the model using the data we had – and one of the strengths of the model is that it allows you to compare a variety of data to see how it interacts – but if a policy maker had a better understanding of *why* two indicators have a strong relationship, then a given policy based on analysis of that relationship would have a better chance of success.

Cross-boundary effects

Along with the urban-rural issue is the issue of cross-boundary effects (at any sub-global scale). That is, when you select a smaller-scale for sustainability assessment, you run into a problem because goods, services, pollutants, and so on, move across the boundaries of whatever sized area you have selected for study; if one county is dependent upon another county for part of its economic or social well-being, then measuring the sustainability of either county becomes more challenging. These effects intensify as you move down the scale in terms of size (smaller areas contain less of the "whole" that sustainability is trying to holistically assess). It is important to be aware of this limitation, but the advantages of local-level assessment (discussed earlier) mean that this is not a reason to abandon this scale of work.

Future Work

The project, while successfully creating the desired baseline assessment of Utah's 29 counties, highlighted several areas where additional future work can be done:

- The first "next step" is to share the findings of the analysis with the counties themselves, in order to gather and assess the reactions of stakeholders and decision-makers. By understanding how they perceive these results – and how they would adjust the model using the survey tool – it will be possible to begin analyzing how effectively this evaluation framework can be operationalized. It would be especially valuable to find an opportunity to partner with one or more counties to explore how the assessment produced in this project can help them in their policy-making process. Lessons from those efforts to use the framework to affect policy then need to be incorporated into the framework itself.
- More work is needed to understand how assessment frameworks can account for exchange between localities while still producing useful measures of sustainability at discreet scales.

- There are several possibilities for new or different indicators that should be explored. This is an ongoing part of any assessment tool, but with the relative weakness in understanding how to do broad, interdisciplinary sustainability assessments at the local level, continuous strengthening and refinement of the indicator set will be needed as that understanding improves. There are several possibilities for new/different indicators that should be explored, including Underemployment, Uninsured Children, better data for recreational/seasonal housing, better data for different economic sectors of the economy, and so on.
- A data clearinghouse is needed (possibly including defining some useful-but-not-currently-collected data that local officials could help supply). The assessment framework makes use of existing, available data. Improving both the scope of data that is available as well as the ease with which it can be accessed will improve both the usability and the value of the tool.
- More work is needed to establish and support the relationship between indicators and the phenomena they supposedly represent. This is a general problem with the whole field of sustainability assessment and not just with local-level indicators, but there is plenty of room for research that can show the relationships between things that we can measure, such as obesity or share of public lands and things that happen in the community such as lost economic opportunities.

- More work is needed on an indicator set that can measure a "sustainable rurality." This is not a problem with the tool or the methodology used in this thesis, but a larger conceptual problem in the way we describe sustainability – because it tends to be too urban-centric. The literature does not appear to be very deep on the topic of rural sustainability as a whole, but a literature review that describes the various definitions and criteria and that then seeks to translate the best of those into a set of indicators that can be matched with data will greatly benefit those counties that are (or will be) looking for a path to sustainability that does not involve sacrificing rurality in order to gain the benefits of urban efficiency.
- Some examination of the proper number/mix of indicators for use with the framework is needed. It is currently much easier to find indicators for social and environmental factors than for economic (especially at local levels). This results in indicator sets where the environmental indicator set is half or less as long as the social or economic sets. Some examination of how this imbalance affects the framework's results is needed so that, if it is a factor, future indicator sets can be sized and balanced appropriately.
- The indicator set could be augmented with time-series data such as the change in primary sector jobs, (which might yield an interesting result in comparison with such things as poverty rate or tax receipts). The assessment tool is currently structured as a snapshot of current conditions, and as such it

certainly has value. However, history is important too, so it might be worthwhile to add these time-series datum to the framework.

Ultimately, this evaluation found that the tested methodology is capable of assessing the three-part concept of sustainable development as it applies to local communities. In doing so, it helps navigate the complex array of interacting relationships that make up a sustainable pattern of development. The resulting analysis should be useful to local stakeholders and decision-makers for creating policies to help them achieve goals related to sustainable development

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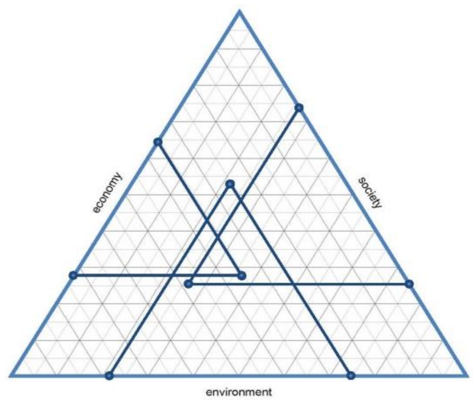
APPENDICES

Appendix A. Final Assessment Results – Graphs and Tables

This appendix contains the final results of the 29-county assessment. Each county's graphic is shown over top of tables with ranks and scores for the interactions between the three components of Sustainable Development.

Sustainable Development Possibilities in Utah Counties

Beaver



inner triangles area [percent of total]:

		rank
ECONOMY	13.6%	26
economy-society OVERLAP	1.1%	26
economy-society CONFLICT	18.7%	4
SOCIETY	23.4%	24
society-environment OVERLAP	5.4%	25
society-environment CONFLICT	12.8%	3
ENVIRONMENT	28.3%	25
environment-economy OVERLAP	2.3%	26
environment-economy CONFLICT	11.9%	11
SUSTAINABLE DEVELOPMENT POSSIBILITIES	1.1%	26

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

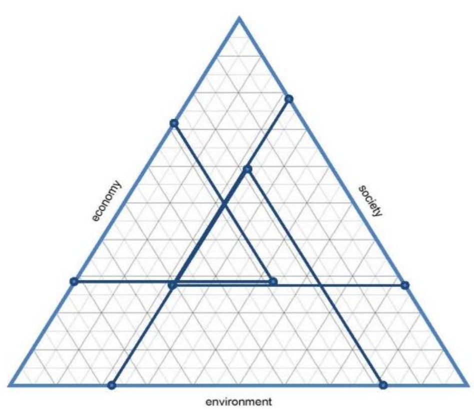
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	25.4%	24
economic restrictions to SOCIETY	26.2%	17
social restrictions to ECONOMY	35.6%	28
environmental restrictions to ECONOMY	27.6%	15
social restrictions to ENVIRONMENT	25.2%	26
economic restrictions to ENVIRONMENT	21.7%	19

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Box Elder



inner triangles area [percent of total]:

		rank
ECONOMY	18.8%	15
economy-society OVERLAP	4.7%	12
economy-society CONFLICT	12.3%	20
SOCIETY	25.7%	20
society-environment OVERLAP	10.2%	15
society-environment CONFLICT	10.0%	12
ENVIRONMENT	35.4%	17
environment-economy OVERLAP	4.4%	19
environment-economy CONFLICT	12.7%	8
SUSTAINABLE DEVELOPMENT POSSIBILITIES	4.4%	11

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

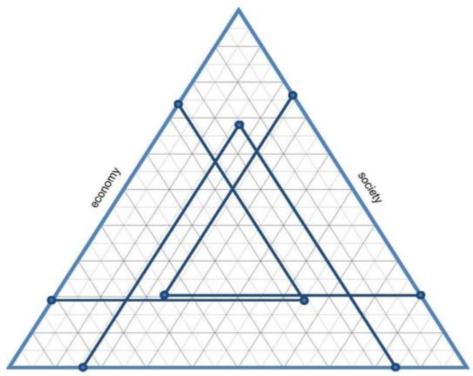
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	27.5%	29
economic restrictions to SOCIETY	21.8%	7
social restrictions to ECONOMY	28.3%	12
environmental restrictions to ECONOMY	28.3%	19
social restrictions to ENVIRONMENT	18.1%	8
economic restrictions to ENVIRONMENT	22.4%	20

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Cache



inner triangles area [percent of total]:

		rank
ECONOMY	30.3%	5
economy-society OVERLAP	8.8%	7
economy-society CONFLICT	12.4%	19
SOCIETY	31.2%	9
society-environment OVERLAP	16.4%	4
society-environment CONFLICT	6.2%	25
ENVIRONMENT	46.9%	5
environment-economy OVERLAP	15.1%	5
environment-economy CONFLICT	6.1%	24
SUSTAINABLE DEVELOPMENT POSSIBILITIES	8.8%	6

