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Environment and Quality of Life: A Conceptual Analysis and Review of Empirical Literature

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Abstract

This chapter describes the conceptual and empirical underpinnings of a system dynamics model of the relationship between environmental changes and quality of life (QoL) indicators in the U.S-Mexican border region. The objectives of this aspect of the Border Plus Twenty Years (B+20) project were to:

- Conceptualize the "quality of life" construct
- Survey existing empirical literature and identify links between QoL indicators and elements of the environment
- Suggest a set of indicators appropriate for measuring dimensions of the QoL of residents of U.S.-Mexican border communities
- Incorporate the indicators in the B+20 system dynamics model

Underpinning this project is the assumption that forecasts of environmental change must take into account the effects of such change on residents of a region because such human impact is intrinsically important and because changes in QoL in a region will feedback and influence the environment.

El Medio Ambiente y la Calidad de Vida: Un Análisis Conceptual y Revisión de Literatura Empírica

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Resumen

Este capítulo describe los apoyos conceptuales y empíricos de un modelo de sistema de dinámicas de la relación entre los cambios ambientales y los indicadores de la calidad de vida (CdV) en la región fronteriza México-Estados Unidos. Los objetivos de este aspecto del proyecto Frontera Más Veinte Años (F+20) fueron:

- Conceptualizar el término “calidad de vida”
- Encuestar la literatura empírica existente e identificar las relaciones entre los indicadores de la CdV y los elementos del medio ambiente
- Sugerir una serie de indicadores apropiados para medir las dimensiones de la CdV de los residentes de las comunidades de la frontera México-Estados Unidos
- Incorporar los indicadores en el modelo de sistema de dinámicas F+20

Apoyar este proyecto supone que proyecciones de cambios ambientales deben de tomar en cuenta los efectos de dicho cambio en los residentes de una región ya que dicho impacto humano es intrínsicamente importante y debido a que los cambios en la CdV en una región realimentaría e influenciaría al medio ambiente.

Conceptualizing Quality of Life

At first glance, the quantitative study of quality of life (QoL) appears to confront significant theoretical and methodological obstacles. Quality is intrinsically a value term that seems to refer more to a matter of opinion than to extant, quantifiable features of a region. Further, there are a number of ways to conceptualize QoL, many of which emphasize the subjective, relative, culturally dependent nature of the construct. The diversity of possible referents for the term is associated with an equally large number of possible measurement approaches, leading to the suspicion that any given measurement of QoL is arbitrary and potentially misleading.

Nonetheless, it can be seen that measurement of QoL is essential to the analysis of human environment interactions. In the current project, QoL is a generic term that refers both to the human impact of environmental changes and to the way in which such impacts are evaluated. It is clear that environmental changes can have both local and far-reaching effects on humans, and that the impact of environmental changes in many cases depends upon how such changes are evaluated. Despite the difficulties involved, the conceptualization and measurement of QoL is essential to the understanding of human-environment interactions.

It is important to note that evaluation is fundamental both to human cognition and to environmental planning. Studies of human cognition (such as Osgood and Tzeng 1990) have repeatedly found that evaluative terms are the most common elements found in studies of semantic space. Humans are apparently incapable of cognizing environments without applying evaluative or qualitative constructs.

Environmental planning, like naturally occurring human cognition, typically involves the assessment of quality. The following questions describe some basic elements involved in any planning process:

- What is likely to occur?
- Will it be good or bad?
- What are some alternative courses of action?

The second question refers to the qualitative assessment of a future scenario. When evaluation concerns the impact of environmental changes on humans, "quality of life" becomes an unavoidable issue.

A Biocultural Approach

The model of QoL proposed in this chapter can be characterized as a biocultural approach. It is based on the assumption that there are biologically based aspects of human nature that characterize members of all cultures, in addition to culturally specific characteristics. A complete description of QoL in the border region would require knowledge of both biological universals and cultural variables. Assume that, for the purposes of the present study, appropriate descriptions of QoL can be constructed by using variables that characterize QoL in all cultures and by adding variables that the cultures in question have in common.

The goal of this research project was to evaluate and model the relationship between environmental changes and QoL in the U.S.-Mexican border region over a 20-year period. For the purposes of the present study, QoL must be conceptualized in a manner that allows empirical assessment of:

- Changes over time of QoL in the border region
- Changes in QoL on the U.S. side of the border
- Changes in QoL on the Mexican side of the border
- Convergence or divergence of the QoL of residents on each side of the border

Cultural Relativism and Quality of Life

The binational region that is the focus of this project is characterized by multiple cultures. Culture was defined in 1871 by one of the founding fathers of anthropology, E. B. Tylor, as "that complex whole which includes knowledge, belief, art, morals, law, custom and other capabilities and habits acquired by man as a member of society." Culture may be built upon demographic variables (nationality, ethnicity, age, gender, place of residence, language), status variables (education, income), or it may be organized in relation to political or religious belief systems.

Culture includes value systems that define QoL, thus the relevant indicators of QoL are likely to vary from culture to culture. Even when different cultures regard the same indicator as relevant to QoL, they may hold different opinions of its importance. For example, one culture may place a high priority on "gender equality" as a QoL indicator, another culture may regard it as desirable but relatively unimportant, while a third culture may not even use the category.

The problems of specifying the units that are appropriate to between-group comparisons are not unique to studies of QoL. Similar issues have been confronted in the disciplines of linguistics, anthropology, and psychology. To be explicit about the methodology used in the current approach, general approaches to cross-cultural and between-group measurement (the etic-emic distinction and the idiographic-nomothetic distinction) will be reviewed and three specific models of QoL considered.

Etic-Emic and Idiographic-Nomothetic Distinctions

The terms "etic" and "emic" (derived from the suffixes of the linguistic concepts of phonetic and phonemic, respectively) were developed by Pike (Pike 1982; Pike 1987; Headland, Pike, and Harris 1990) to distinguish between general, universal classification systems and classification systems specific to a culture or group. An etic category system, like the phonetic alphabet used by linguists, is a universally applicable classification system for categorizing behavior. An etic system is the creation of the researcher—a classification scheme ready to be applied to data encountered in any given context. For example, a researcher who takes an etic approach to the study of QoL might assume that such dimensions as health, education, social equality, employment, and leisure are useful, measurable indicators of QoL. Such a scientist would use these concepts regardless of the population or cultural group being studied.

Phonemic categories involve the subset of the phonetic alphabet that is meaningful to a linguistic community. Emic has thus been used to refer to constructs and categories that reflect locally defined meanings, cultural uniqueness, and "point of view." Emic systems are discovered by the researcher through observation of the distinctions made by local speakers. If the researcher in the previous example took an emic approach to the study of QoL, he would not assume that health, education, social equality, employment, and leisure were concepts relevant to every population or cultural group. The emic researcher would attempt to uncover culturally specific concepts of QoL and might find that some cultures do not place a high value on education or leisure.

With respect to the concept of QoL, researchers have alternated between etic and emic approaches, primarily because there are both similarities among and differences between cultures concerning what constitutes QoL. With respect to the current investigation, an emic analysis would reveal that QoL definitions vary with geographic region and with culture group. Further, an emic analysis would probably show that QoL concepts change over time within a region.

A closely related distinction, which has emerged from the study of personality traits, is the distinction between nomothetic and idiographic assessment methodologies. Nomothetic approaches assume that a set of traits may be defined in advance and used to study and categorize individuals in any given culture or society. Idiographic approaches assume that no a priori set of categories can be applied to an individual or group, but rather that assessment must precede the development of a category system. Idiographic categories are developed inductively through observation and are not assumed to apply to any groups other than the one for which they were developed. Both nomothetic assessment and etic category systems approach a new situation with units prepared in advance, ready to be assessed in that situation, whereas both idiographic and emic approaches lead to the development of category systems only after a particular sociocultural context has been analyzed.

An emic-ideographic analysis is, for these reasons, poorly suited for cross-cultural comparisons. Such comparisons require that the same yardsticks be applied in different contexts. The emic-ideographic view is monocultural, its units derived from the analysis of only one individual, one group, or one culture at a time. In contrast, the etic-nomothetic approach is highly appropriate to cross-cultural measurement in that its units are derived by comparing many systems and by abstracting from them a single scheme that can be applied to multiple cultures.

