**The Human Development Index:
A conceptual and empirical deconstruction**

by

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Abstract

This study investigates the United Nations Human Development Index (HDI). It develops and tests the hypothesis that, at a practical and pragmatic level the HDI is technically a good surrogate for other facets of living conditions, which are often described as Quality of Life (QOL). The study focuses on an investigation of a subset (164) of the 177 countries in the Human Development Index using 32 variables.

In the early stages, the presentation discusses the transition from a technical project in cartographic representation to a statistical analysis of the HDI. Next, the more conceptual aspects related to the definition of human development and quality of life is explored.

The study found that countries with higher life expectancy, education, and income (the ingredients of the HDI) also typically share other benefits. They consume more resources, have better access to technology, have stronger community support, and distribute wealth more equitably on average than countries with low life expectancy, education, and income.

The hypothesis that the HDI is pragmatically a good empirical surrogate for measuring living conditions is accepted. However, issues of concept, construction, and values remain unresolved.

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Table of Contents

ABSTRACT	ii
ACKNOWLEDGEMENTS	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	vi
LIST OF ILLUSTRATIONS.....	vii
LIST OF APPENDICES.....	ix
PREFACE	1
1.0 INTRODUCTION.....	6
2.0 INITIAL RESEARCH INTENTIONS AND SOME REVELATIONS	20
2.1 CONCEPTUAL BACKGROUND AND THEORETICAL BASIS.....	20
2.2 ORIGINAL CONCEPT.....	28
2.3 WEB-MAP PROTOTYPE.....	33
2.3.1 <i>Software</i>	33
2.3.2 <i>Architecture</i>	35
2.3.3 <i>Study Area</i>	35
2.3.4 <i>Data and Data Collection</i>	35
2.4 EXCEL EXPERIMENT	37
2.5 CONCLUSION.....	42
3.0 HUMAN DEVELOPMENT REPORT	44
3.1 HUMAN DEVELOPMENT REPORT BACKGROUND.....	44
3.2 HUMAN DEVELOPMENT INDEX	48
3.3 CONFLATING THE HUMAN DEVELOPMENT INDEX AS QUALITY OF LIFE	54
3.4 HUMAN DEVELOPMENT INDEX CRITICISM	57
3.4.1 <i>Wellbeing of Nations</i>	58
3.4.2 <i>Miscellaneous HDI Criticisms</i>	60
4.0 QUALITY OF LIFE	76
4.1 A REVIEW OF DAVID M. SMITH'S WORK	76
4.1.1 <i>Measuring Well-being</i>	77
4.1.2 <i>Measuring Inequality</i>	79
4.1.3 <i>Opportunities of Power</i>	80
4.1.4 <i>Ethics and Morality</i>	81
4.1.5 <i>Community</i>	83
4.1.6 <i>Inherited Opportunities</i>	84
4.1.7 <i>Basic Human Needs</i>	85
4.1.8 <i>The Environment</i>	86
4.1.9 <i>Summary</i>	87
4.2 DEFINING QUALITY OF LIFE	87
4.3 MEASURING QUALITY OF LIFE	90
4.4 QUANTITATIVE METHODS THEORY.....	92
5.0 DATA SELECTION	99
5.1 DATA CORRECTION	112
5.2 DATA TRANSFORMATION.....	114
5.3 SCATTERPLOT REVIEW.....	119
5.4 CORRELATION ANALYSIS.....	123
6.0 DATA ANALYSIS	127
6.1 FIRST REGRESSION ANALYSIS.....	127

6.2 FIRST PRINCIPAL COMPONENT ANALYSIS.....	132
6.3 SECOND REGRESSION ANALYSIS (USING PRINCIPAL COMPONENTS)	135
6.4 MAP OF RESIDUALS	137
6.5 SECOND DATA TRANSFORMATION	139
6.6 THIRD REGRESSION ANALYSIS (HIGH AND LOW STREAM)	141
6.7 SECOND PRINCIPAL COMPONENT ANALYSIS (HIGH AND LOW STREAM)	143
6.8 FOURTH REGRESSION ANALYSIS (USING PRINCIPAL COMPONENTS HIGH AND LOW STREAM) ...	145
6.9 THIRD DATA TRANSFORMATION.....	146
6.10 FIFTH REGRESSION ANALYSIS (MEDIUM STREAM)	149
6.11 THIRD PRINCIPAL COMPONENT ANALYSIS (MEDIUM STREAM)	151
6.12 SIXTH REGRESSION ANALYSIS (USING PRINCIPAL COMPONENTS MEDIUM STREAM).....	152
6.13 SUMMARY	154
7.0 CONCLUSION	155
8.0 REFERENCES	160
APPENDIX A – HISTOGRAMS AND SCATTERPLOT MATRIX REPORTS USED IN DATA TRANSFORMATIONS	169
APPENDIX B – CORRECTED RAW DATA AND LIST OF EXCLUDED COUNTRIES	181

List of Tables

Table 1 – Human Development Index.....	37
Table 2 – Human Development Index Calculation.....	39
Table 3 – Human Development Report.....	44
Table 4 – Variables Selected for Analysis.....	109
Table 5 – List of Variables with Transformation Functions (All Countries)	118
Table 6 – List of Variables with Transformation Functions (High and Low Countries)	140
Table 7 – List of Variables with Transformation Functions (Medium Countries)	148
Table 8 – Key to Variable Names in Corrected Data Table	181
Table 9 – Corrected Data Table	182
Table 10 – Countries Excluded from the Analysis	186

List of Illustrations

Figure 1 – Social Watch HDI Map with adjusted statistical boundaries	8
Figure 2 – Social Watch HDI Map with equal quintile ranges	9
Figure 3a – Social Watch Map for Visual Comparison – Internet Usage.....	10
Figure 3b – Social Watch Map for Visual Comparison – Tuberculosis Prevalence	11
Figure 3c – Social Watch Map for Visual Comparison – Child Mortality (under 5)	12
Figure 3d – Social Watch Map for Visual Comparison – Access to Improved Sanitation.....	13
Figure 3e – Social Watch Map for Visual Comparison – Gender-related Development Index.....	14
Figure 4a – Social Watch Maps showing missing data – Malaria.....	15
Figure 4b – Social Watch Maps showing missing data – Poverty	16
Figure 4c – Social Watch Maps showing missing data – R&D Expenditures	17
Figure 4d – Social Watch Maps showing missing data – External Debt.....	18
Figure 4e – Social Watch Maps showing missing data – Unemployment	19
Figure 5 – Prototype Architecture.....	35
Figure 6 – Prototype Mock-up.....	36
Figure 7 – HDI Formula.....	38
Figure 8 – U.N. HDI Graph.....	40
Figure 9 – Custom HDI Graph.....	40
Figure 10 – Happiness of U.S.A. Citizens.....	65
Figure 11 – HDI – Electricity Scatterplot	71
Figure 12 – Database Table Mapping.....	111
Figure 13 – Untransformed HDI Data Histogram	114
Figure 14 – Transformed HDI Data Histogram	115
Figure 15 – Untransformed HDI Data Scatterplot	116
Figure 16 – Transformed HDI Data Scatterplot.....	116
Figure 17 – Life Expectancy – GDP Scatterplot.....	119
Figure 18 – GDP – Knowledge Scatterplot	121
Figure 19 – HDI – Knowledge Scatterplot.....	121
Figure 20 – Internet Usage Comparison	122
Figure 21 – Correlation Matrix.....	124
Figure 22 – First Regression Analysis.....	129
Figure 23 – First Principal Component Analysis	132
Figure 24 – First Rotated Component Matrix	133
Figure 25 – First Un-rotated Component Matrix.....	134
Figure 26 – Second Regression Analysis	135
Figure 27 – Map of Residuals	138
Figure 28 – Third Regression Analysis	142
Figure 29 – Second Principal Component Analysis	143
Figure 30 – Second Rotated Component Matrix.....	144
Figure 31 – Fourth Regression Analysis	146
Figure 32 – Fifth Regression Analysis.....	150
Figure 33 – Third Principal Component Analysis	151
Figure 34 – Third Rotated Component Matrix.....	152
Figure 35 – Sixth Regression Analysis.....	153
Figure 36 – All Countries Stream – Untransformed Data Histograms	169
Figure 37 – All Countries Stream – Transformed Data Histograms.....	170
Figure 38 – All Countries Stream – Untransformed Data Scatterplots	171
Figure 39 – All Countries Stream –Transformed Data Scatterplots.....	172
Figure 40 – High and Low Stream – Untransformed Data Histograms.....	173
Figure 41 – High and Low Countries Stream – Transformed Data Histograms	174
Figure 42 – High and Low Stream – Untransformed Data Scatterplots.....	175
Figure 43 – High and Low Countries Stream –Transformed Data Scatterplots.....	176
Figure 44 – Medium Countries Stream – Untransformed Data Histograms	177
Figure 45 – Medium Countries Stream – Transformed Data Histograms.....	178

Figure 46 – Medium Countries Stream – Untransformed Data Scatterplots.....	179
Figure 47 – Medium Countries Stream –Transformed Data Scatterplots	180

List of Appendices

APPENDIX A – HISTOGRAMS AND SCATTERPLOT MATRIX REPORTS USED IN DATA TRANSFORMATIONS	169
APPENDIX B – CORRECTED RAW DATA AND LIST OF EXCLUDED COUNTRIES	181

Preface

The United Nations Human Development Index is designed to describe levels of living (basic living conditions) at the scale of nation-states, such that comparisons can be made over time and space. i.e., progress (or regress) can be tracked using a standard measurement index, which consists of three elements: life expectancy, education, and income. The HDI is calculated as the un-weighted sum of the three elements. The HDI values for countries are then ranked. The ingredients of the HDI reflect judgments about what is important in life, and the weighting algorithm expresses judgments about the relative importance of these things. The picture, or map, that it paints of the world depends on the values and theories inherent in its construction. One of the central principles is that the three elements in the HDI are equally important. So the list (the ranked HDI values) and its visual presentation as a map of how the world is, is but one of an infinite set of possible worlds, each reflecting different weightings of the same ingredients. If we disagree with the way the HDI is constructed, we could argue for different weightings. More radically, we could also challenge and change the ingredients, based on different personal or shared theorizations of what constitutes the good life. Small changes could have big consequences.

My original intention was to build a web-based interactive tool to allow “visitors” to experiment with the weights to produce their own visualizations of the input data. i.e., personal theories could be applied to the data, creating “personal” maps of “personal” HDIs. I expected Canada to slip from first in the HDI rank

order if different weights were applied to each of the categories. I wanted to see which countries, particularly Canada, were elevated or lowered simply by adjusting the weights. Weights reflect different judgments about conditions: the conditions themselves remain unchanged. The tool would have allowed ordinary people with no geographical, GIS, statistical, or cartographic expertise to play with “what if?” scenarios to see what happens to the choropleth map created when different weights are applied to the input.

I spent a considerable amount of time and effort developing the tool before I discovered an Internet web-map application called the ‘Indicators Interactive Map’ developed and supported by Social Watch, an international NGO watchdog network focused on monitoring poverty eradication and gender equality. The Social Watch web site is hosted by the *Third World Institute* in Montevideo, Uruguay. This tool was very similar to my design. However it was significantly richer in features and data. I negotiated access to the tools used by Social Watch. However after running into technical and social barriers I was left with three choices – continue working with the Social Watch application, go back to where I had left off before discovering the Social Watch map, or change the thesis. The social barrier was language. The Social Watch application was designed using Macromedia Flash software and the Flash code was written in Spanish. The technical barrier was the lack of software development knowledge. I thought my software development skills were sufficient but I was wrong. I was concerned that my thesis was becoming more of a technical computer programming exercise than a geography analysis so I decided on the third

choice, to change the thesis into a conceptual and statistical exploration of the HDI.

I used the Social Watch tool to look at country rankings of the individual HDI components and found that the application highlighted one of the major issues I had discovered in trying to develop my own application, that it is impossible to get a full set of country-aggregated data. Most of the Social Watch maps showing social indicators, including components of the HDI, have many countries painted gray indicating missing data.

By this point I had also researched the concepts of human development and quality of life and had taken a closer look at HDI construction. The HDI is based on a multiplicity of assumptions and estimates, because many of the ideal data have never been collected. Deconstructing the HDI into three components to allow them to be weighed differently no longer seemed so important because I had come to view the HDI as not merely a set of numbers, but as a carefully crafted metamodel reflecting choices and values. It is a metamodel that expresses a metanarrative.

What is the metanarrative? The HDI has entered political discourse as the basis of bragging rights as to “who’s number one?” Number one in what?

Statement by the Prime Minister
 September 9, 1998
 Ottawa, Ontario

Prime Minister Jean Chrétien today expressed pride on behalf of the people of Canada on the news that the 1998 United Nations Human Development Report has - for the fifth year in a row - ranked Canada first among 174 countries on its Human Development Index (HDI), which compares relative quality of life, including life expectancy, literacy and income:

"This news tells us what we all know in our hearts - that we live in the best country in the world. Our long run at the top of the UN Index is a tribute to all Canadians - individuals, communities, voluntary organizations, the private and the public sector - each of us doing our part to make our quality of life literally second to none. And I am especially pleased that Canada is number one on the Gender Development Index for the second year running.

While the HDI tracks Canada's impressive achievements, it also tells us where we can improve. That is why, for example, we have made reducing child poverty one of our top priorities; by working in partnership with the provinces and territories to establish the new National Child Benefit, which will deliver some \$1.7 billion in new income support into the hands of low-income working families by the year 2000.

There is a reason that we, as a nation, have received this international honour for five consecutive years. It is because we do not rest on our laurels. We do not become complacent. We constantly strive to make our country - and the world - a better place. That is what makes Canada such a valuable model to the world. And it is deeply gratifying and very moving for all Canadians to be honoured again with this distinction."

- 30 -

PMO Press Office (613) 957-5555 (PMO, 1998)

If we look at Prime Minister Chretien's statement (PMO, 1998) we see that the HDI is stretched or spun so that it is an honour which recognizes the quality of life achieved, the deserved reward of individual and collective virtue for all Canadians, an example to the world.

Yet the HDI does not claim to measure quality of life. At the conceptual level the concept of human development is abstruse, which perhaps goes some way to explaining why the HDI is often conflated, as it was in this press release,

with quality of life. Initially, I wanted to refute the rhetoric of politicians using the HDI to boast about their country's QOL. After researching theories and concepts of human development and QOL, the HDI took on new meaning. I concluded that the U.N. itself has been unjustly accused of explicitly using the HDI to represent QOL. It is nationalist politicians who spin these claims. I also came to appreciate the irony that while the HDI has been criticized as a poor quality of life indicator, there are in fact links between the U.N.'s definition of human development and most contemporary opinions about what QOL means.

Using mostly the data I had already collected, I re-orientated my research to answering the question: "despite criticisms, misinterpretations (intentional and otherwise), and conceptual complexities, does the HDI at a practical and pragmatic level actually capture much of the information found in larger and more general sets of variables covering other facets of living conditions?" Thus, a technical project in cartographic representation became a technical project again, in statistical analysis, but conceptually better informed.

1.0 Introduction

According to the 2006 United Nations Human Development Report (UNDP, 2006: 263) the HDI provides a composite measure of three dimensions of human development: life expectancy, education including adult literacy and school enrolment, and purchasing power parity income. The report acknowledges that the index is not in any sense a comprehensive measure of human development because it does not include, for example, important indicators such as respect for human rights, democracy and inequality.

It is perhaps because life expectancy, education, and income can be counted without too much difficulty or controversy, and these factors combined are a good surrogate for other factors related to human development and well-being that are much more difficult, if not impossible, to count such as human rights, democracy, and inequality, that the United Nations has decided to stick with these variables in the HDI and not introduce others.

Human development, well-being, standard of living, and quality of life are used interchangeably. The concepts are not the same, but they are related. The U.N. HDI is intended to measure capacity for human well-being. In other words, what level of essential ingredients does each country have to support well-being for its citizens? As Smith (1973: 66) suggests, quality of life can be regarded as lying in a conceptual continuum somewhere between human happiness and well-being. Happiness is more fluid than well-being. Societies can have basic ingredients for happiness including food and shelter, yet still lack other psychological or sociological aspects such as security or community spirit. Well-

being is conceptually more concrete than human happiness yet it is still ideologically complex. It is difficult to measure the difference between happiness, quality of life, and well-being because the concepts are overlapping and inherently subjective. Thinking of well-being within a range of abstractions on a continuum is one way to conceptualize the difference between these terms.

Puzzling over this issue I started to wonder whether it really matters what the difference is. The human development index was intended to measure some aspects of human development, but not comprehensively. It is possible that counting some aspects of human development can tell us something about the comprehensive variables related to the state of well-being.

After manipulating the quintiles of different social indicators and analyzing the map output from a web-map application used for reporting world country statistics (see *Figure 1*) I noticed the similarities between the U.N. Human Development Index map and other maps were suggestive. The web-map application is hosted by Social Watch, an international NGO watchdog network monitoring poverty eradication and gender equality. The maps use five colours, to illustrate class ranges of country-aggregated statistics. Blue is the highest (good) category, red the lowest (bad). After a variable is selected, a choropleth world map is displayed with countries illustrated using the colour of the statistical quintile range each country falls into. The quintiles can then be modified into different class ranges by using a slider bar.

Figure 1 – Social Watch HDI Map with adjusted statistical boundaries

Figure 1 shows a custom selection of statistical ranges for five HDI classes. It essentially reports the same data as in Figure 2 but the adjusted statistical boundaries of each quintile have been modified.

Figure 2 – Social Watch HDI Map with equal quintile ranges

Figure 2 illustrates the Human Development Index organized into five equal statistical quintiles. Five other indicators organized into statistical quintile ranges are shown in Figure 3a to 3e for visual comparison with Figure 2. All of the indicators are in ratio scale based on the percentage of country population. The five sample maps are Internet usage, tuberculosis prevalence rate, under-five mortality rate, access to sanitation, and gender-related development index (GDI). The GDI is essentially the HDI combined with a gender-equality measure intended to show the inequalities between males and females in life expectancy, education, and wealth.

Figure 3a – Social Watch Map for Visual Comparison – Internet Usage

Figure 3b – Social Watch Map for Visual Comparison – Tuberculosis Prevalence

Figure 3c – Social Watch Map for Visual Comparison – Child Mortality (under 5)

Figure 3d – Social Watch Map for Visual Comparison – Access to Improved Sanitation

Figure 3e – Social Watch Map for Visual Comparison – Gender-related Development Index

In each map a familiar pattern begins to emerge in different regions of the world when playing with the statistical categories. In all cases Canada, the U.S.A., Western European countries, and Australia typically start off as blue countries (high) when the ranges of values are equal. Most African countries started off in the bottom ranges (yellow, orange, red). Adjusting the quintiles helped to reveal which African countries were slightly better or worse than neighboring countries. Countries in other regions (e.g. Asia) were typically somewhere in-between. This suggested that there may be some, not necessarily linear, relationship between variables like access to communications technology, child mortality, hygiene, disease, and gender equality, and the HDI.

The Social Watch web-map tool also helped to illustrate an issue with trying to compare country social indicators because of missing data. Many social indicators are collected for specific demographic regions (e.g. high and medium developed countries, or medium and low developed countries). For these indicators many countries of the world are grayed out in the map because the values are missing. *Figure 4a to 4e* shows five maps of malaria, poverty, R&D expenditures, external debt, and unemployment.

Figure 4a – Social Watch Maps showing missing data - Malaria

Figure 4b – Social Watch Maps showing missing data – Poverty

Missing data are particularly evident in closed societies or countries in turmoil such as North Korea, Afghanistan, and Iraq.

Figure 4c – Social Watch Maps showing missing data – R&D Expenditures

Figure 4d – Social Watch Maps showing missing data – External Debt

Figure 4e – Social Watch Maps showing missing data – Unemployment

After researching other issues with reporting the HDI, mainly due to problems with defining what human development is, then trying to quantify it, a statistical test was conceived to find out, despite the fact the HDI was never intended to measure QOL, despite the missing data, assumptions, and estimates, and despite the many other criticisms and alleged shortcomings, how well does the HDI perform technically as a surrogate for measuring quality of life by country? This analysis is a quantitative statistical exploration of the HDI with other indicators to test a hypothesis that the HDI is, after all, a good surrogate to measure quality of life.

2.0 Initial Research Intentions and Some Revelations

This section describes background of the original technical project, explaining how this data visualization experiment became a personal, and unsettling, encounter with issues of value, worth, measurement, and meaning in human development, well-being, living conditions, and quality of life.

2.1 Conceptual Background and Theoretical Basis

The original web-map idea was based on GIS methods. The two main epistemological positions that dominate current GIS reasoning are visualization-based empiricism (VBE) and analysis-based rationalism (ABR) (Sui, 2005: 1). The first position, empiricism, sees knowledge as the product of sensory transmission, resulting from a kind of mapping or reflection of external objects, through our sensory organs, possibly aided by different observation instruments, to our brain/mind. Knowledge has to be developed by observation. The second position, rationalism, sees knowledge as the product of rational reflection through the integration of GIS with spatial analysis and modeling. GIS methodology is a transformation of the assumed ontology and epistemology into a set of operational rules and procedures for data collection and analysis (Sui, 2005: 1).

The original plan was to use Multiple-Criteria – Multiple-Objective Decision Analysis (MC-MODA) (Eastman, 1995: 539). This method is more closely related to rationalism because decisions are made based on mathematical evaluations. It gradually became clear that the project was not MC-MODA compatible. It involved multiple criteria (data factors), but not multiple objectives,

and was not designed to help users make rational decisions. It was intended to be educational and illustrative.

The ontological basis of the data modeling process in GIS is to study "how the infinite complexity of the geographical world can be represented within a discrete finite machine" (Goodchild, 1991). Reality can be represented in terms of attribute, location, spatial relationship, and time. In other words, what, where, how, and when? These attributes are represented in the virtual world as discrete objects. GIS is embedded in Euclidean geometry by abstracting real world objects into points, lines, polygons, and volumes, and in Newtonian conceptualizations of space and time (Sui, 2005: 1). Attributes are identified and organized by subjective classes and categories. Spatial relationships of proximity and adjacency are represented topologically. Time is treated as a one-dimensional element in GIS.

GIS concepts and methods are typically involved. Knowledge and meaning are derived from the underlying technology that is hidden by the algorithms and processing hardware. Technological improvements to computer processing power allow increasing levels of GIS automation but can also further remove the GIS user from the ontological and epistemological assumptions behind these operations. "Because of the exclusive technical nature of GIS, mere technical advances in the absence of thoughtful and sound research design do not necessarily advance our understanding of physical and social systems" (Sui, 2005: 1).

Schuurman (1999) suggests what one can do with GIS using different algorithms. However the underlying motive for her essay really seems to be an attempt to confront the human geography critics of GIS and explain why GIS is a science. She suggests that many of the critiques of GIS from human geographers are “delivered largely through a vocabulary culled from philosophy and sociology” (Schuurman, 1999: 8). She spends a whole chapter discussing the critics and challenging their “attempts to theorize the field, coupled with an analysis of what they omitted” (Schuurman, 1999: 9). Schuurman puts the discord between scientists and social scientists into context by suggesting that “at the core of the science wars is the epistemological privilege enjoyed by science and the degree to which science is culturally influenced” (Schuurman, 1999: 12). Most of the criticism of GIS has been focused more on positivism in geography than on GIS itself. Schuurman admits that the critics “assessment initiated a number of important questions about the applications and implications of GIS” (Schuurman, 1999: 97). Schuurman’s approach to theorizing GIS is to negotiate “between conceptual problems with the technology and its implementation” (Schuurman, 1999: 97). She also admits to using the same strategy to denigrate her critics that they used to judge GIS. This was needed to differentiate her critique from others. Her main argument is that effective criticism is motivated by a desire to understand and transform the field. i.e. be constructive. She suggests that “if social theorists want to influence GIS, then they must make their arguments relevant to the technology” (Schuurman, 1999: 22). She states that “in the long run, critics of GIS have had a productive effect,

helping to generate interest in privacy, equity, and theoretical GIS” (Schuurman, 1999: 97). Schuurman argues that many of the shortcomings of GIS can be traced to the development of the technology itself, and it is improving.

Schuurman attributes part of the tension between science and much of human geography to the different ‘vocabularies’. “Discourse separates these two schools. Language is never absolutely clear, and this is especially true when talking across a gulf like the ones that separate GIS from its critics” (Schuurman, 1999: 23). During an interview with Goodchild in 1998, Schuurman was told that “it was partly an absence or explanation that led to the suspicion that social theory was useful only at a theoretical level, that it always missed when applied to the technology, that its discourse was discordant with GIS” (Schuurman, 1999: 97).

Schuurman says that “positivism became one basis for antagonism between the two communities (GIS, human geography)” (Schuurman, 1999: 41) and she questions whether or not the technology is really positivist. She says that because the definition of positivism itself is open to debate the epistemology of GIS is not solvable. “Epistemology in GIS became a complicated issue because it hinges on an accusation (of positivism) poorly understood by researchers and ill defined by critics” (Schuurman, 1999: 41). There are multiple versions of positivism, related to different historical and philosophical contexts. “In the broadest sense, positivism implies that observation precedes assertions” (Schuurman, 1999: 41). She claims that in the 1980s “philosophers of science had turned their attention to positivism and had found it sorely lacking as a

means of describing the scientific and phenomenal world” (Schuurman, 1999: 41). She goes on to say that suggestions were made that GIS inherited an agenda from the quantitative revolution to retreat from knowledge to information and insinuated that GISers were epistemologically naive. “By the mid-1990s, the term (positivism) was fraught with difficulty and the definition was secondary to the imputation that GIS was somehow compromised” (Schuurman, 1999: 42). Assertions of positivism were easily confused with the technology; critics used positivism negatively as interchangeable with GIS. Schuurman suggests that GIS visualization is representational pragmatism and pragmatic approaches to knowledge incorporate self-correcting inquiry. “The rendering of geographical space in GIS fits more closely with pragmatism than with any other epistemological approach” (Schuurman, 1999: 42). Pragmatism is anti-foundationalist because it regards knowledge builders as participants rather than observers. Pragmatic knowledge is a (instrumental) tool for organizing the world. Schuurman suggests that part of the reason for the positivist label in GIS is because GISers promoted the technology as scientific.

Schuurman suggests that ethical issues are easier to debate than arguments about the epistemology of GIS because “they provide the possibility of a locus for intervention and change” (Schuurman, 1999: 45). She argues that the broader issues of GIS application including authorship, social imbrication (GIS as a social expression), and privacy should be shifted to a public forum for debate. She does not suggest that the ethical issues are about GIS technology per se. Examples include locating the authorship of maps or algorithms, the use of GIS

to (mis)represent or (under)represent important information such as marginalized people, the profit motive in GIS innovation, and privacy issues for example. She admits that the technology “enables users to incorporate ill-defined intelligence” (Schuurman, 1999: 47). For example, by using fuzzy logic or other non-precise measures “the technology can accommodate imprecision and ambiguity; prevalent attitudes about the precision of science are often responsible for the exclusion of such information” (Schuurman 1999: 47). One example Schuurman uses to describe an ethical dilemma is with GIS based Internet tools like MapQuest that can provide information to potential stalkers. How GIS contributes to a loss of privacy requires a public forum debate about ethical responsibility.

Schuurman investigates the study of generalization research tracing the history of automation in cartography (automated generalization) and the differences between maps and GIS. For example “In GIS the map is an ephemeral by-product of machinations at the database level. Hidden to the viewer, the database and algorithms are the motor behind the map product” (Schuurman, 1999: 56). Schuurman thinks that artificial intelligence will improve automated generalization techniques and examines in detail the mathematical structure of artificial intelligence, how it works, and what it can do to solve the problems inherent in generalization. “It is likely that objects will become the primary means of representing geographical entities, if only because this approach disperses intelligence widely (among objects) and thus averts the type of linear decision making that has had so little success in generalization” (Schuurman, 1999: 67). She suggests a dual approach “that investigates both

social and digital parameters is necessary” (Schoorman, 1999: 69). This implies that AI can bring in qualitative information to a GIS that has traditionally been quantitative.

The social consolidation of entities (fields and objects) in GIS can be examined by including raster (grid cells) and vector (points and lines) encoding. Schoorman explains that the “adherence of GIS data models to reductionist logic, like their genesis, is the product of historical necessity and the limitations of conventional mathematics (to say nothing of storage space)” (Schoorman, 1999: 75). In other words the more detailed and accurate the model, the more difficult it is to produce. She moves on to a discussion of the ‘metaphysical in GIS’ and explains in an illustration how an image schema is used as a vehicle for understanding. Image schemas are visual (and metaphorical) cognitive devices that are used to describe structures that pattern our everyday life and experience. These include concepts such as containers, paths, and links, for example. She uses this to describe how GIS scholars could relate to the interdisciplinary nature of cognitive research and as a means to show GIS as an emerging science (and a developing theory). Schoorman touches on ontology and what it means to GIS suggesting that “whether metaphysical or technical, ontologies are the products of data models. Ontologies, in GIS, imply not the essence of reality but the objects that emerge from data models. GIS ontologies are a unique cross between essence and arbitrary construction” (Schoorman, 1999: 81). She forays into the philosophical realm and the difficulties of describing GIS philosophically but admits GIS (and data models) are a product of

traditional “Western thinking about space” (Schuurman, 1999: 85). Schuurman says that “if ontologies are functional, rather than elemental, then perhaps GIS, as an application, is one of many means of representing GIS data” (Schuurman, 1999: 99). Her main point is that there are many avenues to apply the technology.

Schuurman touches on philosophical issues and ethical risks. She discusses some of the shortcomings and offers some predictions (e.g. embedding artificial intelligence algorithms). This suggests that the web-map does not really qualify under Goodchild’s definition of Geographic Information Science to ‘represent the complexity of the geographical world within a discrete finite machine’. This is because at this point the focus is on the application and not on what the application is supposed to represent.