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

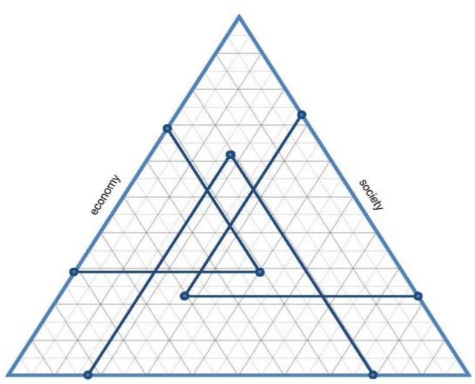
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	20.4%	9
economic restrictions to SOCIETY	23.7%	12
social restrictions to ECONOMY	26.1%	9
environmental restrictions to ECONOMY	18.8%	2
social restrictions to ENVIRONMENT	15.3%	5
economic restrictions to ENVIRONMENT	16.2%	7

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Carbon



inner triangles area [percent of total]:

		rank
ECONOMY	16.2%	23
economy-society OVERLAP	1.7%	22
economy-society CONFLICT	16.8%	8
SOCIETY	25.6%	21
society-environment OVERLAP	9.0%	18
society-environment CONFLICT	9.1%	17
ENVIRONMENT	38.5%	9
environment-economy OVERLAP	5.2%	15
environment-economy CONFLICT	10.0%	19
SUSTAINABLE DEVELOPMENT POSSIBILITIES	1.7%	22

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

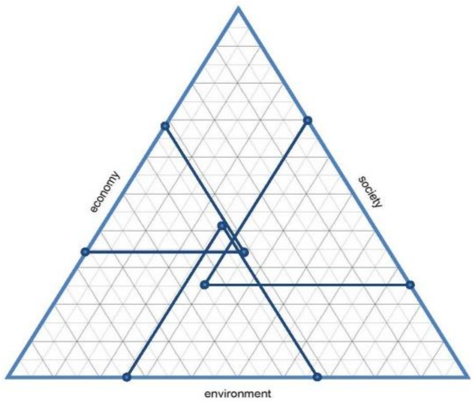
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	22.3%	16
economic restrictions to SOCIETY	27.2%	22
social restrictions to ECONOMY	31.0%	21
environmental restrictions to ECONOMY	28.8%	22
social restrictions to ENVIRONMENT	20.5%	15
economic restrictions to ENVIRONMENT	17.4%	9

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Daggett



inner triangles area [percent of total]:

		rank
ECONOMY	11.8%	28
economy-society OVERLAP	0.2%	28
economy-society CONFLICT	19.1%	2
SOCIETY	19.8%	28
society-environment OVERLAP	1.5%	29
society-environment CONFLICT	16.4%	1
ENVIRONMENT	17.2%	29
environment-economy OVERLAP	0.6%	29
environment-economy CONFLICT	17.7%	1
SUSTAINABLE DEVELOPMENT POSSIBILITIES	0.1%	28

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

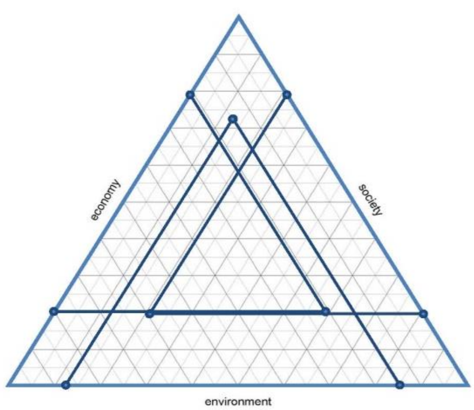
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	25.3%	23
economic restrictions to SOCIETY	30.2%	28
social restrictions to ECONOMY	31.6%	23
environmental restrictions to ECONOMY	33.9%	29
social restrictions to ENVIRONMENT	32.5%	29
economic restrictions to ENVIRONMENT	26.0%	28

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Davis



inner triangles area [percent of total]:

		rank
ECONOMY	34.8%	1
economy-society OVERLAP	14.4%	1
economy-society CONFLICT	8.8%	27
SOCIETY	35.3%	3
society-environment OVERLAP	20.2%	1
society-environment CONFLICT	5.7%	28
ENVIRONMENT	53.2%	3
environment-economy OVERLAP	21.6%	1
environment-economy CONFLICT	5.0%	28
SUSTAINABLE DEVELOPMENT POSSIBILITIES	14.4%	1

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

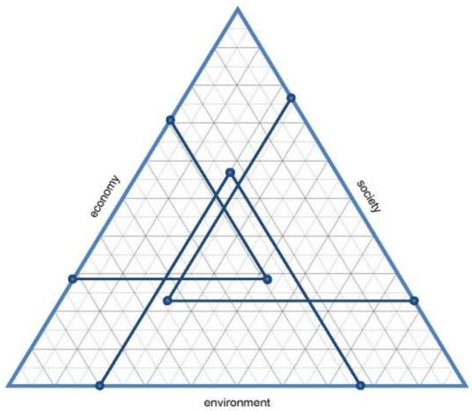
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	19.6%	6
economic restrictions to SOCIETY	21.0%	4
social restrictions to ECONOMY	21.0%	3
environmental restrictions to ECONOMY	20.0%	4
social restrictions to ENVIRONMENT	14.5%	3
economic restrictions to ENVIRONMENT	12.6%	3

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Duchesne



inner triangles area [percent of total]:		rank
ECONOMY	18.0%	17
economy-society OVERLAP	3.6%	17
economy-society CONFLICT	13.7%	15
SOCIETY	28.9%	15
society-environment OVERLAP	9.6%	16
society-environment CONFLICT	10.4%	8
ENVIRONMENT	32.7%	20
environment-economy OVERLAP	5.0%	17
environment-economy CONFLICT	11.4%	13
SUSTAINABLE DEVELOPMENT POSSIBILITIES	3.6%	15

percentages do not add 100 due to multiple area overlap

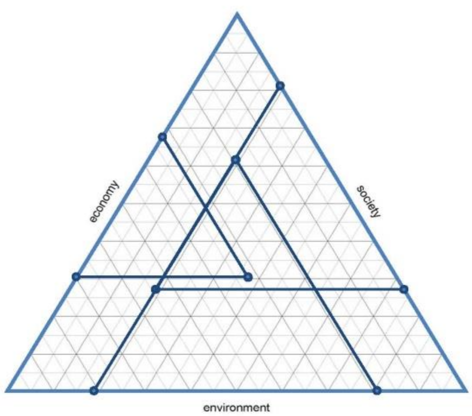
restrictions defining triangles are:
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	22.8%	17
economic restrictions to SOCIETY	23.4%	11
social restrictions to ECONOMY	29.2%	17
environmental restrictions to ECONOMY	28.3%	20
social restrictions to ENVIRONMENT	22.8%	21
economic restrictions to ENVIRONMENT	20.1%	15

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Emery



inner triangles area [percent of total]:		rank
ECONOMY	14.0%	25
economy-society OVERLAP	3.4%	18
economy-society CONFLICT	12.2%	21
SOCIETY	29.2%	13
society-environment OVERLAP	12.1%	13
society-environment CONFLICT	10.4%	10
ENVIRONMENT	38.4%	10
environment-economy OVERLAP	3.4%	22
environment-economy CONFLICT	11.5%	12
SUSTAINABLE DEVELOPMENT POSSIBILITIES	3.4%	18

percentages do not add 100 due to multiple area overlap

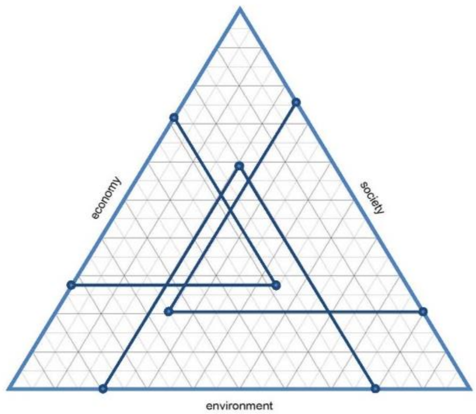
restrictions defining triangles are:
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	27.2%	28
economic restrictions to SOCIETY	18.8%	2
social restrictions to ECONOMY	32.4%	26
environmental restrictions to ECONOMY	30.3%	26
social restrictions to ENVIRONMENT	19.1%	9
economic restrictions to ENVIRONMENT	19.0%	13

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Garfield



inner triangles area [percent of total]:

		rank
ECONOMY	19.6%	14
economy-society OVERLAP	3.9%	16
economy-society CONFLICT	13.9%	14
SOCIETY	30.3%	11
society-environment OVERLAP	12.1%	12
society-environment CONFLICT	8.3%	18
ENVIRONMENT	35.1%	18
environment-economy OVERLAP	5.6%	13
environment-economy CONFLICT	11.2%	14
SUSTAINABLE DEVELOPMENT POSSIBILITIES	3.9%	14