Etic-Nomothetic Methodology and the Biocultural Model

Etic-nomothetic approaches to QoL contain the commonalities abstracted from emic analyses. In terms of the biocultural approach previously outlined, an etic-nomothetic methodology captures the common elements of human nature that characterize QoL in all cultures, as well as the overlap in conceptions of QoL that members of particular cultures have in common. As noted above, long-term goals involve QoL comparisons across cultures and over time. Such comparisons are not possible under the idiographic, emic assumptions that the constituent indicators of QoL vary by region, by culture, or are subject to change over time. Regional assessment of cultural variation in the concept of QoL is beyond the scope of this project. In the following pages, the QoL indicators that have been suggested by various cultural groups are reviewed in various international contexts. The review will show sufficient commonalities to justify the use of etic-nomothetic categories of QoL, which will be proposed for the purposes of this study.

Models of Quality of Life

The literature on QoL contains a variety of implicit models of the construct. To be explicit about the conceptualization employed in the current project, three general approaches to defining QoL will be reviewed: the Hedonic Quality model, the Preference Satisfaction model, and the Value/Ideal models.

Hedonic Quality

Hedonic Quality approaches assume QoL is related to the types of conscious experiences common among inhabitants of an area. Conscious experiences such as feelings of pleasure, happiness, satisfaction, or other positive emotions are said to characterize high QoL. Conversely, low QoL is defined by a predominance of negative emotions.

It is possible to study hedonic tone or hedonic quality empirically. A typical study asks residents to record the emotion or emotions they experience at various intervals during the day. Some studies use behavioral indicators of hedonic quality such as facial expression, frequency of laughter, or even frequency of consumption of tranquilizers or antidepressants. To date, such studies have primarily explored the impact of socioeconomic class. Although this literature is tangentially related to the current topic, it suggests that hedonic quality is ambiguously related to social class and environmental quality. In a number of studies, members of lower income classes have been found to laugh more, worry less, and consume fewer sleeping pills, tranquilizers, and antidepressants than members of higher income classes who presumably have more positive environmental circumstances. In general, however, a systematic body of literature that relates dimensions of the environment to specific emotions or hedonic quality does not exist.

Preference Satisfaction

Preference Satisfaction models define QoL in terms of the extent to which people get what they want, regardless of the extent to which the outcome produces positive emotions. High QoL from this perspective consists of the consistent satisfaction of desires and preferences. Low QoL is associated with the frustration of desires and preferences. For example, if an individual or group desires to watch television and is allowed to watch television, a preference satisfaction framework would suggest that QoL has been improved. Literature that suggests watching television typically has an emotionally depressive effect (Kubey and Csikszentmihalyi 2002) is irrelevant from this standpoint. Similarly, if an individual or group desires to smoke cigarettes and are allowed to do so, preference satisfaction theories suggest that QoL has been improved. Long-term consequences to health or the environment are not relevant when the criterion for QoL is preference satisfaction.

From this perspective, QoL in a region is an aggregation of individual preferences. Since preference measurement is well established in the social sciences, QoL may be addressed by current empirical techniques. Conceptually, aggregate QoL would be related to the ratio of preferences satisfied relative to preferences not satisfied.

Value/Ideal Models

Value or ideal models define QoL in terms of explicit, specific, normative values. Such theories assume that there exists a set of QoL indicators that characterize every region and are somewhat independent of the specific emotional experiences or preferences of any given group. The measurement approach is both etic and nomothetic in that it does not require assessment of any specific group's conception of QoL; it is assumed that the same set of values can define QoL in a variety of cultures and geographical locations. A classic example of a QoL dimension in this approach would be health. From the perspective of an "ideal" model, good health is an indicator of high QoL and poor health is an indicator of low QoL, irrespective of local preferences or local hedonic consequences. Environments that promote good health are said to promote QoL, and conversely, environments that have negative health impacts are said to lower QoL. Other common value domains used to define "ideal" indicators include economic and material well-being, physical health and longevity, mental and emotional health, community health, education, class, and gender equality. These value domains will be discussed in greater detail later in the chapter.

As noted above, "ideal" QoL indicators are thought to reflect both universal conceptions of QoL and commonality between cultures. It should be noted, however, that in some instances "ideal" models conflict with the preferences of subsets of a local population. An example of such an indicator might be "gender equality in access to education." While an ideal model might regard this as a QoL indicator across populations or cultures, local preferences might actually deem such equal access undesirable.

An "ideal" model of QoL is most appropriate for the current project. Ideal indicators have been designed to allow assessment of the rate and degree to which environments are becoming more or less supportive to humans. How is it clear that progress is being made toward the ideal of improving the QoL in a region? How can the rate of progress toward that ideal be assessed? How can the changes in QoL over time on both sides of the border be compared? The role of ideal indicators is to provide an answer to these questions. The indicators should be relevant and applicable to the specific geographic scale—local, regional, national, or international. A successful indicator allows end users of the modeling effort to grasp the human impact of the whole system quickly.

Relationship Between Quality of Life Models and Sustainability Indicators: The Importance of "Ideal" Models

The Border Plus Twenty Years (B+20) Project is concerned with both "a healthy and sustainable natural environment" and an "adequate QoL for all border inhabitants." As such, QoL indicators selected by the project must be constructed with sustainability in mind and may designate criteria that take into account the individual, the social group, and the environment.

The following premise is suggested in this section: QoL models based on either hedonic quality or preference satisfaction will not lead to sustainable environments. Ideal models of QoL, because they can include sustainability as a fundamental value, can lead to the development of sustainable environments. From a Darwinian point of view, there are components of human nature that make it difficult for humans to construct sustainable environments as well as components that encourage thinking about sustainability. Biologically based tendencies that constitute obstacles to sustainability include a human tendency to employ a short-term time perspective, a basic desire for increased status in hierarchical social systems, and a tendency to identify with one's local group and local environment (tribalism or territoriality). The first of these to illustrate the relationship between QoL models and sustainability will be considered.

Short-Term Time Perspective

One reason humans have difficulty constructing sustainable environments is that sustainability is about long-term benefits to the environment that generally come at the expense of short-term satisfactions for humans currently occupying the region. Evolution encourages precisely the opposite tendencies. Humans are adapted to the environment of the Pleistocene era. The environment of evolutionary adaptation posed significantly different problems for human ancestors than are faced by modern humans. During this time period, which constitutes approximately 95% of human history, world-wide planetary population was somewhere between 2 million people and 10 million people. The hunter-gatherers of the Pleistocene were nomadic; they consumed the resources of a region and then moved on. It was adaptive to over-consume food and other resources so that periods of scarcity, such as during winter or drought, could be survived. Humans who could solve immediate problems survived and reproduced. In the Pleistocene, there was no evolutionary advantage that accrued to individuals who conserved the environment.

Evolution has shaped the human mind to respond positively (to prefer, and to experience, hedonic quality) to short-term reinforcements and to have preferences for short-term rather than long-term benefits. As Dawkins (2001) notes, "Short-term genetic benefit is all that matters in a Darwinian world ... The values that will have been built into us will have been short-term values not long-term ones."

Empirical evidence generally supports the notion that humans are predisposed to think and react in terms of the immediate future. Decades of research on human learning have shown that immediate reinforcements and immediate consequences have a far greater impact on human learning and human behavior than do delayed reinforcements or delayed consequences. Emotions such as fear or anger are much more likely to occur when the anticipated threat is imminent. Conversely, delayed threats are unlikely to engender much emotional response. Thus, people repeatedly build in floodplains, on earthquake fault lines, and in areas repeatedly threatened by hurricanes.

Modern humans, however, live in a world in which the long-term threat from unsustainable environments or unsustainable economies may be more serious than immediate threats. Humans are entering this world with a set of desires and emotional responses that have been produced by millions of years of evolution, and are generally unsuited to cope with these problems. If QoL is conceptualized in terms of emotional responses or in terms of preferences, sustainable environments are unlikely.

Fortunately, evolution has also equipped humans with a remarkable ability for foresight and planning. More than any other species, humans are capable of anticipating the future results of present actions and delaying immediate gratification for future gratification. Human history, from the construction of the pyramids to current technological successes such as space flight, illustrates that humans are capable of setting long-term goals and achieving them.