One of the points Schuurman makes about the credibility of different ontologies is that pragmatism bridges two realms of theory. One is the actor-network theory that says geographical entities are transformed into fields and objects through a process of negotiation between scientists, the public, and the actors themselves. The other theory is the ‘rogue epistemology’ of the field/object binary based on the ‘realist’ study of the essential nature of fields and objects. “Quests for unified theories of space do not offer any greater utility than the pragmatism that has served GIS so well in the past” (Schuurman, 1999: 94). This suggests that GIS has dual streams of evolution including negotiation involving different stakeholders, and individual rogues pushing the limits. Pragmatists glue the streams together. This echoes the discord between

methods in physical and human geography, and between philosophical positions in geography (e.g., positivism, humanism, and post-modernism, etc.) It is one of the main reasons why this thesis changed from a data visualization experiment to a statistical analysis.

On review, Visual Based Empiricism seemed like a logical choice to describe the project because it was to be an experiment to see what happens to maps when the data that the maps are based on are changed.

2.2 Original Concept

The U.N. HDI is calculated as an aggregate measure consisting of equally weighted indices of life expectancy, education, and income per capita. Former Prime Minister Jean Chrétien used the HDI to boast that Canadians live in the best country in the world. The urge to refute the PM's statement as rhetoric partly accounts for the thesis inception, a desire to challenge the HDI as a world-standard QOL measurement tool, and replace it with a better one using a tool to integrate and manipulate more data.

My skepticism towards the PM's statement was not because I thought there might be a mistake in the numbers; it was because I had different perceptions about quality of life. I wondered if something was missing in the calculation and I wanted to know what that might be. At the time I thought that adding more variables would make the HDI better. With recent experience in cartography and geomatics an idea came to mind that a web-map application might provide a method to analyze quality of life factors and look for ones that were missing from the equation.

The idea that a specific web-map application could be used to construct social indicators began in a geomatics class. Like other attempts to use GIS to make land resource decisions, the tool would follow multi-criteria decision analysis methods and let users apply widgets to interactively alter mathematical formulas that weight variables and display them in a map. By weighting the importance of quality of life (QOL) factors appropriately, and by 'playing' with the relative weights given to importance, both a choropleth map (model) and a formula to calculate the map would be dynamically constructed.

GIS are designed to synthesize multivariate data and there was no evidence that this type of experiment had been done before using physical and social data within a web-map application. By integrating physical and social data, both important factors for understanding social conditions, it was hoped that the tool would complement traditional statistical mapping techniques by giving users a new way to combine cognitive recognition of mapped data with *a priori* knowledge of regional quality of life differences. The U.N. Human Development Index was chosen as a benchmark with which to compare models.

A synthesized map of QOL, interactively created by inputting and weighting other maps of country-aggregated physical and social data, would be compared to the analyst's mental model of world QOL. After looking at their placement in the HDI, my original idiographic mental map of QOL had New Zealand and Cuba, for example, placed much higher in the list (In 2003, they were respectively ranked 19th and 52nd in the HDI). Perhaps things like climate, crime, corruption, access to health care, and stress were some of the more

important factors missing from the HDI which influenced people's feelings about their quality of life. Starting with variables in the HDI (education, life expectancy, and GDP), adding all the country-aggregated data that could be found, and also weighting the variables according to perceived importance, I had hoped that a better QOL model would emerge.

The physical factors like climate would be averaged for each country. The importance of each factor would be adjusted much like tuning to a radio frequency. The right frequency (i.e. the formula) would be revealed when the synthesized map resembled the mental map. It was anticipated that the tool would be simple to build and the only things needed were some country-aggregated data and the right software. Some prototype experiments using Excel and a prototype application with HTML and ImageMap code was conceived. This would allow exploration and postponement of decisions based on choosing the best software options for creating a production application suitable for sharing. Since then, I have lost track of the number of times I have asked myself, what on Earth was I thinking? I seriously underestimated the work involved, and overestimated the returns I expected from the tool.

My epiphany to use GIS techniques for social statistics research occurred while working on a GIS lab assignment in 2002. I thought of a way to integrate and manipulate statistics using multiple layers of data on a digital topographic map. The assignment involved applying heuristic methods to make decisions from multivariate information on a map. It followed a GIS process (Eastman, 1995) called MC-MODA (multi-criteria, multiple objective decision analysis) to

locate and allocate resource areas to hypothetical competing interest groups including a park warden, an environmentalist, and a land developer. The analysis used a two-stage process: a multi-criteria evaluation (MCE) to establish and qualify the mapping criteria, and a multi-objective land allocation (MOLA) algorithm to interactively create suitability maps. MC-MODA applied relative weights of conflicting concepts such as importance of wetlands, biodiversity, development costs, and access to transport, etc. The fictitious competing interest groups (class members) assigned the weights using hypothetical criteria. Roles were assigned as environmentalists who wanted to preserve the land in its natural state, developers who wanted to transform the land for housing development, or park wardens who wanted to do a little of both but for a different purpose – to create paths and boundaries for humans to enjoy nature without destroying it. Originally, the technique was designed to help solve problems related to physical geography and resource management. This led to conjecturing about whether a similar technique applied to social statistics in a world map would help a computer application user by providing information that would aid decisions about conflicting social objectives. Trying to make human geography decisions often has similar challenges to physical geography decisions - it is often difficult to satisfy one goal without compromising another.

Would it be possible for an application to identify trade-offs between social costs and benefits in particular regions? For example, could a computer application that 'holds all the data cards' help to decide where the distribution of foreign aid would be most effective? These types of questions formed the basis

of the research; however most of the questions were put to rest with a simple answer - no. It is far more difficult to understand and measure a social condition than it is to build a computer modeling tool to analyze data.

The long-term objective was an experiment using HDI data (per capita GDP, education, and longevity) augmented with variables, such as wetlands, biodiversity, and land development costs. These would be interactively weighted using a process similar to MC-MODA to create models representing user choices. Although no hypothetical interest groups were in mind; replicating a MC-MODA type algorithm in a choropleth map application to let anyone weight the importance of factors to construct their own QOL model was possible.

Before integrating physical data with social data a preliminary experiment was conceived that would start with just the U.N. HDI variables to create custom HDI indexes. For example, the 2004 U.N. HDI report used a GDP indicator based on a maximum GDP per capita value of \$40,000 per person even though Luxembourg had a much higher GDP (\$63,120). By modifying the U.N.'s formula, a new index that ignored this restriction was possible. Other variables could be introduced into the equation later (e.g. Quality Adjusted Life Year (QALY) or Disability Adjusted Life Year (DALY) data).

Through mathematical manipulation it was postulated that existing social indicators could create new ones that reflect user preferences. One might feel that longevity is very important but only if one were healthy (i.e. not chronically disabled) and enjoyed a good income. A rank combining income levels and average health might have a lower user-model preference to other variables like

food and shelter. It would be up to the user to decide what variables to use; what their relative weights should be; and whether the relationship between variables should be linear or non-linear. It was hoped that these considerations about input variables could mathematically produce a composite indicator of health-income-life-necessities, as a first step. Then other physical factors including climate would be introduced to create a more meaningful QOL index.

After more careful consideration about the complexity of the MC-MODA technique I decided that I should postpone the idea of trying to solve multiple objectives (i.e. what QOL conditions are required in each region?) and focus instead on one objective (what QOL factors are involved in mapping data to a mental model and to what extent?).

2.3 Web-map Prototype

To bring focus to the experiment it was decided to concentrate on the one key social indicator that prompted the initial interest in applying geomatics methods applied to social statistics. A plan was developed to concurrently research the U.N. Human Development Report while developing the software application.

2.3.1 Software

The plan was to begin with a simple prototype application and later implement a long-term solution after reviewing the best options. This solution would include web-based mapping software and an embedded statistics package.

The choice of software for prototype testing, selected because of familiarity, included HTML ImageMap and Microsoft Excel. Several GIS options including ESRI products, MapInfo, and MapServer were initially considered for the long-term implementation. For simplicity Visual Basic was chosen as the programming language. For web-mapping, the preliminary selection was ESRI GIS products because Carleton University had a site licence for most of ESRI's software and it appeared to have many of the components that were needed including a web-mapping application and a statistical interface. Following some experimentation with the ESRI software it became apparent that this option was overly complex for the scope of the project. A trade map application being used on the Cybercartography project at Carleton University was evaluated and oral permission to modify this application for this project was obtained. This required learning a new programming language (PHP) and a new web-based GIS called MapServer. MapServer GIS, however, only worked with a limited set of databases including Oracle, PostgreSQL, and MySQL. After reviewing these options it was decided that the final product selection would be postponed until after the prototype was completed. This proved fortuitous because the Cybercartography project dropped MapServer in favour of Scalable Vector Graphics (SVG), XML, and OpenGIS technology. The prototype using HTML ImageMap was not a GIS and did not require an interface to other components. However, because of limitations with the software it was not possible to implement a dynamic factor weighting algorithm integrated with an HTML web-map. Therefore the data on the maps needed to be pre-compiled and the

interactivity of the planned web-mapping tool could only be described conceptually.

2.3.2 Architecture

Figure 5 – Prototype Architecture

The diagram in *Figure 5* describes the proposal for the long-term client-server architecture. The application would run on the user machine and access the maps and data over the Internet. The output would be displayed to the user in a map window.

2.3.3 Study Area

For the initial prototype application a world vector map (ESRI shapefile) using 2002 political country boundaries was used. This was converted to HTML ImageMap objects using an ESRI ArcView script.

2.3.4 Data and Data Collection

A snapshot of the 2003 HDI data in Excel format, made available on-line by the U.N., was used. The experiment involved modifying the U.N. HDI weighting formula using Excel statistical formulas.

The U.N. HDI Excel data were missing for some countries including Afghanistan, Iraq, North Korea, Somalia, and Taiwan for reasons related to war and politics. Antarctica, and many small island states, were not listed. However a

large majority of the human population was accounted for. Nevertheless, some of the missing countries were in places where human development tracking was most likely a concern to the United Nations.

Figure 6 – Prototype Mock-up

Figure 6 shows a mock up example of the first planned iteration of the web-map graphical user interface. Sliding the bars would change the relative factor weights of the three HDI indexes (currently shown as 1/3 equal weights). As the weights were adjusted the choropleth map would change accordingly with some countries changing categories between high, medium, and low, depending on the recalculated index and new rank. The mock-up was created using HTML ImageMap where each country is a separate image. Actual HDI data was

referenced and displayed on the map. However the sliding bars were just for illustration. They were not operational.

2.4 Excel Experiment

MONITORING HUMAN DEVELOPMENT: ENLARGING PEOPLE'S CHOICES...									
Human Development Index									
HDI rank*		Life expectancy at birth (years) 2002	Adult literacy rate (% ages 15 and above) 2002 ^a	Combined gross enrolment ratio for primary, secondary and tertiary schools (%) 2001-02 ^c	GDP per capita (PPP US\$) 2002	Life expectancy index	Education index	GDP index	Human development index (HDI) value 2002
High human development									
1	Norway	78.9	e	98	f	0.9	0.99	0.99	0.958
2	Sweden	80	e	114	g/h	0.92	0.99	0.93	0.948
3	Australia	79.1	e	113	g/h	0.9	0.99	0.94	0.946
4	Canada	79.3	e	95	f	0.9	0.98	0.95	0.943
5	Netherlands	78.3	e	99	f	0.89	0.99	0.95	0.942
6	Belgium	78.7	e	111	i/g	0.9	0.99	0.94	0.942
7	Iceland	79.7	e	90	f	0.91	0.96	0.95	0.941
8	United States	77	e	92	h	0.87	0.97	0.99	0.939
9	Japan	81.5	e	84	h	0.94	0.94	0.93	0.936
10	Ireland	76.9	e	90	f	0.86	0.96	0.93	0.936
11	Switzerland	79.1	e	88	f	0.9	0.95	0.95	0.936
12	United Kingdom	78.1	e	113	i/g	0.88	0.99	0.93	0.936
13	Finland	77.9	e	106	i/g	0.88	0.99	0.93	0.936
14	Austria	78.5	e	91	f	0.89	0.96	0.95	0.934
15	Luxembourg	78.3	e	75	f/j	0.89	0.91	1	0.933
16	France	78.8	e	91	f	0.9	0.96	0.93	0.932

Table 1 – Human Development Index

After the U.N. HDI data was downloaded in Excel format from the United Nations Development Programme (UNDP) database, Excel formulas calculated custom HDI values. From reviewing the HDI statistics, it appeared that the data used to build the HDI ranking was often based on estimates and assumptions because it was so difficult for the U.N. to collect data. The data tables (UNDP, 2006) provided by the U.N. included rounded numbers that made it difficult to re-calculate the published HDI ranking. For example, the top country in 2002 was Norway (see *Table 1*). Following the instructions for the HDI calculation in *Figure 7*, Norway's HDI should be: $\frac{1}{3}(0.9) + \frac{1}{3}(0.99) + \frac{1}{3}(0.99) = 0.960$. But the value listed is 0.956. A phone call to the U.N. statistics department confirmed that the

Excel data they provide are less precise than the data used in the original calculations.

Figure 7 – HDI Formula

The HDI was recalculated using the exact formulas listed by the UNDP including caveats (see Human Development Index Calculation in *Table 2*). For example Luxembourg had the highest GDP per capita in the world (\$61,190) but the GDP was entered as \$40,000 because this value is considered a threshold. Estimates for GDP were made for several other countries. A precise adult literacy rate for countries with very high numbers was difficult to estimate so the U.N. applied a value of 99% for the top 19 countries even though it was likely closer to 100% for many of them.

Country	United Nations Calculations							
	Life Expectancy Index	Education Index	GDP Index	HDI	Rank			
Norway	0.9	0.99	0.99	0.96	1	0.99	0.964	2
Sweden	0.92	0.99	0.93	0.95	2	0.93	0.942	9
Australia	0.9	0.99	0.94	0.95	3	0.94	0.945	6
Canada	0.9	0.98	0.95	0.94	4	0.95	0.945	5
Netherlands	0.89	0.99	0.95	0.94	5	0.95	0.943	8
Belgium	0.9	0.99	0.94	0.94	6	0.94	0.941	10
Iceland	0.91	0.96	0.95	0.94	7	0.95	0.943	7
United States	0.87	0.97	0.98	0.94	8	0.98	0.949	3
Japan	0.94	0.94	0.93	0.94	9	0.93	0.937	14
Ireland	0.86	0.96	0.98	0.94	10	0.98	0.948	4
Switzerland	0.9	0.95	0.95	0.94	11	0.95	0.940	11
United Kingdom	0.88	0.99	0.93	0.94	12	0.93	0.934	15
Finland	0.88	0.99	0.93	0.94	13	0.93	0.933	16
Austria	0.89	0.96	0.95	0.93	14	0.95	0.938	13
Luxembourg	0.89	0.91	1	0.93	15	1.07	0.985	1
France	0.9	0.96	0.93	0.93	16	0.93	0.932	17
Denmark	0.86	0.98	0.96	0.93	17	0.96	0.939	12
New Zealand	0.89	0.99	0.9	0.93	18	0.90	0.919	20

Table 2 – Human Development Index Calculation

The experiment (see *Table 2*) was to weight the GDP index at $\frac{1}{2}$, and the life expectancy and education indexes at $\frac{1}{4}$ each, instead of an equal three-way split. i.e. weight wealth as being twice as important as education and longevity. The GDP threshold of \$40,000 was removed, elevating Luxembourg way up on

top of the ranking. The *Figure 9* graph shows how countries in the *Figure 8* graph were affected by the new formula:

$$\frac{1}{4}(\text{LEI}) + \frac{1}{4}(\text{EI}) + \frac{1}{2}(\text{Custom GDPI}) = \text{Custom HDI}.$$

Figure 8 – U.N. HDI Graph

Figure 9 – Custom HDI Graph

Experimenting with Excel to calculate custom HDI tables revealed that a small change to any of the indexes could make a big difference to the HDI rankings. Four countries in the HDI range (0.8 to 1.0) became medium countries because their custom HDI value was now less than 0.8. A few medium and low countries moved up or down in the HDI ranking but generally adjusting the formula to apply more weight to GDP had very little effect on the overall values.

The original and custom HDI values in *Figures 8 and 9* illustrate how modifying the HDI value using the custom formula changed the rank orders. The general trend between the two sets of numbers appears to be similar, meaning that there is a somewhat linear relationship between the GDP index and the other indexes.

Using the custom formula, Luxembourg comes out on top by a considerable margin because of its very high GDP (\$61,190) which is almost 1.7 times higher than Norway with the second highest GDP of \$36,600. The relatively high GDP (\$30,130) of Equatorial Guinea elevates the country in the HDI ranking. If the formula was modified to weight life expectancy as more important than GDP, Equatorial Guinea would become one of the lower countries on the U.N. HDI scale because the average life expectancy is only 49.1 years. Because of its GDP, it is classified as a medium country on the HDI scale. With the custom formula weighting for GDP calculated as twice as important as the other two indexes Equatorial Guinea jumps up to near the high human development range.

Figure 9 helps to illustrate how the U.N.'s formula masks Luxembourg's high GDP and Equatorial Guinea's low life expectancy. It also shows how disaggregating the data can lead to discovery. The search for a custom HDI is essentially the opposite – construction, not a deconstruction. It is a search for an algorithm to calculate aggregated data. Its value is in what it represents. The tool would have produced different algorithms representing the weights of different variables, but the numbers produced by the algorithms would be meaningless without an explanation of the weighting choices of each and every variable in the formula.

2.5 Conclusion

Well into the research three significant, but uncomfortable conclusions emerged. One was that I was technically ill-equipped to develop the web program for my experiment. The second was that the experiment to look at regional QOL differences made sense technically but not practically. And the third was that Geographic Information Systems and other computer map applications such as the proposed web-map are not solely based on any determinable theoretical foundation. The theory really depends on how the application is used and what it is used for.

At this point it did not seem possible to develop a naively empirical tool to find a better QOL, HDI, or any other social indicator since it would presume that 'better' is something that could be defined, and because it depended on a notion of objective and accurate data. Although there may be some theoretical foundations to the experiment, the choice of quantitative methods would only

help to produce new numbers without inherent meaning. Upon reflection, I realized that my idea was based on loose '*a posteriori*' opinions about QOL, and a belief that meaning could be extracted from data using technology. QOL should be studied qualitatively. Statistics and maps can help to explain qualitative assessments but this requires a lot of work deciding what data to use or count and exhaustive reasoning. That is, theory is needed first.

Ultimately I came to the conclusion that I wanted my thesis to do more than entertain by showing what a web application to manipulate data could do to a map. I recognized that there were problems with the data in the map, and I wanted to know if, given those problems, I could still learn something from the data. Initially, I wanted to refute the rhetoric of people using the HDI to boast about their country's QOL. After researching human development reports and the different QOL definitions, the HDI took on new meaning. The U.N. has been unjustly accused of using the HDI to represent QOL. My research suggested that there was a strong link between the U.N.'s definition of human development and most contemporary opinions about what QOL means. I wondered whether the HDI actually was a good QOL yardstick despite the issues with defining QOL, collecting data, and gaining international acceptance. Although there are other methods including qualitative assessments, the only way to test the hypothesis within a reasonable timeframe was to switch the experiment to a technical/statistical investigation of the data.

3.0 Human Development Report

Human Development Report 2005						STATISTICS					
Table 1. Human development index											
HDI rank*		Human development index (HDI) value 2003	Life expectancy at birth (years) 2003	Adult literacy rate (% ages 15 and above) 2003 ^a	Combined gross enrolment ratio for primary, secondary and tertiary schools (%) 2002/03 ^b	GDP per capita (PPP US\$) 2003	Life expectancy index	Education index	GDP index	GDP per capita (PPP US\$) rank minus HDI rank*	
1	Norway	0.963	79.4	..	e	101	f	37,670	0.91	0.99	2
2	Iceland	0.956	80.7	..	e	96	..	31,243	0.93	0.98	4
3	Australia	0.955	80.3	..	e	116	f	29,632	0.92	0.90	7
4	Luxembourg	0.949	78.5	..	e	88	g	62,298	0.89	0.95	-3
5	Canada	0.949	80.0	..	e	84	j	30,677	0.92	0.97	2
6	Sweden	0.949	80.2	..	e	114	f	26,750	0.92	0.99	14
7	Switzerland	0.947	80.5	..	e	90	..	30,552	0.93	0.96	1
8	Ireland	0.946	77.7	..	e	93	..	37,738	0.88	0.97	-8
9	Belgium	0.945	79.9	..	e	114	f	28,335	0.90	0.99	3
10	United States	0.944	77.4	..	e	93	..	37,562	0.87	0.97	-6
11	Japan	0.943	82.0	..	e	84	..	27,967	0.95	0.94	2
12	Netherlands	0.943	78.4	..	e	99	..	29,371	0.89	0.99	-1
13	Finland	0.941	78.5	..	e	100	f	27,619	0.89	0.99	3
14	Denmark	0.941	77.2	..	e	102	f	31,465	0.87	0.99	-9
15	United Kingdom	0.939	78.4	..	e	123	fj	27,147	0.89	0.90	3
16	France	0.938	79.5	..	e	92	..	27,677	0.91	0.97	-1

Table 3 – Human Development Report

3.1 Human Development Report Background

The HDI is calculated using social and economic indicators consisting of life expectancy, education, and income per person on a national scale. The report ranks countries by human development score. Canada's number one ranking from 1994 to 2000 fell to number three in 2001 and 2002, down to eighth in 2003, back up to fourth in 2004, and down again to fifth in 2005. *Table 3* is a sample of the top countries in the 2005 HDI report sorted in ascending order of rank (descending order of HDI). It shows the statistics used to calculate the HDI value for each country.

The HDI uses a complex formula that, in summary, tries to measure human development at a country scale based on the average achievements on three dimensions (UNDP, 2005). According to the U.N. these include:

- life expectancy at birth - meant to measure someone can expect to have a long and healthy life
- literacy rate – includes the adult literacy rate (with two-thirds weight) plus combined primary, secondary and tertiary gross education enrolment ratio (with one-third weight), meant to measure education and knowledge potential
- GDP per capita in purchasing power parity US dollars - meant to measure whether someone can expect to have a decent standard of living

Three separate indexes, on a scale from zero to one, using a formula that includes minimum and maximum values are calculated. Summing the three indices and dividing the total by three, calculates the HDI value.

The United Nations Development Programme commissioned the first U.N. Human Development Index in 1990. Pakistani economist and finance minister Mahbub ul Haq and his team created it with support from Indian Nobel Laureate for Economics Amartya Sen. The report was a response to the concern by the U.N. that balancing budgets and payments seemed a higher international priority than concern for people. The first, and subsequent, report, advocated a shift from economic growth towards a concern for equity, sustainability, productivity and empowerment. The U.N. promotes the HDI as an alternative to the simple gross national product (GNP) to measure human development because it accounts for other factors besides income.

Each annual U.N. Human Development Report (HDR) has a theme. The 2005 report theme was *International cooperation at a crossroads, Aid Trade and Security in an unequal world*. It criticized developed countries for not living up to their promises of the 2000 Millennium Declaration to cut extreme poverty in half, reduce child deaths, provide all of children in the world with an education, and reduce infectious diseases by the year 2015. The report's focus was getting back on track to achieve the millennium goals (UNDP, 2005). Although the theme was different each year, the tone and focus of the reports is consistent. The tone is pro-democratic and utilitarian. The focus is to find a way to motivate political action, mostly but not solely, from economically successful democratic countries. The U.N. wanted the reports to influence a change in the way wealth and power is distributed to bring disadvantaged countries closer in line with developed nations.

The theme of the 2004 report was *cultural liberty in today's diverse world*—a challenge (to U.N. member countries) to build inclusive, culturally diverse societies. “Accommodating people’s growing demands for their inclusion in society, for respect of their ethnicity, religion, and language, takes more than democracy and equitable growth. Also needed are multicultural policies that recognize differences, champion diversity and promote cultural freedoms, so that all people can choose to speak their language, practice their religion, and participate in shaping their culture—so that all people can choose to be who they are.” (UNDP, 2004)

Recent reports had argued that human development should be about protecting human rights and democracy. “Human development is first and foremost about allowing people to lead the kind of life they choose—and providing them with the tools and opportunities to make those choices” (UNDP, 2004: v). The 2004 report claimed it had helped to introduce “the human development concept into national policy dialogue—not only through human development indicators and policy recommendations, but also through the country-led and country-owned process of consultation, research and report writing” (UNDP, 2004). Based on the 2005 theme to get back on track, the 2004 dialogue theme was not successful.

The 2004 report advocated political action at local and national levels to help the poor and marginalized promote access to jobs, schools, hospitals, justice, security and other basic services. “Constitutions and legislation that provide protections and guarantees for minorities, indigenous people and other groups are a critical foundation for broader freedoms. But unless the political culture also changes—unless citizens come to think, feel and act in ways that genuinely accommodate the needs and aspirations of others—real change will not happen” (UNDP, 2004: v). The reports did not explicitly say that they were about morality and ethics. However, the way the UNDP structured them, (i.e. these are the problems, here are the moral solutions), suggests that this was exactly what they were about. To correct world injustice, the reports tried to explain the moral choices governments had, and persuade them to make ethical decisions.

3.2 Human Development Index

This HDI research project began with a review of the 2005 Human Development Report (HDR). Two omissions look striking. First, the data in the HDI table lag at least two years behind the report. i.e. the data are from 2003 and before. This should not be a surprise. It is unusual to find completely up-to-the-minute social statistics. However, this could have been an issue if people were not aware that the report they were looking at reflected, in part, conditions in past years and not the current year, especially if there were current circumstances that might already have altered the findings. Second, nowhere in the report was 'Quality of Life' mentioned. The HDR reports discussed issues in the context of 'living standards' but did not get into the debate about defining quality of life. This could be an issue because many people, including myself, had assumed that the HDI and QOL meant the same thing.

The 2005 report explained that the HDI provided a useful entry point into the rich information contained in the subsequent indicator tables on different aspects of human development (UNDP, 2005). The report listed many of the issues including:

- The concept of human development is much broader than can be measured by any single composite index.
- Because of a lack of data, 16 U.N. member countries are not included in the report.
- For a number of countries data are missing from primary international data sources for one or more of the four HDI components.

- The availability of new evidence on the HIV/AIDS epidemic and demographic trends often requires adjustment to earlier estimates.
- Because definitions and data collection methods vary across countries, literacy estimates should be used with caution.
- Though intended as a proxy for educational attainment, combined gross enrolment ratios do not reflect the emphasis of education outcomes. Even when used to capture access to education opportunities, combined gross enrolment ratios can hide important differences among countries because of differences in the age range corresponding to a level of education and in the duration of education programs.
- Grade repetition and dropout rates distort the data.
- As currently defined, the combined gross enrolment ratio does not take into account students enrolled in other countries. Current data for many smaller countries where many people pursue tertiary education abroad could significantly under represent de facto access to education or the educational attainment of a population and thus lead to a lower HDI value.
- The current PPP (converted GDP per capita) data set suffers from several deficiencies, including lack of universal coverage, of timeliness of the data and of uniformity in the quality of results from different regions and countries.

A recent UNDP report more concisely describes the HDI (Johansson, 2004). Johansson explained that the concept of human development has many dimensions. He said the basic, measurable dimensions include health, education, and standard of living. Proposed additions to the HDI, (e.g. political

freedom, environment, and child mortality) either were hard to measure or overlapped with existing dimensions.

The report stated that a single indicator can never capture all facets of human development. The three dimensions in the HDI were equally weighted. Johansson stated that equal weighting was not an accident; it reflected a belief that all three were equally important. On the contrary, a 1991 report on development data constraints and the HDI, discussed the conceptually difficult issue of relative weights of the component indicators in the composite indicator, and stated that despite complex justifications for particular weighting schemes, the ultimate choice was arbitrary (Murray, 1991).

Johansson also suggested that the HDI was not very sensitive to changing weights because, for the full set of countries, the components were highly correlated. He argued that GDP per capita was included as a proxy for a decent standard of living and reflected a number of issues not explicitly included (e.g. the expanding choices available in many areas with increasing income). A logarithm of GDP reflected the diminishing return in expanding choices. He did not explain what he took 'standard of living' to mean.

A political freedom index (PFI) was presented in the 1991 HDR and was meant to be incorporated in the HDI (Johansson, 2004). However, it caused technical and political controversy and ultimately was dropped because of the difficulties of measurement.

Johansson listed a number of key problems with literacy data. It said literacy is conceptually and practically limited. Definition and collection of literacy

information varied widely from country to country. It suggested literacy is culturally specific. i.e. script systems and other factors vary across the world so there is no way to make authoritative comparisons.

Johansson stated that life expectancy does not take into account health, just length. He argues that the HDI has become one of the best known and most used indicators of development, has staying power, and despite some remaining controversies, the HDI is broadly accepted and used by media, policymakers and academics. He said it continues to have both policy relevance and acceptability. However one of the issues that became a recurring theme in my research is that while the HDI is well known, accepted, and has staying power, it is also often conflated by the same media, policymakers and academics.

Johansson listed four characteristics that underpin the HDI: 1. Conceptual clarity that facilitates its power as a tool of communication, 2. Reasonable level of aggregation, 3. Use of universal criteria and variable, and 4. Use of standardized international data explicitly designed for comparison.

The U.N.'s list of data deficiencies was not a surprise, but it was encouraging that the U.N. openly publishes both the data and metadata including problems, assumptions, and caveats. Accepting data at face value without understanding the rationale and problems behind it is the most serious issue in statistical analysis. In *How to Lie with Maps*, Monmonier discusses the ways data and maps can be used to represent the information in different ways to give different messages or meanings (Monmonier, 1991). Meaning, value, or truths are other abstract concepts that are difficult to define or measure. However, after

reading many different U.N. articles, one important intangible consideration that the HDI is valuable and 'meaningful' is the sense that it has integrity. Nowhere does the U.N. appear to conceal the HDI's flaws. The U.N. clearly states that most indicators of living conditions, particularly those using readily available data, are indirect approximations (i.e. surrogates) rather than direct measurements of what they are intended to measure (McGranahan, et. al., 1990). In short, the authors honestly believe what they are trying to say in the HDR reports.