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

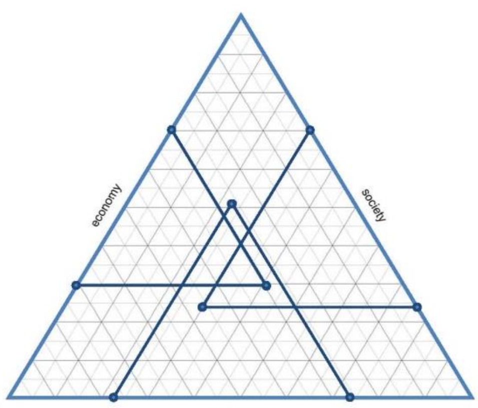
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	20.5%	11
economic restrictions to SOCIETY	24.4%	14
social restrictions to ECONOMY	28.4%	14
environmental restrictions to ECONOMY	27.3%	14
social restrictions to ENVIRONMENT	20.2%	12
economic restrictions to ENVIRONMENT	20.5%	16

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Grand



inner triangles area [percent of total]:

		rank
ECONOMY	16.8%	21
economy-society OVERLAP	1.2%	25
economy-society CONFLICT	17.8%	7
SOCIETY	21.4%	27
society-environment OVERLAP	4.1%	27
society-environment CONFLICT	12.5%	5
ENVIRONMENT	26.2%	26
environment-economy OVERLAP	3.3%	23
environment-economy CONFLICT	13.4%	6
SUSTAINABLE DEVELOPMENT POSSIBILITIES	1.2%	25

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

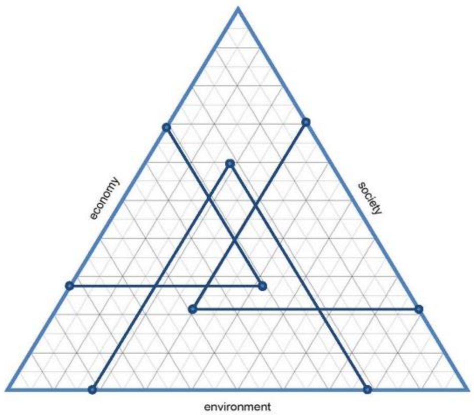
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	23.9%	20
economic restrictions to SOCIETY	29.9%	27
social restrictions to ECONOMY	29.7%	18
environmental restrictions to ECONOMY	29.3%	23
social restrictions to ENVIRONMENT	26.1%	27
economic restrictions to ENVIRONMENT	22.8%	23

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Iron



inner triangles area [percent of total]:

		rank
ECONOMY	17.5%	20
economy-society OVERLAP	1.5%	23
economy-society CONFLICT	18.3%	6
SOCIETY	24.0%	23
society-environment OVERLAP	7.6%	21
society-environment CONFLICT	9.2%	16
ENVIRONMENT	36.0%	14
environment-economy OVERLAP	5.4%	14
environment-economy CONFLICT	10.1%	18
SUSTAINABLE DEVELOPMENT POSSIBILITIES	1.5%	23

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

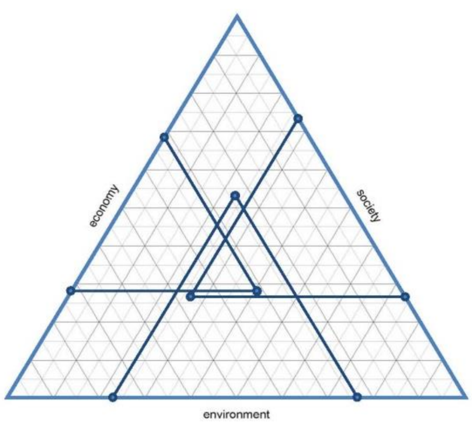
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	21.4%	13
economic restrictions to SOCIETY	29.6%	25
social restrictions to ECONOMY	30.9%	20
environmental restrictions to ECONOMY	27.3%	13
social restrictions to ENVIRONMENT	21.5%	17
economic restrictions to ENVIRONMENT	18.6%	12

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Juab



inner triangles area [percent of total]:

		rank
ECONOMY	16.4%	22
economy-society OVERLAP	1.9%	21
economy-society CONFLICT	16.8%	9
SOCIETY	21.8%	26
society-environment OVERLAP	5.4%	24
society-environment CONFLICT	12.5%	4
ENVIRONMENT	28.6%	23
environment-economy OVERLAP	3.0%	24
environment-economy CONFLICT	13.0%	7
SUSTAINABLE DEVELOPMENT POSSIBILITIES	1.9%	21

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

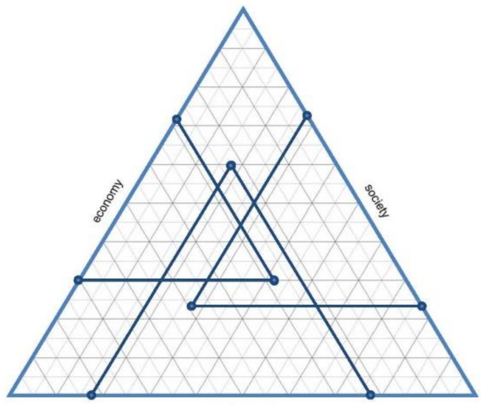
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	26.6%	27
economic restrictions to SOCIETY	26.7%	20
social restrictions to ECONOMY	31.5%	22
environmental restrictions to ECONOMY	28.0%	17
social restrictions to ENVIRONMENT	23.4%	23
economic restrictions to ENVIRONMENT	23.2%	24

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Kane



inner triangles area [percent of total]:

		rank
ECONOMY	17.5%	19
economy-society OVERLAP	2.1%	20
economy-society CONFLICT	15.5%	12
SOCIETY	24.3%	22
society-environment OVERLAP	7.3%	22
society-environment CONFLICT	10.4%	9
ENVIRONMENT	36.1%	12
environment-economy OVERLAP	5.9%	12
environment-economy CONFLICT	10.5%	16
SUSTAINABLE DEVELOPMENT POSSIBILITIES	2.1%	20

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

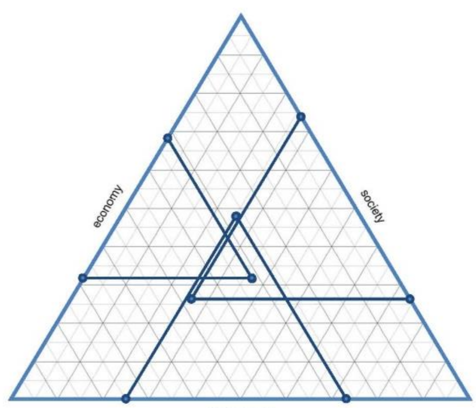
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	23.3%	19
economic restrictions to SOCIETY	27.4%	23
social restrictions to ECONOMY	28.3%	13
environmental restrictions to ECONOMY	29.8%	25
social restrictions to ENVIRONMENT	22.3%	20
economic restrictions to ENVIRONMENT	17.7%	10

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Millard



inner triangles area [percent of total]:

		rank
ECONOMY	13.5%	27
economy-society OVERLAP	1.1%	27
economy-society CONFLICT	16.6%	10
SOCIETY	22.6%	25
society-environment OVERLAP	4.3%	26
society-environment CONFLICT	14.1%	2
ENVIRONMENT	23.1%	27
environment-economy OVERLAP	1.3%	27
environment-economy CONFLICT	15.9%	2
SUSTAINABLE DEVELOPMENT POSSIBILITIES	1.1%	27

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

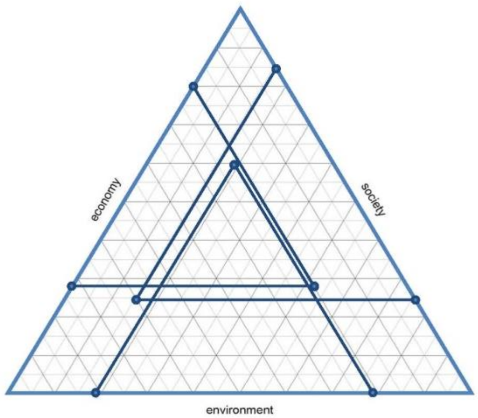
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	26.3%	26
economic restrictions to SOCIETY	26.2%	16
social restrictions to ECONOMY	31.7%	24
environmental restrictions to ECONOMY	31.5%	27
social restrictions to ENVIRONMENT	26.7%	28
economic restrictions to ENVIRONMENT	25.2%	27