Such considerations argue for the use of "ideal" indicators of QoL as opposed to hedonic quality or preference satisfaction indicators. The latter are associated with short-term outcomes, while ideal indicators can include sustainability as a value.

A Survey of "Ideal" Quality of Life Indicators

There has been an increasing interest in developing generally applicable QoL indicators in the last 20 years. The assessment of QoL has received special attention from several international organizations including the United Nations, the World Bank, the World Health Organization, and the International Labor Office. New and modified indicators of QoL for many regions of the world appear continuously in journals such as *Social Indicators Research*. Table 1 displays QoL indicators recommended by various groups.

Diener (1995) reviewed the process of selecting indicators for a QoL index and found, not surprisingly, no standard method of selection. He consequently proposed seven categories of "universal values" that had been developed by Mukherjee (1989) and Schwartz

Table 1. Survey of Indicators

UN	OECD	Philippines	Japan
Health Food Education Employment Housing Social security Clothing Recreation Human freedoms Population Income and expenditure Communication and transport	Nutrition Clothing Shelter Health Education Leisure Social security Social environment Physical environment Social status Education	Health, nutrition Learning Income Employment Environmental resources Housing, utilities Public safety Justice Political values Social mobility	Health Education, learning Employment Quality of work Leisure Income Spending Material environment Crime Law enforcement Family Community life Class, social mobility
Finland	**Sweden**	**India**	**U.S. (Calvert-Henderson)**
Health Education Physical environment Inequality Housing, habitat Working conditions	Work, working conditions Economic resources Political resources Schooling Health, medical care Family origin, family relations Housing Nutrition Leisure time and pursuits	Population Health, nutrition Housing Education Labor, employment Income, expenditure, wealth	Education Employment Energy Environmental health Human health Human rights Income Physical infrastructure National security Public safety Recreation Shelter

Source: Authors

(1994). Schwartz arrived at seven value domains from a comprehensive list of 45 values derived from an extensive literature review. He then sampled 41 cultural groups in 38 nations and assembled from other sources 38 samples of schoolteachers and 35 university students. The seven value domains provided in Table 2 were gleaned from these samples.

In another comprehensive effort based on an extensive literature review, Mukherjee derived four value domains that contain elements similar to Schwartz's list. The elements classified by Mukherjee are indicated in Table 3.

Among the myriad indices measuring QoL, the Physical Quality of Life Index (PQLI) has received considerable attention. The initial version of PQLI was published early in 1977; expanded technical explanations followed (Morris 1979). PQLI (like the Human Development Index of the United Nations) was developed as an alternative to the gross national product (GNP) as a measure for a

Table 2. QoL Elements Classified by Schwartz

Value Regions	QoL Elements
Masterly (Success, capable, ambitions)	Length of life Infant mortality rate Families at risk
Affective autonomy (Enjoying life, pleasure, exciting life)	Suicide rate Self-rated health
Intellectual autonomy (Curious, broad-minded, creative)	College education
Egalitarian commitment (Equality, social justice, freedom)	Unemployment rate Poverty rate
Harmony (Protective of environment, aesthetic appreciation, unity with nature)	Residential density Environmental toxins index
Conservation (Social order, self-discipline, family security)	Violent crime rate
Hierarchy (Wealth, social power, authority)	Per capita personal income

Source: Schwartz 1994 and 1996; Diener 1995

Table 3. Elements of Quality of Life Classified by Mukherjee

Mukherjee's Value Regions	QoL Elements
Survival of the species	Suicide rate Length of life Infant mortality Self-rated health
Security in the life-span of humans	Families at risk Violent crime rate Environmental toxins index
Material prosperity for well-being	Per capita personal income Unemployment rate Poverty rate Percent households with 1.1 or more persons per room
Mental progress to unfold potentials of all	Percent with 4 or more years of college

Source: Mukherjee 1989

region's socioeconomic development. The study team argued that while there are some general correlations among per capita income and longevity, health, and literacy, among other factors, the relationships are not obvious in many countries. Moreover, there were glaring exceptions in cases where countries with high per capita incomes fared poorly in many other human development indices and vice versa. Thus, the objective of PQLI was to develop a measure that would address the distributional effects of income growth but also be effective across cultural and structural differences among countries. In this respect, this measure is particularly helpful in the case of binational regions having two distinct economies and cultures.

The PQLI ultimately settled on three apparently universal concerns. First, health seemed to be a primary concern in all cultures as longevity and good health were generally prized in almost every culture. Second, infant mortality was a rallying issue for government action across many regions and countries. Third, literacy was widely accepted as a surrogate for individual capacity and social participation. On the basis of these assumptions, three indicators were selected for inclusion in the PQLI—infant mortality, life expectancy at age one, and basic literacy.

While the three indicators by themselves do not explicitly illustrate the distributive effects of development among social groups, an improvement in these indicators does indicate the change in proportion of the people sharing the benefit. This is quite obvious with infant mortality and literacy because an improvement in either of these measures would indicate that the benefits of development have become more widespread. In summary, the simple three-indicator index has served as an effective proxy for the stage of development of a region.

Characteristics of Indicators

QoL indicators must meet conventional standards for reliability of measurement and must be capable of being validated. Blair (2000) has carefully considered the criteria that should be applied to border environmental indicators or sustainability indicators. His conclusions, presented in Table 4, were considered in the selection of QoL indicators for the B+20 project.

Aggregation of Quality of Life Indicators

It is critical to distinguish between measurement models designed to yield an aggregate index of QoL and models designed to yield a variety of relatively independent QoL indicators. In relation to the current systems model of the environment, aggregate QoL would be a global index that quantifies the total human impact of various environmental changes. Aggregate QoL would clearly be useful for planning or political decisions because it would allow decision-makers to gauge the overall effect of various alternative choices on the residents of a region. It would be useful, for example, to know how changes in the U.S. or Mexican economies affect overall QoL in the border region or how policy decisions regarding water distribution or immigration policy impact QoL.

Table 4. Requirements for Indicators

Criterion	Comment
Sensitive to change	Quick response to change; and permitting a trend to be established with a time scale tailored to the problem
Policy-relevant	Focused on issues and problems pertinent to the government agencies in the region
Valid	Theoretically sound; that is, measures the phenomenon intended and valid in relation to goals
Reliable	Data is consistent over time and can be replicated by different observers with sound collection methods
Clarity	Concept readily understood by community; preferably clear in value so no uncertainty about which direction is good and which is poor
Measurable	Technically feasible to collect data at reasonable cost; also, long term measurement of the indicator should be likely
Realistic	Broadly accepted by the community; the results should not be so controversial that implementation would be impossible
Publishable	Attractive and clear to local media so that they are publicized

Source: Blair 2000

There are however, significant obstacles to the quantification of aggregate QoL. QoL is clearly a multidimensional construct. As an example of the difficulty of aggregation, consider The Binational Quality of Life Indicators Project (2001), which specifies nine classes of indicators: demographic, public safety and crime, economic, education, health and healthcare, environmental, housing, transportation, and governance. These diverse components are not scaleable in terms of a common metric. For such disparate components to be aggregated, it is necessary to know their relative magnitudes of importance. For example, how should health indicators be weighted in relation to the economic indicators? Since there is currently no accepted method for weighting the various dimensions of QoL, aggregation is more likely to obscure real relationships between environment and QoL than it is to clarify them.

A similar logic can be applied to aggregating individual QoL measurements into scale scores. Consider the following operational measures related to health: infant mortality rate, adult mortality rate, life expectancy, lung disease, cardiovascular disease, gastrointestinal disease, daily calorie intake, and physicians per capita. Accurate aggregation of such disparate measures into a global health index would require knowledge of both their relative importance and the degree of correlation between measures. Further, the global health index would be unable to depict important relationships—lung disease is related to air quality, gastrointestinal problems to water quality, and calorie intake and physicians per capita to economic factors.

For this reason, the B+20 team's approach has been to use specific operational measures that have been designated as QoL indicators. Each specific index of QoL is linked in the STELLA® model with environmental antecedents and consequences. This approach allows decision-makers to see the human consequences of environmental changes in detail.