However, HDI is not strictly a measure of human development. Development implies a transition and progress but the report is more often used as a snapshot of where countries rank. Transition and progress happen only if the potential for change exists. Along with economist ul Haq who conceived the original HDI in 1990, Sen was one of the principle developers. In *Quality of Life*, Sen discusses a 'Capability Approach' to achieve a state of well-being. He avoids the term quality of life, and also does not mention human development, but it is clear that he is trying to describe how to measure 'capabilities' for human development (Nussbaum and Sen, 1993). This is one of the early hints that the HDI required variables such as knowledge and income to measure capabilities for well-being. However, the definition of what constitutes human development progress is contested. There are many different interpretations of progress. In addition, many people are strongly critical of the HDI methods and data. In *Damned Lies and Statistics*, Best warns that we often place too much value on social statistics. "In a sense, the social problem becomes the statistic and, because we treat statistics as true and incontrovertible, they achieve a kind of

fetishlike, magical control over how we view social problems. We think of statistics as facts that we discover, not as numbers we create” (Best, 2001). Reality is complicated. Statistical analysis or reasoning tries to simplify that complexity but this often fails.

Another issue with the HDI is that measuring health using only life expectancy, extrapolating education and knowledge potential strictly from literacy rates, and quantifying decent living standards using solely GDP, do not on their own represent what the U.N. intended them to measure. Summing all of these concepts into a new index is a further abstraction from the raw data. Using a formula that includes minimum and maximum values is an added ‘value judgment’ abstraction.

It can be argued that the HDI’s power indeed comes from the criteria listed by the UNDP; it is relevant, well known, generally well respected, and has staying power. It appears that any conflation between the HDI and QOL is most certainly not the U.N.’s fault. A world map of HDI conveys an accurate picture of where and to what extent problems in the world lie and which places need to improve the most.

The next section illustrates that the HDI is used as a de facto standard of QOL and suggests one on the reasons why. The difficulty in defining the meaning of the word ‘model’ is used to argue that defining concepts like human development, well-being, quality of life, and living standards are circular.

3.3 Conflating the Human Development Index as Quality of Life

Many people think of the HDI as a QOL measure whether they use it superficially or rhetorically or as a useful tool. Former Prime Minister Jean Chrétien often used the HDI to boast to Canadians and to the rest of the world that Canada was the best country in the world to live in (see Preface). He is not the first politician to spin something to support a political statement. A small sampling of 'hits' from Internet search engines for the phrase 'quality of life' returned pages containing the following quotes:

*For almost a decade (up to the year 2001), Canada was ranked number one among 175 countries in the United Nation's **Quality of Life** survey. (vec.ca, 2004)*

*UNITED NATIONS: Norway, Sweden, Australia, Canada and the Netherlands ranked as the best five countries to live in but Africa's **quality of life** plummeted because of AIDS, said a UN report released on Thursday. (ETO, 2004)*

*The Human Development Index (HDI), published annually by the UN, ranks nations according to their citizens' **quality of life** rather than strictly by a nation's traditional economic figures. The criteria for calculating rankings include life expectancy, educational attainment, and adjusted real income. (creativecity.ca, 2006)*

*The UN's Human Development Report ranks 173 countries for their **quality of life**, using indicators such as life expectancy and income per person. (bbcnews, 2002)*

*The index is calculated by averaging the values of the three aforementioned components to produce a final tabulation, or ranking, in the world. It thus proves helpful in assessing a country's development by measuring not only economic power, but also **quality of life**. (Morales, 2003)*

*Heading: **QUALITY OF LIFE***

The human development index (HDI), produced by the United Nations Development Programme, is a broader measure of economic and social progress than GDP per head, a more conventional gauge of living standards. (Volgy, 2006)

*Even as India appears to be at the forefront in terms of economic growth, it continues to lag in the **quality of life** as measured by its Human Development Index; it remains unchanged at a low 127 among 177 countries. (hindu.com, 2005)*

*Heading: Top **quality of life** in Norway*

According to the UNDP's most recent Human Development Report, Norway has the highest standard of living in the world. (norway.org, 2001)

The HDI's purpose is to measure human development. However, there is no authoritative standard measure of quality of life or human development. Both 'human development' and 'quality of life' are abstract and ambiguous statements. The HDI has been conflated to mean many different things, QOL being the most common. People most likely interpret the HDI as QOL is because 'Quality of Life' it is a more recognizable personal phrase. It is an easier term to relate to, even

though it is much more difficult to describe. QOL is static whereas development implies a transition and progress. It is easier to describe a static state.

Other HDI connotations include 'well-being', 'living standards', 'the best place to live', 'social progress', and 'the human condition'. In *The Geography of Social Well-being* Smith says that the concept of social well-being is sometimes thought of as synonymous with the quality of life. "But it may be preferable to regard it as being at the more concrete or specific end of the continuum of abstraction that descends from human happiness through the concept of the quality of life to social well-being" (Smith, 1973, 66).

Using Smith's analogy, the HDI may be considered to be closer to the well-being end of the continuum because it measures things (GDP, education, longevity) that are less abstract. 'Living potential' might be a better word to describe the HDI than human development.

However, Smith's proposal to help conceptualize the difference between Quality of Life and Well-being does not help to overcome problems with semantic definition. One of an infinite number of nouns has been selected to illustrate the problem with semantic definition: the word "model".

The original thesis objectives and research questions involved constructing and analyzing models. The word model has multiple meanings. Haggett gives three interpretations of the word. As a noun 'model' signifies a representation. As an adjective 'model' implies an ideal. In addition, as a verb, 'model' means 'to demonstrate'. He suggests that scientific models, to some extent, have all three meanings. "Scientific model-builders create idealized

representations of reality in order to demonstrate certain of its properties. Models are made necessary by the complexity of reality. They are a prop to our understanding and a source of working hypotheses for research. They convey not the whole truth, but a useful and apparently comprehensible part of it.”

(Haggett, 1983: 20). Haggett’s ‘scientific model’ is circular. Haggett uses words such as idealized, reality, scientific, useful, and truth. These words are equally difficult to interpret. Trying to understand the definition of quality of life seems more difficult of a concept to grasp than the definition of the word model.

This issue made me question whether it really matters what the difference is between human development, well-being, and QOL. Should I have been so critical of Canada’s Prime Minister for conflating HDI with QOL? They obviously are related. Despite the fact the HDI was never intended to measure QOL, maybe in some ways it does.

3.4 Human Development Index Criticism

The HDI has a broad and varied target audience. The Human Development reports do not explicitly state whom the targets are but it has been mentioned in other reports that the primary targets include government policy makers. Some common discourses emerged depending on the type of source. There seemed to be a scale of criticism. The less critical opinions generally seemed to be based on comprehension of the issues. I.e. a better QOL indicator than the HDI is desirable but difficult. Most of the harsher criticism seemed to be based on vague notions.

Many sources offered better choices of data to measure QOL without acknowledging that the HDI was not specifically intended for that purpose. As mentioned in the Preface the HDI is not merely a set of numbers, but a carefully crafted metamodel, or metanarrative, reflecting choices and values. There is little evidence that the HDI is understood as a benchmark for human progress. The HDI is placed on either the left or right of the political spectrum depending on the metanarrative of the author. It is often treated with suspicion on both sides. Most articles in economic journals seemed to suggest that the HDI undervalued income, while many social journal articles suggested the opposite.

3.4.1 Wellbeing of Nations

The Wellbeing of Nations: A Country-by Country Index of Quality of Life and the Environment is a holistic approach to combining 180 variables in 27 different tables into one well-being index. The WON data is discussed later in the Data Selection section. Many WON variables were used to statistically test the HDI. The WON synthesizes a human well-being index and an ecosystem well-being index into an overall well-being index. It is critical of many other assessment methods including the HDI because they do not cover the full extent of human and environmental concerns (Prescott-Allen, 2001). The report is also critical of using GDP to measure human progress. Politicians, the business community, the media, and the public misuse GDP as a sign of prosperity and well-being. Prescott-Allen says that GDP is designed to do nothing more than measure the output of the market economy. It has a narrow focus and misses many aspects of the economy including unpaid work, and non-monetary

contributors to human fulfillment for things like health, education, freedom, security, and peace. It also ignores the state of the ecosystem and misses the environmental and social costs of pollution, resource depletion, cancer, and crime or counts them as benefits if they cause money to change hands.

The WON says that, because they are monetary based measures, attempts at less distorted 'green' accounts, such as the System of Integrated Environmental and Economic Accounting, the Genuine Progress Indicator, and the World Bank's estimates of genuine progress are unsatisfactory. When discussing the HDI, the Environmental Pressure Index, and the Ecological Footprint, the report says that despite the advances of major innovations in methods of assessing sustainable development in the last decade or so, assessments continue to lag behind accounts in influencing national policy. These indicators have yet to cover the full extent of human and environmental concerns and distill them into an index as powerful as the GDP.

The Wellbeing Assessment Method covers both people and the ecosystem, and gives them equal weight using a broad range of indicators chosen to represent widely shared values and key properties of human societies and the ecosystem. The report suggests that the HWI is a more realistic measure of socioeconomic conditions than the GDP and covers more aspects of human well-being than the HDI. It says the HDI, with so few indicators, is more susceptible to distortion by missing data, forcing its compilers to provide their own estimates.

The report has the following disclaimer: “It is extremely difficult to take a clear and easily communicated snapshot of something as complex and poorly understood as human societies, the ecosystem, and the interactions between them. There is no perfect or even a best way to do it. All methods entail hard choices about what to focus on and are bound to omit aspects that someone considers important. Problems of data quality and conflicting values mean that crucial parts of the picture are blurred and open to alternative interpretations. Hence no method can provide a definitive assessment, and the Wellbeing Assessment is no exception” (Prescott-Allen, 2001: 10). This argument seems to contradict Prescott-Allen’s earlier criticism that the HDI is insufficient because it does not capture the full extent of human concerns.

3.4.2 Miscellaneous HDI Criticisms

In *Redefining Progress*, Cobb thinks the HDI is useful but it could be improved (Cobb, 2000). Cobb says the HDI would presumably be strengthened if some measure of income distribution were included in the calculation (Cobb, 2000). He argues that social indicators are not direct measures of QOL because there is no way to measure a ‘value’. He says all definitions of QOL are by necessity roundabout or metaphoric. The desire to know purposes of life is impossible to fulfill. Cobb says there will always be disagreement about which metaphors are most helpful in thinking about the nature of value. He thinks future research is needed on possible ethical frameworks and indicators have to be constructed from some standpoint or ideology. The past effort to achieve neutrality and universal acceptance has been a recipe for preserving the status

quo. What indicator is not constructed from an ideological standpoint? There are many reasons for the status quo (the HDI) including relevancy, integrity, and longevity. The status quo will change when something more relevant replaces it.

Neumayer (2004) argued that the HDI should account for environmental sustainability as a measure of current well-being. He explains various proposals and admits all of them suffer from a range of fundamental conceptual problems. He argued that a combination of the HDI and the World Bank's Genuine Savings (GS) index holds great promise for an assessment of well-being and its sustainability, particularly in developing countries (Neumayer, 2004). Several other articles suggested that the HDI should include elements of human security, the environment, equity, employment, and social justice, to use just a few of the examples. Matsui (2004) says that the HDI neglects many aspects of the human condition. His paper suggests that by including poverty, inequality, and the environment as additional components, it is possible to construct a Social Development Index from the HDI. This is a typical example of the opinion that the HDI should do more and 'be' more than it is. The inventors of the Calvert-Henderson Quality of Life Indicators suggest that aggregating "apples and oranges" into one index (like the HDI) is inappropriate and often confusing. The irony of this statement is that both are fruit; why not mix them? They say you cannot measure wealth, progress, and human development in one index. They propose a systems approach to un-bundle central social, economic, and environmental issues into 12 distinctive domains of quality of life (Henderson, et. al., 2000). The Calvert-Henderson Quality of Life indicators measure education,

employment, energy, the environment, health, human rights, income, infrastructure, national security, public safety, recreation, and shelter. However, the Calvert-Henderson QOL assessment is U.S. focused. The report does not discuss the problems or challenges faced by the U.N.

David Suzuki complains that the HDI does not measure poverty, environmental quality, employment, social justice or a number of other indicators that would aid in a true assessment of a country's quality of life. He says to be fair, the HDI is a much better way to measure quality of life than simple GDP. He thinks we need a measure that takes into account GDP, lifespan, education, plus other factors such as poverty, employment, pollution levels and crime. Other non-economic values should be used like: hours spent on free time or time with family, friends and community; volunteer hours; time spent caring for children and the elderly; and more. He says Genuine Wealth Indicators (GWI) or Genuine Progress Indicators (GPI) in his opinion do a better job at measuring progress (Suzuki, 2004). A National Union research paper also preferred the GPI (National Union, 2000). They say the GPI broadens the conventional accounting framework incorporated into the GDP, to take account of the economic contributions of the family and the community, as well as a number of other costs. Both Suzuki and the National Union Research paper conflate the HDI with QOL. There is a lot of agreement that more measures (e.g. poverty, environmental quality, employment, or social justice) would give a better QOL assessment. However the difficulty in collecting this data globally is not discussed.

Experts from the Economic Growth Center at Yale University are critical of HDI as being reductionist and incomplete. They say the HDI is missing variables like political freedom, guaranteed human rights, and self-respect (Ranis, et. al., 2005). They suggested that under-five mortality is a better measure of human development than the HDI. Concepts like political freedom, human rights, and self-respect are very difficult to accurately measure. There is a reason for the missing variables suggested by Ranis. They are very difficult to collect. The under-five mortality rate (U5MR) proves to be a very good QOL variable. This was discovered in the data analysis discussed in section 6.1 with over 90 percent of the variability of the HDI can be predicted by the U5MR data.

Mark McGillivray from the United Nations University has co-authored many papers looking for improvements to the HDI. However, many of his studies discovered that the HDI is better than other measures (McGillivray and Pillarisetti, 2002, McGillivray and Pillarisetti, 2003, McGillivray and Noorbakhsh, 2004, McGillivray and Pillarisetti, 2004). He has proposed some improvements to the HDI such as adding a human security variable. He found that gender related indicators do not tell us much more about human development than the non-gender adjusted ones. A Canada/U.S. government and academic project called *Global Environmental Change and Human Security* argues that significant increases in human security may occur with only small HDI increases. They suggest the Index of Human Insecurity (IHI) may be more useful to measure sustainability, development, and human security than the HDI. The Index of Human Insecurity is a classification system that distinguishes countries based on

how vulnerable or insecure they are using various environmental, economic, societal, and institutional variables. The report says the IHI has a much stronger theoretical base to both human security and development than the HDI, and the HDI may mask much of the variability in human security (Aviso, 2000).

Andrew Sharpe from the Canadian Centre for the Study of Living Standards likes a number of different indicators including the HDI. These include the Measure of Economic Welfare (MEW); the Genuine Progress Indicator (GPI); the Index of Economic Well-Being (IEWB); the Index of Social Health (ISH); the Quality of Life Index (QOL), and the Index of Social Progress (ISP) (Sharpe, 1999). He argues that although the link between better understanding of economic and social trends and progress may be tenuous, social indicators are important because while indexes are arbitrary constructs, when taken together, they do and can provide an accurate picture of general trends in well-being. His research is Canada focused. He says that the criticism of the HDI from both the right and left could be motivated by the fear that the index's good news message may mitigate pressures for the adoption of the policies they are recommending (e.g., tax cuts, increased social spending, etc.).

As previously noted, the critical opinions followed a scale based on how familiar the critics seemed to be with the HDI. For example, a psychologist from the Slovak Republic lists different problems with objective and subjective measures and argues the importance of spirituality. He shows the unimportance of wealth to satisfaction after a certain income (See *Figure 10*).

Figure 10 – Happiness of U.S.A. Citizens

He prefers the Happy Life Expectancy Index (HLE) that measures attained age and experiencing of happiness to the HDI to measure QOL (Kováč, 2004). Kováč seems to conflate QOL with happiness. The link between the number of Psychologists and QOL is not explained. Kováč does not explain what is wrong with the HDI; only that he prefers (the HLE). Many have argued that money (income) does not buy happiness. However analysis of the HDI, reported later, finds a strong correlation between income, life expectancy, and education – all QOL factors. So in some ways, while money may not bring happiness it certainly helps in the QOL equation.

Statisticians from the University of California and Duke University think that a consensus for the best choice of QOL indicators and weights can be established using surveys and a simple model for predicting the extent of individuals' agreement on QOL judgments with other individuals. They think it is possible to create a better QOL index than alternatives including the HDI from real social indicators endorsed by a majority of individuals. The report does not

His hypothesis is that where there is a higher quality of life, there are also a higher number of psychologists and the other way round.

say what that QOL index might be, only that it may be possible to construct it (Hagerty and Land, 2004). A Government of India paper on Gender Development Indices criticizes the GDP component in the HDI because income increases with many negative economic activities like military expenditures, crime, drugs and exploitation of natural resources. The paper also says that income does not measure positive development issues like unpaid family work, and voluntary services etc (Mathur, 1999). They would like the income element removed. Because a GDP number does not tell us how the money is spent, it can mask the benefit of income to human development and can possibly be misleading. However there is statistical evidence (discussed in the data analysis section) that higher GDP goes hand in hand with other QOL factors like health, knowledge, and equity, for example.

Lanteigne (2005) compares HDI in Canadian and U.S. cities. In the 2001 HDR, the student found a reference stating that it is impossible to come up with a comprehensive measure – or even a comprehensive set of indicators – because many vital dimensions of human development, such as participation in the life of the community, are not readily quantified. The UNDP realized that having too many indicators within the index would blur its focus and make it difficult to interpret and use. However, no dimension of human development is readily quantifiable. The HDI uses three variables because adding more might make the index less effective. Salzman (2003), a Canadian Statistician from the Centre for the Study of Living Standards assessed the U.N.'s methods to construct the HDI. She found that the U.N. does use 'best practices'. The report is very detailed and

statistically complex discussing things like the use of “functional forms when the marginal changes in a variable are significantly different within the range of values taken on by the variable in the index. The use of the functional form of log in the HDI, that is, scaling the log of the per capita GDP values is methodologically consistent with the idea that per capita income has sharply decreasing returns to scale. This is an important point made by the UNDP, and the use of the log functional form is a methodologically consistent way of representing this normative view. The use of the log functional form in the HDI is fairly transparent, and is the only non-trivial functional form used on the variables: the other data is simply scaled with LST” (Salzman, 2003).

HDI criticisms in economic journals typically thought that income was undervalued in QOL measurement and articles in social science publications often found income to be overvalued. In the *Harvard-Radcliff's Liberal Monthly* Jaikumar (2001) says the HDI is a flawed measure of human development because it does not include nonmaterial aspects of the quality of life like crime rates or by surveys of people's overall happiness. The HDI may still give too much importance to income because if monetary income is primarily a means for purchasing food, education, and health care, then one's income matters much less when these goods are provided. The HDI also does not examine how well these things are distributed between social classes, between regions of the country, and between genders (Jaikumar, 2001). Jaikumar is correct in arguing that the HDI does not examine distribution between social classes, or how the money is spent. However no argument is presented about what importance

should be placed on income. In a Ethics@Work column a Rabbi (Meir, 2004) disagrees with the GDP component in the HDI. He says it (hard currency) does not contribute much to well-being. He thinks that the GDP component should not be part of the HDI. Again, No argument explaining what contributes to well-being is presented.

The Fraser Institute argues that the HDI is little more than a tool for rhetoric citing Canadian media hype. They argue that when you change the variables slightly, you change the results drastically. The report says that GDP calculations undervalue economically advanced countries, and it tries to compare apples to oranges. It uses the example that some of the indices are in years, others in dollars, and others in percentages. They question the HDI scale as a set of 'value judgments' that should be acknowledged as such (TFI, 2003). However, the value judgments are acknowledged. The criticism of HDI rhetoric is itself rhetorical. Nothing is offered as a better alternative to the HDI. The Fraser Institute's argument, that when you change the variables slightly, you change the results drastically depends on what 'results' they are referring to. An experiment discussed in section 2.5 – Excel experiment, shows that adjusting the weights of the HDI components does not drastically alter the HDI values, but it does change the rank order.

Montenegro (2002) found that the HDI is not a good economic development measure. He says the various modifications and methodological changes to the HDI over the years can make its credibility suspect and diminish its usefulness for inter-temporal comparisons. The Colombian economist is

correct in saying the HDI is not a good economic measure; it was never intended to be one. HDI modifications over time should not undermine the reports credibility because the HDR reports provide an HDI table for temporal comparison calculated with consistent methodology. Another article with an economic focus states that a quick look at the HDI seems to support the idea that diversity has its costs. It says the bottom 35 countries ranked as having “low human development” are concentrated in multi-cultural, multi-ethnic Africa. The top of the HDI list includes rare single-ethnicity states like Norway, Sweden, the Netherlands, Japan, Ireland and Austria (Economist, 2004). The article does not explain how diversity manifests itself into lower human development but using the word ‘cost’ implies that cultural diversity is a negative human development factor. Although he was unable to find a suitable indicator to include culture Prescott-Allen (2001: 36) suggests that culture (a society’s systems of belief and expressions) is actually a positive QOL factor.

A Canada/New Zealand University paper on economic planning uses economic models to argue that economic policies based on the HDI emphasize expenditures on education and health over other things that would reduce inequality (Engineer, et. al., 2005). The paper does not explain what those other things are. A publication called the Daily Bruin explains that life quality depends on perspective because the results vary significantly between the HDI and the Economist's index, which places Ireland at the top and Zimbabwe at the bottom. Ireland was ranked in 8th place and Zimbabwe 145th out of 177 countries in the 2005 HDI. The article states that the Economist's index, being a mixed product of

human and statistical data, has more human input than the United Nations HDI. It warns that some of the factors in the Economist index are based on hard statistics and others could be called arbitrary. For example, material well-being is based on GDP per person while family life is based on divorce rate (Foxman, 2005).

Moving down the scale of HDI criticism revealed several opinions that were frivolously non-sensical. There were some articles that attacked the HDI's credibility. The web page sustainableworld.com lists reference data problems including country name spelling mistakes in the HDI table (sustainableworld, 2003). Spelling mistakes are not uncommon in any database. A few name spelling mistakes should not be a gauge to the credibility of the HDI. A Canadian blogger sarcastically challenged Canada's number one HDI position saying, "Virtually everywhere could be determined to be "best" depending on the criteria used to determine "best-ness." Greenland and Antarctica, for example, might be locked in competition for the "Best Country" had the criteria focused upon the needs of those with serious hay fever." (Benson, 2005) The author much prefers the *Economist* 'life satisfaction' survey to the HDI as a measure of the best place to live.

An article in a weekly Cairo publication is very critical of U.N. policies promoting genetic engineering to solve poverty. It complains that the HDI only measures aggregate levels of development. "It, therefore, lumps the good with the bad, the high with the low, averaging out unsightly bumps. In this sense, even

the HDI's 'good news', by definition, veils a more sordid reality" (Weekly on-line, 2005).

Several articles used the HDI to illustrate a point. In a PhysicsToday.org article, the author quotes Alan Pasternak of Lawrence Livermore National Laboratory who compared energy usage in the 60 most populous countries for

which the U.N. had an HDI. He said that those nations contain 90% of Earth's population and found a correlation between electricity consumption and the HDI (see *Figure 11*).

Figure 11 – HDI – Electricity Scatterplot

His analysis showed that the HDI reached a high plateau when a nation's people consumed about 4000 kWh of electricity annually per capita, a value unchanged between 1980 and 1997. Pasternak concludes that reaching the goal of basic human well-being in poor countries will require "significantly greater global consumption of electricity and primary energy than Department of Energy projections for 2020 (Benka, 2002). Fanchi (2004) produced a similar energy/HDI chart.

As mentioned in the preface, the HDI has become a metanarrative of different 'meanings' because of political discourse (e.g. bragging rights by rank).

Justus (1995) used the HDI formula as a proxy to argue that if Canada is number one, and based on the HDI criteria to compare Atlantic Canada to other provinces, then Atlantic Canada would be ahead of the US and Japan in Human Development. A Virginia community publication called VitalSigns argues that the HDI and other reports mislead Americans into thinking that there must be a better place to live. The report suggests linking QOL research with the concept of sustainable development (VitalSigns, 1999). Many people (e.g. Prescott-Allen and Neumayer) agree that sustainable development should be tied to QOL research so this is not a novel suggestion. However the statement that the HDI could be misleading Americans into thinking that there must be a better place to live is an interesting perspective. It suggests that the author thinks that the U.S. is the best place to live and the HDI challenges the perception. An *Environment Times* report about human development in the Arctic complains that the quality of life values most important to indigenous Arctic residents involve maintenance of traditional hunting, gathering, and herding practices. GDP per capita cannot measure the health of these subsistence systems. Literacy rates do not capture extraordinary knowledge outside of education and school enrollment. A shorter life rooted in traditional activities may be preferable to a longer life spent trying to adjust to the loss of a deeply valued lifestyle. The author suggests that Arctic residents have come to doubt the usefulness of the HDI to measure their development (Young, 2004).

The Government of Australia cautions that given the comments by analysts (about the HDR), such as Ian Castles, it needs to be read in the light of

other research (Woods, 1999). The Zealand Government Treasury dismisses the HDI as a proxy for living standards because McGillivray, in 1992, presented a case that the HDI is no better than income (NZG, 2005). Both of these comments criticize the HDI without explaining the criticism. They cite other author's criticism as the reasons for being cautious. It is not the HDI per se that is being criticized; it is the HDI's virtue. The South Africa Government Statistics department does not like the 2005 findings that conditions of life in South Africa have deteriorated. They argue that while the HDI represents an advance over purely economic comparisons, it is still unable to capture the complexity of national development processes and compare these across countries. The statistician-general tabled misgivings at the U.N. Statistics Commission in March in response to the Human Development Report released in 2004. The statistician questioned the reliability and consistency of some of the data used in computing the HDI. They argue that data, used to calculate South Africa's ranking in the 2005 HDI, was from mostly unofficial sources extracted from pre-2003 statistics. They suggest the U.N. uses poor 'recycling' practices to derive unavailable data from other periods without explicitly explaining the extrapolation methods. "Without explanation, the report ignored the mid-year estimates of an infant mortality rate of 43 per 100 000 people, quoting instead a rate of 53 per 100 000" (Lehohla, 2005). This report challenges the HDI using infant mortality with an explanation that is not based on infant mortality. IMR is calculated using a formula of number of infant deaths (less than one year of age) divided by the number of live births multiplied by 1000. The statistics mentioned are not IMRs. This is a case where the HDI has

injured some pride in the country. It illustrates the importance Government's place on their ranking compared to the HDI value. The UNDP is neither malicious nor careless. An article in an Icelandic on-line publication called *In Focus* boasts that the number two HDI position "confirms Iceland's place among the top 10 to 20 nations when it comes to quality of life." (InFocus, 2003) There are many other examples of rhetorical HDI use. Former Prime Minister Chrétien might hold the record for rhetorical HDI comments.

Several economists, students, and teachers, etc., think both the HDR and HDI are educational, predictive, and useful (Gibbs, et. al., 1998, Heylighen and Bernheim, 1999, Fos, 2004, Rasmussen, 2005, Kolenikov, 1998). A Homeless People's advocate criticized the findings (not the HDI) of the 1998 report saying, "the good life here is limited to middle- class Canadians who are not affected by the growing gap between rich and poor." He pointed out that the report did issue caveats about Canada's top spot, warning of the growing income gap and of the need to deal with aboriginal poverty and social issues (Boland 1999).

The Sustainable Human Development project in Jordan says that the HDI reflects essential developmental elements and remains more comprehensive in measuring the quality of life than any other statistical indicator. SHD agrees with the GDP "discounting" process that calculates the logarithmic average per capita income for each country because it give less weight to additional income units and, according to the Sustainable Human Development theory, there are diminishing returns for income in improving the quality of life (SHD, 2005).

Development experts from France point out that the HDI has helped show significant QOL improvements since the 1950's. They think well-being can better be measured objectively in real terms of health and life expectancy, etc. than subjective measures. They also think that development assistance has played a significant role in human development (Severino and Charnoz, 2003). As will be discussed under section 4.2 - *Defining Quality of Life*, the words objective and subjective raise many issues. However, this is one of the few reports where the HDI is used as intended – to track human development progress.

In summary, the most critical articles were disapproving of the HDI because the authors did not agree with the variables or methods to assess QOL. Only one article (Cobb, 2000) argued that social indicators were not direct measures of QOL because there was no way to measure a 'value'.

Most of the criticism was trivial such as complaints about name spelling mistakes in the HDI, and others complaints about methodology due to incorrect data assumptions without an explanation of why they thought the assumptions were wrong. Many critics misunderstood (i.e. conflated) the HDI as QOL and suggested alternatives that had nothing to do with human development.

The HDI is a policy tool that has captured the attention of philosophers, politicians, economists, journalists, scientists, statisticians, environmentalists, social activists, psychotherapists, and entrepreneurs, etc. How the HDI is framed seems to depend on the ideological stance of the user.

4.0 Quality of Life

Originally I too thought the Human Development Index was a global Quality of Life yardstick. The human development report was like a yearly report card that showed us where nations ranked with each. The HDI is solely based on income, life expectancy, and education factors. When I started working on the thesis my focus was on creating a tool that would combine maps and statistics in a web application and make it easier to manipulate data to discover its 'meaning'. I thought I could create a tool that would help to find other ingredients to explain quality of life. I eventually came to appreciate that meaning cannot be squeezed from data. At the time, I only intended to experiment and look for new methods to manipulate data. But I began to realize that to find a better QOL index I must take a philosophical stand. There was no utility in mixing numbers unless those numbers had meaning.