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Morgan



inner triangles area [percent of total]:		rank
ECONOMY	27.2%	8
economy-society OVERLAP	13.5%	2
economy-society CONFLICT	6.2%	29
SOCIETY	36.1%	2
society-environment OVERLAP	12.6%	10
society-environment CONFLICT	10.3%	11
ENVIRONMENT	35.9%	15
environment-economy OVERLAP	10.3%	9
environment-economy CONFLICT	10.6%	15
SUSTAINABLE DEVELOPMENT POSSIBILITIES	10.3%	3

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

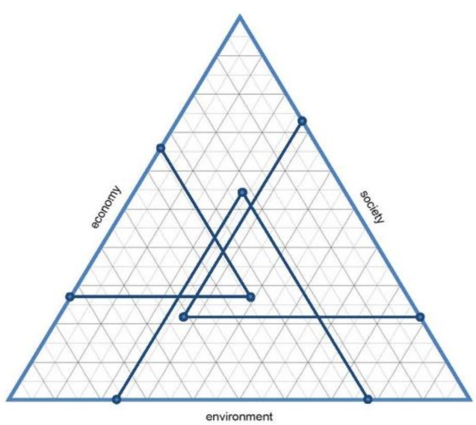
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	24.4%	21
economic restrictions to SOCIETY	15.5%	1
social restrictions to ECONOMY	20.0%	2
environmental restrictions to ECONOMY	27.8%	16
social restrictions to ENVIRONMENT	21.0%	16
economic restrictions to ENVIRONMENT	19.1%	14

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Piute



inner triangles area [percent of total]:		rank
ECONOMY	15.2%	24
economy-society OVERLAP	1.4%	24
economy-society CONFLICT	18.5%	5
SOCIETY	26.2%	19
society-environment OVERLAP	8.6%	19
society-environment CONFLICT	9.5%	14
ENVIRONMENT	29.8%	22
environment-economy OVERLAP	2.4%	25
environment-economy CONFLICT	12.6%	9
SUSTAINABLE DEVELOPMENT POSSIBILITIES	1.4%	24

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

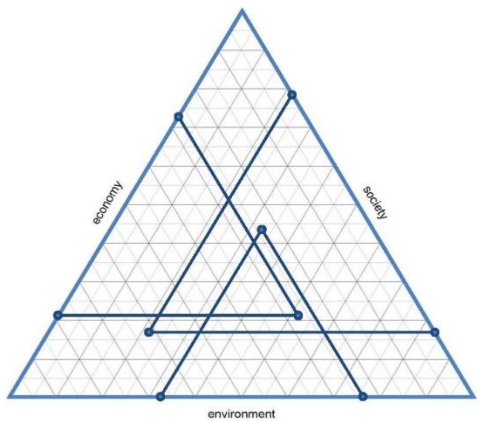
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	21.8%	14
economic restrictions to SOCIETY	27.1%	21
social restrictions to ECONOMY	34.1%	27
environmental restrictions to ECONOMY	26.9%	12
social restrictions to ENVIRONMENT	21.8%	19
economic restrictions to ENVIRONMENT	23.5%	25

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Rich



inner triangles area [percent of total]:

		rank
ECONOMY	26.7%	9
economy-society OVERLAP	9.0%	6
economy-society CONFLICT	11.8%	24
SOCIETY	37.8%	1
society-environment OVERLAP	7.2%	23
society-environment CONFLICT	8.0%	20
ENVIRONMENT	19.1%	28
environment-economy OVERLAP	3.6%	20
environment-economy CONFLICT	13.8%	5
SUSTAINABLE DEVELOPMENT POSSIBILITIES	3.6%	16

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

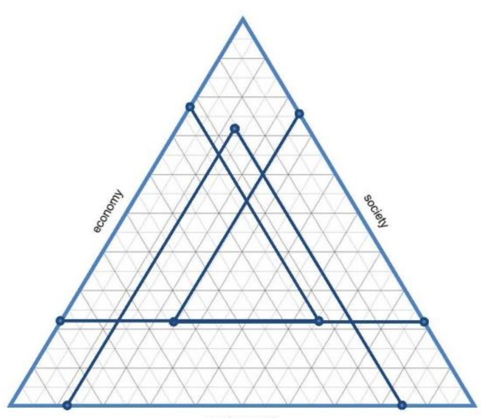
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	16.9%	1
economic restrictions to SOCIETY	21.6%	6
social restrictions to ECONOMY	27.2%	11
environmental restrictions to ECONOMY	21.1%	6
social restrictions to ENVIRONMENT	23.6%	24
economic restrictions to ENVIRONMENT	32.7%	29

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Salt Lake



inner triangles area [percent of total]:

		rank
ECONOMY	30.8%	4
economy-society OVERLAP	9.7%	4
economy-society CONFLICT	11.0%	25
SOCIETY	28.9%	14
society-environment OVERLAP	14.8%	5
society-environment CONFLICT	6.7%	24
ENVIRONMENT	52.3%	4
environment-economy OVERLAP	18.6%	2
environment-economy CONFLICT	5.4%	26
SUSTAINABLE DEVELOPMENT POSSIBILITIES	9.7%	4

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

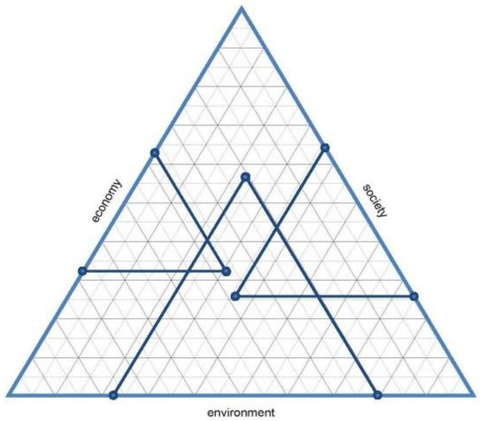
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	21.9%	15
economic restrictions to SOCIETY	24.4%	13
social restrictions to ECONOMY	22.5%	5
environmental restrictions to ECONOMY	21.9%	7
social restrictions to ENVIRONMENT	15.3%	4
economic restrictions to ENVIRONMENT	12.4%	2

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

San Juan



inner triangles area [percent of total]:

		rank
ECONOMY	9.5%	29
economy-society OVERLAP	0.0%	29
economy-society CONFLICT	26.6%	1
SOCIETY	14.7%	29
society-environment OVERLAP	3.2%	28
society-environment CONFLICT	10.5%	7
ENVIRONMENT	32.5%	21
environment-economy OVERLAP	0.7%	28
environment-economy CONFLICT	14.6%	3
SUSTAINABLE DEVELOPMENT POSSIBILITIES	NS	29

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

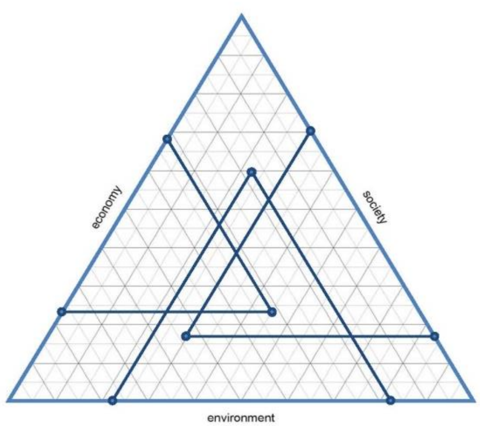
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	25.8%	25
economic restrictions to SOCIETY	35.9%	29
social restrictions to ECONOMY	37.1%	29
environmental restrictions to ECONOMY	32.1%	28
social restrictions to ENVIRONMENT	20.4%	14
economic restrictions to ENVIRONMENT	22.7%	22

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Sanpete



inner triangles area [percent of total]:

		rank
ECONOMY	20.3%	13
economy-society OVERLAP	2.4%	19
economy-society CONFLICT	18.9%	3
SOCIETY	28.5%	16
society-environment OVERLAP	12.8%	8
society-environment CONFLICT	5.9%	26
ENVIRONMENT	36.0%	13
environment-economy OVERLAP	5.1%	16
environment-economy CONFLICT	10.4%	17
SUSTAINABLE DEVELOPMENT POSSIBILITIES	2.4%	19