Conclusions Drawn from the Literature on Quality of Life Indicators

It is clear from the previous survey of QoL indicators that there is significant overlap in models of QoL indicators and considerable overlap in the indicators themselves within the models. Implicit in many of these models is the recognition that QoL is not simply related to environmental sectors—in many cases QoL is defined by quality of the environment. Residents with poor air quality, poor water quality, poor housing, or poor regional economies are, by definition, low on a host of QoL indicators. In other instances, QoL indicators such as infant or adult mortality rates are related to human responses to environmental sectors such as air quality or water quality.

The challenge for this project is to propose a set of value domains relevant to the project goals, applicable across the cultures within the border region, and readily measurable. The QoL indicators selected for this study must take into account both the commonalities among the prevalent models of QoL and the criteria outlined by Blair in Table 4. They must be selected with sustainability in mind. Given the scope of the B+20 Project, the QoL indicators included in this study are also restricted to:

- Aspects of human health or behavior that may be described by data
- Environmental features for which current descriptive statistics are available
- Aspects of human health or behavior that have been empirically linked to environmental sectors

Given these constraints, a set of six value domains has been developed that draws heavily on the work of Diener (1995), Mukherjee (1989), and Schwartz (1994; 1996), but which the B+20 team believes speaks more directly to the needs of the B+20 Project. The value domains and related indicators are presented in Table 5. Note that neither the value domains nor the indicators are considered to be an exhaustive list.

As previously discussed, the indicators will not be aggregated but rather used individually as needed to assess the impact on QoL of particular sector components.

Relationships Between Quality of Life Indicators and Sector Components

The primary goal of the present project is to model dynamic relationships between environmental components and QoL indicators. While there are many environmental factors that affect QoL, this chapter limits its discussion to those elements of the environment that have previously been identified as most significant by the B+20 Project (Figure 1). This modeling effort is based on an empirical literature review that documents links between the environment and QoL. In the following sections, the literature that underpins this model is reviewed and the relationship between QoL indicators and

Table 5. B+20 Value Domains and Indicators of Quality of Life

Value Domain	Sample QoL Indicators
Economic and material well-being	Per capita income Income variance Poverty rates Unemployment rates Home ownership rates
Physical health and longevity	Infant mortality Life expectancy Access to prenatal care Access to health insurance Communicable disease rates Environmental disease rates
Mental and emotional health	Suicide rates Access to mental health care Surveys of perceived happiness
Community health	Civic participation Number of parks and green spaces Access to transportation Access to communication Homicide rates Burglary rates Rapes Drug crimes
Education	Literacy rates Average years of schooling Achievement test scores Participation in higher education Dropout rates
Class and gender equality	Poverty rates Income variance Ratio of female to male average years of schooling Ratio of women’s literacy to men’s Ratio of women’s employment to men’s

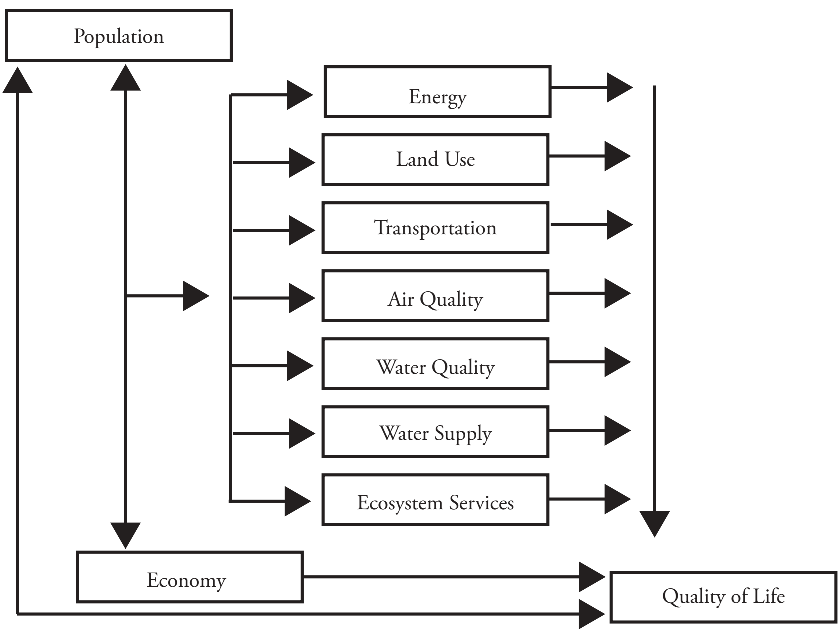
Source: Authors

four environmental factors—air quality; water quantity, quality, and infrastucture; transportation and land use; and economics—is specifically addressed. The challenge is to select indicators that are both relevant to these factors and representative of the QoL indicators commonly accepted in current literature.

Air Quality and Quality of Life

The Air Quality Sector focuses on particulate emissions from both static and mobile sources in the border region. Air quality is influenced by population size, economic factors, airshed dynamics, and border policy (border impedances will increase the number of cars producing pollution while waiting). The model depicts how industrial development, population growth, and postulated changes in vehicle ownership might ultimately affect air quality in a binational community.

Figure 1. SCERP System Dynamics Model



Source: Authors

Air quality—or its converse, air pollution—has a substantial human health impact. Air pollutants have been linked to lung disease, cardiovascular disease, and overall mortality rate. The increased rate of health problems, in turn, has an economic impact in terms of health costs and missed days at work and school.

Air pollution has been shown to contribute to lung disease, which is the third leading cause of death in the United States (Centers for Disease Control 1995). Airborne pollutants can affect areas far from those in which they are emitted, so the human impact of pollution sources must take into account both the quality of emissions, the magnitude of emissions, and their pattern of dispersal. Air toxics consist of 188 specific pollutants, many of which have been associated with negative health effects. Eighty-nine air toxics have a cancer potency value, and 16 of them account for 97% of the estimated excess cancer instances in California, with only four of them accounting for more than 70% of the estimated cases. It has been estimated that in 1990 there were more than 8,600 excess cancer cases in California, mostly due to these air toxics (Morello-Frosch, et al. 2000).

PM_{10} Levels, Lung Disease, and Mortality

Considerable research has been directed at air pollution (or particulate matter) with an aerodynamic diameter of less than 10 microns (μm), referred to as PM_{10}. Between 1987 and 1994, PM_{10} was positively associated with rates of death from all of the 20 most populated cities in the United States (Samet, et al. 2000). PM_{10} levels are positively correlated with heart attacks, strokes, lung disease, asthma, and overall mortality rates (Hester and Harrison 1998; Samet, et al. 2000)

In 1992, the national standards for PM_{10} were exceeded in 16 counties in which an estimated 9.1% of the population of the entire United States resided. Acute and chronic exposure to air pollution, namely PM_{10}, is associated with an increased risk of premature death, and it is estimated that 700,000 avoidable deaths will occur by 2020 because of PM_{10} (Samet, et al. 2000). Table 6 displays the health risks of PM_{10}.

Table 6. Combined Effect Estimates of Daily Mean Particulate Pollution

Indicator	% Change in Health Indicator per Each 10/μg/m^3 Increase in PM_{10}
Increase in daily mortality	
Total deaths	1.0
Respiratory deaths	3.4
Cardiovascular deaths	1.4
Increase in hospital usage (all respiratory)	
Admissions	0.8
Emergency department visits	1.0
Exacerbation of asthma	
Asthmatic attacks	3.0
Bronchodilator	2.9
Emergency department visits	3.4
Hospital admissions	1.9
Increase in respiratory systems reports	
Lower respiratory	3.0
Upper respiratory	0.7
Decrease in lung function	
Forced expired volume	0.2
Peak expiratory flow	0.2

Source: Dockery and Pope 1994

Although less research has been directed at other particle sizes, it has been suggested that particles with diameters of less than 10 μm pose an even greater health risk because they are more easily inhaled deep into the lungs and are more likely to be trapped in lung tissue.

Ozone, Sulfur Dioxide, Carbon Dioxide, and Health

The border region is generally characterized by abundant sunlight. As population and traffic increases in this region, ozone pollution is likely to increase. Ozone pollution occurs when hydrocarbons and nitrogen oxides from automobiles and other sources react together in the presence of sunlight. The National Ambient Air Quality Standard for ozone levels is 0.12 parts per million (ppm) averaged over one hour; this standard is met if this value is not exceeded more than once per year. In 1991, the U.S. Environmental Protection Agency (EPA) standard for ozone was exceeded in 98 areas in the United States, exposing 140 million people to excess ozone levels. During the summer months, it is estimated that an increase of 10 parts per billion in the ozone level will cause a 0.41% increase in the rate of death (Samet, et al. 2000).