4.1 A review of David M. Smith's Work

Smith convinced me that things that he deemed important like equality, access to opportunities, and community spirit are some of the most critical components to well-being however these things are the most difficult to measure. During my research I discovered that Smith struggled with similar issues that I encountered. He started out with quantitative methods because he recognized areas with human inequality and wanted to account for the variation. Later in his career his methods became more qualitative in nature because he could not produce explanations using statistics.

Smith's moral message in his later work is "the imperative of developing more caring relations with others, especially those most vulnerable, whoever and wherever they are, within a more egalitarian and environmentally sustainable way of life in which some of the traditional strengths of community can be realized and spatially extended" (Smith, 2000: 208). Smith's views resonate with my thinking about Quality of Life and the possibilities to improve it globally. Since Smith has a background in measuring well-being and has evolved his thinking over a long career I felt I had an opportunity to learn from his mistakes. This section is an outline of some of Smith's work and how it has influenced my data selection and analyses choices.

4.1.1 Measuring Well-being

After reviewing some of Smith's most recent books and looking back at his earliest work it is apparent that his views and methods have evolved. One of his first publications *The Geography of Social Well-Being in the United States – an Introduction to Territorial Social Indicators* (Smith, 1973) dealt with the need for a standard measure of social indicators to evaluate social problems. The difficulty was agreeing on the standard. Problems involved the level of aggregation needed (i.e. scale and time period). In this book, Smith uses case studies at different scales and discusses pros and cons of different alternatives. He also applies multivariate statistical techniques and other mathematical models (i.e. quantitative methods) to evaluate social well-being. Smith admits that "no rigorous interpretations of cause and effect relationships are offered, and no fresh solutions to contemporary problems are proposed (Smith, 1973: xii). He

emphasizes at a theoretical level the need for using other criteria besides economic data to measure well-being. The book is an early indication of his social perspective. He says a revolution is required to correct injustices in society but admits “it is one thing to propose a grand ideal, but quite another to achieve it” (Smith, 1973: 141). After reviewing this book, it was apparent that trying to use maps and numbers to show cause and effect was extremely challenging. This was not a surprise. But it was the first time I began to contemplate whether my original thesis idea to create a web-map application might not be a useful tool to study QOL because I was ignoring qualitative aspects. I started to wonder if my software/data focus might be clouding my judgment.

In the early 1970's Smith came across as an advocate for change. He recognized there were social problems in the US that had not been measured and he wanted to use maps and statistics to illustrate the problems. I agreed with Smith that economic numbers alone were insufficient to measure well-being. But I had not given any thought about what the problem was and what needed fixing.

I started to realize that I agreed with Smith's philosophical arguments and the things he was advocating. My focus began to transform from building a data processing experiment, toward a quest to learn about my philosophy and what I should advocate. In other words, rather than focusing on creating a better QOL index, my end goal started to turn toward trying to understand what QOL really means to me.

4.1.2 Measuring Inequality

In *Where the Grass is Greener – Geographical Perspectives on Inequality* Smith (1979) provides a geographical perspective to describe inequality using quantitative methods to measure infant mortality ratios. Smith discusses some patterns (e.g. north-south on the world scale, urban-rural on the regional scale) that clearly indicate differences between advantaged and disadvantaged regions. Case studies are used “to exemplify problems of inequality in different kinds of societies” (Smith, 1979: 12). He describes the spatial distribution of resources and wealth and what makes the world unequal including economic drivers and social factors. In a section titled *Socialist Countries: Where some are more equal than others* (Smith, 1979: 148), Smith explains that the “principles of Marxism-Leninism that guide development in socialist societies place great stress on the reduction of inequalities among regions” (Smith, 1979: 148) but social engineering policies have often failed – “the removal of inequalities (in the Soviet Union) is still a future aspiration, sixty years after the October revolution” (Smith, 1979: 149). Regional inequities within nations and within cities and neighborhoods are described. Case studies from the U.S., Great Britain, Peru, and Eastern Bloc socialist countries are used. Access to health care is compared (and differentiated) on the international scale. Smith says that in his opinion “most of us would like to see a more equal world” (Smith, 1987: 346) and describes a plan ‘for the promotion of equality’ based on re-allocating resources. This plan “recognizes the leading role of the major corporations within individual nations” (Smith, 1979: 351) and the power and ‘parasitic’ nature they impose.

While the state of the world has changed somewhat since that publication (e.g. the failures of socialism have been replaced by failures of capitalism in Russia after the collapse of the Soviet Union), inequality remains.

4.1.3 Opportunities of Power

In *Geography, Inequality, and Society* (1987) Smith explains the shift of emphasis in geography from aerial differentiation to spatial organization (and quantitative techniques) and a re-direction toward human geography in the late 1960s. Case studies and quantitative modes (e.g. statistical trends) are used to illustrate uneven economic distribution (and inequality) between regions and the consequences of those differences (e.g. social pathology). He explains uneven development by examining aerial differentiation of spatial patterns such as resource endowment, political structure, and economic systems. He goes on to describe the “interdependence of space and society arising from the uniqueness of place and the people there at particular times” (Smith, 1987: 39). He argues that “position in the spatial organization or reorganization of the economy” (Smith, 1987: 52) is more important than regional resource endowment. But position alone is not enough “with one-third of (Hancock County, Georgia) families below the official poverty level only fifty miles or an hour’s drive from Atlanta – the symbol of Sunbelt prosperity” (Smith, 1987: 52). Atlanta is used as a case study to describe “the geographical selectivity of capital as it moves around a surface of differentiated opportunities for profit” (Smith, 1987: 67). He explains that for many people “quality of life arises only in a trivial sense from place itself: what matters far more is their position in the interdependent

structures of spatial and social relations” (Smith, 1987: 68). Advantages given to the ‘urban specialist class’ in the USSR are created through the vested interest in maintaining the “privilege of place associated with restricted access to cities in general” (Smith, 1987: 87).

4.1.4 Ethics and Morality

In some of his more recent work Smith advocates a movement towards geographically sensitive ethics during his exploration of the interface between geography, ethics, and morality where he discusses their historical and spatial aspects (Smith, 2000). He distinguishes morality and ethics in geography. “Ethics is the same as moral philosophy” (Smith, 2000: 10) or “the conscious reflection on our moral beliefs” (Hinman 1994: 5). Morality is the practice of ethics. “Morality is what people actually believe and do, or the rules they follow” (Smith, 2000: 10).

Smith explains the term metaethics – which “considers what it means to engage in ethics: what moral argument is all about” (Smith, 2000: 11). Metaethics is difficult to engage because it is complicated by enormous differences among philosophers. Most of the large problems with metaethics arise “from the apparent incompatibility of alternative moral theories” (Smith, 2000: 13). Metaethical relativism deals with a claim that “there is no reliable way of knowing what is right or wrong, making cross-cultural evaluation impossible; some ways of life may be better or worse than others, but this cannot be demonstrated” (Smith, 2000: 15). This recognizes that beliefs in what is right or wrong differ between people and cultures. However Smith also suggests “another approach

with obvious geographical appeal is to accept the universality of certain grand moral sentiments or values and to recognize the spatial (and temporal) particularity of their application” (Smith, 2000: 17). In other words Smith suggests there are ‘universal moral beliefs’ that can be recognized and accepted. This is difficult to do. However I believed we could start with basic principles like opportunities for access to food, shelter, health care, and the right to live in peace. I also thought it was possible to count these things at a national average.

Smith offers that “the geographer’s traditional preoccupation with the diversity of human life can readily be applied to moral thought and practice” (Smith, 2000: 18) and finding differences does not deny commonalities. He thinks that systematic considerations of ethics in professional geography should be treated separately because of its large scope. Smith borrows from MacIntyre to explain the changing understanding of moralities and ethics over time and the “importance of the historical and social context, and hence the interdependence of moral philosophy and sociology, recognizing that moral concepts change as social life changes” (MacIntyre, 1998). An example of changing moral values is a shift from small-scale societies to the city-state in ancient Greece. Skill, courage, cunning, and that were considered moral came to be viewed as anti-social during this shift. In the historical context Smith says that “as we have already observed, it is working between the universal and the particular that morality is created, lived and understood. This is the central truth of ethics in a world of difference” (Smith, 2000: 44). In other words, morality is not fixed; it depends on time and place. Decisions about what factors are important to QOL in an ideal world model

must be sensitive to the context of space, time, and circumstances in determining what is considered moral.

On a grand (generalized) scale disparity between and within nation-states is due in large part to moral decisions made by the more advantaged population. Morality is an abstract concept that is more difficult to measure than equality-inequality. But morality started to become an important consideration of my mental QOL model. Moral decisions lead to different equality-inequality and QOL outcomes.

4.1.5 Community

Smith describes how a 'moral order' is established in the context of landscape, location, and space using a case study from the city of Łódź in Poland in the nineteenth century. He shows how this "landscape reflected the consolidating class structure of capitalism" (Smith, 2000: 59). Smith thinks proximity in localities and communities is important because "morality favors close people over more distant (and different) others" (Smith, 2000: 73). Distance affects the concept of 'community'. He also thinks it is possible that the world could aspire to create a sense of a world community. "Life would surely be better if the concern for persons in close proximity conventionally associated with community could be transformed into a spatially extensive beneficence, in the sense of actively caring for more distant others in need" (Smith, 2000: 93), i.e. a global community of caring. Smith uses the German holocaust of Jews as a vivid example that explains why separation of Jews from the community into ghettos and fierce propaganda was used to distance them from moral Germans, i.e. if

you keep them too close they just might become friends. Jerusalem is used as an example that Smith draws on to explain the difficulties of creating communities within the divisions of geographical contested space (e.g. territories, borders, etc.) Within this space there is a struggle between not only Palestinians and Jews, but also between the ultra-orthodox Jews and moderately religious Jews. The orthodox Jews expand their scope of territory using religious persuasion and dress codes, etc.

Community is often associated with positive (good), participatory, grass roots cooperation between people that share space or common interests. A counter argument is that there are different types of 'community' that have come about (were constructed) through modernity and are complicit with capitalism and the operations of the marketplace (Watts, 2004: 197). One of the most difficult challenges in creating a quality of life model to replace the HDI is to integrate the concept of community.

4.1.6 Inherited Opportunities

A key point that Smith raises in his book *Moral Geographies – Ethics in a World of Difference* (2000) is that where you are born has a lot to do with your life chances. In ancient Greece "it was recognized that achievement of the good life might not be entirely a matter of individual volition" (Smith, 2000: 138). Throughout history the lucky have inherited this fortune from their parents, but "for most people the capacity to change their place, from poorly to richly endowed, may be as limited as it is to change their gender or skin pigmentation" (Smith, 2000: 141). Smith is optimistic that in the process of engaging the

specific manifestations of inequality in particular societies in a manner that facilitates comparison and generalization “contextual thickening will take place, as understanding of the particular society is built up” (Smith, 2000: 155). He says the findings can then be related to others and quotes Fisk, “past resolutions begin to lay a basis of formulating principles of justice that achieve a higher level of universality than what would be involved if cases were taken in isolation” (Fisk, 1995: 227). From an ethical perspective this ‘luck of the draw’ should not determine our QOL chances but it does.

4.1.7 Basic Human Needs

Smith reviewed various socio-economic development model strategies. One of them is John Friedmann’s ‘morally informed’ framework that suggests that “everyone is entitled to adequate material conditions of life and to be politically active subject to their own community, based on the three foundations of human rights, citizen rights, and the notion of human flourishing” (Smith, 2000: 161). But Smith counters that considering Friedman’s relativist stance when it comes to implementation, “poor countries are unable to afford what might be considered basic needs” (Smith, 2000: 161). Smith uses a case study of post-apartheid South Africa to illustrate ethical perspectives of development and some of the positive initiatives to resolve moral questions including the Truth and Reconciliation Commission (TRC). But Smith also thinks much more needs to change in South Africa “in which those with more wealth and power not just accept having less, but welcome this as a means to a better quality of life” (Smith, 2000: 176). Although there are many factors involved, at a community

level there must be a trade-off between wealth and power, and peace and security. The problem at the national level is that wealth and power to achieve peace and security has proven ineffective.

Upon reflection I started to think that my idea was more of a solution that was looking for a problem to solve rather than the other way around. I thought I could modify the tool to do things without first having a clear understanding of the problems that needed to be solved. Data was like a bank vault of information and data processing tools were the instruments to open the vault and get to the meaning. Smith looks for the meaning first then, if this happened to be an effective option, does the best that he can to collect information to answer his questions.

4.1.8 The Environment

Smith brings the physical side of geography into his discussion of environmental ethics and some of the problems faced by environmentalists including the 'not in my back yard' attitude. One of the problems with environmental ethics is that it tends to be preoccupied with philosophical issues at the expense of solving actual environmental problems. Smith says that "whatever the future of environmental ethics, and of life on this planet, recognition of caring within community as a virtue capable of incorporating nonhuman nature should be a moral imperative" (Smith, 2000: 196). One of Smith's statements accentuated the issue I was having. I was grappling to understand philosophically why I was losing interest in my original experiment. My preoccupation with technology was slowing me down. I finally recognized that

there were a lot of people like Smith out there that have spent their life's work trying to understand the issues, and correct injustices. My moral decision was to stop considering that my technical skills somehow held the keys to higher knowledge.

4.1.9 Summary

Smith helped me understand that quality of life is not a formula waiting to be unlocked. There are important ingredients besides food and shelter including aspects of equality, community, and care for the environment. But the ingredients alone give us only a glimpse of the meaning of QOL. I started to question whether adding more data variables or finding new ways to look at data would tell me anything more about QOL than the HDI. Maybe the HDI does a pretty good job on its own.

4.2 Defining Quality of Life

There are dozens of QOL definitions in journal articles, books, reports, and on the Internet. Here are some examples.

A web site devoted to explaining QOL lists over 50 QOL attributes in a glossary beginning with 'Ability' and ending with 'Working Conditions' and argues that QOL is all of these things (gdrc.org, 2006). The site lists several other definitions including: QOL may be defined as subjective well-being. Recognizing the subjectivity of QOL is a key to understanding this construct. QOL reflects the difference, the gap, between the hopes and expectations of a person and their present experience. Human adaptation is such that life expectations are usually

adjusted so as to lie within the realm of what the individual perceives to be possible. This enables people who have difficult life circumstances to maintain a reasonable QOL (gdrc.org, 2006).

Quality of Life is tied to perception of 'meaning'. The quest for meaning is central to the human condition, and we are brought in touch with a sense of meaning when we reflect on that which we have created, loved, believed in or left as a legacy (Frankl, 1984).

As in the previous definition, one must first understand what 'meaning' is to understand how it 'is tied' to the perception of meaning. This opens up the same issues as with understanding the word model with circular definitions.

Psychologist Joseph Sirgy (2002) gives a more structured, but no less complex explanation of QOL. Quoting fellow psychologist R. Lane, he says QOL is the relation between a person's subjective and objective sets of circumstances. The subjective set, of a person reflecting a high QOL, involves nine elements: (1) capacity for enjoying life, (2) cognitive complexity, (3) a sense of autonomy and effectiveness, (4) self-knowledge, (5) self-esteem, (6) ease of interpersonal relations, (7) an ethical orientation, (8) personality integration, and (9) a productivity orientation. The objective set of circumstances includes the quality of the environmental conditions representing opportunities for the person to achieve subjective quality. Sirgy lists nine environmental conditions including (1) adequate material support, (2) physical safety and security, (3) available friends and social support, (4) opportunities for the expression and receipt of love, (5) opportunities for intrinsically challenging work, (6) leisure opportunities that have

elements of skill, creativity, and relaxation, (7) available set of moral values that can give meaning to life, (8) opportunities for self-development, and (9) a justice system that is managed by disinterested and competent parties.

Sirgy states that Lane believes the nine subjective elements are the hallmark of mental health and social responsibility and they describe the psychological makeup of a person. They are responsible for our sense of subjective well being and societal development. He goes on to prescribe strategies to measure and obtain higher subjective quality of life.

QOL is often split into objective and subjective circumstances. Other dichotomies such as physical and psychological, or quantitative and qualitative try to separate the abstract from the less abstract. This implies that there is some boundary between the two and some way to tell the difference. But what is the boundary between the objective and the subjective? The boundary disappears as soon as you look for it.

Although the term 'human development' is not the same as QOL, conceptually it is similarly difficult to define. The Dictionary of Human Geography devotes over a page to defining what human development is (Johnston, et. al., 1989: 103). It starts by saying development is a process of becoming and a potential state of being. A more concise United Nations definition of human development is "a complex concept of development, based on the priority of human well-being, and aimed at ensuring and enlarging human choices which lead to equality of opportunities for all people in society and empowerment of people so that they participate in - and benefit from - the development process"

(UNDP, 1996). This definition is a little more helpful but it gets into the same sort of issues defining the word *model*. How do you define 'complexity'? What is well-being and how is the prioritized? How do you measure equality? What 'opportunities' are they talking about? Does society imply 'the global society' (i.e. everyone) or a particular society. If it implies everyone, why use the term? What does empowerment mean? If 'development' means to recursively participate and benefit (from the development process), how can you tell what direction you are going in? (I.e., participate in or miss out, benefit or lose, progress or regress?)

As with semantics and definitions, one other thing I struggled with was trying to understand why I cared about and wanted to map national quality of life numbers in the first place. What would I do with those numbers? In the back of my mind I thought that an ideal world model could be constructed using multi layer map technology. I later realized that I was missing the most critical element – the information. To use a car analogy, I had the Porsche but I had not thought about how to refine the gas to make it run.

4.3 Measuring Quality of Life

The dilemma of coming up with an accepted QOL standard definition has not stopped people from trying. There are almost as many definitions about defining QOL measurement, as there are definitions for QOL. Here are some examples:

One recommendation on the GDRC (gdrc.org, 2006) web site to measuring QOL is: The best way of approaching quality of life measurement is to measure the extent to which people's 'happiness requirements' are met - i.e.

those requirements which are a necessary (although not sufficient) condition of anyone's happiness - those 'without which no member of the human race can be happy' (McCall, 1975). McCall was really trying to say that we should start with the basics. i.e. the most necessary requirements. But no suggestion is given as to what those requirements might be. McCall's explanation about how to measure quality of life illustrates the problem that definitions of abstract concepts tend to be recursive with other equally abstract concepts.

Irina Malkina-Pykh (2001) argues that quality of life is, by definition, a subjective concept, dependent on cultural perspectives and values. These values, derived from our individual perspectives, are the attributes that we believe are functionally important, morally good, or personally desirable. She says that our age, ethnicity, gender, socioeconomic status, education, health, religion, occupation, etc shape our perspectives. Our personal experiences lead us to different beliefs about what is important, good, or desirable (Malkina-Pykh, 2001).

The approach to the measurement of the quality of life derives from the position that there are a number of domains of living. Each domain contributes to one's overall assessment of the quality of life. The domains include family and friends, work, neighborhood (shelter), community, health, education, and spiritual (gdrc.org, 2006).

There are essentially two perspectives taken in quality of life research: social indicators research which considers the elites' valuation of what people

need, and conventional quality of life research which studies what people actually want, in order to improve their quality of life (Mukherjee, 1989).

I did not find any particular approach or strategy to define or measure QOL that is more convincing than the others. The number of perspectives could be infinite. There are issues with all of these definitions because they use words like objective, subjective, well-being, feelings, happiness, hopes, and meaning. If you have to use abstract words to describe another, the description becomes recursive. It is interesting that these abstract and ambiguous definitions all seem to argue that QOL is a state of mind – the same thing as a subjective interpretation. Things that might be considered as objective factors, like food and shelter, are precursors to QOL, and may be our best bet in deciding what to count.

4.4 Quantitative Methods Theory

To build something, and then demonstrate its value, requires an interpretation of merit that is always based on a pre-conceived notion of utility. There must be a theoretical foundation for any type of construction; otherwise we would not know we are building something. I therefore decided that I would establish a theoretical position, and then work toward a design and implementation to demonstrate its utility. My approach to try to research and choose the best theoretical position for my project actually led me down several unnecessary and sometimes agonizing paths. It would have been easier had I understood information theory before trying to build an information tool.

The initial research plan was broken down into three steps:

1. Research the theory and application of the Quality of Life Indicators in the U.N. Human Development Index Report.
2. Develop a web-based map application that allows users to interactively alter the formulas and see the changes in the map. I.e. create custom human development indexes.
3. Report the results.

I made the mistake of trying to do the first two steps concurrently when they should have been done sequentially.

My original view was that my project fell into the realm of Cartographic theory because it involved mapping and information. I decided that, for the time being, it was best just to call my project an empirical statistical mapping experiment until I had a better idea of its theoretical basis. The original choice of theory did not quite fit because my application involved more than the principles of cartography, cartographic communication, and map design. My list grew rapidly to include GIS theory, Cybercartography theory, Spatial information theory, and Social theory for example. Deciding a single theoretical umbrella for a project involving many different technical and social aspects was inconceivable. I decided that it was likely that many different theories would come into play and I would begin by trying to inventory them. I began by researching books on Geographic thought and the more I read the more confused I became. I began to question whether I was indeed planning an empirical experiment to test a hypothesis that social indicators could be discovered through manipulation of

variables in a map, and if so what did that mean? To me, a hypothesis was a guess that something is repeatable. A theory was a statement of confidence that given a set of conditions, tested by a hypothesis, the actions are repeatable. A law elevated the statement from confidence to certainty. However the more I tried to understand them the more I doubted these assumptions. The assumptions make sense in physical science experiments, but theories about what conditions make something better or worse is very difficult to test. My hypothesis that an application to manipulate map data and view integrated social and physical statistics could help lead to the discovery of a better QOL indicator was far too vague if I could not also qualitatively argue why it was better.

On reflection, my thesis application research topic did not explain the value of what I hoped to accomplish. I soon realized that the proposal involved much more than the three research statements. While the initial plan seemed clear-cut, it became difficult to make the connection between step one (QOL data research) and two (tool development). I decided to try to do the first two steps at the same time and see if they came together in the end. While initially exploring both steps I found myself getting drawn into other topics not in my research plan.

I came to realize that my thesis was an endeavor to demonstrate my technical computer and map skills through an application that others would use to extract value. I learned enough about quality of life to know that this tool likely would not help others to learn anything more about quality of life than the fact that many data variables are related and reorganizing or weighting them would likely draw a similar map.

More importantly though, I also came to appreciate that the HDI is a difficult compromise because it tries to document the state of the world's human development with no universally accepted definition of what this concepts means.

I started to lose interest in my experiment partly because my thunder had been stolen by the Social Watch map application, and partly because I wanted to learn more about why the HDI had become a recognized QOL touchstone. My next big decision was what to do next?

I decided that qualitatively, I could learn about metaphysical dimensions of QOL that are unquantifiable. However a qualitative assessment would consume far more time than my budget allowed. But I thought that with all of the time and energy I had spent learning about the HDI and QOL, a quantitative experiment to test the HDI might be valuable. The HDI's purpose is to explain whether the conditions for QOL are there, not what the state of QOL is. But is the HDI is a good surrogate for QOL anyway?

The gateway graduate course called *Approaches to Geographical Enquiry* which I took in 2004 raised many questions and philosophical debates about quantitative methods. One of the discussions in the course centred on what the quantitative revolution was all about and how some human geographers were opposed to it. While spatial statistical analysis and maps (both generalization techniques) are important and vital tools, they can also be easily misused. My concern in the initial attempt to create a web-map tool to manipulate social data was that an interactive world map to allow users to manipulate the quantitative data, without the metadata explaining the inherent errors in the data or showing

the rationale or methods describing the raw information, might offer people a method to interpret and report incongruous and erroneous information.

It became evident that the HDI values in the U.N. report, when categorized into high, medium, and low countries are actually both quantitative and qualitative statistics. “The divisions of qualitative space correspond to salient discontinuities in our apprehension of quantitative space” (Galton 2000: 6). The difference between quantitative and qualitative properties is that the former forms a continuous space while the latter forms a discrete space. Galton holds out hope for the emerging discipline of qualitative spatio-temporal information theory based on artificial intelligence (AI) with one important strand in AI research concerned with “automated reasoning about spatial and temporal aspects of the world” (Galton 2000: 2). Robotics, cognitive science, philosophy, linguistics, logic, geography, and geographic information science are all contributing to this discipline. Consideration of some of the ‘quantitative revolution’ implications of a statistical analysis was a concern. This was because of the suspicion many geographers had about people who had some computer and statistics skills and an inclination to use them, without solid theoretical foundations.

One of the arguments by a quantitative geographer to explain the antithesis between methods in geography is “that spatial data analysis and spatial modeling are perceived to be relatively difficult, not only by students, but also by many academics and geographers who typically have non-quantitative backgrounds” (Fotheringham, et. al. 2000: Preface). It is not a matter of difficulty: people do think differently and have different strengths and weaknesses. This is

part of the reason for debate – people do not understand each other on the same level. Fotheringham says that “a major goal of geographical research, whether it be quantitative or qualitative, empirical or theoretical, humanistic or positivist, is to generate knowledge about the processes influencing the spatial patterns, both human and physical, that we observe on the earth’s surface” (Fotheringham, et. al. 2000: 8). In a sense the ‘*Approaches to Geographical Enquiry*’ course helped begin to cure my quantitative tunnel vision replacing it the realization that there are many different theories of geographic analysis and many different ways to approach a problem, all of them with merit. It made me want to avoid limiting my options by focusing on the original idea to build a computer application. I believe this is the main reason why I found myself off on various tangents looking into theoretical issues and trying to get a better grasp about what quality of life means. It is also why I decided to use statistics the way I was taught. This means that I can have no pre-conceived bias about the data I have or am looking for. I must stay dispassionate.

Some geographers in the early 1970s believed that the criticism of quantification has more to do with data quality than theory. “Quantification is a very valuable concept in geography if we can upgrade the accuracy of our data and our methods of data collection” (French, et. al. 1971: 177). French admits that “some geographic fields, for example cultural geography, do not lend themselves to quantification and, even after another fifty years of standardization of data collection, there will still be a great problem of the definition of cultural terms which will render quantification difficult” (French, et. al. 1971: 177). I

believe this is exactly the point that I discovered while looking at U.N. data for the thesis. We should not be having a debate about whether quantitative methods, qualitative methods, positivism, humanism, or regionalism are right or wrong, good or bad. The application of theory and method depends on what is being studied. I believe that every theory and method has its place. The debate should be about which theory and method is most appropriate given the subject being studied.

The statistical analysis is not meant to discover the ingredients for QOL. But, given what I have to work with and what I think I know about QOL, it is meant to help me learn whether the U.N. has actually given us more than they bargained for with an HDI index that also happens to be a pretty good QOL index.

5.0 Data Selection

This section describes the steps taken to select data and correct the data for missing values. Testing a hypothesis that the HDI performs well as a QOL indicator is a paradox because it is based on the assumption that QOL is measurable. Whether it is or is not is debatable. The concepts that would probably tell us the most about comparing quality of life are the ones that are the most difficult to quantify. As discussed in 4.2 – Defining Quality of Life, there are many QOL definitions. One of the broadest definitions is from Sirgy (2002) who separates QOL into subjective and objective sets of elements. The subjective elements include capacity for enjoying life, cognitive complexity, a sense of autonomy and effectiveness, self-knowledge, self-esteem, ease of interpersonal relations, an ethical orientation, personality integration, and a productivity orientation. The objective environmental conditions include adequate material support, physical safety and security, available friends and social support, opportunities for the expression and receipt of love, opportunities for intrinsically challenging work, leisure opportunities that have elements of skill, creativity, and relaxation, available set of moral values that can give meaning to life, opportunities for self-development, and a justice system that is managed by disinterested and competent parties. Country-aggregated data for the subjective elements do not exist at any comprehensive level. Though the list is comprehensive, none of the objective elements listed by Sirgy focus on access to health care or education. The other objective elements also are not distinctly objective. For example, one must first decide the boundary between what

elements to use to count material support and what the boundaries are between adequate and inadequate. All other the objective elements are very broad concepts that would be very difficult to define, then measure, particularly something like an available set of moral values that can give meaning to life.

The data search suggested the “The Wellbeing of Nations” by Robert Prescott Allen would be a good starting point. This document includes 27 tables and hundreds of data variables for 180 countries. Because Prescott-Allen performed comprehensive analyses of well-being using numerous data sources, this document was the starting point for where to find QOL data. Due to time and budget constraints, and because many of the WON variables suited my purpose, some WON indices were selected for this analysis. The data were available in the publication, and Prescott-Allen’s composite indices of many QOL aspects sufficiently represented desirable variables such as community and equity.

Smith’s experience in measuring well-being guided the initial quest for what data to look. His approach to QOL measurement starts with basic needs like food and shelter, and is followed by more abstract and difficult concepts like community and equity. Smith argues that, after basic needs are met, QOL can improve if attitudes about equality, community, and the environment were to change. This implies less inequality, more concern for others (a way to build community), and concern for all environments (not just local), leads to higher QOL. A table with categories was established to slot available indicators. These included ‘basic needs’, ‘equality’, ‘community’, and environment. Another miscellaneous category was added because some variables did not fit

specifically into the other four categories (see *Table 4* on page 109). The initial topics were health, income, education, leisure/recreation/culture, physical environment, security/safety, access to communications technology, and employment.