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

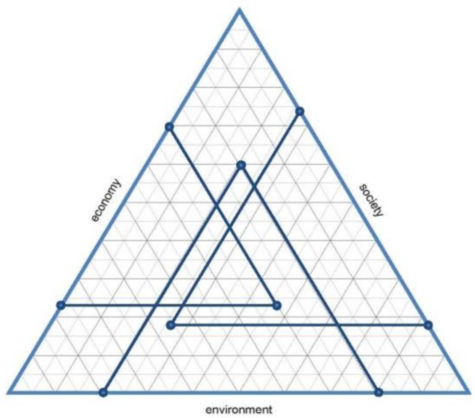
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	17.0%	2
economic restrictions to SOCIETY	29.7%	26
social restrictions to ECONOMY	31.8%	25
environmental restrictions to ECONOMY	23.1%	9
social restrictions to ENVIRONMENT	17.5%	7
economic restrictions to ENVIRONMENT	22.5%	21

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Sevier



inner triangles area [percent of total]:

		rank
ECONOMY	21.9%	12
economy-society OVERLAP	4.2%	14
economy-society CONFLICT	15.9%	11
SOCIETY	31.2%	8
society-environment OVERLAP	13.4%	7
society-environment CONFLICT	6.9%	23
ENVIRONMENT	36.1%	11
environment-economy OVERLAP	6.9%	11
environment-economy CONFLICT	9.4%	20
SUSTAINABLE DEVELOPMENT POSSIBILITIES	4.2%	12

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

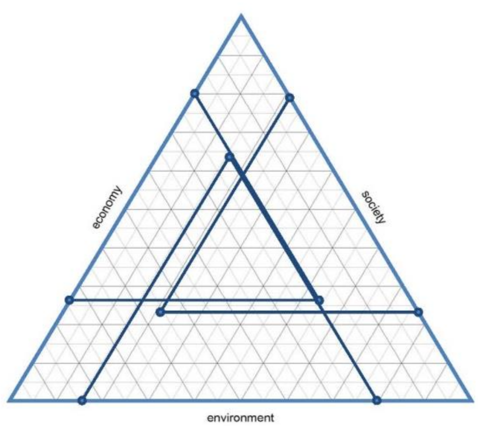
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	17.8%	3
economic restrictions to SOCIETY	26.3%	18
social restrictions to ECONOMY	30.3%	19
environmental restrictions to ECONOMY	22.9%	8
social restrictions to ENVIRONMENT	19.3%	10
economic restrictions to ENVIRONMENT	20.6%	17

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Summit



inner triangles area [percent of total]:

		rank
ECONOMY	29.1%	7
economy-society OVERLAP	10.8%	3
economy-society CONFLICT	8.4%	28
SOCIETY	31.0%	10
society-environment OVERLAP	12.6%	11
society-environment CONFLICT	9.4%	15
ENVIRONMENT	40.9%	8
environment-economy OVERLAP	14.3%	8
environment-economy CONFLICT	8.3%	22
SUSTAINABLE DEVELOPMENT POSSIBILITIES	10.6%	2

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

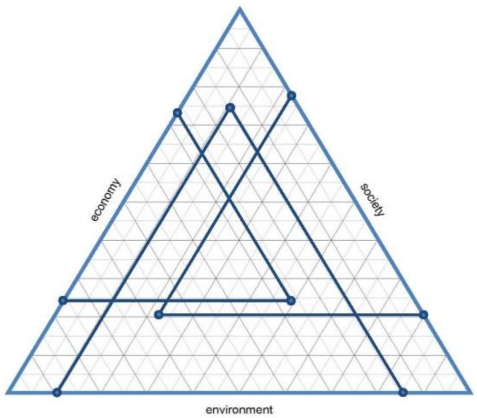
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	23.2%	18
economic restrictions to SOCIETY	21.1%	5
social restrictions to ECONOMY	19.9%	1
environmental restrictions to ECONOMY	26.2%	11
social restrictions to ENVIRONMENT	20.2%	13
economic restrictions to ENVIRONMENT	15.8%	6

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Tooele



inner triangles area [percent of total]:		rank
ECONOMY	24.2%	11
economy-society OVERLAP	7.2%	9
economy-society CONFLICT	12.0%	22
SOCIETY	32.6%	4
society-environment OVERLAP	18.3%	3
society-environment CONFLICT	5.9%	27
ENVIRONMENT	56.3%	1
environment-economy OVERLAP	14.8%	6
environment-economy CONFLICT	5.1%	27
SUSTAINABLE DEVELOPMENT POSSIBILITIES	7.2%	8

percentages do not add 100 due to multiple area overlap

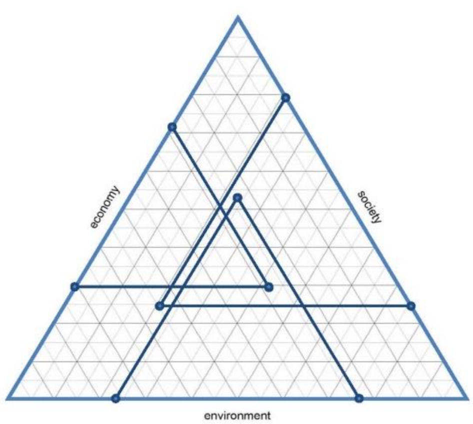
restrictions defining triangles are:
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	20.5%	10
economic restrictions to SOCIETY	22.4%	8
social restrictions to ECONOMY	26.8%	10
environmental restrictions to ECONOMY	24.0%	10
social restrictions to ENVIRONMENT	14.3%	2
economic restrictions to ENVIRONMENT	10.7%	1

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Uintah



inner triangles area [percent of total]:		rank
ECONOMY	17.8%	18
economy-society OVERLAP	4.5%	13
economy-society CONFLICT	11.9%	23
SOCIETY	29.8%	12
society-environment OVERLAP	8.2%	20
society-environment CONFLICT	11.4%	6
ENVIRONMENT	28.3%	24
environment-economy OVERLAP	3.5%	21
environment-economy CONFLICT	13.8%	4
SUSTAINABLE DEVELOPMENT POSSIBILITIES	3.5%	17

percentages do not add 100 due to multiple area overlap

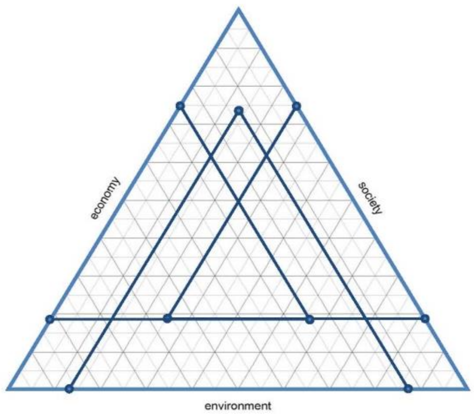
restrictions defining triangles are:
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	24.5%	22
economic restrictions to SOCIETY	20.8%	3
social restrictions to ECONOMY	28.5%	15
environmental restrictions to ECONOMY	29.3%	24
social restrictions to ENVIRONMENT	23.2%	22
economic restrictions to ENVIRONMENT	23.6%	26

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Utah



inner triangles area [percent of total]:

		rank
ECONOMY	31.8%	2
economy-society OVERLAP	9.4%	5
economy-society CONFLICT	12.7%	18
SOCIETY	31.3%	7
society-environment OVERLAP	18.8%	2
society-environment CONFLICT	4.7%	29
ENVIRONMENT	54.8%	2
environment-economy OVERLAP	18.6%	3
environment-economy CONFLICT	4.9%	29
SUSTAINABLE DEVELOPMENT POSSIBILITIES	9.4%	5

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

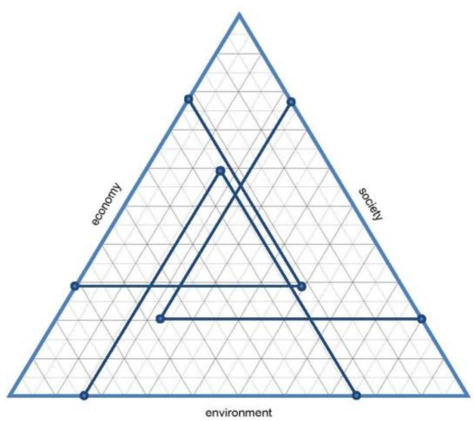
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	18.8%	4
economic restrictions to SOCIETY	25.3%	15
social restrictions to ECONOMY	25.2%	7
environmental restrictions to ECONOMY	18.4%	1
social restrictions to ENVIRONMENT	12.6%	1
economic restrictions to ENVIRONMENT	13.4%	4