Sulfur dioxide causes respiratory problems, which, while rarely fatal, do impair QoL. Sulfur dioxide does not have a significant effect on the relative rate of death of those exposed, but the respiratory problems it causes (such as asthma) are serious (Samet, et al. 2000). In 1991, 50 areas in the United States exceeded national recommended levels for sulfur dioxide. It has been estimated that the number of people exposed to sulfur dioxide in excess of the guidelines established by the World Health Organization will rise from an already high 650,000 people in 1990, to 14 million in 2020 (Streets, et al. 1999).

As noted above, variables that impact health also influence the region's economy. Sick residents incur direct health care costs and miss days of work. In a study of air quality and health in Shanghai, it was estimated that by the year 2020, air pollution would cost $500 million annually (Streets, et al. 1999). It should be noted that many of the consequences of air pollution's impact on QoL are themselves sources of stress. Increased health care costs and reduced leisure time may, in turn, further reduce QoL.

Table 7 displays an overview of the relationship between air quality variables and QoL indicators. These indicators meet Blair's criteria of appropriateness and the restrictions for the B+20 Project.

Table 7. Relationships Between Air Quality and Quality of Life

Air Quality Variables	Possible QoL Indicators	Consequences
PM_{10}	Cardiovascular disease rates Cardiovascular deaths Heart attack rates Stroke rates Hospitalizations for asthmatic attacks Lung disease rates Respiratory deaths	Health care costs Missed work or school Lost leisure time
Ozone	Lung disease rates Respiratory problems	Health care costs
Sulfur dioxide	Hospitalizations for asthmatic attacks Lung disease rates Respiratory deaths	Health care costs Missed work or school Lost leisure time
Carbon monoxide	Not described	
Nitrogen dioxide	Not described	

Source: Authors

Water Quantity, Quality, and Infrastructure

Intuitively, it seems plausible that the quantity of water in a region should increase the QoL of residents of the region. Increased water stocks should be associated with cheaper water for home use, industrial use, recreation, and landscaping. There should be economic consequences as well as aesthetic consequences to water availability.

The border that separates the United States and Mexico separates several watersheds shared by the two countries. The supply of water in the region has historically been influenced by border policies and politics, but the flow of waste and contamination follows a topography independent of the border itself. The history of this region is a history of conflicts over access to water, water quality, water distribution, and the effects of contamination, which originates on either side of the border.

The lower Colorado River and the upper Gulf of California comprise a water supply and distribution system relevant to the Mexicali, B.C.-Calexico, Calif. (Imperial Valley) region and the San Diego, Calif.-Tijuana, B.C., region. On the Mexican side, the Colorado River delta and the upper Gulf of California comprise a wetland and marine ecosystem that provides an important habitat for many migratory and local species. The region serves as a combined fresh- and salt-water nursery that has long supported the fishing industry along the coasts of Baja California and Sonora. The marshy ciénegas of the delta, along with the Salton Sea on the U.S. side of the border, form an important haven for waterfowl on the Pacific Flyway, a north-south avian migratory route that runs from Alaska to Central America. Decisions made about water use thus have impacts on biodiversity, economic opportunities, and the QoL indicators related to these sectors.

The Project on Water and Quality of Life at the California-Mexico Border, coordinated by the University of California Institute for Mexico and the United States (UC MEXUS), reports:

> The complex of interconnected ecosystems nominally protected by the biosphere reserve designation is fed by and dependent upon water from the Colorado River. This critical water supply is diminishing in the face of increasing demands on both sides of the border for agriculture and industry. Colorado River water is claimed by many states, and by the time the watercourse reaches Mexico, much of its content has been dammed, diverted, and consumed, despite international treaties governing the supply to the downstream user. Native American tribes, Mexican indigenous groups, ejidal farmers, and fishermen have legal, economic, and cultural claims on Colorado River water, and their needs and rights are overwhelmed by agribusiness, manufacturing, and urban consumption.

Groundwater aquifers in the border region have been affected by population growth, industrial and agricultural use, and water policy. Wells pump the water out for agriculture and industry, and effluents seep back into the underground supply. Contaminants in both surface and groundwater flow across the border and into the Gulf of Mexico or the Salton Sea. The Salton Sea has been affected by decreased inflow and by the build-up of pesticides from agricultural runoff. The quality and quantity of Salton Sea water is diminishing to the point that migratory species and local ecosystems are affected. For example, in 1996 and 1997 there were a substantial number of deaths of brown pelicans that inhabited the region. Some projections forecast that the Salton Sea will become incapable of supporting marine life in the next 20 years. Whether this projection proves true is uncertain, but the increasing levels of pollution in the Salton Sea will likely affect biodiversity and aesthetic and recreational QoL indicators in the region.

Water Infrastructure

The most significant relationships between water and QoL appear not to stem from water quantity *per se*, but rather from variables related to water infrastructure—the wells, pumping stations, pipes, and sewers that deliver water to residents and remove wastewater. Water infrastructure is frequently included in QoL indicator inventories as part of the housing infrastructure. The Instituto Nacional de Estadística, Geografía e Informática (INEGI), for example, records as a measure of "well-being" *(bienestar)* data on the percentage of houses with piped-in water, sewers or septic systems, and bathrooms. The rationale here is that residents who have piped water, drains, and bathrooms *de facto* have higher QoL; however, it is also true that such infrastructure influences other QoL indicators, such as health.

Turbidity

It has long been known that drinking water contamination can be associated with gastrointestinal disease. Recently it has been shown that some of what is considered "endemic" gastrointestinal illness is actually waterborne. Children and the elderly are at the highest risk for gastrointestinal disease. Drinking water turbidity, a measure of the cloudiness of the water, is commonly used as a proxy measure for the risk of microbial contamination of public drinking water. Several studies have shown a correlation between turbidity levels and microbial contamination of treated water, although it should be noted that water can be clear and still be contaminated. Schwartz, Levin, and Goldstein (2000) found an association between daily fluctuations in drinking water turbidity and subsequent hospital admissions for gastrointestinal illness in the elderly. Because hospitalizations represent a small percentage of total morbidity, the relationship between water turbidity and gastrointestinal illness appears to be substantial.

Significant differences in drinking water turbidity exist between U.S. cities and communities along the U.S.-Mexican border. While such water quality problems have been documented in U.S. cities, the contamination is slight and primarily affects individuals with weakened immune systems. It is unlikely that San Diego or El Paso, Tex., the U.S. cities targeted in this study, have significant health problems due to water contamination. In contrast, many of the *colonias marginales* adjacent to El Paso and San Diego that house workers attracted to the maquiladora industries have significant water problems (Sadalla, Swanson, and Velasco 2000). Such communities on both the U.S and Mexican sides of the border typically rely on questionable water delivery systems (for example, trucked-in water pumped directly from groundwater sources) and have water with significant turbidity.

A recent survey of residents of *colonias* in Nogales, Son. (Sadalla, Swanson, and Velasco 2000) documented that 24% of residents reported the water they use looks cloudy or contains sediments. The majority (93%) of *colonia* residents who do not have piped-in water buy water from private trucks that service the area. The most common storage method (used by 82% of the residents who buy water from trucks) is the use of portable containers outside the residence. Of the residents who buy water from trucks, 47% reported consuming it directly without treating it, 37% reported boiling it before consumption, and 16% reported adding a disinfectant such as chlorine before consumption. Water quality in such communities is therefore likely to be associated with significant gastrointestinal infections.

Nitrates

Research has also been directed at nitrate contamination of groundwater. The potential impact of nitrate contamination on human health has led government agencies to limit the amount of nitrates allowed in drinking water. While nitrates are essential for life and occur naturally in soil and water, excessive quantities of these chemicals can be lethal in some circumstances. Humans and animals convert excess nitrates into a toxic contaminant during the digestive process. These nitrites (NO_2) react with the hemoglobin in red blood cells and create methemoglobin. Excess methemoglobin causes the blood to turn from a bold red color to a deep brown, giving the skin a bluish hue called cyanosis. Such blood cells do not carry oxygen to body cells, causing babies and individuals with compromised immune systems to develop methemoglobinemia, often called “blue baby syndrome.” Without immediate treatment the body will eventually suffocate. Adults and older children have relatively greater abilities to absorb excess nitrogen and excrete it, minimizing the risk of toxicity and methemoglobinemia.