Many variables including, for example, the number of Internet users per country, were available only at a cost. Many of the purchasable data were available indirectly through the WON text. A decision was required about what level of data disaggregation was best suited to the analysis. For example Prescott-Allen calculated a Health Index to measure 'healthy' life expectancy at birth. Healthy life expectancy is calculated using a count of total life expectancy at birth adjusted for the number of years likely to be lost to disease and injury (Prescott-Allen, 2001: 21). The raw data used to construct the Health Index is based on estimates of the prevalence, duration, and severity of communicable and non-communicable illnesses, neuropsychiatric disorders, and intentional and unintentional injuries. The WON analysis is an attempt to "build on the idea of human development promoted by the United Nations Development Programme in its human Development Report" (Prescott-Allen, 2001: 13). Prescott-Allen argues that, despite the technical and political challenges posed, assessments of human well-being must include all aspects of well-being including features such as self-respect, opportunities for being creative and productive, security against crime and violence, guaranteed human rights, and political, economic, and social freedom. Prescott-Allen states that the UNDP excludes these from the HDI because they are hard to measure and spark disagreement over the balance

between personal and community interests and between material and nonmaterial values. Prescott-Allen decided to produce a measure of well-being that includes these aspects despite the issues with collection and definition. Using his aggregated indices of health, wealth, knowledge, and culture, for example, implies acceptance of the validity of the methods and decisions used to construct the data. The WON was constructed with diligence based on pragmatic logic so its data were used here.

The WON report is a painstaking effort aimed at selecting, justifying, and correcting data to represent five dimensions of human well-being (Health and Population, Wealth, Knowledge and culture, Community, and Equity, subdivided into two elements each of human well-being (Prescott-Allen, 2001: 13) including:

Health	People enjoy long lives in good health
Population	while keeping their numbers within the bounds of human and natural resources
Household Wealth	Individuals and households have the material goods and income to secure basic needs and decent livelihoods,
National Wealth	and the community has the resources to support enterprise and maintain prosperity.
Knowledge	People have the knowledge to innovate and cope with change, live well and sustainably, and fulfill their potential,
Culture	with avenues for spiritual growth, creativity, and self-expression.
Freedom and governance	Human rights are fully respected; and individuals are free to choose how decisions are made and who should make them. Decision-making bodies are open, clean, and effective,
Peace and order	Communities coexist peacefully and protect their members from crime and violence,

Household equity Benefits and burdens are shared fairly among households and groups

Gender equity and between males and females.

The WON has an equally comprehensive environmental component and treats human well-being and ecosystem well-being as equally important. The overall well-being assessment scores are a combination of the two. However this thesis focuses on the human component. The variable called 'Ecosystem Wellbeing Index' is included in the study solely to see if there is any relationship between the HDI and Prescott-Allen's interpretation of ecosystem well-being.

As mentioned above the Health Index uses life expectancy and disability data from the World Health Organization. Population is calculated using fertility rate data from the U.N. Population Division. Household wealth averages needs and basic services using a complex formula of food sufficiency, prevalence of stunted children, underweight children, babies with low birth weight, access to safe water and sanitation with income (GDP per capita). The data were collected from sources such as the Food and Agriculture Organization, the World Health Organization, and UNICEF. The National Wealth Index uses economic and employment data including inflation and debt for example. The Knowledge Index averages an education score with a communication score. The education score is similar to the HDI's education index, and the communication score measures technology use including Internet, telephone, and cell phones. Although the WON text lists Culture as one of the two elements of Knowledge and Culture it

states that “Culture (a society’s systems of belief and expression) could not be covered here for lack of a suitable indicator” (Prescott-Allen, 2001: 36).

The Community Index is a combination of a freedom and governance measure and a peace and order measure. It uses statistics on political rights, press freedoms, civil liberties, and crime rates, etc. The Equity Index averages a household equity score calculated using an income distribution ratio, and a more complex formula to calculate gender equity.

All of Prescott-Allen’s tables include detailed metadata to describe the origins of the data and the decisions that were made to give estimates where data were missing. In many cases data from different sources were substituted to fill the gaps. The complex decisions Prescott-Allen made about which available data could be used to represent more abstract concepts like freedom and governance are robust. This thesis is not intended to test or challenge the validity of the Wellbeing of Nations assessment: rather the WON is being used because it seems to be the only comprehensive (180 country) data source that accounts for QOL components suggested by Smith including equality, community, and environment.

Based on assessing the work that went into the WON text and after reviewing the metadata in the data tables, it became clear that the data collection component of this thesis could take months or years. Prescott-Allen’s efforts using dozens of sources and painstaking decisions about data influenced the decision to use the higher aggregates that represent the concepts similar to the categories that were identified earlier. The WON became the primary source for

data, and a decision was made to try to collect secondary sources to validate whether the WON indexes performed well in representing concepts like health and equity. The primary WON indexes selected included the Human Wellbeing Index (HWI), Health score, National Wealth, Household Wealth score, Knowledge Index, Community Index, and Equity Index. The HWI is calculated using complex and comprehensive methods and process. It is partially derived from the other selected tables. It involves many of the concepts Smith talks about including health, equity, and community. Although this table is somewhat redundant because it is calculated using other indices selected for the analysis it was decided to leave it in to see how close it is related to the HDI. Household Wealth is the closest variable available from any source to measure Basic Needs. No data sources for discretionary income were found.

Prescott-Allen argues that the conditions for sustaining long, healthy lives, requires population control. On this basis the WON Population score was included to see if there is a correlation between the HDI and population management.

Since there was no budget to purchase additional data (the WON text with data was purchased), secondary sources of data used include the United Nations Statistics Division and U.N. umbrella organizations including World Health Organization, U.N. Educational, Scientific and Cultural Organization (UNESCO), U.N. Children's Fund (UNICEF), U.N. Environment Programme (UNEP), U.N. Development Programme (UNDP), and the U.N. Food and Agriculture Organization (FAO). Next were the World Bank, and the Population Research

Bureau. The WON used other sources including for example the International Monetary Fund (IMF), Freedom House (press freedom), and the International Intergovernmental Panel on Climate Change (IPCC).

Three important issues surfaced from exploring data sources. Either the data did not exist (e.g. housing and shelter), it was severely incomplete (e.g. Tuberculosis was the only reasonably complete disease statistic), or it came at a cost (e.g. a table of Internet usage could be purchased from the International Telecommunications Union).

Physical data about environmental considerations like climate, recreational topography, mosquitoes, smog, etc. that can influence people's attitudes about QOL should have been included, but sufficient environmental data were not available. These factors vary significantly across countries, particularly in countries such as Canada and the Russian Federation with large land masses. Ideally find data indicating concern for the environment which is one of the important considerations that Smith believes can improve QOL should have been included but there seemed to be no freely available country-aggregated data tracking environmental concern.

The WON includes factors such as native forest change, land use, land quality, species diversity, etc. It is an attempt to determine whether ecosystems are sustainable. This is not really what was needed here (except in cases where people live in regions with ecosystems incapable of sustaining basic needs for QOL). The WON Ecosystem Wellbeing Index (EWI) is intended to track how well each country's ecosystems (on average) maintain its diversity and quality. The

WON treats this index as equally important to its Human Wellbeing Index because the ecosystems are essential to supporting people and other life. It measures the quality of land, water, air, species and genes, as well as resource use. Although the EWI was not a direct measure of concern for the environment it was decided to use it in the analyses in case it might tell us something about the relationship between human development and environmental sustainability.

Many statistics were freely available from the United Nations, the Population Research Bureau, the FAO, and WHO. Overall 32 variables were selected to test the HDI including nine comprehensive variables from the WON. A decision was made to try to select statistics as close to the year 2003 as possible. This was because the preliminary research used the 2005 Human Development Report with the reported data recorded in 2003. The same data was carried forward for consistency.

The three components of the HDI including the education index, life expectancy index, and GDP index were included as variables in the study to see how well correlated they are with each other and with the test variables. They are not used in the principal component or linear regressions because they are ingredients of the dependent variable so they cannot appear on both sides of the equation.

Finding data sources to test the WON variables proved difficult. Many complete data sets related to morbidity are freely available from many sources. From the U.N., infant mortality, maternal mortality, and under-five mortality rate data were included as basic health measures. Life expectancy at birth, calculated

using age specific death rates was also included as a variable to measure whether basic needs like a long life were being met. Tuberculosis was the only reasonably complete and available disease statistic. Other disease statistics like AIDS, HIV, and Malaria were not freely available.

The gender-related development index (GDI) is essentially the HDI combined with a gender-equality measure. The GINI Index (named after Italian statistician Corrado Gini) measures the degree of income inequality in a society. The gender empowerment measure (GEM) measures gender inequality in three basic dimensions of empowerment—economic participation and decision-making, political participation and decision-making and power over economic resources. All three of these variables were selected as equality measures.

Public expenditure on health, education, and military spending were included as community variables to indicate where income is spent. CO₂ emissions and electricity consumption data were included to see if human development is related to resource consumption.

From the Population Research Bureau, Gross National Income per capita was selected as an income component of basic needs. Net Migration Rate (the difference between the number of immigrants entering a country and the number of emigrants leaving per 1000 population) was added to see if there is a relationship between it and human development.

A variable from the Food and Agriculture organization to track undernourishment based on age-specific calorie requirements for the population was included under the general category. Statistics to track access to safe

drinking water and adequate sanitation from the World Health Organization were included under basic needs. The Social Watch organization thinks that too much emphasis is placed on income when measuring basic needs and gender equality. They produced their own indices called Basic Capabilities Index (BCI) and Gender Equity Index (GEI), which are calculated without an income component. For example the 2007 Social Watch GEI table places Rwanda in the third highest spot because of Rwanda's affirmative action policies such as legislation to ensure minimum quotas for women's political participation and labour market equity.

SOURCE	TOPIC				
	<i>General</i>	<i>Basic Needs</i>	<i>Equality</i>	<i>Community</i>	<i>Environment</i>
<i>Wellbeing of Nations</i>	Human Wellbeing Index	Health Score	Equity Index	Community Index	Ecosystem Wellbeing Index
	Population Score	Household Wealth Score			
	National Wealth Score	Knowledge Index			
<i>United Nations</i>	HDI	Infant Mortality Rate	Gender-related development index	Public expenditure on health (% of GDP)	Carbon dioxide emissions per capita
	Life Expectancy Index	Under-five Mortality Rate	Gender empowerment measure	Public expenditure on education (% of GDP)	Electricity consumption per capita
	Education Index	Maternal Mortality Ratio	GINI index	Military expenditure (% of GDP)	
	GDP Index	Life expectancy at birth			
		Tuberculosis per 1,000 population			
<i>Population Research Bureau</i>	Migration (net) per 1,000 population	GNI (PPP per capita)			
<i>Food and Agriculture Organization</i>	Undernourishment				
<i>World Health Organization</i>		Improved Water Sources			
		Improved Sanitation			
<i>Social Watch</i>		Basic Capabilities Index	Gender Equality Index		

Table 4 – Variables Selected for Analysis

The BCI is based on three indicators including the proportion of births attended by skilled health personnel, under-five infant mortality, and the proportion of children who stay in school through the fifth grade. It does not have an income component. These variables were included to see if the HDI is still related to these concepts despite the way they were constructed.

Table 4 lists the variables that were selected for analysis. They are categorized into my key components.

An advantage to using the WON data was that it mapped very well to most United Nations tables. It includes 180 countries with data for some countries that the U.N. does not report (Afghanistan, Iraq, North Korea, Liberia, and Serbia and Montenegro). It does not include three countries tracked by the U.N. (Hong Kong, Occupied Palestinian Territories, and East Timor). Since the WON tracked almost all of the U.N. countries and because other data sources (e.g. PRB) generally followed the U.N. list, the 177 countries tracked by the U.N. were originally considered for the study.

Microsoft Access was used to compile a database and link the data sources to construct a master data table. This required a file to map country names between the tables. For example, the Population Research Bureau uses the name 'East Timor'. The other sources use the name 'Timor-Leste' for the same country. The mapping file is analogous with a name translation table. None of the six main data sources used exactly the same names for every country.

Figure 12 is a screen capture of the tables, fields, and relationships used to construct the master table in MS Access.

Figure 12 – Database Table Mapping

A complex query in MS Access was used to join all of the tables and keep all country records regardless of whether a table was missing data for any countries. The query output containing a master variable list was saved to another table file. This master data file contained 231 records (one record per country) with 33 fields including the country_name field and 32 variables. However the U.N. tables and the WON tables contained data for only 177 and 180 countries. Most of the approximately 50 countries not tracked by the U.N. or WON are small Island states. A decision was made to start with only the 177 U.N. countries and delete the rest before reviewing the remaining data. After a quick review it was evident that many countries being tracked by the U.N. were also missing data for many variables. Most of these also were small Island

states. Because the study is concerned with reviewing how well the HDI performs for the World's QOL, and since small Island states account for a fraction of the World's 6+ billion population, all countries with populations less than 200,000 were deleted. This brought the list down by 13 countries to 164. However significant holes of missing data still remained in the list. *Table 9* in Appendix B lists the included countries. *Table 10* lists the excluded ones.

5.1 Data Correction

SPSS software was used for all statistical analysis and reporting. MS Excel was used to manage the data corrections in the master data file. All data variables selected were at the ratio scale. Therefore no adjustments were needed to put the data into a functional form for regression testing. Also, using ratio measurements remove the influence of size, area, and demographics. However operational decisions were needed to address holes in many of the data variables.

Undernourishment data from the FAO was the first immediate data issue that was encountered because the variable used a value of less than 2.5 (i.e. '<2.5') for countries with low undernourishment. This was replaced 1.25, half way between 0.01 and 2.5.

Initially, missing data were to be replaced with either the mean value, calculated in the descriptive statistics, or the median (middle) value. *Table 9* in *Appendix B* shows the fields that were changed because of missing data.

In most cases the variable's median value was used to fill in missing data except for Water and Sanitation. For these two variables 100 was substituted for all countries above .840 HDI that were missing data. Countries below .840 were assigned the median values of 88 and 70 respectively.

The mean was not in fact used for any of the variables because the median was a better fit when looking at the distribution of values sorted by HDI. In other words, after looking at the HDI sorted record of a country missing data, the median was generally much closer to the neighboring country's values than was the mean value.

As expected, some statistics for variables with many missing cases changed substantially after missing values were replaced. (e.g. the mean value changed) These variables included public expenditure on education, gender-related development index, gender empowerment measure, and GINI index. These variables had 46, 37, 97, and 53 missing cases respectively. Military expenditure with 47 missing cases did not seem to change much.

One other data correction was made after analysing scatterplots looking for outliers later during the analysis. The outliers pointed back to the U.N.'s HDI table containing infant mortality rates where there is a value of 12 for Zambia. It would not be possible for Zambia to be ranked so low in the HDI (166th out of 177 countries) because such a low IMR would certainly influence both the life expectancy index and HDI. The countries directly above and below Zambia including Malawi and the Democratic Republic of Congo have IMRs of 122 and 129. The average IMR for the ten countries above and below Zambia is

approximately 113. The value is most likely a typographic error and the value should be 102, 112, 120, or 122. It was replaced with the value 120 since Zambia's nearest HDI neighbors are higher.

5.2 Data Transformation

Linear regression analysis requires data to follow a linear scale relationship, and one where the residuals of the regression are as normally distributed as possible. Linearity can be determined by a scatterplot of input data

but the residual criterion is not known until the regression has been performed. A method to try to transform the variables so that their regression residuals will come out normally distributed is to use a combination of descriptive statistics, histograms, and scatterplots.

Figure 13 – Untransformed HDI Data Histogram

The descriptive statistics show skewness of data. In other words, if data were counted within equal interval ranges, the data is skewed if there are more cases to the left or right of the median. A normal or near normal distribution of original data is not necessary in regression analysis. However linearity is important because Pearson Product Moment Correlation and the associated linear regression model are linear techniques. This can be observed in a scatterplot by fitting a straight line to the plots of data between all pairs of

variables. However skewness, histograms, and trying to fit a straight line to the plots of data between pairs of variables in a scatterplot go hand in hand.

Histograms display skewness pictorially. Using a histogram of the HDI

variable as an example, we see that the HDI is slightly skewed negatively because it tails to the left. In fact it may be bi-modal. The variable can be converted to a different scale using a transformation function which reduces the amount of skewness in the data.

Figure 14 – Transformed HDI Data Histogram

Every value in the variable is transformed by the same function so mathematically it is exactly the same data on a different scale. It can be converted back by using the opposite transformation. *Figure 13* is a histogram of the HDI distribution before transformation. *Figure 14* shows a histogram of the data transformed by multiplying every HDI value by the power of 2.25. Through trial and error all of the variables that were originally skewed were transformed into a scale that is more normally distributed.

It was decided to try to transform all variables skewed by more than 0.2 and bring the skewness factor to below 0.15. The transformed variables were named using a prefix indicating the function that was used. For example the HDI variable was transformed into the P2p25_HDI variable because the function HDI

to the power of 2.25 brought the skewness value below HDI to the power of 2.0

Figure 15 – Untransformed HDI Data Scatterplot

Another method to check transformations for linearity is to observe scatterplots of pair wise variables. Two variables are linear when the data points are clustered close to a straight line. *Figure 15* shows a scatterplot of the original

Figure 16 – Transformed HDI Data Scatterplot

or HDI to the power of 2.5.

The transformed data illustrated in the histogram (*Figure 14*) still does not appear to be normally distributed however it is more normal than the untransformed data reported in the untransformed data histogram (*Figure 13*).

HDI and electricity consumption variables. The line is severely curvilinear and not linear meaning that one or both of the variables is skewed. *Figure 16* shows the same relationship after transformation. It is now linear. The transformation from a curved to a linear relationship is obvious.

With a few exceptions where attempts to transform the original data to a skewness factor of less than 0.2, the other transformations all were successful. It turned out that the variables that were most difficult to transform were also not very well correlated with other variables and did not help in the hypothesis.

Figures 36, 37, 38, and 39 in Appendix A contain SPSS output of Histogram and Scatterplot matrix reports that were used to verify that the transformations were successful. *Figures 36 and 37* are the histograms untransformed and transformed variables, and *Figures 38 and 39* are the scatterplot matrix reports of the untransformed and transformed variables. Specific comments on each graph are not given because the descriptions are similar. Generally scatterplots became more linear or did not change very much. None became less linear. Similarly some histograms became more normal, some did not change much, and none were any worse after transformation.

Note that some data corrections were required after positively skewed data were transformed because a log of zero cannot be calculated. The log of one is zero. Logged data that was originally zero was changed to zero after transformation. These included military expenditures (Iceland, Costa Rica), maternal mortality ratio (Iceland), migration (about 50 cases of zero migration), and community index (6 zero cases).

The histograms and scatterplot matrix reports in Appendix A are shown highly reduced so that data for all variables can be shown at once. This means that the text is too small to read, but the filename is recognizable. The key to the filename for each original histogram in *Figure 36* is AC_orig_xx where xx is a

number corresponding to a variable. The first number, 0, is the first variable in the list – the HDI variable. Similarly the key to the filename for each histogram of transformed data in *Figure 37* is AC_trans_xx. The scatterplots matrix reports are arranged in the same order with HDI being the topmost variable top to bottom and the leftmost variable left to right.

Transformed Variable Name	Transformation Function	Orig. Skewness	Trans. Skewness	#
P2p25_HDI	Power 2.25	-0.49	-0.036	0
R5_Electricity consumption per capita (kilowatt-hours)	Power 1/5	2.657	0.05	1
R7_Carbon dioxide emissions per capita (metric tons)	Power 1/7	3.381	0.01	2
R2_Public expenditure on education (% of GDP)	Sq. Root	0.656	-0.188	3
R2_Public expenditure on health (% of GDP)	Sq. Root	0.582	0.086	4
L10_Military expenditure (% of GDP)	Log 10	4.126	0.297	5
P2p5_Gender-related development index (GDI)	Power 2.5	-0.647	0.019	6
Gender empowerment measure (GEM)	NONE	0.103	0.103	7
L10_GiniIndex	Log 10	0.932	0.32	8
P3_Life Expectancy Index	Power 3	-0.834	-0.063	9
P4_Education Index	Power 4	-1.042	-0.031	10
GDP Index	NONE	-0.045	-0.045	11
R5_Infant mortality rate (per 1,000 live births)	Power 1/5	0.933	0.041	12
L10_Under-five mortality rate (per 1,000 live births)	Log 10	1.213	-0.098	13
R6_Maternal mortality ratio - Ratio Adjusted (per 100,000 live births)	Power 1/6	1.778	-0.013	14
R5_Tuberculosis cases per 100,000 people	Power 1/7	1.232	0.023	15
P5_water	Power 5	-1.009	-0.102	16
P2p25_sanitation	Power 2.25	-0.458	-0.012	17
R3_Migration (net) per 1,000 Population	Power 1/3	6.067	0.149	18
L10_GNI PPP Per Capita, 2005 (US\$)	Log 10	1.7	-0.091	19
HealthScore	NONE	-0.147	-0.147	20
PopulationScore	NONE	0.041	0.041	21
R2_HouseholdWealthScore	Sq. Root	0.35	-0.055	22
Pp666_NationalWealthScore	Power 2/3	0.456	0.078	23
Knowledge	NONE	0.043	0.043	24
Community	NONE	0.131	0.131	25
Equity	NONE	-0.027	-0.027	26
Pp75_HumanWellbeingIndex	Power 3/4	0.296	0.085	27
EcosystemWellbeingIndex	NONE	0.117	0.117	28
L10_Undernourishment	Log 10	1.576	-0.097	29
P1p5_GEI	Power 1.5	-0.183	0.028	30
P7_BCI	Power 7	-0.951	-0.026	31

Table 5 – List of Variables with Transformation Functions (All Countries)

The transformation function, the original and transformed skewness statistics, and the identifier number of the variable used in the histograms reports in *Figures 36 and 37* are shown in *Table 5*. The table shows that only variables which were not successfully transformed to the goal of reducing skewness below 0.2 were military expenditures and migration.

5.3 Scatterplot review

Figure 17 – Life Expectancy – GDP Scatterplot

Figure 17 is a scatterplot of Life Expectancy with GDP. Six outliers are circled in red. The outliers are Swaziland, Botswana, Equatorial Guinea South Africa, Namibia, and Gabon. Other outliers that were noticed in scatterplots and investigated including high CO₂ emissions compared to basic capabilities in Qatar, high military expenditures in Eritrea compared to HDI, and high net migration compared to all other variables in Qatar and the U.A.E.

All of the outliers in *Figure 17* are countries with high incomes compared with low life expectancy. All are in Africa. According to the CIA world factbook

Outliers are data points in a scatterplot that lie well away from other points. They are considered either data anomalies or possibly data errors. Outliers usually show up as residuals in a regression analysis because the data points lie outside an imaginary linear regression line.

(CIA, 2007) Swaziland, Botswana, Namibia, and South Africa all have high HIV/AIDS prevalence rates (38.8%, 37.3%, 21.3%, 21.5% of the adult population respectively) causing much lower life expectancy, and all have higher GDP (\$5500, \$11,400, \$7400, \$13,000 respectively) than most other African countries with low life expectancies.

The CIA world factbook describes the exports that have helped raise the income for these countries compared with the neighboring countries that lack the resources and infrastructure. Swaziland exports sugar and wood pulp. Botswana has diamond mines and a strong financial services sector. Namibia also exports diamonds, as well as other minerals including uranium, lead, zinc, tin, silver, and tungsten. South Africa has an abundant supply of natural resources; well-developed financial, legal, communications, energy, and transport sectors; a stock exchange that ranks among the 10 largest in the world; and a modern infrastructure supporting an efficient distribution of goods to major urban centers throughout the region (CIA, 2007). Gabon's abundant natural resources have helped make Gabon one of the more prosperous African countries. The CIA world factbook lists the GDP and life expectancy at \$7200 and 54.49 years. The HIV/AIDS prevalence rate is 8.1% of the adult population. Equatorial Guinea also showed up as an outlier in the scatterplot between GDP and both knowledge and education in *Figure 18*.

Figure 18 – GDP – Knowledge Scatterplot

a massive increase in government revenue in recent years, there have been few improvements in the population's living standards" (CIA, 2007). The average life expectancy is 49.54 years and the GDP is listed at \$50,200.

Figure 19 – HDI – Knowledge Scatterplot

have much higher education index values in the table. East Timor seems to have an unusually low GDP compared to moderate life expectancy and literacy rates. As mentioned earlier South Africa's low life expectancy, because of the

Although the HIV/AIDS rate in Equatorial Guinea is much lower (3.4% of the adult population) the CIA factbook says that the country was seized in a 1979 coup, is run by a dictator, discovered large offshore oil reserves and "despite the economic windfall from oil production resulting in

Figure 19 shows outliers in the HDI – knowledge scatterplot. Hong Kong is most likely an outlier because it has an unusually low literacy rate (93.5%) compared to very high GDP and life expectancy.

All of the countries ranked higher than Hong Kong in the HDI

prevalence of HIV/AIDS (21.5%), and high income help to make this country an outlier. Bosnia and Herzegovina and the Maldives have low knowledge scores compared to the relatively high HDI values. Bosnia and Herzegovina is scored as zero (after rounding) for Internet usage in the WON calculation because the Internet usage rate was 1.29 users per 10,000 people. This severely dragged down its knowledge score. A statistics table on an Internet World Stats web page shows that Internet usage in Bosnia grew from 7,000 users (0.2%) in 2000 to 225,000 users (4.9%) in 2006 (IWS, 2007). Prescott-Allen's 1998 data precedes this. Now, seeing Bosnia and Herzegovina showing up as outliers is not surprising. In 1998 Bosnia was probably either not quite on the same Internet bandwagon as its neighbours, or the ITU collected its data before its neighbors and reported it in the same year.

Country	CIA World Factbook		WON	CIA World Factbook		WON	CIA World Factbook		WON		
	Population	Internet Users	Internet Users per 10,000 population	Telephone - main lines per 1000 population	Telephone main lines per 1000 population	Cell phone per 100 population	Cell phone per 100 population	Communications score			
Albania	3,581,655	75,000	209.40	2.72	255000	7.12	3.05	1259000	35.15	0.15	6
Bosnia and Herzegovina	4,498,976	806,400	1792.41	1.29	968900	21.54	9.07	1594000	35.43	0.69	16
Macedonia	2,050,554	392,671	1914.95	100.05	533200	26.00	19.87	1261000	61.50	1.53	40
Yugoslavia (Serbia and Montenegro)	9,396,411	1,400,000	1489.93	94.04	2685000	28.57	21.81	5229000	55.65	2.26	42
Croatia	4,494,749	1451000	3228.21	446.33	1890000	42.05	34.77	2984000	66.39	4.07	70

Figure 20 – Internet Usage Comparison

Figure 20 shows a comparison of Bosnia and Herzegovina Internet usage statistics compared with some of its neighboring countries. Because Macedonia, Yugoslavia, and Croatia were significantly far ahead of Bosnia and Herzegovina in Internet usage according to the WON knowledge table, these countries had much higher communications scores. The communication score contributes to one half the weights of the knowledge score. Recent CIA World Factbook

statistics (also derived from the ITU) show that in 2006 Bosnia and Herzegovina had higher Internet usage rates than Serbia and Montenegro, and the country was very close to Macedonia. It showed the most significant rate of gain, from 1.29 users per 10,000 to 1792.41 users per 100,000.

Mobile (cell) phone statistics used in the WON to help calculate the knowledge score have a similar issue. The cell phone data in the WON is from 1998. For Bosnia and Herzegovina cell phone use has grown from less than one percent of the population in 1998 to over 35% in 2005.

Because the statistics are so volatile over a relatively short span compared to most other social data related to knowledge, such as literacy and educational attainment, using Internet and mobile phone rates to help account for knowledge might be misleading. It is very difficult to take a snapshot of world Internet and cell phone use in order to compare countries.

5.4 Correlation Analysis

A correlation analysis shows how well variables are related to each other. SPSS reports the significance level of each coefficient. Coefficients flagged as not significant should not be used in a multiple regression analysis. The Pearson correlation analysis flagged military expenditures as not significant in the correlation analysis. The correlation analysis produced a correlation matrix that was transcribed into the diagram in *Figure 21*. The variables were sorted by a total correlation coefficient value calculated by summing the total absolute values of all coefficients for each variable and dividing by the total number of variables.

correlation values were then colour coded into class ranges from extremely high blue (>0.95), down to moderate red ($0.6 - 0.649$). This was done to try to help identify clusters of variables that are more related to each other, than to other highly correlated variables. Values below 0.6 were ignored.

This correlation map suggests that a principal component analysis might reduce the data into meaningful groups. The transformed HDI variable, which had the highest total coefficient value, was strongly correlated to most other variables, with the highest correlation being under-five mortality rate (.954). The Human Wellbeing Index was a little less strongly correlated to most other variables than the HDI; however it was very highly correlated to knowledge (.950). These two variables appear to span all of the clusters identified. However there obviously are correlations between the clusters (i.e. they span each other).

There were three main clusters including:

1. Under-five mortality rate (U5MR), infant mortality rate (IMR), maternal mortality ratio (MMR), HealthScore, and life expectancy
2. Gross national income (GNI), HouseholdWealth, gross domestic product (GDP), and national wealth
3. Knowledge, and education

The first cluster could also include water which was moderately correlated with U5MR and IMR, and tuberculosis which was moderately correlated with HealthScore and Life expectancy. Electricity consumption appears to be strongly or moderately correlated to many other variables but does not fit into a cluster. IMR and U5MR have a correlation coefficient of .996. However they represent

different things (the probability of dying under the age of one and the probability of dying under the age of five) so they are not considered redundant. Gender equity index, community, equity, gender empowerment measure, GINI index, public expenditure on education, and migration all have weaker correlations to other variables. They seem not to belong to any cluster.

The significance levels from the correlation report are not shown because, except for military expenditures, all variables were significantly correlated with the HDI at a significance level better than .00001. Only variables with high absolute correlations are worth considering as candidates for the regression. i.e. from those achieving significance, only the strongest are used.

Three of the highly correlated variables have high correlation coefficients with the HDI because they are redundant. The life expectancy index, education index, and GDP index make up the HDI. They were left in the correlation analysis to see how well correlated they are with each other. These all turned out to be highly correlated with correlation coefficients ranging from 0.79 to 0.85.

6.0 Data Analysis

Hypothesis: At a practical and pragmatic level is the HDI technically a good surrogate for other facets of living conditions?