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Wasatch



inner triangles area [percent of total]:

		rank
ECONOMY	24.3%	10
economy-society OVERLAP	7.1%	10
economy-society CONFLICT	10.0%	26
SOCIETY	32.4%	6
society-environment OVERLAP	10.8%	14
society-environment CONFLICT	9.8%	13
ENVIRONMENT	35.5%	16
environment-economy OVERLAP	9.5%	10
environment-economy CONFLICT	9.4%	21
SUSTAINABLE DEVELOPMENT POSSIBILITIES	6.0%	10

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

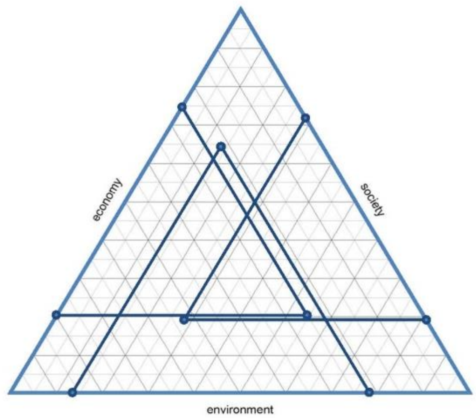
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	20.4%	8
economic restrictions to SOCIETY	22.7%	9
social restrictions to ECONOMY	21.9%	4
environmental restrictions to ECONOMY	28.7%	21
social restrictions to ENVIRONMENT	24.0%	25
economic restrictions to ENVIRONMENT	16.4%	8

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Washington



inner triangles area [percent of total]:

		rank
ECONOMY	29.6%	6
economy-society OVERLAP	6.9%	11
economy-society CONFLICT	14.3%	13
SOCIETY	27.6%	17
society-environment OVERLAP	9.6%	17
society-environment CONFLICT	8.3%	19
ENVIRONMENT	41.9%	7
environment-economy OVERLAP	16.7%	4
environment-economy CONFLICT	5.5%	25
SUSTAINABLE DEVELOPMENT POSSIBILITIES	6.9%	9

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

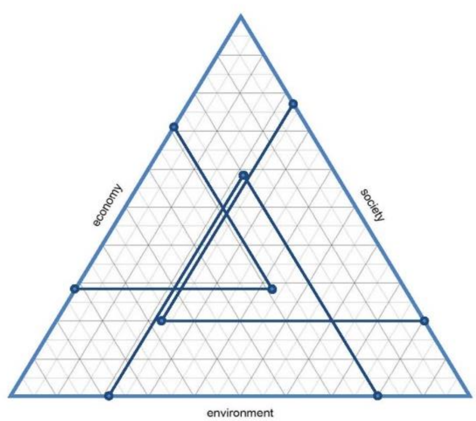
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	19.2%	5
economic restrictions to SOCIETY	28.2%	24
social restrictions to ECONOMY	25.3%	8
environmental restrictions to ECONOMY	20.3%	5
social restrictions to ENVIRONMENT	21.6%	18
economic restrictions to ENVIRONMENT	13.6%	5

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Wayne



inner triangles area [percent of total]:

		rank
ECONOMY	18.4%	16
economy-society OVERLAP	4.0%	15
economy-society CONFLICT	13.3%	16
SOCIETY	32.6%	5
society-environment OVERLAP	13.9%	6
society-environment CONFLICT	7.9%	21
ENVIRONMENT	34.4%	19
environment-economy OVERLAP	4.6%	18
environment-economy CONFLICT	12.1%	10
SUSTAINABLE DEVELOPMENT POSSIBILITIES	4.0%	13

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

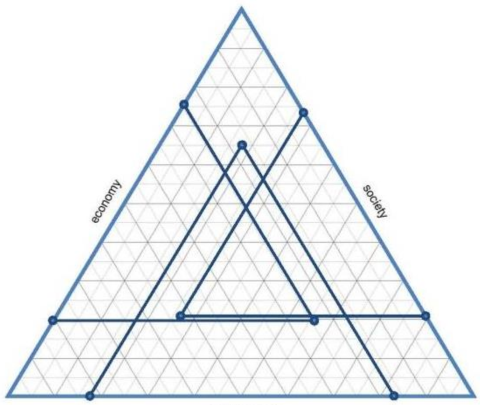
this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	20.0%	7
economic restrictions to SOCIETY	22.9%	10
social restrictions to ECONOMY	28.9%	16
environmental restrictions to ECONOMY	28.2%	18
social restrictions to ENVIRONMENT	19.8%	11
economic restrictions to ENVIRONMENT	21.5%	18

dark shade means value out of range

Sustainable Development Possibilities in Utah Counties

Weber



inner triangles area [percent of total]:

		rank
ECONOMY	31.3%	3
economy-society OVERLAP	7.8%	8
economy-society CONFLICT	13.0%	17
SOCIETY	27.5%	18
society-environment OVERLAP	12.7%	9
society-environment CONFLICT	7.0%	22
ENVIRONMENT	42.8%	6
environment-economy OVERLAP	14.6%	7
environment-economy CONFLICT	6.9%	23
SUSTAINABLE DEVELOPMENT POSSIBILITIES	7.8%	7

percentages do not add 100 due to multiple area overlap

restrictions defining triangles are:

this restrictions are plotted as the "separation" of triangles from the large triangle edges.

		rank
environmental restrictions to SOCIETY	20.9%	12
economic restrictions to SOCIETY	26.6%	19
social restrictions to ECONOMY	24.5%	6
environmental restrictions to ECONOMY	19.6%	3
social restrictions to ENVIRONMENT	16.9%	6
economic restrictions to ENVIRONMENT	17.7%	11

dark shade means value out of range

Appendix B. Indicator Descriptions and Data Sources

This appendix contains a list of the indicators used in this study. Each indicator is listed by name, followed by a brief description of the indicator and an explanation of where the data used for that indicator was found.

Following the list of indicators, a list of data sources is given in the form of a reference list.

List of Indicators Used

Population Growth

This indicator gives the population growth rate from 2000 to 2010 as reported by the 2010 Census.

Percent non-public land

The percentage of privately owned land in each county. This data is taken from Utah State University's Western Rural Development Center (WRDC).

In Utah, as in many western states, much of the land area is owned by the national government. Other tracts of land are owned by tribal governments or by the state. The result is that the net portion of land area in private hands is smaller – often significantly so – than the total land area of a given county. Consequently, the land available to meet needs of county residents is more constrained than a 'total land area' figure would indicate.

This indicator was not used in previous studies, but on the advice of the WRDC, it was included in the Utah Study as its importance in the function of Utah's development cannot be overlooked. The large portion of public lands extant in Utah presents both opportunities and constraints related to sustainable futures for its communities.

Public lands create opportunities by preserving valuable natural, scenic and environmental resources in perpetuity. These lands create opportunities for tourist and recreation-based economic activities from which flow jobs and economic growth that does not come at the expense of the environment or of the ability of future generations to provide for themselves.

Public lands create constraints by limiting the amount of land available for economic productivity and by locking up some kinds of resources so that they cannot be exploited for economic and social ends.

On a practical note, this indicator is useful because it shines a light on possible confusion about the relative impacts and benefits of the activities that the model is attempting to measure. Including all of the acres of a given county could mask the importance of things like pollution or population density. Hypothetically speaking, the sustainability potential of two counties with equal population and equal *total* area will be very different if one is 80% public lands and the other is substantially all private lands.

Population Density

Given in persons per square mile of privately-owned land. Calculated from Census 2010 population data and non-public land area acquired from WRDC.

Percent State Population

Each county's share of the total state population. Calculated from Census 2010 data.

Unincorporated Population

Percentage of each county's population living outside of incorporated towns or cities. This is calculated using data taken from the Utah Department of Workforce Services.

For each county, the population for the incorporated entities was added up, then that subtotal was subtracted from the total county population to give the population living in unincorporated areas, which was then converted to a percentage. The percentage of population living in unincorporated areas gives us some indication of the rurality of the communities being assessed.

Car Ownership

Number people per car. Calculated by taking the number of people living in the county according to Census 2010 divided by the number of registered vehicles as reported by the Utah State Tax Commission for that same year.

VMT per Capita

The number of vehicle miles traveled each day divided by the population of the county. VMT comes from UDOT's 2010 report. Population comes from Census 2010. This indicator shows how much driving people in the county are doing.

VMT per Acre

The number of vehicle miles traveled each day divided by the number of private acres in the county. VMT comes from UDOT's 2010 report. Area of private acres comes from WRDC. This indicator shows the relationship between travel and land area in the county.

Solo Commuters

Percentage of workers who drove to work alone. Taken from Census 2010.

Carpoolers

Percentage of workers who carpooled to work. Taken from Census 2010.

Alt Modes

Percentage of workers who walked, biked or took transit to work. Taken from Census 2010.