The National Cancer Institute has also linked excessive nitrogen in the human diet to gastric and stomach cancer and non-Hodgkin’s lymphoma (NHL). The National Cancer Institute studied the amount of nitrates consumed daily in tap water by Nebraska residents who were diagnosed with NHL and found a relationship between the amount of nitrates consumed and development of the disease. Future studies are crucial to determine the degree of risk associated with nitrate ingestion (Ward, et al. 1997).

Specifying unsafe levels of nitrogen concentration in water is difficult because of the confounding effect of the intake of nitrogen from food. Roughly 80% of an average person’s daily nitrate intake of 75 milligrams (mg) to 100 mg comes from vegetables, while only 10% to 20% comes from drinking water. Vegetarians and vegans have much higher nitrate intakes, frequently up to 250 mg per day. However, nearly half of the daily nitrate intake for individuals who drink water with more than 10 milligrams per liter (mg/L) comes from drinking water. In 1962, the U.S. Public Health Service developed drinking water standards, which were later adopted by EPA, in an attempt to control nitrate-polluted water. Present standards require that public water systems have no more than 10 milligrams per liter (mg/L).

While research is presently focused on long-term effects from the presence of nitrogen in the water supply for humans, this chemical also affects plants, animals, and marine life. When excess nitrates are present in the soil (due to over-fertilization, manure, and/or sewage), plants soon develop high levels of nitrates. The remaining nitrogen stays in the ground until it is washed away by irrigation, rainwater, or snowmelt. These plants are then fed to the livestock, horses, cows, sheep, pigs, and chickens, which are also susceptible to methemoglobinemia. Since nitrates are extremely water-soluble and leach into the ground, they eventually make their way into aquatic ecosystems (Cherry, Schmidt, and Soucek 2001).

Table 8 displays an overview of the relationship between water quality variables and QoL indicators. These indicators meet Blair's criteria of appropriateness and the restrictions for the B+20 Project.

Table 8. Relationships Between Water Quality and Quality of Life

Water Quality Variables	Possible QoL Indicators	Consequences
Quantity/availability	% of houses with piped-in water % of houses with sewers or septic systems % of houses with bathrooms	Personal and community health
Turbidity	Hospitalizations for GI tract infections	Health care costs Missed work or school Lost leisure time
Nitrate contamination	Cyanosis rates in newborns Methemoglobinemia rates Gastric and stomach cancer rates Non-Hodgkin's lymphoma rates	Health care costs Missed work or school Lost leisure time

Source: Authors

Transportation and Land Use

A number of indicators have been used to measure the quality of a transportation system. Engineers address the level of service a roadway provides to motorists and vehicle miles traveled (VMT). The National Environmental Protection Act and other regulations have provided ways to measure the impact of a transportation system on the environment. Environmental Impact Studies (EIS) require a broad evaluation of construction projects.

It is, however, important to note that measures of the quality of a transportation system do not necessarily measure its impact on the people using the system. A high-quality highway does not necessarily guarantee a higher QoL for people using the highway; in fact, the increased travel time and traffic congestion that frequently results from new highway construction may actually lower QoL. Transportation systems influence QoL directly by affecting physical and mental health and environmental aesthetics such as noise, leisure time, and social interaction. They also affect QoL through their impact on other environmental components such as air quality, land use, and economy, which in turn influence QoL. This section discusses indicators designed to describe relationships between land use, transportation, and QoL.

Land Use: The Cost of Urban-Suburban Sprawl

Sprawl is the unplanned expansion of development at low densities away from the urban center. The private marketplace optimizes each individual development in ways not necessarily the most efficient or desirable from the overall public viewpoint. Sprawl development is characterized by the following five components:

- Housing subdivisions and areas that are exclusively residential
- Shopping centers, strip centers, shopping malls, and big-box retail (such places are used exclusively for shopping and are distinguished from traditional counterparts by a lack of housing or offices, and the parking lot between the building and the roadway)
- Office parks and business parks consisting of places used only for work

- Civic institutions, public buildings, town halls, churches, and schools, among other institutions (in traditional neighborhoods these buildings often serve as focal points, but in sprawl development their location is based on the assumption of massive automotive transportation)
- Roadways

Sprawl increases costs by making automobile travel a necessity. Because each piece of land serves only one type of activity, and because daily life involves a wide variety of activities, the residents living in areas of sprawl spend an unprecedented amount of time and money moving from one place to the next. Because most of this motion takes place in singly occupied cars, even a low-density area can generate the traffic of a much larger traditional town.

Sheer distance often precludes the most inexpensive and environmentally friendly forms of transportation—walking or bicycling. Metropolitan areas dominated by a uniform spread of subdivision, office parks, and strip malls are harder to serve with transit and necessitate driving between every destination.

While the government builds the roads, private individuals buy fuel and maintain the automobiles needed to drive them. Transportation is a major component of household spending as families end up owning small fleets of vehicles. Such high up-front expenses make it difficult to economize on travel. According to the Federal Highway Administration, three-quarters of all automobile expenses stem from the fixed cost of simply owning a car, regardless of how much it is driven. The average American household devotes 18 cents of every dollar it spends to transportation. In metro areas with low real estate values, households spend more on transportation than shelter. The vast majority of that spending—98%—is for the purchase, operation, and maintenance of automobiles. Most American families spend more on driving than on health care, education, or food. People occupying the lower socioeconomic levels spend proportionally more on transportation.

Example: Transportation in San Diego

In San Diego, the average household travels 24,415 miles by car annually. Some 88.8% of trips are taken by car, 0.4% by transit, 5% by foot, and 0.6% by bicycle. Transportation is the second leading cost of household expenditures (Table 9) (U.S. Bureau of Labor Statistics 2002).

Costs of Congestion and Impedance

Two transportation variables are most commonly linked to QoL indicators: travel time and "impedance." Impedance is "anything that frustrates the goal of arriving at a given time at a particular destination—for example, distance, slow speed, or traffic congestion" (Koslowsky 1997). Both variables tend to increase with growth in population. Table 10 depicts recent increases in congestion in the United States.

Table 9. Breakdown of All Household Expenditures for San Diego Residents

Expense	Annual Cost	% of Total Expenditures
Transportation	$6,319	15.8%
Shelter	$10,037	25.1%
Food	$4,979	12.5%
Utilities	$1,990	5.0%
Other household	$3,361	8.4%
Insurance and pensions	$3,869	9.7%
Health care	$1,791	4.5%
Entertainment	$1,938	4.9%
Apparel and services	$1,941	4.9%
Education	$834	2.1%
Miscellaneous	$2,464	6.2%

Source: U.S. Bureau of Labor Statistics 2002

Table 10. Urban Congestion Indicators for 70 Urban Areas

Year	Average Roadway Congestion Index	Annual Delay per Eligible Driver (person-hours)	Wasted Fuel per Eligible Driver (gallons)	Annual Fuel Wasted per Urban Area (million gallons)
1982	0.91	16	23	39
1986	1.01	22	32	54
1990	1.07	27	39	68
1992	1.09	30	44	76
1994	1.11	35	51	84
1995	1.12	37	54	91
1996	1.14	40	58	96

Source: Texas Transportation Institute 1998

Congestion is associated with a variety of increased costs. In the United States, congestion has been estimated to cost $78 billion per year in wasted time and burned gasoline (Texas Transportation Institute 1998). Table 11 depicts an estimate of other social costs of congestion.

Table 11. Social Costs per Vehicle-Mile (1982 Price)

Travel time	$0.12
Air pollution	$0.03
Noise pollution	$0.00
Excess fuel comsumption	$0.11
Traffic accidents	$0.13
Total	$0.38

Source: Khisty and Kaftanski 1986

Impedance *per se* has been associated with a variety of negative economic outcomes. The direct results of delay include sub-optimal vehicle use, higher vehicle operating costs, and reduced productivity due to the additional labor costs associated with longer trips made by employees during business hours. Delay also leads to increased delivery costs and recruitment and turnover problems in congested areas (Cambridge Systematics, Inc. 2002). These costs are assumed to be significant, but they are difficult to quantify. A survey of U.S. business leaders indicated that traffic conditions affect employee morale, productivity, punctuality, and emotions (Lomax, et al. 1988).