After the variables related to QOL are selected, testing the hypothesis involves running a regression to see how well the variables predict HDI. If the regression equation is sufficiently strong the hypothesis is supported. The null hypothesis is the HDI cannot be predicted using other QOL variables.

This section describes the process to test the hypothesis. It was an iterative process of data transformation to prepare the data for linear analyses followed with the decisions that were made to perform a regression analysis, run a principal component analysis, and re-run the linear regression using scores on principal components.

6.1 First Regression Analysis

The Scatterplot review and Pearson Correlation Analysis shows us that the HDI is related to other variables, and many other variables are related to each other. A Linear Regression “is the name conventionally given to a technique for calculating the equation of a least squares line” (Ebdon, 1987: 108). The least squares line is the best fit that passes as close to as many of the data points as possible. The equation can help to tell us how well a number of variables (independents) can help predict the likely value of another single variable (the dependent). The regression report also helps to show what variables are most useful in predicting the dependent variable. There are various input options in

SPSS to decide how the regression is to be calculated. This analysis only uses 'stepwise', where the program tests variables one at a time by bringing in and taking out variables until the best fit is found. The analysis is trying to find which variables account for the most variance, and which variables to not come into the equation because they are essentially redundant (i.e. interrelated with other variables). The program constructs several models with each model based on a previous model with an additional variable. One must decide which model is sufficient. In other words, the analyst decides whether adding another variable improves the regression equation.

A Stepwise Regression using all of the basic variables is conceptually clear, but may contain too much multi-collinearity. A regression using the HDI as the dependent variable, and all other variables in *Table 5* on page 118 except military expenditures, life expectancy index, education index, and GDP index produced nine models. The first regression was somewhat experimental, and was not expected to be conclusive; rather it is a first step towards re-constituting the independent variables into a smaller number of non-collinear factors or components.

Figure 22 is a summary of the first three models that were calculated in the regression analysis.

Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.956(a)	.913	.913	.073322		
2	.975(b)	.951	.950	.055319		
3	.982(c)	.965	.964	.046974		
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.168	1	9.168	1705.348	.000(a)
	Residual	.871	162	.005		
	Total	10.039	163			
2	Regression	9.546	2	4.773	1559.761	.000(b)
	Residual	.493	161	.003		
	Total	10.039	163			
3	Regression	9.686	3	3.229	1463.209	.000(c)
	Residual	.353	160	.002		
	Total	10.039	163			
a Predictors: (Constant), L10_Under-five mortality rate (per 1,000 live births)						
b Predictors: (Constant), L10_Under-five mortality rate (per 1,000 live births), Knowledge						
c Predictors: (Constant), L10_Under-five mortality rate (per 1,000 live births), Knowledge, P2p5_Gender-related development index (GDI)						
Coefficients(a)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.125	.016		68.860	.000
	L10_Under-five mortality rate (per 1,000 live births)	-.423	.010	-.956	-41.296	.000
2	(Constant)	.717	.039		18.530	.000
	L10_Under-five mortality rate (per 1,000 live births)	-.265	.016	-.598	-16.356	.000
	Knowledge	.004	.000	.407	11.117	.000
3	(Constant)	.510	.042		12.171	.000
	L10_Under-five mortality rate (per 1,000 live births)	-.190	.017	-.429	-11.407	.000
	Knowledge	.003	.000	.279	7.992	.000
	P2p5_Gender-related development index (GDI)	.322	.040	.311	7.955	.000

Figure 22 – First Regression Analysis

The regression equation of the third model in the first analysis is:

$$\text{HDI} = 0.510 + (-0.190 * \text{U5MR}) + (0.003 * \text{knowledge}) + (0.322 * \text{GDI})$$

The first model, which included the under-five mortality rate (U5MR) variable and held all other variables constant, calculated an adjusted R square value of 0.913. This meant that over 90% of the variance in the HDI can be explained by a single variable - U5MR. The second model, which added the WON knowledge variable, improved the adjusted R square value to 0.950, or 95%. The third model added gender-related development index (GDI) increasing the adjusted R square value to 0.964, only a slight improvement but still noticeable. Beyond the third model, the adjusted R square improved marginally at each step until exhausting the possibilities and finishing with the ninth model with an adjusted R square of 0.975. This meant that after GDI, adding GNI (4), HealthScore (5), CO2 emissions (6), GEI (7), public expenditures on health (8), and tuberculosis (9), did not really make much of a difference. Therefore the U5MR, knowledge, and GDI variables do a good job predicting HDI.

Knowledge is a variable from Prescott-Allen which uses similar numbers to the education index in the HDI for its education component but averages it with a measure of communication which counts telephone, cell phone, and Internet use. That means that in the third model the equation has a communications element which the HDI does not have. With the GDI it also has a small gender-equity element.

The residuals tell us what cannot be explained and where the equation works best for which data (i.e. country records). Residuals, when aggregated, are the amount of variation in the dependent variable unaccounted for (i.e. left over) by the independent variables (acting collectively). Each individual residual tells us

how far "off" our model is in predicting the value for that country. After reviewing the residual statistics for each country it was found that the regression equation worked better for countries with high and low human development values, according to the U.N.s HDI class distinctions, than it does for medium countries. The residuals are measured in standard errors of the estimate.

The average of the total absolute residual values for high, medium, and low countries were 0.58, 0.91, and 0.59 respectively. While a residual of less than 1.0 means that the predicted regression value was very good, it was decided to retest the regression after splitting the data into two groups: (1) high and low, and (2) medium countries. These will be discussed later in *sections 6.5 to 6.12*.

Sorting the data by residual value showed which countries the regression equation did not work as well for. Africa seemed to be highly variable with Equatorial Guinea having the highest residual and Nigeria having the lowest. Equatorial Guinea's residual numbers can probably be explained by the unequal distribution of high GDP to poor living conditions.

The other underestimated country in the 3+ range is Hong Kong. It seems to have an unusually low literacy rate (93.5%) compared to very high GDP and life expectancy. All of the countries ranked higher than Hong Kong in the HDI have much higher education index values in the table. The only over-estimated country with a residual higher than 3 was East Timor (-3.237). East Timor seems to have an unusually low GDP compared to moderate life expectancy and literacy rates.

6.2 First Principal Component Analysis

Principal Component Analysis (PCA) is a statistical data reduction technique that helps to identify separate clusters of variables, with orthogonal constraints, containing correlated variables within the cluster. The output, the principal components (PCs), can be interpreted and given names, and scores for cases on these “manufactured”/compound variables. The PCs can be used as input to a regression analysis.

A decision was made to run a PCA to see if it could identify different PCs that represent the concepts hypothesized (e.g. equity and community). The same list of variables used in the first regression analysis, except the dependent variable (HDI), was entered into the PCA. *Figure 23* describes the percentage of variance that each of the three principal components accounts for from the list of variables used in the analysis.

Principal Component Analysis Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	17.805	65.946	65.946	17.805	65.946	65.946	13.975	51.759	51.759
2	1.773	6.568	72.514	1.773	6.568	72.514	4.762	17.637	69.397
3	1.234	4.572	77.086	1.234	4.572	77.086	2.076	7.690	77.086

Figure 23 – First Principal Component Analysis

All independent variables used in the first regression analysis were used in the PCA regression. i.e. military expenditures, life expectancy index, education index, and GDP index were excluded. Varimax rotation was used because, after the PCA has identified the best PCs, they can be rotated around a central pivot point to find the best separation of correlation values to make it easier to identify what the PCs represent. *Figure 24* is a rotated component matrix showing the

Rotated Component Matrix ^a			
	Component		
	1	2	3
R5_Electricity consumption per capita (kilowatt-hours)	(.872)	.332	.046
R7_Carbon dioxide emissions per capita (metric tons)	(.863)	.159	.010
R2_Public expenditure on education (% of GDP)	.125	(.600)	-.069
R2_Public expenditure on health (% of GDP)	.374	(.737)	.064
P2p5_Gender-related development index (GDI)	(.806)	.441	.214
Gender empowerment measure (GEM)	.179	(.701)	.117
L10_GiniIndex	-.336	-.016	(.732)
R5_Infant mortality rate (per 1,000 live births)	(.861)	-.374	-.166
L10_Under-five mortality rate (per 1,000 live births)	(.863)	-.381	-.176
R6_Maternal mortality ratio - Ratio Adjusted (per 100,000 live births)	(.855)	-.316	-.223
R5_Tuberculosis cases per 100,000 people	(.814)	-.324	-.105
P5_water	(.841)	.316	.066
P2p25_sanitation	(.862)	.280	.124
R3_Migration (net) per 1,000 Population	.425	.076	-.487
L10_GNI PPP Per Capita, 2005 (US\$)	(.863)	.375	.093
HealthScore	(.867)	.307	.212
PopulationScore	.714	.339	.431
R2_HouseholdWealthScore	(.875)	.361	.034
Pp666_NationalWealthScore	(.831)	.389	.003
Knowledge	(.822)	.428	.180
Community	.368	(.662)	.121
Equity	.254	.421	(.745)
Pp75_HumanWellbeingIndex	(.796)	.510	.203
EcosystemWellbeingIndex	(.797)	.060	-.063
L10_Undernourishment	(.786)	-.322	-.206
P1p5_GEI	.350	(.654)	.345
P7_BCI	(.811)	.372	.211

Extraction Method: Principal Component Analysis.
 Rotation Method: Varimax with Kaiser Normalization.
 a. Rotation converged in 5 iterations.

Figure 24 – First Rotated Component Matrix

The three PCs from the varimax rotated component matrix are:

make up of each PC. High eigen loadings (over 0.59) are circled in red. There is no significance test for eigen loadings. We must use absolute values according to rules of thumb. The PCA identified three principal components. *Figure 25* shows the unrotated components. Only one high eigen value in each of the second and third PC (circled in red) was reported. After rotation it was easier to identify groupings because there is better separation of correlation values. The cumulative percentage of variance was 77% with each PC accounting for ~ 52%, 17.5%, and 7.5% after rotation.

1. Human Development, 2. Community, and 3. Equity. The first principal component is made up mainly of health, wealth, knowledge, and resource consumption. The second component is dominantly public spending, community, and Social Watch's gender equality measure which excludes income and rewards gender empowerment. The third component is mainly distribution of income.

Component Matrix(a)			
	Component		
	1	2	3
R5_Electricity consumption per capita (kilowatt-hours)	.919	-.165	.042
R7_Carbon dioxide emissions per capita (metric tons)	.826	-.293	-.037
R2_Public expenditure on education (% of GDP)	.364	.282	.411
R2_Public expenditure on health (% of GDP)	.668	.335	.358
P2p5_Gender-related development index (GDI)	.943	.038	-.007
Gender empowerment measure (GEM)	.492	.436	.324
L10_GiniIndex	-.444	-.304	.599
R5_Infant mortality rate (per 1,000 live births)	-.951	.059	.021
L10_Under-five mortality rate (per 1,000 live births)	-.959	.050	.025
R6_Maternal mortality ratio - Ratio Adjusted (per 100,000 live births)	-.932	.059	.100
R5_Tuberculosis cases per 100,000 people	-.877	.107	-.001
P5_water	.888	-.149	.022
P2p25_sanitation	.902	-.146	-.048
R3_Migration (net) per 1,000 Population	.309	-.448	.356
L10_GNI PPP Per Capita, 2005 (US\$)	.939	-.104	.036
HealthScore	.936	-.077	-.099
PopulationScore	.860	.149	-.224
R2_HouseholdWealthScore	.932	-.156	.070
Pp666_NationalWealthScore	.900	-.136	.117
Knowledge	.944	.001	.008
Community	.641	.325	.268
Equity	.556	.609	-.342
Pp75_HumanWellbeingIndex	.962	.081	.046
EcosystemWellbeingIndex	-.682	.370	.205
L10_Undernourishment	-.870	.033	.073
P1p5_GEI	.666	.466	.095
P7_BCI	.915	-.010	-.049
Extraction Method: Principal Component Analysis.			
a 3 components extracted.			

A varimax rotation takes the original principal components that were calculated and rotates all of them collectively on a central axis so that the sum of the variances of the loadings is the maximum possible. The important result is that the principal component values calculated for each country remain

Figure 25 – First Un-rotated Component Matrix

unaltered but the varimax rotation can (but might not) help to identify the input variables that contribute to each component and thus make it easier to name them. In this case varimax rotation helped. Without rotation it was difficult to name principal components two and three.

6.3 Second Regression Analysis (using Principal Components)

Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.884(a)	.781	.780	.116508		
2	.962(b)	.926	.925	.067797		
3	.978(c)	.957	.956	.051860		
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.840	1	7.840	577.572	.000(a)
	Residual	2.199	162	.014		
	Total	10.039	163			
2	Regression	9.299	2	4.650	1011.563	.000(b)
	Residual	.740	161	.005		
	Total	10.039	163			
3	Regression	9.609	3	3.203	1190.914	.000(c)
	Residual	.430	160	.003		
	Total	10.039	163			
a Predictors: (Constant), REGR factor score 1 for analysis 1						
b Predictors: (Constant), REGR factor score 1 for analysis 1, REGR factor score 2 for analysis 1						
c Predictors: (Constant), REGR factor score 1 for analysis 1, REGR factor score 2 for analysis 1, REGR factor score 3 for analysis 1						
Coefficients(a)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.493	.009		54.209	.000
	REGR factor score 1 for analysis 1	.219	.009	.884	24.033	.000
2	(Constant)	.493	.005		93.157	.000
	REGR factor score 1 for analysis 1	.219	.005	.884	41.300	.000
	REGR factor score 2 for analysis 1	.095	.005	.381	17.816	.000
3	(Constant)	.493	.004		121.784	.000
	REGR factor score 1 for analysis 1	.219	.004	.884	53.992	.000
	REGR factor score 2 for analysis 1	.095	.004	.381	23.291	.000
	REGR factor score 3 for analysis 1	.044	.004	.176	10.731	.000

Figure 26 – Second Regression Analysis

The stepwise regression using the three principal components as input produced very similar results to the first regression analysis. *Figure 26* is a summary of the three models that were calculated in the regression analysis.

The regression equation of the third model in the second analysis is:

$$\text{HDI} = 0.493 + (0.291 * \text{PC1}) + (0.095 * \text{PC2}) + (0.044 * \text{PC3})$$

The adjusted R square after the third component was brought into the equation was 0.956. In the first regression analysis the third model produced an adjusted R square of 0.964. This means that the three principal components do a good job of predicting the HDI.

The first regression analysis showed us that U5MR, education and access to communication technology, and gender equality in education, life expectancy, and income, are good variables to predict the HDI.

The second regression shows that concepts can be identified within different components and those components also do a good job predicting the HDI. Those concepts include human development (health, wealth, education, resource consumption), community (where money is spent, freedom and governance, peace and order as measure in the WON, and gender empowerment as measured by Social Watch), and finally equity (is income distributed equitably?).

If both regression equations do a good job predicting the HDI, this means that the HDI does a pretty good job representing the other variables.

6.4 Map of Residuals

As mentioned in section 6.1 the average of the residuals of medium countries was much higher than either the high or low countries. To investigate a decision was made to repeat the correlation and regression analyses using the two sets of data separately, the high and low stream, and the medium stream. The repeated analyses are described in sections 6.5 to 6.10.

Figure 27 on the next page is a world country population cartogram created in ArcGIS to illustrate which countries have the highest positive and negative residuals from the first regression analysis. A cartogram-choropleth map is used instead of a more traditional choropleth map with a geographic projection because the statistics are all population-ratio based. The cartogram helps to emphasise the numeric data values.

Generally the map shows that for about half of the world's population the regression equation does an extremely good job at predicting the HDI because the residuals are close to zero (between -1 and +1). Extreme residual values (e.g. Hong Kong, East Timor, and Equatorial Guinea) greater than 3 and less than -3, account for a very small percentage of the total world population. But the residuals map does not suggest a spatial pattern of residuals.

Figure 27 – Map of Residuals

6.5 Second Data Transformation

The second phase of the analysis used data for high and low countries on the HDI scale. There were 85 high and low countries out of the total of 164 countries. As discussed in section 6.1 linear regression analysis requires data to follow a linear scale where the residuals of the regression are as normally distributed as possible. The data transformation process described in section 5.2 was repeated because the distribution of data values was different when using a subset of data. Repeating the analyses meant that the complete process of data transformation and scatterplot reviews, etc. discussed in section 5.1 to 5.4 had to be repeated twice, once for each stream. For both sets, the required transformations to make the data linear were different to the original transformation exercise.

Appendix A shows SPSS output of Histogram and Scatterplot matrix reports that were used to verify that the transformations were successful. The scatterplot matrix reports and histograms are reduced in size so that data for all variables can be shown at once. The key to the filenames follows the same logic as naming the histograms for all countries. *Figures 40 and 41* are the histograms of the untransformed and transformed variables. *Figures 42 and 43* are the scatterplot matrix reports of the untransformed and transformed variables.

Specific comments are not given because the descriptions are similar. Generally scatterplots became more linear or did not change very much. None became less linear. Similarly some histograms became more normal, some did not change much, and none were any worse after transformation. Again, some

data corrections were required after positively skewed data were transformed because a log of zero cannot be calculated.

Transformed Variable Name	Transformation Function	Orig. Skewness	Trans. Skewness	#
P5_HDI	Power 5	-.525	-.044	0
R3_Electricity consumption per capita (kilowatt-hours)	Power 1/3	1.773	.026	1
R4_Carbon dioxide emissions per capita (metric tons)	Power 1/4	2.599	-.005	2
R3_Public expenditure on education (% of GDP)	Power 1/3	.881	-.059	3
R2_Public expenditure on health (% of GDP)	Sq. Root	.222	-.166	4
R_VP3_Military expenditure (% of GDP)	Power 0.3	4.653	-.187	5
P4_Gender-related development index (GDI)	Power 4	-.622	-.077	6
Gender empowerment measure (GEM)	NONE	.116	.116	7
L10_GiniIndex	Log 10	.765	.192	8
P5_Life Expectancy Index	Power 5	-.648	-.066	9
P6_Education Index	Power 6	-.879	-.053	10
P3_GDP Index	Power 3	-.444	-.029	11
L10_Infant mortality rate (per 1,000 live births)	Log 10	.790	.336	12
L10_Under-five mortality rate (per 1,000 live births)	Log 10	.865	.361	13
R7_Maternal mortality ratio - Ratio Adjusted (per 100,000 live births)	Power 1/7	1.256	.027	14
L10_Tuberculosis cases per 100,000 people	Log 10	1.199	.012	15
P12_water	Power 12	-1.008	-.288	16
P12_sanitation	Power 12	-.742	-.205	17
L10_Migration (net) per 1,000 Population	Log 10	5.009	1.022	18
R2_GNI PPP Per Capita, 2005 (US\$)	Sq. Root	.809	.100	19
P2_HealthScore	Power 2	-.324	-.005	20
P_V1p2_PopulationScore	Power 1.2	-.202	-.145	21
P_V1p2_HouseholdWealthScore	Power 1.2	-.210	-.141	22
NationalWealthScore	NONE	-.048	-.048	23
P_V1p3_Knowledge	Power 1.3	-.260	-.139	24
P_V1p3_Community	Power 1.3	-.335	-.145	25
P_V1p1_Equity	Power 1.1	-.204	-.110	26
HumanWellbeingIndex	NONE	-.180	-.180	27
EcosystemWellbeingIndex	NONE	.138	.138	28
L10_Undernourishment	Log 10	1.431	.270	29
P2_GEI	Power 2	-.416	-.021	30
P12_BCI	Power 12	-1.028	-.243	31

Table 6 – List of Variables with Transformation Functions (High and Low Countries)

The transformation function, the original and transformed skewness statistics, and the number of the variable used in the histograms reports in Figures 40 and 41 are shown in Table 6. With the exception of one variable

(migration), transformation, if needed, worked very well to reduce skewness to improve the normal distribution for regression.

6.6 Third Regression Analysis (High and Low Stream)

A correlation analysis was run to determine which variables were significant or not significant. Again, the military expenditures variable was the only one flagged as not significant.

A Stepwise Regression using P5_HDI as the dependent variable, and all other variables listed in *Table 6* except military expenditures, life expectancy index, education index, and GDP index produced nine models.

Figure 28 summarizes the first three models that were calculated in the regression analysis. Generally the correlation between variables went up slightly from the first regression analysis. On average, the residuals went up slightly from the first analysis. All in all, this regression analysis was very similar to the analysis using all the data.

Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.972(a)	.946	.945	.070743		
2	.987(b)	.974	.974	.049004		
3	.990(c)	.980	.980	.043056		
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.210	1	7.210	1440.637	.000(a)
	Residual	.415	83	.005		
	Total	7.625	84			
2	Regression	7.428	2	3.714	1546.635	.000(b)
	Residual	.197	82	.002		
	Total	7.625	84			
3	Regression	7.475	3	2.492	1344.032	.000(c)
	Residual	.150	81	.002		
	Total	7.625	84			
a Predictors: (Constant), R2_GNI PPP Per Capita, 2005 (US\$)						
b Predictors: (Constant), R2_GNI PPP Per Capita, 2005 (US\$), P_V1p3_Knowledge						
c Predictors: (Constant), R2_GNI PPP Per Capita, 2005 (US\$), P_V1p3_Knowledge, P2_HealthScore						
Coefficients(a)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.136	.015		-8.877	.000
	R2_GNI PPP Per Capita, 2005 (US\$)	.005	.000	.972	37.956	.000
2	(Constant)	-.100	.011		-8.916	.000
	R2_GNI PPP Per Capita, 2005 (US\$)	.003	.000	.534	10.824	.000
	P_V1p3_Knowledge	.001	.000	.470	9.538	.000
3	(Constant)	-.088	.010		-8.651	.000
	R2_GNI PPP Per Capita, 2005 (US\$)	.002	.000	.449	9.657	.000
	P_V1p3_Knowledge	.001	.000	.310	5.750	.000
	P2_HealthScore	.000	.000	.254	5.022	.000

Figure 28 – Third Regression Analysis

The regression equation of the second model in the second analysis is:

$$\text{HDI} = -0.100 + (0.003 * \text{GNI}) + (0.001 * \text{knowledge})$$

The first regression model (discussed in section 6.1) brought in under-five mortality rate (U5MR) as the first variable with an adjusted R square value of 0.913. The third regression model using the same set of variables and a subset of the data (high and low countries) brought in gross national income as the first variable with an adjusted R square value of 0.945. This means that for the high

and low countries on the HDI scale, income is the most determinant component and it alone significantly predicts the HDI. The second model, which added the WON knowledge variable, improved the adjusted R square value to 0.974, or over 97%. The third model added health score but the 0.006 adjusted R square improvement is so insignificant that it could be random noise. Beyond the second model, the adjusted R square improved marginally at each step until exhausting the possibilities and finishing with the ninth model with an adjusted R square of 0.990. For this set of data the second model best predicts the HDI.

This analysis shows that by removing the medium countries, predicting the HDI using the selected set of variables improved slightly. GNI on its own does a very good job at predicting the HDI.

6.7 Second Principal Component Analysis (High and Low Stream)

The principal component analysis was repeated using high and low countries to see if the components changed from the first analysis. The same list of variables used in the third regression analysis was entered into the PCA. The PCA calculated two principal components. *Figure 29* explains the percentage of variance that each of the two principal components accounts for from the list of variables used in the analysis.

Component	Total Variance Explained								
	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	19.821	73.411	73.411	19.821	73.411	73.411	13.660	50.593	50.593
2	2.004	7.424	80.835	2.004	7.424	80.835	8.165	30.242	80.835

Figure 29 – Second Principal Component Analysis

Rotated Component Matrix(a)		
	Component	
	1	2
R3_Electricity consumption per capita (kilowatt-hours)	.868	.378
R4_Carbon dioxide emissions per capita (metric tons)	.897	.165
R3_Public expenditure on education (% of GDP)	.073	.524
R2_Public expenditure on health (% of GDP)	.443	.721
P4_Gender-related development index (GDI)	.740	.606
Gender empowerment measure (GEM)	.301	.641
L10_GiniIndex	-.309	-.576
L10_Infant mortality rate (per 1,000 live births)	-.832	-.514
L10_Under-five mortality rate (per 1,000 live births)	-.839	-.504
R7_Maternal mortality ratio - Ratio Adjusted (per 100,000 live births)	-.815	-.490
L10_Tuberculosis cases per 100,000 people	-.758	-.549
P12_water	.850	.443
P12_sanitation	.845	.417
L10_Migration (net) per 1,000 Population	.638	-.420
R2_GNI PPP Per Capita, 2005 (US\$)	.835	.475
P2_HealthScore	.786	.548
P_V1p2_PopulationScore	.697	.633
P_V1p2_HouseholdWealthScore	.860	.448
NationalWealthScore	.857	.429
P_V1p3_Knowledge	.779	.591
P_V1p3_Community	.458	.671
P_V1p1_Equity	.202	.850
HumanWellbeingIndex	.755	.634
EcosystemWellbeingIndex	-.837	-.160
L10_Undernourishment	-.755	-.541
P2_GEI	.355	.781
P12_BCI	.767	.568
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.		
a. Rotation converged in 3 iterations.		

All independent variables used in the third regression analysis were used in the PCA regression. Varimax rotation again helped to identify strongly correlated variables to name the two principal components. *Figure 30* is a rotated component matrix showing the make up of each PC.

Figure 30 – Second Rotated Component Matrix

The cumulative percentage of variance was 75% with each PC accounting for ~ 51%, and ~30% after rotation.

The two PCs from the varimax rotated component matrix are: 1. Human Development, and 2. Community and Equity.

The first principal component is made up mainly of health, wealth, knowledge, and resource consumption. The second component is dominantly public spending, community, gender equality and distribution of income. Knowledge and education are pretty evenly split over the two components, as was the gender development index and population score. This makes it more difficult to distinctly identify the two components.

6.8 Fourth Regression Analysis (using Principal Components High and Low Stream)

The stepwise regression using the two principal components as input produced a very similar results to the third regression analysis. *Figure 31* summarizes the two models that were calculated in the regression analysis. The regression equation of the second model in the fourth analysis is:

$$\text{HDI} = 0.368 + (0.244 * \text{PC1}) + (0.168 * \text{PC2})$$

The adjusted R square after the second component was brought into the equation was 0.965. In the second regression, the third model using principal components calculated using data for all countries produced an adjusted R square Of 0.956. This means that the two principal components in this regression do a similarly good job predicting the HDI.

Model Summary(c)						
Model	R	R.Square	Adjusted R.Square	Std. Error of the Estimate		
1	.809(a)	.655	.651	.178094		
2	.983(b)	.965	.965	.056704		
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.992	1	4.992	157.404	.000(a)
	Residual	2.633	83	.032		
	Total	7.625	84			
2	Regression	7.361	2	3.681	1144.734	.000(b)
	Residual	.264	82	.003		
	Total	7.625	84			
a Predictors: (Constant), REGR factor score 1 for analysis 1						
b Predictors: (Constant), REGR factor score 1 for analysis 1 , REGR factor score 2 for analysis 1						
c Dependent Variable: P5_HDI						
Coefficients(a)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.368	.019		19.060	.000
	REGR factor score 1 for analysis 1	.244	.019	.809	12.546	.000
2	(Constant)	.368	.006		59.863	.000
	REGR factor score 1 for analysis 1	.244	.006	.809	39.405	.000
	REGR factor score 2 for analysis 1	.168	.006	.557	27.143	.000

Figure 31 – Fourth Regression Analysis

6.9 Third Data Transformation

The third phase of the analysis used data for medium countries on the HDI scale. There were 79 medium countries out of the total of 164 countries. The data transformation process described in section 5.2 was repeated because the distribution of data values was different using a subset of data. Repeating the analyses meant that the process of data transformation had to be repeated for the medium stream.

Appendix A shows SPSS output of Histogram and Scatterplot matrix reports that were used to verify that the transformations were successful. The scatterplot matrix reports and histograms are reduced in size so that data for all variables can be shown at once. The key to the filenames follows the same logic

as naming the histograms for all countries. *Figures 44 and 45* are the histograms of the untransformed and transformed variables. *Figures 46 and 47* are the scatterplot matrix reports of the untransformed and transformed variables. Specific comments are not given because the descriptions are similar. Generally scatterplots became more linear or did not change very much. None became less linear. Similarly some histograms became more normal, some did not change much, and none were any worse after transformation. Again, some data corrections were required after positively skewed data were transformed because a log of zero cannot be calculated. It was more difficult to reduce skewness for the medium stream than for the first two streams

The transformation function, the original and transformed skewness statistics, and the number of the variable used in the histograms reports in *Figures 44 and 45* are shown in *Table 7*. With the exception of one variable (GINI index), transformation, if needed, worked very well to reduce skewness to improve the normal distribution for regression.