No Car

Percentage of workers with no car in their household. Taken from Census 2010.

Commute Time

The average amount of time each worker takes to travel to work. Taken from Census 2010.

Household Size

Average number of people per household. Taken from Census 2010.

Single-Parent Households

The percentage of households with children under the age of 18 where only one parent resides in the home. Calculated from data taken from Census 2010.

Single-Person Households

The percentage of households with only one person resident. Calculated from data taken from Census 2010.

Vacancy Rate

Percent of housing units not occupied. Taken from Census 2010.

Owner Occupied

Percent of housing units owned by their occupants. Taken from Census 2010.

Literacy

Percent of population that can read. Taken from the 2003 National Assessment of Adult Literacy (US Dept. of Education).

College Educated

Percentage of the population over the age of 25 with a college degree. Taken from Census 2010.

Undereducated

Percentage of population over the age of 16 completing neither high school nor college. Taken from Census 2010.

Youth

Percentage of the population younger than 18 years of age. Taken from Census 2010.

Seniors

Percentage of the population 65 years of age and older. Taken from Census 2010.

Dependents

Percentage of the population made up of Youth and Seniors. Calculated from data taken from Census 2010.

Dependency Ratio

Ratio of dependent population to jobs. Calculated from data taken from Census 2010 and the 2006-2010 American Community Survey 5-Year Estimates.

Cancer risk (Inhalation)

Rate of inhalation-related cancer cases; given as a number of cases per million of population. Taken from the EPA's "MY Environment" web tool.

Obesity

Percentage of population that is obese (2007 data). Taken from PBS Newshour's Patchwork Nation series.

Solid Waste

Pounds of municipal solid waste generated per person per day. Taken from the 2006 State of Utah Solid Waste Plan.

Labor Productivity

Gross taxable sales per job. Taken from the Utah Department of Workforce Services (quick fact sheets).

Unemployment

Unemployment rate (annualized). Taken from the Bureau of Labor Statistics.

Labor Force Utilization

Percentage of workforce-aged population with jobs. Calculated from Utah Department of Workforce Services data.

Primary Sector Jobs

Percent of jobs in the primary sector of the economy. Taken from 2006-2010 American Community Survey 5-Year Estimates. Primary sector jobs are resource-extraction and agricultural jobs.

Secondary Sector Jobs

Percent of jobs in the secondary sector of the economy. Taken from 2006-2010 American Community Survey 5-Year Estimates. Secondary sector jobs are transportation and resource-processing jobs.

Tertiary Sector Jobs

Percent of jobs in the tertiary sector of the economy. Taken from 2006-2010 American Community Survey 5-Year Estimates. These are service-sector jobs

Income

Income per capita. Taken from Census 2010.

Wages

Wages per job. Taken from Utah Department of Workforce Services fact sheets. Another basic economic indicator.

Land productivity

Gross taxable sales per private acre. Calculated from data taken from the Utah Department of Workforce Services (fact sheets) and from WRDC

Poverty

Percentage of the population living below poverty. Taken from Census 2010.

Food Stamps

Percentage of households receiving food stamps. Taken from Census 2010.

Hardship Index

An index of economic hardship created by PBS Newshour for their Patchwork Nation segment. PBS's description of the index is as follows:

> Patchwork Nation's hardship index captures recent economic changes as well as current economic conditions in individual counties based on a series of data indicators.
>
> The hardship index is calculated based on six pieces of data at the county level:
>
> - Gas prices in the previous month
> - The change in gas prices from two months ago to the previous month
> - An estimate of the percentage of monthly household spending dedicated to fuel consumption and car maintenance
> - The unemployment rate from two months ago
> - Home foreclosures per 1,000 homes in the previous month
> - Change in home foreclosures per 1,000 homes from two months ago to the previous month.

Crime

Rate of violent and property crimes committed per 1000 population. Taken from the Utah Department of Public Safety "2010 Crime in Utah" report.

Police

Number of police officers with arrest authority per 1000 population. Taken from the Utah Department of Public Safety "2010 Crime in Utah" report

Cost of living

Index of the cost of living. Taken from a web-based cost of living calculator (Sperling's BestPlaces).

Natural Amenities Scale

USDA produced scale measuring the natural features contributing to quality of life and the desirability of a place to live.

Water Use

Gallons per capita per day. Taken from the US Geological Survey report, Estimated Water Use in the United States (2005).

Irrigation

Percentage of aglands irrigated. Taken from the US Geological Survey report, Estimated Water Use in the United States (2005).

CO2 per capita

Tons of CO2 produced per person per year. Taken from the Vulcan Project (REFf?) and converted from tonnes to tons.

CO2 per private acre

Tons of CO2 produced per private acre per year. Calculated from data taken from the Vulcan project and WRDC and converted from tonnes to tons.

Total Air Pollution

Total tons of air pollution per private acre per year. Taken from Utah Department of Environmental Quality's 2008 Statewide Emissions Inventory.

List of Data Sources

PBS Newshour. (2010). Patchwork Nation: 2007 Obesity rate in Utah counties. Retrieved from PBS website http://www.pbs.org/newshour/interactive/patchworknation/stats/health/obesity-rate/ut/.

PBS Newshour. (2010). Patchwork Nation: 2010 Hardship index in Utah counties. Retrieved from PBS website http://www.pbs.org/newshour/interactive/patchworknation/stats/hardship/hardship-index/ut/

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Utah Department of Public Safety. (2010). Crime in Utah report. Retrieved from UT DPS website http://publicsafety.utah.gov/bci/documents/2010CrimeinUtahReport_000.pdf

Utah Department of Transportation. (2010). VMT road ownership by county report. Retrieved from http://www.udot.utah.gov/main/f?p=100:pg:0::::V,T:,530.

Utah Department of Workforce Services. (2011). County Fact Sheets. Retrieved from Utah Department of Workforce Services website https://jobs.utah.gov/jsp/wi/utalmis/countyprofile.do;jsessionid=D362112E85F6618443C9762443260ADB (fact sheets are found on the right hand side of the page under the “quick information” heading).

Utah State Tax Commission. (2010). On-road registrations by county and vehicle type. Retrieved from Utah State Tax Commission website http://tax.utah.gov/esu/mv-registrations.

Vulcan Project. (2008). Research data accessed May 2012 from: http://www.eaps.purdue.edu/carbon/vulcan/.

Western Rural Development Center. (2008). Utah’s 2008 County Data. Retrieved from WRDC website http://wrdc.usu.edu/htm/regional-data/utah.

Appendix C. Correlation Matrices

This appendix contains selected portions of the correlation matrices used. The first matrix shows selected correlations between the base indicators.

The second matrix shows correlations between different scores produced by the evaluation model. A selection from this matrix is shown on page 40 of the text, and explanations of the headings used can be found on pages 40 and 41.