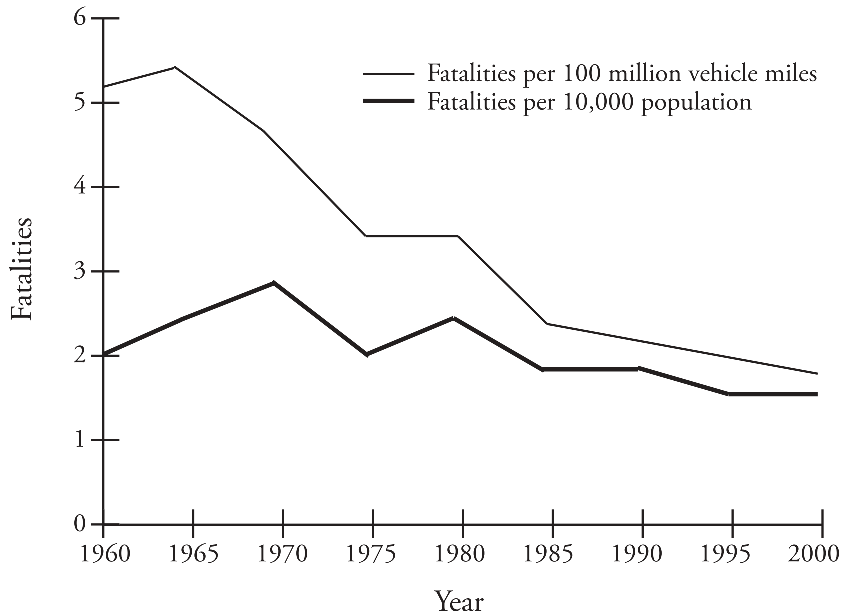
Transportation and Physical Health Indicators

In 1995, the U.S. Bureau of Transportation Statistics estimated that VMT was 9,220 per capita. This amount of travel by car is associated with a significant risk of accident. U.S. Bureau of Census data indicate that motor vehicle accidents are the leading cause of death for people ages 1 to 24. In terms of distance traveled, the cost of accidents to cars in passenger-kilometers is virtually the same as the cost of accidents to trucks in ton-kilometers and about 10 times higher than that of buses.

Transportation professionals measure road risk based on crash and fatality rates per unit of vehicle distance travel (such as per hundred million vehicle-miles or vehicle-kilometers). According to the figures published in the Federal Highway Administration report “Highway Statistics,” total VMT in the United States increased by 59% from 1980 to 1995. Most of this increase is attributed to increasing trip and commuter distances, reflecting an increasing segregation between jobs and housing. Figure 2 depicts traffic fatalities per VMT and per capita.

When crashes and fatalities are measured per capita, such as per 10,000 population, as with other health risks, there has been surprisingly little improvement over this period. This is despite massive investments in safer roads and vehicles, tremendous increases in the use of seatbelts and other safety devices, reductions in drunken driving, and improvements in emergency response and trauma care.

Figure 2. U.S. Traffic Fatalities



Source: BTS 2000

Stokols, et al. (1978) initiated a study of the relationship between transportation variables and QoL health indicators. In their initial study, the degree of impedance encountered by travelers was indexed in terms of two situational parameters: distance traveled and time spent in transit. As predicted, subjective reports of traffic congestion and annoyance were greater among high and medium impedance commuters than among low impedance individuals. Both commute time and commute distance were found to be positively correlated with increases in systolic and diastolic blood pressure. The study indicates that these transportation variables are stressors that may have significant long-term health effects.

Evans and Carrere (1991) reported a high degree of association between exposure to peak traffic conditions and elevation of certain urinary catecholamines. Catecholamines include the stress hormones epinephrine and cortisol. An imbalance of these endocrine messengers alters physical homeostasis. Epinephrine affects blood sugar by promoting lipolysis and depressing insulin. Elevated insulin can, in turn, result in an imbalance of free fatty acids and blood sugar, causing increased susceptibility to cardiovascular problems. Epinephrine also increases contractility of the heart, making each beat increasingly forceful. Long-term exposure can predispose the heart to cardiac hypertension or heart disease (Brown 1997).

Congestion increases impedance and also reduces commuting speed. Slow driving speeds have been correlated with increases in systolic and diastolic blood pressure (Schaeffer, et al. 1988; Kluger 1998).

Carbon monoxide, sulfur dioxide, and other particulates can accumulate in areas of high traffic congestion, making the air less safe. Presumably, remaining stationary in traffic exposes the lungs to an increase in air toxics. Elevated heart rates have been empirically linked to air pollutants inhaled by drivers (Kluger 1998). Current evidence thus suggests that increases in commuting time and distance have a negative affect on health.

Transportation and Mental Health Indicators

In addition to its consequences for physical health, impedance can also cause negative psychological states and moods. Chronic exposure to congestion can increase negative mood states, reduce tolerance for frustration, and can lead to impatient driving behavior (Novaco, Stokols, and Milanesi 1990). Transportation-related stress, including impedance, can make people adopt undesirable or inappropriate (aggressive) behaviors (Yago 1983).

Two factors appear to mediate mental health consequences of congestion—the opportunity for social support and the presence of another person—and thus lessen the effects of impedance. “Interestingly, single-drivers, as compared to car-pool drivers, did have significantly higher scores on hostility and anxiety measures” (Koslowski 1997). Kluger (1998) found that lack of commute choices and commute variability were correlated with the strain measures even after controlling for length.

Transportation and Social Interaction Indicators

American adults spend on an average 72 minutes every day behind the wheel. According to time diary studies, this exceeds the time spent cooking or eating and is more than twice the time that parents spend with their children on average (Putnam 2000). In the United States, children who live in conditions of urban sprawl—and need to be driven to most social activities—watch three to four times more television per week than those who live in more high-density, vertical settlements. Putnam also shows that for every additional 10 minutes spent commuting, there is a 10% drop in civic engagement in activities like scouting, clubs, and community work. Because time is a finite resource, driving time can cause decrements in social interaction and leisure QoL indicators. Simply stated, any time spent behind the wheel could have been used elsewhere.

In societies with inequalities in the distribution of wealth, there are also inequalities in travel time. Macek, Khattak, and Quercia (2001) found than urban families with lower incomes had longer commute times than their suburban counterparts, and that commute time was negatively correlated with the probability of being employed. These types of workers may find less time to spend with their friends and family or to devote to social activities, which leads to a decreased QoL.

Meaningful social interactions also occur in places of employment. A variety of studies have indicated that impedance leads to decreased job satisfaction. "For employees in general, women and men who spent a longer time commuting expressed greater intention to quit the firm" (Burke 1995). The depression in employee loyalty can decrease motivation to socialize with coworkers. Kluger (1998) hypothesizes that commute impedance causes, among other things, negative attitudes toward commuting and decrements in performance. The greater the distance or time of commute, the more likely that the employee will be strained, and hence, less efficient.

Summary of the Impact of Transportation on Quality of Life

The transportation variables with the greatest impact on QoL are VMT, travel time, congestion, and impedance. Each of these variables is associated with urban growth and each is exacerbated by sprawl. QoL consequences of these transportation factors include diminishing:

- Physical health (death and injury due to accidents, increases in blood pressure, increases in cardiovascular disease)
- Mental health (decreases in mood; increases in irritability, hostility, impatience; decreased job satisfaction; decreased frustration tolerance)
- Social interaction (decreased time with family, friends, leisure, and community activities)
- Economic well-being (increased transportation costs)

Additionally, these transportation variables affect air quality, land use, and the local economy, which in turn lead to impacts on other QoL indicators. Table 12 displays an overview of the relationship between transportation and land use variables and QoL indicators. These indicators meet Blair's criteria of appropriateness and the restrictions for the B+20 Project.

Economic Sector

A central feature of all lists of QoL indicators involves values related to material well-being. Indeed, economic factors may well be the most significant environmental antecedents of QoL. Economic resources, income, expenditures, wealth, productivity, and employment occupy central positions in virtually all descriptions of QoL. Substantial research has been directed at the impact of regional economies on the residents of a region. Simply stated, the question is "does life get better during economic growth?" Conversely, does life get worse during economic contractions? What QoL indicators respond to economic fluctuations?