Transformed Variable Name	Transform- ation Function	Orig. Skewn ess	Trans. Skewn ess	#
P7_HDI	Power 7	-.804	-.010	0
R3_Electricity consumption per capita (kilowatt-hours)	Power 1/3	1.406	-.053	1
R6_Carbon dioxide emissions per capita (metric tons)	Power 1/6	1.921	.092	2
R_Vp75__Public expenditure on education (% of GDP)	Power 0.75	.508	.098	3
R2_Public expenditure on health (% of GDP)	Sq. Root	.443	-.080	4
L10_Military expenditure (% of GDP)	Log 10	2.831	-.204	5
P9_Gender-related development index (GDI)	Power 9	-1.213	-.020	6
P10_Gender empowerment measure (GEM)	Power 10	-1.795	-.132	7
L10_GiniIndex	Log 10	1.197	.625	8
P6_Life Expectancy Index	Power 6	-1.530	.067	9
P5_Education Index	Power 5	-1.010	.090	10
P_V1p5_GDP Index	Power 1.5	-.179	.022	11
R8_Infant mortality rate (per 1,000 live births)	Power 1/8	.635	-.035	12
L10_Under-five mortality rate (per 1,000 live births)	Log 10	.873	-.066	13
L10_Maternal mortality ratio - Ratio Adjusted (per 100,000 live births)	Log 10	1.705	.067	14
R6_Tuberculosis cases per 100,000 people	Power 1/6	1.293	-.143	15
P5_water	Power 5	-1.192	.093	16
P_V1p5_sanitation	Power 1.5	-.325	-.046	17
R3_Migration (net) per 1,000 Population	Power 1/3	2.047	.002	18
R2_GNI PPP Per Capita, 2005 (US\$)	Sq. Root	.830	.141	19
P2_HealthScore	Power 2	-.863	-.077	20
R2_PopulationScore	Sq. Root	.291	-.075	21
R2_HouseholdWealthScore	Sq. Root	.247	-.134	22
R_Vp666_NationalWealthScore	Power .666	.265	-.052	23
P_V1p75_Knowledge	Power 1.75	-.612	.014	24
P_Vp75_Community	Power 0.75	.456	.037	25
	NONE	.080	.080	26
P2_HumanWellbeingIndex	Power 2	-.450	.090	27
R_Vp666_EcosystemWellbeingIndex	Power .666	.169	.011	28
R6_Undernourishment	Power 1/6	1.298	-.115	29
GEI	NONE	-.168	-.168	30
P6_BCI	Power 6	-1.023	-.022	31

Table 7 – List of Variables with Transformation Functions (Medium Countries)

6.10 Fifth Regression Analysis (Medium Stream)

A correlation analysis was run to determine which variables were significant or not significant. This time there were several other variables in addition to military expenditures that were flagged as not significant. These included public expenditures on health, public expenditures on education, gender empowerment measure, GINI index, migration, community, and equity. All of these variables were excluded from further analyses. Generally the correlation between variables went down. In some cases the correlation coefficients were substantial. For example, in the first correlation analysis using all country variables the correlation coefficient between HDI and the WON HWI was .937. Using medium HDI countries the correlation coefficient between HDI and the WON HWI was .674.

A Stepwise Regression using P7_HDI as the dependent variable, and all other variables listed in Table 7 except life expectancy index, education index, GDP index, and the excluded variables mentioned above produced four models.

Figure 32 summarizes the first three models that were calculated in the regression analysis.

The regression equation of the third model in the fifth analysis is:

$$\text{HDI} = -0.085 + (0.870 * \text{GDI}) + (-0.072 * \text{U5MR}) + (0.077 * \text{CO}_2)$$

Model Summary						
Model	R	R Square	Adjusted R Square		Std. Error of the Estimate	
1	.851(a)	.724	.720		.033415	
2	.894(b)	.799	.793		.028729	
3	.918(c)	.843	.836		.025555	
4	.924(d)	.854	.846		.024782	
a Predictors: (Constant), P9_Genderrelated_development_index_GDI						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.225	1	.225	201.869	.000(a)
	Residual	.086	77	.001		
	Total	.311	78			
2	Regression	.249	2	.124	150.631	.000(b)
	Residual	.063	76	.001		
	Total	.311	78			
3	Regression	.262	3	.087	133.931	.000(c)
	Residual	.049	75	.001		
	Total	.311	78			
a Predictors: (Constant), P9_Genderrelated_development_index_GDI						
b Predictors: (Constant), P9_Genderrelated_development_index_GDI, L10_Underfive_mortality_rate_per_1000_live_births						
c Predictors: (Constant), P9_Genderrelated_development_index_GDI, L10_Underfive_mortality_rate_per_1000_live_births, R6_Carbon_dioxide_emissions_per_capita_metric_tons						
Coefficients(a)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.014	.007		1.960	.054
	P9_Genderrelated_development_index_GDI	1.576	.111	.851	14.208	.000
2	(Constant)	.175	.031		5.652	.000
	P9_Genderrelated_development_index_GDI	1.043	.139	.563	7.525	.000
	L10_Underfive_mortality_rate_per_1000_live_births	-.081	.015	-.397	-5.307	.000
3	(Constant)	.085	.034		2.510	.014
	P9_Genderrelated_development_index_GDI	.870	.129	.470	6.748	.000
	L10_Underfive_mortality_rate_per_1000_live_births	-.072	.014	-.353	-5.250	.000
	R6_Carbon_dioxide_emissions_per_capita_metric_tons	.077	.017	.247	4.588	.000

Figure 32 – Fifth Regression Analysis

The third model in the first regression analysis (using data for all countries), and the second model in the third regression analysis (using data for high and low countries) were both significantly strong predictors of HDI with adjusted R square values of 0.963, and .974 respectively. The best (third) model in the fifth regression analysis (using data for medium countries) was only .836, a noticeable change. Not as many variables were used in this equation because they were flagged as not significant in the correlation analysis. The third model

brought in GDI, U5MR, and CO₂ emissions as the best variables to predict HDI for medium countries.

The selected best model in the first and second regression analyses perform as better predictors of HDI for medium countries. In other words, combining the medium data with high and low data helps.

6.11 Third Principal Component Analysis (Medium Stream)

The principal component analysis was repeated using medium countries to see the difference from the two earlier PCAs. The same list of variables used in the fifth regression analysis was entered into the PCA. *Figure 33* shows the percentage of variance that each of the three principal components accounts for from the list of variables used in the analysis. The fourth model, not listed, did not improve the third model. In the third model only 69% of the variance is explained in the three principal components.

Component	Total Variance Explained								
	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.651	53.257	53.257	10.651	53.257	53.257	5.695	28.477	28.477
2	1.613	8.065	61.322	1.613	8.065	61.322	5.192	25.961	54.438
3	1.544	7.718	69.040	1.544	7.718	69.040	2.920	14.601	69.040

Figure 33 –Third Principal Component Analysis

All independent variables used in the fifth regression analysis were used in the PCA regression. Varimax rotation again helped to identify strongly correlated variables to name the two principal components.

Figure 34 is a rotated component matrix showing the make up of each PC. The PCA identified three principal components. The cumulative percentage of variance was about 69% with each PC accounting for ~53%, ~8%, and ~8%.

Rotated Component Matrix(a)			
	Component		
	1	2	3
R3_Electricity_consumption_per_capita_kilowatthours	.300	.782	.311
R6_Carbon_dioxide_emissions_per_capita_metric_tons	.249	.820	.189
P9_Genderrelated_development_index_GDI	.631	.374	.424
R8_Infant_mortality_rate_per_1000_live_births	-.846	-.242	-.184
L10_Underfive_mortality_rate_per_1000_live_births	-.858	-.259	-.197
L10_Maternal_mortality_ratio_Ratio_Adjusted_per_100000_live	-.637	-.393	-.348
R6_Tuberculosis_cases_per_100000_people	-.766	-.381	.147
P5_water	.577	.382	.093
P_V1p5_sanitation	.743	.325	.187
R2_GNI_PPP_Per_Capita_2005_US\$	.269	.771	.155
P2_HealthScore	.764	.203	.333
R2_PopulationScore	.457	.122	.694
R2_HouseholdWealthScore	.364	.736	.183
R_Vp66_NationalWealthScore	.147	.686	.244
R_V1p75_Knowledge	.253	.551	.570
P2_HumanWellbeingIndex	.434	.349	.688
R_Vp66EcosystemWellbeingIndex	-.275	-.620	.062
R6_Undernourishment	-.362	-.624	-.063
GEI	-.019	.068	.847
P6_BCI	.579	.477	.340
Extraction Method: Principal Component Analysis.			
Rotation Method: Varimax with Kaiser Normalization.			
a. Rotation converged in 6 iterations.			

The PCs are:

1. Health, 2. Wealth and Consumption,
- and 3. Knowledge and Gender equality.

Figure 34 –Third Rotated Component Matrix

6.12 Sixth Regression Analysis (using Principal Components Medium Stream)

The stepwise regression using the three principal components as input produced very similar results to the fifth regression analysis. *Figure 35* summarizes the three models that were calculated in the regression analysis.

The regression equation of the third model in the sixth analysis is:

$$\text{HDI} = 0.99 + (0.42 * \text{PC1}) + (0.30 * \text{PC2}) + (0.23 * \text{PC3})$$

The adjusted R square after the third component was brought into the equation was 0.802. The best (third) model in the fifth regression analysis (also using data for medium countries) was only .836, a noticeable change from the earlier regression analyses using the complete set of world country data and a subset of high and low country data. The relatively low adjusted R square value compared to the first four regression analyses is not a surprise because the principal components were constructed from the set of medium countries data.

Model Summary						
Model	R	R Square	Adjusted R Square		Std. Error of the Estimate	
1	.672(a)	.452	.445		.047080	
2	.821(b)	.674	.665		.036556	
3	.900(c)	.810	.802		.028089	
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.141	1	.141	63.477	.000(a)
	Residual	.171	77	.002		
	Total	.311	78			
2	Regression	.210	2	.105	78.502	.000(b)
	Residual	.102	76	.001		
	Total	.311	78			
3	Regression	.252	3	.084	106.544	.000(c)
	Residual	.059	75	.001		
	Total	.311	78			
a Predictors: (Constant), REGR factor score 1 for analysis 1						
b Predictors: (Constant), REGR factor score 1 for analysis 1, REGR factor score 2 for analysis 1						
c Predictors: (Constant), REGR factor score 1 for analysis 1, REGR factor score 2 for analysis 1, REGR factor score 3 for analysis 1						
Coefficients(a)						
Model		Unstandardized Coefficients		Standardized Coefficients		Sig.
		B	Std. Error	Beta	t	
1	(Constant)	.099	.005		18.692	.000
	REGR factor score 1 for analysis 1	.042	.005	.672	7.967	.000
2	(Constant)	.099	.004		24.073	.000
	REGR factor score 1 for analysis 1	.042	.004	.672	10.261	.000
	REGR factor score 2 for analysis 1	.030	.004	.471	7.191	.000
3	(Constant)	.099	.003		31.329	.000
	REGR factor score 1 for analysis 1	.042	.003	.672	13.354	.000
	REGR factor score 2 for analysis 1	.030	.003	.471	9.359	.000
	REGR factor score 3 for analysis 1	.023	.003	.369	7.329	.000

Figure 35 – Sixth Regression Analysis

For both regression analyses using medium country data the residual values went down slightly on average. All in all - the calculated regression model using medium HDI countries was much worse than the other two streams of analyses.

6.13 Summary

The analysis shows that countries with higher life expectancy, education, and income also typically share other benefits. They consume more resources, have better access to technology, have stronger communities, and distribute wealth more equitably on average than countries with low life expectancy, education, and income. The HDI, composed of three components including life expectancy, education, and income to represent development can also act as a surrogate to represent other QOL components such as community and equity.

Hypothesis: At a practical and pragmatic level is the HDI technically a good surrogate for other facets of living conditions?

Result: Hypothesis accepted conditionally. When a reasonably complete set of world countries is used, such as the list of countries that the U.N. uses to track human development, the HDI does a very good job ranking quality of life by country. However, quality of life for the subset of medium countries on the HDI scale is not as well represented by the HDI.

7.0 Conclusion

The human development index is important for many intangible reasons including its relevance and popularity with world policy makers, its integrity, and its longevity. I am convinced that its production is a sincere and honest effort every year. The data are not perfect, but perfection does not exist. All of the data that were used in the thesis, including tables from the United Nations, World Health Organization, Food and Agriculture Organization, Population Research Bureau, Social Watch, and Wellbeing of Nations text, for example, were constructed to count something of value. But in every case there is metadata to explain where the difficulty was in counting and what assumptions had to be made. I would have liked to have had a complete set of world country-aggregated data to work with for health, wealth, culture, knowledge, rights and freedoms, law, peace, crime, and climate, to name just a very few of the dimensions of quality of life. But this complete set does not exist and probably never will. So after all the effort made to collect data, all we can do next is make the most of what we have. All of the data alternatives suffer from the same fundamental issues: insufficient data and scale. National statistics miss important variations within national boundaries. Even at the national scale, it has proven impossible to collect accurate HDI data for all countries. The U.N., like everyone else, also has to deal with the challenge of collecting data from unreceptive countries (Ghai, et. al., 1988).

The U.N. intended the HDI to be a policy tool to measure human progress on a national scale. However, I found that it, more often than not; it is

misunderstood to be a quality of life report card. It is used to support other arguments, often without understanding it. Very few seem to take the time to understand the HDI before tearing it apart. Most of the harshest criticism was from people who argued that it did not represent something else – like saying, your lawnmower is not a very good snowmobile. Despite the misunderstandings I am beginning to think that calling the HDI a quality of life yardstick might be reasonable after all. The HDI most certainly was not intended to measure quality of life. But, because quality of life and human development are related, pragmatically it happens to do a pretty good job anyway.

When I first embarked on my thesis I was advised to review the work of David M. Smith. At first, I did not see the connection between Smith and what I was looking for because I was focused on web-map technology. However near the end I understood that it had everything to do with it because it made me question the validity of what I was trying to do and it convinced me to make my own transformation from empirical experimentation toward more qualitative and quantitative research into what quality of life means to me and how to test it. Smith is one of the few geographers who have tried to measure social well-being using quantitative methods. His views about morality, ethics, and community touch on what I consider to be some of the most important inputs into an ideal QOL output. His insight into standard QOL measures including inequality, and his understanding of basic human needs, the environment, the importance of birth place, and power relations guided my thoughts about what I could and should do. I concluded that quality of life is a complex concept that I would find too difficult to

explain even if I found a set of data to match my model of what I thought quality of life was. But I discovered that even if I am not certain what QOL is, I can at least test to see if something else (the HDI) represents what I think it is. I think my statistical analysis is enough evidence to suggest that the HDI adds more value than it was intended for. This is because I am now convinced that if I were to use it to track QOL in the world, the numbers probably would correspond to the conditions in most cases.

Although I am not prepared for a debate to argue what quality of life is, at least I feel I am getting closer to understanding what it might take to make it better. In one of Smith's earlier case studies of South Africa and apartheid, he suggests that the "only certainty is that the White government will not voluntarily dismantle apartheid, in the foreseeable future and probably not ever" (Smith 1987: 99). This is because Whites, being a small minority, appropriate most of the wealth and their fortune depends on racial inequality and cheap labour. This is one statement where thankfully Smith was proven wrong with the dismantling of apartheid. But it gives me the sense that even back in 1987, Smith balanced his optimism with realism. Therefore he might not have been overly optimistic when he said more recently that the intellectual environment in which geography is engaging with ethics is a situation that should make geographers feel comfortable "given the discipline's long-standing attention to difference, and to the tension between the ideographic approach concerned with the unique and particular and a nomothetic approach concerned with the general and universal" (Smith, 2000: 198). Smith paints a picture of a world filled with unjust treatment

and disparities between and within nations. But he believes inequalities can and have been successfully measured and geographers can influence positive changes. This is because we are more adept at modeling our physical and social environments to understand them. I think that Smith argues successfully that if people were to realize that caring for ideas like equality, community, and the environment would help to raise our collective quality of life much more than raising our income would.

There were many things I learned along the way that form the crux of the argument that it is far more difficult to count the things that count most. Quality of life is an important human issue that cannot be scientifically measured with robust validity, accuracy or precision. Measuring the potential for human development is slightly less difficult. However any choice of variables used to represent it is inherently partial. This does not mean it should not be counted. There were two lessons that I learned about quantifying QOL. One is that while numbers alone cannot represent human conditions, some numbers can have utility and others can be deceptive if we choose to not put the effort into understanding them. If it is interpreted as intended, the HDI can be useful. The other lesson was that, as hard as I tried, conceptually there was no way for me to distinguish a clear border between objective and subjective data. This is how some people like to explain quality of life -the tangible aspects can be counted and intangible aspects can be 'understood'. After many philosophical debates with myself I have come to the conclusion that a regression formula to predict

quality of life is not possible because many of the variables in the equation are unquantifiable. But I am satisfied that the HDI is a pretty good approximation.

The research has helped me to understand the challenges of collecting, synthesising, and reporting social statistics. And it helped me to better appreciate the practical value of the human development index, and its role in provoking debate.

8.0 References

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Appendix A – Histograms and Scatterplot Matrix Reports Used in Data Transformations

Figure 36 – All Countries Stream – Untransformed Data Histograms

Figure 37 – All Countries Stream – Transformed Data Histograms

Figure 38 – All Countries Stream – Untransformed Data Scatterplots

Figure 39 – All Countries Stream –Transformed Data Scatterplots

Figure 40 – High and Low Stream – Untransformed Data Histograms

Figure 41 – High and Low Countries Stream – Transformed Data Histograms

Figure 42 – High and Low Stream – Untransformed Data Scatterplots

Figure 43 – High and Low Countries Stream –Transformed Data Scatterplots

Figure 44 – Medium Countries Stream – Untransformed Data Histograms

Figure 45 – Medium Countries Stream – Transformed Data Histograms

Figure 46 – Medium Countries Stream – Untransformed Data Scatterplots

Figure 47 – Medium Countries Stream –Transformed Data Scatterplots

Appendix B – Corrected Raw Data and list of excluded countries

ID	Source	Variable
HDI	UN	Human Development Index
Elect.	UN	Electricity consumption per capital (kilowatt-hours)
CO ₂	UN	Carbon dioxide emissions Per Capita (metric tons)
PEE	UN	Public expenditure on education (% of GDP)
PEH	UN	Public expenditure on health (% of GDP)
ME	UN	Military expenditure (% of GDP)
GDI	UN	Gender-related development index (GDI)
GEM	UN	Gender empowerment measure (GEM)
GINI	UN	GiniIndex
LEI	UN	Life Expectancy Index
EI	UN	Education Index
GDPI	UN	GDP Index
IMR	UN	Infant mortality rate (per 1,000 live births)
U5MR	UN	Under-five mortality rate(per 1,000 live births)
MMR	UN	Maternal mortality ratio - (per 100,000 live births)
TB	UN	Tuberculosis cases per 100,000 people
H ₂ O	WHO	water
San	WHO	sanitation
Mig	PRB	Migration (net) per 1000 population
GNI	PRB	GNI PPP Per Capita, 2005 (US\$)
HS	WON	HealthScore
PS	WON	PopulationScore
HHWS	WON	HouseholdWealthScore
NWS	WON	NationalWealthScore
Kn	WON	Knowledge
Cm	WON	Community
Eq	WON	Equity
HWI	WON	HumanWellbeingIndex
EWI	WON	EcosystemWellbeingIndex
Un	FAO	O Undernourishment
GEI	SW	Gender Equality Index
BCI	SW	Basic Capabilities Index

Table 8 – Key to Variable Names in Corrected Data Table

Table 8 references the source variable names to the corresponding identifiers in the table heading of the corrected data table in *Table 9*.

Table 9 – Corrected Data Table

Country_name	HDI	Elect.	CO ₂	PE E	PE H	ME	GDI	GEM	GNI	LEI	EI	GD PI	IMR	U5 MR	MMR	TB	H ₂ O	San	Mig	GNI	HS	PS	HH WS	NW S	Kn	Cm	Eq	HWI	EWI	Un	G	BCI
Norway	0.963	26640	12.2	7.6	8.0	2.0	0.960	0.928	25.8	0.91	0.99	0.99	3	4	16	5	100	100	4	40420	85	86	83	84	91	77	73	82	43	1.3	86	99.9
Iceland	0.956	29247	7.7	6.0	8.3	0.0	0.953	0.834	37.9	0.93	0.98	0.96	3	4	0	3	100	100	5	34760	83	82	87	82	86	80	70	80	43	1.3	80	99.9
Australia	0.955	11299	18.3	4.9	6.5	1.9	0.954	0.826	35.2	0.92	0.99	0.95	6	6	8	6	100	100	5	30610	88	88	81	79	95	70	62	79	28	1.3	79	99.1
Sweden	0.949	16996	5.8	7.7	7.8	1.8	0.947	0.852	25.0	0.92	0.99	0.93	3	3	2	4	100	100	4	31420	88	92	80	76	92	60	78	79	49	1.3	89	99.9
Canada	0.949	18541	16.5	5.2	6.7	1.2	0.946	0.807	33.1	0.92	0.97	0.96	5	6	6	4	100	100	7	32220	86	92	82	72	95	72	62	78	43	1.3	78	99.1
Luxembourg	0.949	10547	21.1	4.5	5.3	0.9	0.944	0.555	37.9	0.89	0.95	1.00	5	5	28	10	100	100	3	65340	84	90	86	93	80	78	55	77	24	1.3	58	97.1
Switzerland	0.947	8483	5.7	5.8	6.5	1.0	0.946	0.795	33.1	0.93	0.96	0.96	4	5	7	7	100	100	5	37080	87	94	82	81	82	85	53	78	43	1.3	74	99.8
Ireland	0.946	6560	11.0	5.5	5.5	0.7	0.939	0.724	35.9	0.88	0.97	0.99	6	6	5	12	100	100	13	34720	81	86	80	77	85	80	55	76	32	1.3	70	99.5
Belgium	0.945	8749	6.8	6.3	6.5	1.3	0.941	0.828	25.0	0.90	0.99	0.94	4	5	10	12	100	100	3	32640	85	92	81	68	90	78	71	80	23	1.3	74	99.8
United States	0.944	13456	20.1	5.7	6.6	3.8	0.942	0.793	40.8	0.87	0.97	0.99	7	8	17	3	100	100	3	41950	82	84	85	83	94	58	49	73	31	1.3	78	99.4
Japan	0.943	8612	9.4	3.6	6.5	1.0	0.937	0.534	24.9	0.95	0.94	0.94	3	4	10	42	100	100	0	31410	91	96	84	74	93	76	60	80	25	1.3	61	99.9
Netherlands	0.943	6958	9.4	5.1	5.8	1.6	0.939	0.814	30.9	0.89	0.99	0.95	5	5	16	6	100	100	2	32480	86	94	87	78	92	67	65	78	22	1.3	76	99.8
Denmark	0.941	6925	8.9	8.5	7.3	1.5	0.938	0.860	24.7	0.87	0.99	0.96	3	4	5	6	100	100	1	33570	81	90	86	81	89	74	76	81	31	1.3	81	99.8
Finland	0.941	16694	12.0	6.4	5.5	1.2	0.940	0.833	26.9	0.89	0.99	0.94	4	5	6	10	100	100	1	31170	83	90	86	74	93	70	77	81	44	1.3	86	99.9
United Kingdom	0.939	6614	9.2	5.3	6.4	2.8	0.937	0.716	36.0	0.89	0.99	0.94	5	6	13	12	100	100	4	32690	85	90	83	78	90	52	59	73	30	1.3	77	99.5
France	0.938	8123	6.2	5.6	7.4	2.6	0.935	0.555	32.7	0.91	0.97	0.94	4	5	17	12	100	100	2	30540	88	90	80	70	86	69	58	75	29	1.3	64	99.2
Austria	0.936	7845	7.8	5.7	5.4	0.8	0.926	0.779	30.0	0.90	0.96	0.95	4	5	4	12	100	100	7	33140	85	96	81	77	91	81	66	80	42	1.3	72	99.8
Italy	0.934	5840	7.5	4.7	6.4	1.9	0.928	0.589	36.0	0.92	0.95	0.94	4	4	5	6	100	100	5	28840	87	100	80	63	84	69	60	74	30	1.3	63	98.5
New Zealand	0.933	10301	8.7	6.7	6.6	1.1	0.929	0.769	36.2	0.90	0.99	0.90	5	6	7	11	100	100	2	23030	80	84	81	74	85	80	42	73	38	1.3	81	99.8
Germany	0.930	6989	9.8	4.6	8.6	1.4	0.926	0.813	28.3	0.90	0.96	0.94	4	5	8	7	100	100	1	29210	83	98	81	72	85	75	64	77	36	1.3	61	99.8
Spain	0.928	6154	7.3	4.5	5.4	1.2	0.922	0.745	32.5	0.91	0.97	0.90	4	4	4	27	100	100	6	25820	87	100	82	60	86	60	59	73	20	1.3	76	99.8
Hong Kong SAR of China	0.916	6237	5.2	4.4	3.2	1.8	0.912	0.555	43.4	0.94	0.87	0.94	5	6	17	79	100	100	5	34670	53	55	37	34	48	37	46	40	43	8.0	73	92.7
Israel	0.915	6698	11.0	7.5	6.0	9.1	0.911	0.622	35.5	0.91	0.95	0.88	5	6	17	8	100	100	2	25280	83	60	61	63	81	43	51	59	25	1.3	73	99.5
Greece	0.912	5247	8.5	4.0	5.0	4.1	0.907	0.594	35.4	0.89	0.97	0.88	4	5	9	22	100	100	3	23620	87	98	74	59	79	63	54	70	33	1.3	65	99.8
Singapore	0.907	7961	13.8	4.5	1.3	5.2	0.742	0.654	42.5	0.89	0.91	0.92	3	3	30	42	100	100	20	29780	81	90	85	78	79	44	46	66	32	8.0	61	92.7
Slovenia	0.904	6791	7.8	6.1	6.2	1.5	0.901	0.603	28.4	0.86	0.98	0.88	4	4	17	22	100	100	3	22160	78	98	73	63	81	71	59	71	35	3.0	73	98.9
Portugal	0.904	4647	6.0	5.8	6.6	2.1	0.900	0.656	38.5	0.87	0.97	0.87	4	5	5	37	100	100	5	19730	81	96	74	70	79	71	56	72	31	1.3	73	99.8
Korea, Rep of	0.901	7058	9.4	4.2	2.6	2.5	0.896	0.479	31.6	0.87	0.97	0.87	5	5	20	118	92	100	1	21850	64	90	76	59	93	63	49	67	27	1.3	56	99.8
Barbados	0.878	3193	4.6	7.6	4.7	1.8	0.876	0.615	37.9	0.83	0.96	0.84	11	13	95	14	100	100	1	10710	64	94	75	46	72	68	48	62	32	1.3	79	98.6
Czech Republic	0.874	6368	11.2	4.4	6.4	2.2	0.872	0.595	25.4	0.84	0.93	0.85	4	4	9	12	100	98	4	20140	76	100	72	51	76	70	69	70	33	1.3	72	99.2
Malta	0.867	4939	7.5	4.5	7.0	0.8	0.858	0.486	37.9	0.89	0.85	0.86	5	6	21	6	100	100	5	18960	83	86	76	60	73	80	45	70	14	1.3	58	99.5
Brunei Darussalam	0.866	8903	17.7	4.5	2.7	1.8	0.742	0.555	37.9	0.86	0.86	0.88	5	6	37	61	100	100	2	10710	62	58	76	60	44	17	47	47	42	4.0	61	97.4
Argentina	0.863	2383	3.5	4.0	4.5	1.2	0.854	0.665	52.2	0.82	0.96	0.80	17	20	82	55	96	91	1	13920	71	60	54	41	67	55	46	55	40	3.0	71	96.4
Hungary	0.862	3972	5.6	5.5	5.5	1.8	0.860	0.528	26.9	0.80	0.96	0.83	7	8	16	33	99	95	0	16940	61	98	70	46	75	69	61	65	33	1.3	73	98.7
Poland	0.858	3549	7.7	5.6	4.4	2.0	0.856	0.612	34.1	0.82	0.96	0.79	6	7	13	34	100	100	0	13490	69	94	65	47	72	70	56	65	30	1.3	74	99.4
Chile	0.854	2918	3.6	4.2	2.6	3.5	0.846	0.475	57.1	0.88	0.91	0.77	8	9	31	17	95	91	2	11470	79	70	60	51	62	60	55	30	4.0	63	99.4	
Estonia	0.853	5767	11.8	5.7	3.9	1.9	0.852	0.595	37.2	0.77	0.97	0.82	8	9	63	53	100	97	0	15420	58	98	51	50	81	62	60	62	34	1.3	73	99.1
Lithuania	0.852	3239	3.6	5.9	4.3	1.6	0.851	0.614	31.9	0.79	0.97	0.79	8	11	13	73	100	100	3	14220	60	96	63	51	67	70	53	61	44	1.3	79	98.7
Slovakia	0.849	5256	6.8	4.4	5.3	1.9	0.847	0.597	25.8	0.82	0.91	0.82	7	8	3	29	100	99	1	15760	70	96	40	51	69	61	69	61	40	7.0	75	95.9
Qatar	0.849	17489	53.1	4.5	2.4	1.8	0.742	0.555	37.9	0.80	0.87	0.88	11	15	7	72	100	100	40	10710	59	38	82	60	59	20	13	40	24	8.0	61	95.9
United Arab Emirates	0.849	14215	25.1	1.6	2.3	3.1	0.742	0.555	37.9	0.88	0.76	0.90	7	8	54	26	100	98	54	24090	66	43	70	76	60	21	8	41	16	1.3	43	98.1