Excerpt from first correlation matrix

	acres per people	private acres per person	% state pop	% pop in unincorporated areas	Daily VMT per capita	Daily VMT per private acre	Percent of workers who drove to work alone	home ownership	Household size	One-parent households	literacy	% college education	% pop older than 65	% pop dependent	Cancer risk (Inhalation)	Obesity rate	% Primary Sector Jobs	income per capita	per capita water use	CO2 per capita	CO2 per private acre	CO per capita	Nox per capita	Particulates per capita
% pop in unincorporated areas	-0.264	-0.212	0.981	1																				
Percent of workers who drove to work alone	-0.011	-0.034	-0.835	-0.84	0.121	0.129	1																	
Household size	-0.594	-0.138	0.216	0.158	-0.371	0.203	-0.07	0.081	1															
One-parent households	-0.289	-0.253	0.996	0.987	-0.313	0.329	-0.819	-0.245	0.187	1														
One-person households	-0.283	-0.249	0.993	0.99	-0.306	0.33	-0.813	-0.246	0.169	0.999														
% Owner Occupied	0.24	0.475	-0.301	-0.27	0.252	-0.228	0.119	0.84	0.143	-0.298														
% college education	-0.402	-0.235	0.285	0.245	-0.436	0.356	-0.164	-0.242	0.235	0.269	0.732	1												
% pop younger than 18	-0.36	0.028	0.041	0.007	-0.12	0.066	0.009	0.309	0.88	0.02	-0.063	-0.017												
% pop older than 65	0.656	0.296	-0.283	-0.266	0.366	-0.311	0.063	0.243	-0.748	-0.274	-0.106	-0.507	1											
dependency ratio I	0.064	0.282	-0.249	-0.257	0.089	-0.232	0.052	0.627	0.291	-0.261	-0.04	-0.306	0.254	0.756										
Cancer risk (Inhalation)	-0.615	-0.471	0.315	0.227	-0.529	0.815	0.114	-0.4	0.4	0.324	0.228	0.513	-0.534	-0.403	1									
Land productivity	-0.348	-0.324	0.339	0.294	-0.381	0.976	0.116	-0.232	0.171	0.372	0.087	0.348	-0.305	-0.316	0.818	-0.029	-0.351	0.232						
Cost of living	-0.385	-0.221	0.054	0.079	-0.171	0.2	0.026	-0.004	0.157	0.052	0.516	0.753	-0.401	-0.423	0.222	-0.735	-0.398	0.784						
per capita water use	0.506	0.724	-0.218	-0.199	0.315	-0.273	-0.02	0.382	-0.329	-0.216	-0.066	-0.227	0.511	0.449	-0.506	0.111	0.717	-0.167	1					
CO2 per private acre	-0.041	-0.19	0.099	0.067	0.112	0.473	0.132	0.017	0.099	0.113	-0.053	-0.033	-0.127	-0.037	0.282	0.147	0.076	0.017	-0.012	0.774	1			
CO per capita	0.856	0.554	-0.291	-0.267	0.586	-0.346	-0.025	0.346	-0.637	-0.288	-0.116	-0.391	0.789	0.444	-0.615	0.047	0.491	-0.19	0.73	0.129	-0.121	1		
Nox per capita	0.282	0.059	-0.133	-0.121	0.558	-0.14	0.132	0.066	-0.126	-0.132	-0.21	-0.291	0.168	0.151	-0.25	0.062	0.353	-0.132	0.241	0.969	0.723	0.226	1	
Particulates per capita	0.801	0.651	-0.332	-0.292	0.741	-0.398	0.039	0.323	-0.553	-0.328	-0.185	-0.427	0.571	0.293	-0.635	0.027	0.661	-0.199	0.708	0.473	0.172	0.816	0.549	1
Sox per capita	0.147	-0.02	-0.096	-0.087	0.363	-0.096	0.107	0.093	-0.065	-0.095	-0.184	-0.267	0.087	0.102	-0.173	0.142	0.291	-0.137	0.138	0.947	0.801	0.064	0.919	0.418
VOCs per capita	0.902	0.369	-0.265	-0.244	0.523	-0.308	0.022	0.129	-0.683	-0.262	-0.119	-0.394	0.766	0.323	-0.588	0.026	0.438	-0.142	0.54	0.067	-0.139	0.916	0.193	0.712

Excerpt from second correlation matrix

	rRSE	rRES	rRNS	rRSN	rREN	rRNE	rECON	rSOC	rENV	rOvES	rOvSN	rOvNE	rSUST	rCES	rCSN	rCNE	RSE	RES	RNS	RSN	REN	RNE	ECON	SOC	ENV	OvES	OvSN	OvNE	SUST	CES	CSN	CNE
rECON	0.88	0.42	0.66	0.62	0.65	0.82																										
rSOC	0.66	0.75	0.62	0.47	0.42	0.53	0.72																									
rENV	0.56	0.21	0.43	0.84	0.92	0.61	0.70	0.44																								
rOvES	0.91	0.69	0.47	0.58	0.61	0.68	0.93	0.83	0.63																							
rOvSN	0.60	0.48	0.57	0.87	0.70	0.68	0.79	0.75	0.81	0.77																						
rOvNE	0.83	0.31	0.60	0.68	0.88	0.73	0.91	0.62	0.88	0.82	0.81																					
rSUST	0.90	0.63	0.45	0.66	0.72	0.68	0.93	0.77	0.73	0.97	0.85	0.88																				
rCES	-0.83	-0.89	-0.18	-0.37	-0.49	-0.33	-0.70	-0.79	-0.44	-0.89	-0.59	-0.61	-0.83																			
rCSN	-0.50	-0.19	-0.82	-0.83	-0.63	-0.83	-0.78	-0.66	-0.78	-0.66	-0.86	-0.79	-0.69	0.37																		
rCNE	-0.64	-0.18	-0.59	-0.70	-0.933	-0.73	-0.78	-0.51	-0.934	-0.67	-0.80	-0.939	-0.76	0.43	0.79																	
RSE	0.98	0.56	0.36	0.35	0.63	0.48	0.85	0.67	0.55	0.90	0.61	0.81	0.89	-0.85	-0.47	-0.63																
RES	0.56	0.96	0.02	0.22	0.25	0.18	0.44	0.75	0.22	0.69	0.49	0.35	0.64	-0.86	-0.18	-0.22	0.61															
RNS	0.36	-0.03	0.99	0.38	0.33	0.72	0.64	0.59	0.41	0.45	0.55	0.58	0.42	-0.15	-0.81	-0.57	0.34	-0.01														
RSN	0.44	0.32	0.43	0.96	0.69	0.67	0.67	0.52	0.85	0.63	0.85	0.73	0.69	-0.43	-0.84	-0.75	0.39	0.26	0.42													
REN	0.56	0.16	0.25	0.63	0.96	0.42	0.56	0.31	0.89	0.50	0.67	0.82	0.65	-0.39	-0.54	-0.89	0.55	0.18	0.22	0.66												
RNE	0.55	0.17	0.74	0.63	0.53	0.97	0.85	0.54	0.66	0.70	0.69	0.76	0.69	-0.37	-0.84	-0.74	0.50	0.18	0.73	0.71	0.45											
ECON	-0.88	-0.41	-0.61	-0.57	-0.68	-0.83	-0.981	-0.68	-0.70	-0.92	-0.74	-0.90	-0.91	0.70	0.75	0.79	-0.86	-0.43	-0.59	-0.63	-0.58	-0.86										
SOC	-0.67	-0.76	-0.61	-0.41	-0.39	-0.57	-0.74	-0.969	-0.41	-0.84	-0.72	-0.62	-0.77	0.79	0.63	0.50	-0.69	-0.79	-0.59	-0.46	-0.26	-0.57	0.70									
ENV	-0.56	-0.26	-0.39	-0.86	-0.912	-0.61	-0.69	-0.46	-0.955	-0.64	-0.83	-0.86	-0.74	0.46	0.76	0.90	-0.53	-0.24	-0.36	-0.90	-0.918	-0.65	0.69	0.40								
OvES	-0.89	-0.67	-0.42	-0.51	-0.59	-0.65	-0.89	-0.79	-0.59	-0.962	-0.70	-0.79	-0.923	0.86	0.59	0.64	-0.9	-0.67	-0.39	-0.57	-0.50	-0.66	0.91	0.79	0.61							
OvSN	-0.62	-0.53	-0.57	-0.86	-0.74	-0.70	-0.79	-0.77	-0.83	-0.79	-0.983	-0.83	-0.85	0.62	0.86	0.82	-0.62	-0.52	-0.54	-0.88	-0.70	-0.71	0.76	0.74	0.87	0.74						
OvNE	-0.81	-0.31	-0.50	-0.67	-0.86	-0.75	-0.89	-0.55	-0.85	-0.82	-0.77	-0.938	-0.87	0.60	0.73	0.90	-0.79	-0.32	-0.47	-0.71	-0.83	-0.78	0.92	0.53	0.87	0.83	0.80					
SUST	-0.87	-0.59	-0.39	-0.63	-0.73	-0.66	-0.89	-0.70	-0.73	-0.925	-0.79	-0.86	-0.952	0.80	0.64	0.76	-0.88	-0.59	-0.36	-0.66	-0.68	-0.68	0.92	0.69	0.75	0.96	0.82	0.92				
CES	0.84	0.85	0.22	0.32	0.49	0.38	0.72	0.78	0.43	0.87	0.62	0.64	0.84	-0.945	-0.37	-0.48	0.88	0.91	0.19	0.36	0.40	0.39	-0.72	-0.84	-0.43	-0.84	-0.64	-0.61	-0.80			
CSN	0.49	0.24	0.76	0.85	0.64	0.80	0.77	0.66	0.78	0.67	0.85	0.78	0.69	-0.40	-0.966	-0.79	0.44	0.20	0.76	0.90	0.56	0.83	-0.72	-0.62	-0.79	-0.59	-0.86	-0.71	-0.63	0.36		
CNE	0.66	0.22	0.56	0.74	0.92	0.77	0.81	0.52	0.93	0.71	0.80	0.94	0.79	-0.48	-0.80	-0.978	0.63	0.24	0.54	0.81	0.88	0.80	-0.83	-0.51	-0.932	-0.68	-0.83	-0.93	-0.79	0.49	0.82	