Table 12. Relationships Between Transportation and Quality of Life

Transportation/ Land Use Variables	Possible QoL Indicators	Consequences
Sprawl	Average commuting time Average distance commuted Increases in numbers of exclusively residential subdivisions Increases in numbers of shopping centers, strip malls, and big box retail outlets Increases in numbers of office parks and business parks Blood pressure levels Levels of urinary catecholamines Increased incidences of aggression (road rage) Average time spent in social interactions (family, community, etc.)	Reduced leisure time Decreased use of public transportation Increased air pollution Increased physical stress levels Increased mental stress levels Increased health care costs Increased transportation costs Reduced civic engagement Reduced time spent with family, increased family and marital stress
Congestion and impedence	Average commuting time Average delay Blood pressure levels Levels of urinary catecholamines Increased incidences of aggression (road rage) Average time spent in social interactions (family, community, etc.)	Wasted fuel Reduced business productivity Increased delivery costs Reduced leisure time Decreased use of public transportation Increased air pollution Increased health care costs Increased transportation costs Reduced civic engagement Reduced time spent with family, increased family and marital stress
Transportations risks	Motor vehicle crash rates Motor vehicle fatality rates	Injury Death

Source: Authors

Examining economic growth in the border region presents a number of challenges. From a national perspective, the economic disparity between the United States and Mexico is enormous. In 2000, the per capita gross domestic product (GDP) for the United States was $32,778 while the per capita GDP in Mexico was $5,036 (United Nations Statistics Division 2002). Economic comparisons of the two countries along the border are difficult in spite of the fact that the region is becoming increasingly economically integrated. Local comparisons are especially problematic. On the Mexican side, the border runs along the states of Tamaulipas, Nuevo León, Coahuila, Chihuahua, Sonora, and Baja California. On the U.S. side, the area consists of 48 counties in the states of Texas, New Mexico, Arizona, and California. Data for states and sub-state levels *(municipios)* are not as readily available for the Mexican side as they are for the U.S. side, and often these data are defined differently in the two countries (Sharp 1998).

It is clear, however, that the population along the border is growing dramatically. For example, the birth rate along the Texas border is growing faster than in the rest of the state by more than 40%. In addition, net migration to the area by the year 2020 is estimated to be more than 1 million people. While economic growth in the region is greater than the rest of the state, the prosperity of the region is not expected to improve due to high unemployment and a continued influx of unskilled workers willing to work for low wages. This situation has been characterized by the Texas Comptroller of Public Accounts as "growth without prosperity" (Sharp 1998).

The population on the Mexican side of the border is growing even more rapidly (in no small part due to the maquiladora industry). In 1920, the U.S. city in four out of five pairs of twin cities along the border was larger. By 1990, all the cities on the Mexican side were much larger than those on the U.S. side (Sharp 1998). From the Mexican perspective, the region represents a land of opportunity where 1,500 maquiladoras have created nearly 500,000 jobs (Border Low Income Housing Coalition 2002). From a U.S. perspective, the border region is economically and socially troubled.

Some of the poorest counties in the United States are located in this border area. More than a third of U.S. border families live at or below the poverty line. An estimated 350,000 people live in *colo-*

nias—un-zoned, semi-rural, unincorporated communities, many of which have no access to public drinking water, paved roads, or wastewater systems. The unemployment rate along the border is 250% to 300% higher than in the rest of the country (U.S.-Mexico Border Health Task Force 2002).

The rapid growth in the region also comes with an increase in crime. Drug-related crimes are particularly high in the border region. Armed encounters between border patrol officers and traffickers increased in Texas and drug law violations doubled along the border during the 1990s. In 1996 there were approximately 60 violent crimes and 660 property crimes every day (Sharp 1998).

Per Capita Income

Current literature on growth does point to a positive relationship between income per capita and indicators of well-being such as health (Barro and Sala-i-Martin 1995; Pritchett and Summers 1996). Unfortunately, research on economic development and QoL relies heavily on the use of cross-sectional data, which essentially means that nations at different levels of development are compared. Such cross-sectional data obviously have serious comparability problems. Methods of data collection, definitions of income and wealth, and reporting rates vary widely from country to country. Therefore, such data do not directly bear upon the question of how life in a particular country or region might change during a period of economic growth.

Time series data on per capita income for particular nations or regions are sparse, and when data from economic history are available, the impact of rising per capita income is mixed. As a prime example of this problem, Easterly (1999), using a data set with multiple nations and four time periods (1960, 1970, 1980, and 1990), analyzed changes in 81 QoL indicators. Using cross-national data, he found significant, positive improvements in 32 of the 81 indicators. Using a fixed-effects estimator (controlling for country effects), he found significant improvements in only 10 of the indicators. Using a first-difference estimator (analyzing changes from one time period to the next), he found improvements for only six indicators. Yet, he remains optimistic about the use of cross-sectional data, primarily because he believes there is strong evidence that improvements in QoL often lag behind economic development for decades.

The economic history literature has also documented long lags between rising per capita income and improved QoL. Morris (1996) studied three episodes of rapid capitalist development and concluded that four to five decades passed before the majority of the population got "delivery of the goods." Fogel (1994) believes that the gain in nutrition in Organisation for Economic Co-operation and Development (OECD) countries between 1910 and 1980 "was due to a series of investments made as much as a century earlier" (Easterly 1999).

Economic Development v. Crime Rates

Economic development is related to crime, but not all crime is affected in the same way by development. Using cross-national data, Bennett (1991) found that industrial development is positively correlated with theft rates. His research suggests that the generation of wealth and the acquisition of more consumer goods combined with variance in income lead to greater opportunities for property crimes. However, proximity of targets to a crime-committing population is also a relevant predictor of theft. In a study based on the National Crime Victimization Study and on neighborhood-level homicide data, Levitt (1999) found that "property crime victimization has become increasing concentrated on the poor." Grant and Martínez (1997) found that "[w]hen crime is examined across time and space, the unemployment rate has a powerful effect on crime rates, particularly property crimes."

Influential work by Wilson (1987; 1996) suggests that the economic restructuring of inner cities has produced social dislocation, which has in turn produced a host of social ills, including violent crime and property crime. Wilson also relates diminishing economic opportunities in inner cities to juvenile delinquency. Bellair and Roscigno (2000) found that unemployment and underemployment were related to drug use and fighting in adolescents. The proportion of juveniles in the population has also been positively correlated with both homicide and theft (Benett 1991). As the border region is a rapidly growing industrial region with a young population and a great deal of poverty, rapid increases in both violent and property crimes might be expected.

A recent investigation by Daly, Wilson, and Vasdev (2001) indicates that the Gini Index of Income Inequality (Sen 1973)[1] is a better predictor of homicide than average income. While previous research on inequality and homicide had already shown a positive relationship between inequality and homicide (Krohn 1976; Krahn, Hartnagel, and Gartrell 1986; Gartner 1990), that research was confounded by the problem of a strong correlation between low average income and high income inequality; those nations and regions that are poorer have greater inequality in average income and higher homicide rates. Daly, Wilson, and Vasdev used data from Canadian provinces with a positive correlation between average income and income inequality and found strong support for their hypothesis. Interestingly, Gartner (1990) found that the Gini Index is a better predictor of the number of adults murdered than it is for children murdered. It is also more predictive of men's rather than women's murder rates.

Table 13 displays an overview of the relationship between economic variables and QoL indicators. These indicators meet Blair's criteria of appropriateness and the restrictions for the B+20 Project.

Endnote

[1] Gini scores range from 0.0 to 1.0. A Gini of 0.0 would mean that all households in the sample have equal incomes. A Gini of 1.0 would mean that one household had all the income. In other words, the higher the Gini score, the greater the income inequality.

Table 13. Relationships Between Economic Variables and Quality of Life

Economic Variable	Possible Related QoL Indicators
Per capita income	Physical Health and Longevity Infant mortality Life expectancy Rates of health insurance Rates of prenatal care Community Health Access to transportation Access to communication Burglary rates Drug crimes Education Literacy rates Average years of schooling Achievement test scores Participation in higher education Dropout rates Class and Gender Inequality Ratio of female to male average years of schooling Ratio of women's literacy to men's Ratio of women's employment to men's
Income inequality	Community Health Homicide Rape

Source: Authors

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