Country_name	HDI	Elect.	CO ₂	PE	PE	ME	GDI	GEM	GNI	LEI	EI	GD	IMR	U5	MMR	TB	H ₂ O	San	Mig	GNI	HS	PS	HH	NW	Kn	Cm	Eq	HWI	EWI	Un	G	BCI
Bahrain	0.846	10830	30.6	4.5	3.2	5.1	0.837	0.393	37.9	0.82	0.86	0.86	12	15	28	52	100	100	7	21290	62	58	73	48	70	12	29	46	17	8.0	45	99.3
Kuwait	0.844	16544	24.6	4.5	2.9	9.0	0.843	0.555	37.9	0.87	0.80	0.87	8	9	5	31	100	100	14	24010	58	55	80	76	52	37	27	50	25	5.0	45	90.2
Croatia	0.841	3558	4.7	4.5	5.9	2.1	0.837	0.599	29.0	0.83	0.90	0.79	6	7	8	68	100	100	3	12750	72	92	45	49	71	39	69	57	33	7.0	75	98.8
Uruguay	0.840	2456	1.2	2.6	2.9	1.6	0.836	0.504	44.6	0.84	0.94	0.74	12	14	27	33	100	100	3	9810	72	70	59	45	66	66	53	61	52	1.3	70	96.8
Costa Rica	0.838	1765	1.4	5.1	6.1	0.0	0.829	0.668	46.5	0.89	0.87	0.76	10	10	43	18	97	92	1	9680	71	55	56	42	61	74	40	56	41	5.0	67	96.2
Latvia	0.836	2703	2.7	5.8	3.3	1.7	0.834	0.606	33.6	0.78	0.96	0.77	10	12	42	78	99	78	0	13480	56	98	61	53	68	67	60	62	46	3.0	79	98.6
Bahamas	0.832	6084	6.7	4.5	3.4	1.8	0.742	0.719	37.9	0.75	0.89	0.86	11	14	60	52	97	100	2	10710	50	60	66	50	71	54	39	54	32	8.0	80	95.8
Cuba	0.817	1395	2.1	9.0	6.5	1.8	0.742	0.555	37.9	0.87	0.91	0.67	6	8	33	13	91	98	3	10710	78	92	37	33	44	2	51	40	45	1.3	66	99.1
Mexico	0.814	2280	3.7	5.3	2.7	0.5	0.804	0.583	54.6	0.83	0.85	0.75	23	28	83	45	97	79	4	10030	64	58	50	44	59	23	37	45	21	5.0	61	92.1
Bulgaria	0.808	4624	5.3	3.5	4.4	2.6	0.807	0.604	31.9	0.79	0.91	0.73	14	15	32	47	99	99	0	8630	62	100	59	31	70	57	56	58	31	8.0	74	98.2
Panama	0.804	1654	2.0	4.5	6.4	1.8	0.800	0.563	56.4	0.83	0.88	0.71	18	24	160	52	90	73	0	7310	68	60	53	31	54	70	32	52	37	23.0	72	91.5
Trinidad and Tobago	0.801	4422	31.9	4.3	1.4	1.8	0.796	0.650	40.3	0.75	0.88	0.78	17	20	160	13	91	100	3	13170	62	92	39	46	50	70	43	53	32	10.0	70	98.0
Libyan Arab Jamahiriya	0.799	3915	9.1	4.5	1.6	2.0	0.742	0.555	37.9	0.81	0.86	0.72	13	16	97	21	86	97	0	10710	51	36	58	58	54	3	58	38	24	1.3	61	92.7
TFYR of Macedonia	0.797	3363	5.1	3.5	5.8	2.5	0.794	0.555	28.2	0.81	0.87	0.70	10	11	23	37	86	69	0	7080	59	82	35	22	48	50	50	46	42	5.0	70	95.4
Malaysia	0.796	3234	6.3	8.1	2.0	2.8	0.791	0.502	49.2	0.80	0.83	0.76	7	7	41	135	99	94	4	10320	55	48	54	54	59	33	38	46	33	3.0	61	94.3
Russian Federation	0.795	6062	9.9	3.8	3.5	4.3	0.742	0.477	31.0	0.67	0.96	0.76	16	21	67	157	97	87	1	10640	54	96	60	37	67	26	43	48	42	3.0	75	92.7
Romania	0.792	2385	4.0	3.5	4.2	2.4	0.789	0.488	30.3	0.77	0.89	0.72	18	20	49	194	57	89	1	8940	57	100	31	34	55	56	63	50	30	1.3	71	95.2
Brazil	0.792	2183	1.8	4.2	3.6	1.6	0.786	0.555	59.3	0.76	0.89	0.73	33	35	260	91	90	75	0	8230	50	80	46	39	57	50	26	45	36	7.0	68	92.0
Mauritius	0.791	1631	2.6	4.7	2.2	0.2	0.781	0.555	37.9	0.79	0.80	0.79	16	18	24	136	100	94	0	12450	57	86	60	49	43	72	46	54	44	5.0	55	98.8
Bosnia and Herzegovina	0.786	2527	4.8	4.5	4.6	2.9	0.742	0.555	26.2	0.82	0.86	0.68	14	17	31	63	97	95	2	7790	64	96	17	13	16	0	57	24	45	9.0	61	92.7
Belarus	0.786	3326	6.0	6.0	4.7	1.3	0.785	0.555	30.4	0.72	0.95	0.68	13	17	35	59	100	84	0	7890	55	96	45	41	64	22	67	46	50	4.0	69	98.6
Colombia	0.785	1019	1.3	5.2	6.7	4.4	0.780	0.500	57.6	0.79	0.86	0.70	18	21	130	80	93	86	1	7420	58	58	57	35	48	25	36	43	42	13.0	77	88.6
Oman	0.781	5219	12.1	4.6	2.8	12.2	0.759	0.555	37.9	0.82	0.71	0.82	10	12	87	12	86	69	12	14680	58	16	58	52	36	18	46	31	28	8.0	44	97.2
Albania	0.780	1844	0.8	4.5	2.4	1.2	0.776	0.555	28.2	0.81	0.89	0.64	18	21	55	33	96	91	3	5420	52	70	52	26	45	18	40	38	46	6.0	56	93.9
Thailand	0.778	1860	3.7	5.2	3.1	1.3	0.774	0.452	43.2	0.75	0.86	0.72	23	26	44	203	99	99	0	8440	52	90	48	41	47	57	51	50	23	22.0	71	98.0
Saudi Arabia	0.772	6620	15.0	4.5	3.3	8.7	0.749	0.253	37.9	0.78	0.72	0.82	22	26	23	57	86	69	2	14740	62	16	70	64	38	3	36	31	23	4.0	43	94.8
Venezuela	0.772	3484	4.3	4.5	2.3	1.3	0.765	0.441	49.1	0.80	0.87	0.65	18	21	96	52	83	68	0	6440	64	53	37	32	49	43	34	43	46	18.0	68	94.4
Ukraine	0.766	3525	6.4	5.4	3.3	2.9	0.763	0.417	29.0	0.69	0.95	0.67	15	20	35	133	96	96	0	6720	58	96	24	39	62	38	54	47	26	1.3	73	98.1
Peru	0.762	907	1.0	3.0	2.2	1.3	0.745	0.511	49.8	0.75	0.88	0.66	26	34	410	231	83	63	2	5830	51	53	39	32	59	36	40	44	62	12.0	60	84.0
Kazakhstan	0.761	4030	9.9	3.0	1.9	1.1	0.759	0.555	32.3	0.64	0.94	0.70	63	73	210	152	86	72	1	7730	45	80	52	44	54	25	50	43	32	6.0	65	96.2
Lebanon	0.759	2834	4.7	2.7	3.5	4.3	0.745	0.555	37.9	0.78	0.84	0.66	27	31	150	13	100	98	2	5740	53	60	36	23	59	19	40	45	37	3.0	46	96.0
Armenia	0.759	1554	1.0	3.2	1.3	2.7	0.756	0.555	37.9	0.77	0.90	0.60	30	33	55	89	92	83	3	5060	71	90	50	32	40	31	42	45	55	24.0	61	96.9
Ecuador	0.759	943	2.0	1.0	1.7	2.4	0.742	0.490	43.7	0.82	0.86	0.60	24	27	130	209	94	89	4	4070	54	50	34	23	50	46	43	43	56	6.0	61	80.8
Philippines	0.758	610	0.9	3.1	1.1	0.9	0.755	0.526	46.1	0.76	0.89	0.63	27	36	200	458	85	72	2	5300	50	39	38	33	57	46	48	44	32	18.0	76	77.5
Suriname	0.755	4447	5.1	4.5	5.2	1.8	0.742	0.555	37.9	0.74	0.83	0.70	30	39	110	102	92	94	7	5960	57	80	34	50	58	59	46	52	58	8.0	65	90.3
China	0.755	1484	2.7	4.5	2.0	2.3	0.754	0.555	44.7	0.78	0.84	0.65	30	37	56	245	77	44	0	6600	56	88	18	50	40	13	50	36	28	12.0	68	93.0
Paraguay	0.755	1129	0.7	4.4	3.2	0.9	0.742	0.427	57.8	0.77	0.86	0.64	25	29	170	105	86	80	1	4970	58	31	25	43	40	25	35	46	35	15.0	66	81.5
Jordan	0.753	1585	3.2	4.5	4.3	8.9	0.740	0.555	36.4	0.77	0.86	0.63	23	28	41	5	97	93	2	5280	52	24	48	20	52	42	43	38	28	6.0	47	98.1
Belize	0.753	713	3.1	5.2	2.5	1.8	0.734	0.486	37.9	0.78	0.77	0.71	33	39	140	56	91	47	10	6740	54	39	33	31	65	74	40	50	64	4.0	62	90.4
Tunisia	0.753	1205	2.3	6.4	2.9	1.6	0.743	0.555	39.8	0.80	0.74	0.71	19	24	120	24	93	85	1	7900	55	65	45	38	50	29	45	44	32	1.3	51	94.5
Fiji	0.752	625	1.6	5.6	2.7	1.6	0.742	0.381	37.9	0.71	0.86	0.68	16	20	75	38	47	72	5	5960	51	58	45	46	46	56	47	50	46	5.0	60	95.7
Sri Lanka	0.751	366	0.5	4.5	1.8	2.7	0.747	0.370	33.2	0.82	0.83	0.61	13	15	92	89	79	91	1	4520	58	82	27	30	37	39	49	40	57	22.0	65	85.9

Country_name	HDI	Elect.	CO ₂	PE E	PE H	ME	GDI	GEM	GINI	LEI	EI	GD PI	IMR	U5 MR	MMR	TB	H ₂ O	San	Mig	GNI	HS	PS	HH WS	NW S	Kn	Cm	Eq	HWI	EWI	Un	G EI	BCI
Turkey	0.750	1904	3.0	3.7	4.3	4.9	0.742	0.285	40.0	0.73	0.82	0.70	33	39	70	40	96	88	0	8420	58	70	33	29	57	37	41	45	28	3.0	46	92.3
Dominican Republic	0.749	1326	2.5	2.3	2.2	1.8	0.739	0.527	47.4	0.70	0.84	0.70	29	35	150	123	95	78	3	7150	57	58	44	41	47	65	35	49	46	29.0	63	84.9
Maldives	0.745	448	3.4	4.5	4.0	1.8	0.742	0.555	37.9	0.69	0.90	0.65	55	72	110	39	83	59	0	5960	40	19	26	36	13	24	42	22	47	10.0	61	79.8
Jamaica	0.738	2640	4.1	6.1	3.4	1.8	0.736	0.555	37.9	0.76	0.83	0.62	17	20	87	9	93	80	7	4110	73	70	50	29	49	57	53	54	35	9.0	65	94.3
Turkmenistan	0.738	2126	9.1	4.5	3.0	1.8	0.742	0.555	40.8	0.62	0.91	0.68	79	102	31	83	72	62	0	5960	41	39	38	18	56	4	55	32	30	7.0	61	85.9
Iran (Islamic Republic of)	0.736	2075	5.3	4.9	2.9	3.8	0.719	0.316	43.0	0.76	0.74	0.71	33	39	76	36	94	69	4	8050	53	58	39	46	49	19	29	38	32	4.0	48	93.4
Georgia	0.732	1508	0.7	2.2	1.0	1.1	0.742	0.416	36.9	0.76	0.90	0.54	41	45	32	95	82	94	9	3270	69	86	29	41	53	35	61	48	41	9.0	69	93.7
Azerbaijan	0.729	2579	3.4	3.2	0.8	1.9	0.725	0.555	36.5	0.70	0.89	0.60	75	91	94	109	77	54	0	4890	59	84	39	48	46	21	52	42	28	7.0	63	83.0
Occupied Palestinian Territory	0.729	1608	2.7	4.5	3.2	1.8	0.742	0.555	37.9	0.79	0.88	0.52	22	24	100	37	92	73	2	5960	53	55	37	34	48	37	46	40	43	16.0	51	94.8
Algeria	0.722	881	2.9	4.5	3.2	3.3	0.706	0.555	35.3	0.77	0.71	0.69	35	41	140	53	85	92	1	6770	55	36	51	28	43	0	41	29	44	4.0	44	94.7
El Salvador	0.722	665	1.0	2.9	3.6	0.7	0.715	0.467	53.2	0.76	0.76	0.65	32	36	150	78	84	62	1	5120	55	48	37	47	43	12	42	36	46	11.0	64	78.1
Syrian Arab Republic	0.721	1570	2.8	4.5	2.3	7.1	0.702	0.555	37.9	0.81	0.76	0.60	16	18	160	52	93	90	0	3740	50	34	34	23	44	7	34	28	25	4.0	44	86.8
Cape Verde	0.721	99	0.3	7.9	3.8	0.7	0.714	0.555	37.9	0.76	0.75	0.66	26	35	150	328	80	43	6	6000	47	39	19	35	49	74	51	47	47	15.7	55	90.4
Guyana	0.720	1195	2.2	8.4	4.3	1.8	0.716	0.555	37.9	0.63	0.90	0.63	52	69	170	178	83	70	11	4230	52	75	48	21	43	74	53	51	63	8.0	58	81.2
Viet Nam	0.704	392	0.8	4.5	1.5	1.8	0.702	0.555	37.0	0.76	0.82	0.54	19	23	130	238	85	61	0	3010	48	65	14	18	37	11	67	28	49	16.0	65	90.6
Kyrgyzstan	0.702	2252	1.0	3.1	2.2	2.9	0.700	0.555	34.8	0.70	0.93	0.48	59	68	110	140	77	59	5	1870	44	48	37	30	47	28	52	38	42	4.0	60	85.9
Indonesia	0.697	463	1.4	1.2	1.2	1.5	0.691	0.555	34.3	0.70	0.81	0.59	31	41	230	674	77	55	1	3720	51	65	24	17	42	31	48	36	48	6.0	52	83.7
Uzbekistan	0.694	2008	4.8	4.5	2.5	0.5	0.692	0.555	26.8	0.69	0.91	0.48	57	69	24	156	82	67	2	2020	52	43	32	30	57	13	52	36	30	25.0	57	85.9
Nicaragua	0.690	496	0.7	3.1	3.9	0.9	0.683	0.555	43.1	0.75	0.74	0.58	30	38	230	78	79	47	4	3650	48	29	33	20	33	24	38	28	49	27.0	55	73.1
Bolivia	0.687	485	1.2	6.3	4.2	1.7	0.679	0.525	44.7	0.65	0.87	0.54	53	66	420	301	85	46	2	2740	39	30	31	13	48	37	43	34	63	23.0	59	80.0
Mongolia	0.679	1318	3.3	9.0	4.6	1.8	0.677	0.388	30.3	0.65	0.90	0.49	56	68	110	237	62	59	0	2190	40	65	16	20	39	60	47	39	60	27.0	74	94.5
Republic of Moldova	0.671	1314	1.6	4.9	4.1	0.4	0.668	0.494	36.9	0.71	0.85	0.45	26	32	36	177	92	68	1	2150	55	90	19	30	52	34	53	41	35	11.0	78	95.0
Honduras	0.667	696	0.9	4.5	3.2	0.4	0.742	0.356	55.0	0.71	0.74	0.55	32	41	110	102	87	69	2	2900	54	31	28	27	32	45	29	33	45	23.0	67	72.6
Guatemala	0.663	660	0.9	4.5	2.3	0.5	0.649	0.555	59.9	0.70	0.66	0.62	35	47	240	104	95	86	4	4410	40	23	25	35	28	11	35	23	44	22.0	52	71.5
Egypt	0.659	1287	2.1	4.5	1.8	2.6	0.742	0.274	34.4	0.75	0.62	0.61	33	39	84	36	98	70	1	4440	49	45	40	34	49	25	50	39	43	4.0	45	87.8
South Africa	0.658	4715	7.4	5.3	3.5	1.6	0.652	0.555	57.8	0.39	0.81	0.77	53	66	230	341	88	65	1	12120	21	45	55	49	70	33	39	43	27	1.3	68	87.1
Equatorial Guinea	0.655	54	0.4	0.6	1.3	1.8	0.641	0.555	37.9	0.30	0.78	0.88	97	146	880	351	43	53	0	7580	27	17	21	15	18	6	29	15	62	15.7	44	59.2
Tajikistan	0.652	2559	0.7	2.8	0.9	2.2	0.650	0.555	32.6	0.64	0.91	0.40	92	118	100	267	59	51	1	1260	46	33	21	18	49	12	30	28	39	56.0	57	83.0
Gabon	0.635	1226	2.6	3.9	1.8	1.8	0.742	0.555	37.9	0.49	0.72	0.69	60	91	420	242	88	36	2	5890	32	18	44	30	20	37	44	28	62	5.0	61	82.0
Morocco	0.631	560	1.4	6.5	1.5	4.2	0.616	0.555	39.5	0.75	0.53	0.62	36	39	220	105	81	73	1	4360	50	53	30	31	32	33	38	36	32	6.0	44	79.9
Namibia	0.627	1608	1.1	7.2	4.7	2.8	0.621	0.603	70.7	0.39	0.80	0.69	48	65	300	477	87	25	0	7910	15	23	38	44	40	40	49	34	54	24.0	75	85.9
India	0.602	569	1.2	4.1	1.3	2.1	0.586	0.555	32.5	0.64	0.61	0.56	63	87	540	287	86	33	0	3460	39	50	16	26	26	39	44	31	27	20.0	39	72.8
Solomon Is	0.594	69	0.4	3.4	4.5	1.8	0.742	0.555	37.9	0.62	0.68	0.48	19	22	130	60	70	31	0	1880	42	24	34	35	10	80	44	37	61	21.0	53	85.9
Myanmar	0.578	135	0.2	4.5	0.4	1.8	0.742	0.555	37.9	0.59	0.76	0.39	76	107	360	183	78	77	0	5960	37	75	14	12	34	0	62	21	49	5.0	61	70.1
Cambodia	0.571	10	2.7	1.8	2.1	2.5	0.567	0.364	40.4	0.52	0.69	0.51	97	140	450	742	41	17	0	2490	29	26	10	17	23	20	47	20	57	33.0	61	59.3
Botswana	0.565	1608	2.3	2.2	3.7	4.1	0.559	0.505	63.0	0.19	0.76	0.75	82	112	100	342	95	42	1	10250	11	30	35	49	38	45	51	34	68	32.0	74	90.5
Lao People's Dem Republic	0.545	133	0.2	2.8	1.5	1.8	0.540	0.555	37.0	0.49	0.66	0.48	82	91	650	327	51	30	0	2020	29	16	12	17	18	14	59	15	63	19.0	54	57.9
Bhutan	0.536	236	0.2	5.2	4.1	1.8	0.742	0.555	37.9	0.63	0.48	0.50	70	85	420	194	62	70	0	5960	37	18	16	32	2	11	40	14	67	15.7	61	69.0
Pakistan	0.527	469	0.7	1.8	1.1	4.4	0.508	0.379	33.0	0.63	0.44	0.51	81	103	500	358	91	59	1	2350	44	21	18	23	13	17	47	18	44	24.0	38	59.5
Nepal	0.526	62	0.2	3.4	1.4	1.6	0.511	0.555	36.7	0.61	0.53	0.44	61	82	740	316	90	35	1	1530	34	29	9	23	21	46	43	28	64	17.0	41	56.1
Papua New Guinea	0.523	249	0.4	2.3	3.8	0.6	0.518	0.555	50.9	0.50	0.52	0.55	69	93	300	527	39	44	0	2370	31	26	19	25	19	22	32	22	53	15.7	61	74.8

Country_name	HDI	Elect.	CO ₂	PE E	PE H	ME	GDI	GEM	GINI	LEI	EI	GD PI	IMR	U5 MR	MMR	TB	H ₂ O	San	Mlg	GNI	HS	PS	HH WS	NW S	Kn	Cm	Eq	HWI	EWI	Un	G	BCI
Bangladesh	0.520	119	0.3	2.4	0.8	1.2	0.514	0.218	31.8	0.63	0.45	0.48	46	69	380	490	74	39	0	2090	35	50	15	33	15	36	44	27	46	30.0	45	52.8
Ghana	0.520	416	0.4	4.5	2.3	0.7	0.517	0.555	40.8	0.53	0.51	0.52	59	95	540	369	75	18	0	2370	29	20	15	22	5	46	48	22	38	11.0	56	66.3
Timor-Leste	0.513	1608	2.7	4.5	6.2	1.8	0.742	0.555	37.9	0.51	0.64	0.39	87	124	660	753	58	36	1	5969	53	55	37	34	48	37	46	40	43	9.0	61	85.9
Togo	0.512	120	0.3	2.6	5.1	1.6	0.491	0.555	37.9	0.49	0.57	0.47	78	140	570	673	52	35	0	1550	22	14	14	18	28	27	25	21	66	24.0	40	70.3
Sudan	0.512	89	0.3	4.5	1.0	2.4	0.495	0.555	37.9	0.52	0.52	0.49	63	93	590	355	70	34	3	2000	25	26	17	9	10	4	45	13	46	26.0	42	80.0
Congo	0.512	210	0.6	3.2	1.5	1.4	0.507	0.555	37.9	0.45	0.71	0.38	81	108	510	489	58	27	6	810	28	14	12	7	29	9	39	15	72	33.0	43	93.4
Uganda	0.508	61	0.1	4.5	2.1	2.3	0.502	0.555	43.0	0.37	0.71	0.45	81	140	880	621	60	43	1	1500	12	8	14	11	7	14	47	10	44	19.0	61	63.1
Zimbabwe	0.505	981	1.0	4.7	4.4	2.1	0.493	0.555	56.8	0.20	0.78	0.53	78	126	1100	500	81	53	1	1940	12	36	23	26	31	25	34	23	55	47.0	50	76.7
Madagascar	0.499	42	0.1	2.9	1.2	1.8	0.483	0.555	47.5	0.51	0.64	0.35	78	126	550	325	46	32	0	880	17	18	12	7	10	59	43	24	50	38.0	54	65.2
Swaziland	0.498	1608	0.9	7.1	3.6	1.8	0.485	0.492	60.9	0.12	0.73	0.64	105	153	370	683	62	48	1	5190	19	25	26	47	36	6	30	24	54	22.0	61	77.1
Cameroon	0.497	207	0.2	3.8	1.2	1.5	0.487	0.555	44.6	0.35	0.64	0.51	95	166	730	221	66	51	0	2150	24	19	20	10	14	13	38	15	64	26.0	61	70.4
Lesotho	0.497	1608	2.7	10.4	5.3	2.6	0.487	0.555	63.2	0.19	0.76	0.54	63	84	550	390	79	37	4	3410	17	24	15	24	19	40	35	24	57	13.0	55	69.9
Djibouti	0.495	296	0.5	4.5	3.3	1.8	0.742	0.555	37.9	0.46	0.52	0.51	97	138	730	988	73	82	5	2240	18	19	20	23	4	30	16	18	60	24.0	61	78.8
Yemen	0.489	159	0.7	9.5	1.0	7.1	0.448	0.123	33.4	0.59	0.51	0.36	82	113	570	151	67	43	1	920	34	5	13	13	17	24	29	15	51	38.0	26	61.3
Mauritania	0.477	58	1.1	4.5	2.9	1.6	0.471	0.555	39.0	0.46	0.49	0.48	120	183	1000	664	53	34	2	2150	23	18	15	12	15	24	39	17	40	10.0	61	75.5
Haiti	0.475	73	0.2	4.5	3.0	1.8	0.742	0.555	37.9	0.44	0.50	0.48	76	118	680	386	54	30	3	1840	26	29	12	20	8	28	51	19	43	46.0	61	85.9
Kenya	0.474	155	0.2	7.0	2.2	1.7	0.472	0.555	42.5	0.37	0.66	0.39	79	123	1000	821	61	43	0	1170	20	30	14	17	14	22	38	18	51	31.0	62	85.9
Gambia	0.470	96	0.2	2.8	3.3	0.5	0.464	0.555	47.5	0.51	0.41	0.49	90	123	540	337	82	53	3	1920	32	19	14	18	13	18	33	16	62	29.0	47	69.5
Guinea	0.466	95	0.1	1.8	0.9	1.8	0.742	0.555	40.3	0.48	0.41	0.51	104	160	740	394	50	18	6	2240	18	18	15	16	6	23	41	15	66	24.0	47	67.2
Senegal	0.458	141	0.4	3.6	2.3	1.5	0.449	0.555	41.3	0.51	0.39	0.47	78	137	690	429	76	57	2	1770	27	18	26	18	12	30	41	20	54	20.0	53	74.1
Nigeria	0.453	148	0.4	4.5	1.2	1.2	0.439	0.555	50.6	0.31	0.66	0.39	98	198	800	518	48	44	0	1040	19	20	12	12	15	17	30	16	56	9.0	43	63.1
Rwanda	0.450	23	0.1	2.8	3.1	2.8	0.447	0.555	28.9	0.31	0.61	0.42	118	203	1400	628	74	42	0	1320	12	14	19	5	14	12	57	12	57	33.0	75	52.2
Angola	0.445	135	0.5	2.8	2.1	4.7	0.438	0.555	37.9	0.26	0.54	0.53	154	260	1700	256	53	31	2	2210	19	10	15	12	6	4	56	8	67	35.0	50	85.9
Eritrea	0.444	66	0.2	4.1	3.2	19.4	0.431	0.555	37.9	0.48	0.49	0.36	45	85	630	431	60	9	9	1010	18	16	6	32	7	0	39	10	60	75.0	45	66.6
Benin	0.431	92	0.3	3.3	2.1	1.8	0.419	0.555	37.9	0.48	0.41	0.40	91	154	850	141	67	33	2	1110	24	16	10	17	13	65	36	27	71	12.0	46	73.3
Cote d'Ivoire	0.420	197	0.4	4.6	1.4	1.5	0.403	0.555	44.6	0.35	0.46	0.45	117	192	690	618	84	37	4	1490	25	21	16	13	19	27	40	20	57	13.0	36	70.9
U. Rep of Tanzania	0.418	83	0.1	4.5	2.7	2.1	0.414	0.538	38.2	0.35	0.60	0.30	104	165	1500	476	62	47	2	730	16	18	18	3	6	39	48	18	54	44.0	67	73.8
Malawi	0.404	80	0.1	6.0	4.0	1.8	0.396	0.555	50.3	0.24	0.67	0.30	112	178	1800	469	73	61	0	650	7	10	3	10	25	50	42	22	62	35.0	46	62.5
Zambia	0.394	603	0.2	2.0	3.1	1.8	0.383	0.555	52.6	0.21	0.61	0.36	120	182	750	508	58	55	2	950	8	18	11	5	15	35	35	16	43	46.0	53	74.3
Dem Rep of the Congo	0.385	91	2.7	4.5	1.1	1.8	0.373	0.555	37.9	0.30	0.53	0.32	129	205	990	537	46	30	0	720	16	12	7	5	11	0	47	7	65	74.0	61	85.9
Mozambique	0.379	378	0.1	4.5	4.1	1.3	0.365	0.555	39.6	0.28	0.45	0.40	109	158	1000	557	43	32	0	1170	14	13	11	5	5	17	50	11	55	44.0	57	60.6
Burundi	0.378	25	2.7	3.9	0.6	5.9	0.373	0.555	33.3	0.31	0.51	0.31	114	190	1000	519	79	36	7	640	14	13	10	4	4	0	49	6	60	66.0	58	56.3
Ethiopia	0.367	32	0.1	4.6	2.6	4.3	0.355	0.555	30.0	0.38	0.40	0.33	112	169	850	507	22	13	0	1000	13	13	7	4	5	30	38	13	64	46.0	46	48.8
Central African Rep	0.355	28	0.1	4.5	1.6	1.3	0.742	0.555	61.3	0.24	0.43	0.40	115	180	1100	493	75	27	0	1140	16	23	11	10	7	30	17	16	66	44.0	38	85.9
Guinea-Bissau	0.348	41	0.2	4.5	3.0	1.8	0.326	0.555	47.0	0.33	0.39	0.33	126	204	1100	300	59	35	1	700	17	16	11	4	11	20	18	13	66	39.0	45	60.1
Chad	0.341	12	2.7	4.5	2.7	1.5	0.322	0.555	37.9	0.31	0.30	0.42	117	200	1100	439	42	9	3	1470	20	14	10	13	5	22	28	13	59	35.0	36	46.7
Mali	0.333	33	2.7	4.5	2.3	1.9	0.323	0.555	50.5	0.38	0.23	0.38	122	220	1200	582	50	46	2	1000	12	11	4	8	6	62	35	21	44	29.0	46	66.0
Burkina Faso	0.317	32	0.1	4.5	2.0	1.3	0.311	0.555	48.2	0.38	0.16	0.41	107	207	1000	303	61	13	1	1220	15	11	12	11	4	42	37	17	58	15.0	40	71.3
Sierra Leone	0.298	54	0.1	3.7	1.7	1.7	0.279	0.555	62.9	0.26	0.35	0.28	166	284	2000	794	57	39	3	780	2	14	4	3	7	12	36	6	63	51.0	37	85.9
Niger	0.281	40	0.1	2.3	2.0	1.8	0.271	0.555	50.5	0.32	0.17	0.35	154	262	1600	272	46	13	0	800	7	9	7	8	2	30	25	11	56	32.0	46	54.7

Afghanistan	Grenada	Puerto Rico
American Samoa	Guadeloupe	Réunion
Andorra	Guam	Samoa
Anguilla	Iraq	San Marino
Antigua and Barbuda	Isle of Man	Sao Tome & Principe
Aruba	Kiribati	Serbia and Montenegro
Bermuda	Korea, Dem People's Rep of	Seychelles
British Virgin Islands	Liberia	Somalia
Cayman Islands	Liechtenstein	Saint Helena
Channel Islands	Macao SAR of China	Saint Kitts and Nevis
Comoros	Marshall Islands	Saint Lucia
Cook Is	Martinique	Saint-Pierre-et-Miquelon
Cyprus	Monaco	St Vincent & the Grenadines
Dominica	Montserrat	Tokelau
Falkland Is (Malvinas)	Nauru	Tonga
Faeroe Islands	Netherlands Antilles	Turks and Caicos Islands
Micronesia (Fed States of)	New Caledonia	Tuvalu
French Guiana	Niue	US Virgin Islands
French Polynesia	Northern Mariana Is	Vanuatu
Gibraltar	Palau	Wallis et Futuna
Greenland	Pitcairn	Western Sahara

Table 10 – Countries Excluded from the Analysis