Fractal Analysis Of Global Fresh Water Use

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Abstract

Fresh water withdrawals refer to the total fresh water withdrawn in a given year, expressed as a percentage of total renewable water resource. Withdrawals can exceed 100 percent of total renewable resource where extraction from nonrenewable aquifers or desalination plants is considerable or where there is significant water reuse. Exploratory data analysis using Fractal Statistics were used to determine significant information about the global freshwater extractions of the different countries. Fractal Statistics Analysis, has determined the data to be exponential in distribution across regions and the impact of water scarcity on countries is fractal. Other significant issues are over-extraction of underground water, fresh water depletion, and environmental degradation.

Keywords: Fractal Statistics Analysis, Freshwater extraction, water scarcity, water scarcity impact, water stress, environmental degradation, desertification

1.0 Introduction

Of all the planet's renewable resources, fresh water may be the most unforgiving. It is difficult to purify, expensive to transport, and impossible to substitute. Water is essential to food production, to economic development, and to life itself (Gardner-Outlaw & Engelman, 1999).

Fresh water is naturally occurring on the Earth's surface. The US Geographical Survey states that of the total global water, only 2.5% is fresh water. 1.2% of fresh water comes from the Earth's surface, 30.1% from groundwater, and 68.7% is from glaciers and ice caps. Surface water consists of ground ice and permafrost, rivers, swamps, marshes, streams, ponds, and lakes. The term specifically excludes seawater and brackish water.

The United Nations reports that many areas of the world are experiencing stresses on water availability. Water stress or shortage occurs when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use (Pereira, Cordery, & Iacovides, 2009). Water shortage is both natural and human-made phenomenon. There is an increase in demand for fresh water as population increases. On the other hand, the amount of clean water is also reduced by pollution and mismanagement (Jønch-Clausen, 2004).

This paper investigates the rate of freshwater extraction by countries around the globe. Using fractal statistics analysis (FSA), this paper intends to examine the rates of freshwater extractions, its fractal characteristics, and its insights. It intends to look into countries with extreme freshwater extraction data and analyze these deviations. Study selected countries with cases of water stress. Examine the thresholds, the method of management, the interventions, and technologies employed to address the crisis.

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2.0 Literature

Water stress refers to a state of being able to facilitate and meet the human and ecological demand for water. It is a broad concept. It considers several physical aspects related to water resources, including water quality, environmental flows, and water scarcity or the accessibility of water (Schulte, 2014).

In the past, people thrived around waterholes, and civilization flourished in urban centers where water supply is plenty. In the modern times, distribution and availability of potable water is a significant component to a decent living and determines human settlement. It is an essential component in guaranteeing the sustainable socio-economic development of a society (Tortajada, 2009). While the global economic growth may bring prosperity to citizens, it has caused severe stresses on human living conditions particularly water sustainability.

As a result of population growth, increasing pollution, poor water management practices, and climatic variations, freshwater resources are becoming scarce in many countries (Lazarova et al., 2001). In the developing world, the lack of proper water sanitation and infrastructure constricts economic growth (Garrett, & Ruel, 2000). It is for this reason that businesses regard water availability as a major factor when making decisions about where to invest or locate facilities.

The recent projections are that in 2025 about half of the population will face real constraints in their water supply, and two-thirds of the world's population will be suffering moderate to high water stress (Lazarova et al., 2001). There are currently more than 430 million people living in countries considered "water stressed." Population Action International (PAI) projects that by 2050, the percentage of the world's population living in water-stressed countries will increase by at least threefold (Water, 2003).

According to Malthus, 1798, subsistence increases only in an arithmetical ratio, while population, when unchecked, increases in a geometrical ratio. The population must always be kept down to the level of the means of subsistence. Uncontrolled growth will eventually hasten the deterioration of the natural resources. Unless a country can afford to import the more expensive resource, then growth and development will experience its natural decline. When resources are consumed beyond its threshold limits, growth and developments will be logistic.

2.1 Freshwater extractions

According to the AQUASTAT, FAO of the United Nations global water information system, freshwater withdrawals refers to the total fresh water withdrawn in a given year, expressed as a percentage of total renewable water resources. Withdrawals can exceed 100 percent of total renewable resources where extraction from nonrenewable aquifers or desalination plants is considerable or where there is significant water reuse. Withdrawals do not count evaporation losses from storage basins but also include water from desalination plants in countries where these are a significant source (Jønch-Clausen, 2004).

The rate of freshwater extraction mirrors the rate of natural resource consumption. The increased extraction may be due to a positive communal growth or an indicator of an excessive, mismanage consumption of resources. The threshold limit of this resource is a significant gauge of how much growth or development the current resource can sustain. Lester R. Brown, 2001, a keynote speaker at

the 10th Stockholm Water Conference said, "We are now beginning to feed ourselves with water that belongs to our children. We are borrowing water from the next generation." This discussion anchors on the rate of worldwide freshwater extractions and the UN population projections.

Water as a natural capital may have critical thresholds, have finite limits, and the impact extends across many generations (Everett, 2010). Currently several countries are on the threshold limits, manifesting water stress and costly resource. Thus, while the natural resource is used to generate growth, it needs to be used sustainably, and efficiently, by considering any critical thresholds it exhibit to secure growth in the long run (Everett, 2010).

2.2 Concepts of Fractal Statics Analysis

Natural growth follows an exponential distribution and the data are fractal unless unnatural and pervasive interventions are exerted to subvert this natural course (Padua, 2015) (Brown et al., 2011). Mandelbrot, 1983, asserted that the geometry of nature is fractal. He further states that the natural state of order is fractal as opposed to their normal state. In the natural state, there will be smaller variations than larger ones; more of the smaller values than larger values. Smaller ripples of waves build up momentum to produce layer waves. From the natural state of order, which is fractal, one can usually find that the state of order is what we consider normal. The reason for this is that we need some intervention in some way to the natural processes of nature. One intervenes to ensure that changes in the natural processes will turn to man's advantage.

According to Padua, 2015, fractal statistical analysis (FSA) intends to determine if the state of order of an event, phenomenon, or objects has deviated from its natural or fractal state. It intends to define the deviation or lack thereof in light of possible interventions and analyze the local characteristics of fractal observations. Mandelbrot, 1983, states that to develop fractal statistics, one begins by an analogy to the definition of a fractal dimension λ of geometric objects by

$$\boldsymbol{\lambda = \frac{\log(m)}{\log(r)} = \frac{\log(no.\,of\ copies)}{\log(scale)}}$$

From the world of concrete geometry, the concept can be similarly applied to the world of ideas or data. Let x be a random variable such that:

$$\boldsymbol{\lambda = \frac{\log(no.\,of\ copies\ of\ x)}{\log(scale\ of\ x)} = \frac{\log(f(x))}{log\left(\frac{\theta}{x}\right)}\ where\ \theta = \min_i\{x_i\}.}$$

where $\boldsymbol{\lambda}$ is referred to as the fractal dimension of the variable $\boldsymbol{x}$. This definition leads to:

$$f(x) = A\left(\frac{x}{\theta}\right)^{-\lambda}, \lambda > 0, x > \theta,$$

From the density or probability distribution of x, large values of x will have smaller probabilities of occurrence while small values of x will have larger probabilities of occurrence.

For X to have a probability distribution f(x), this requires that:

$$A = \frac{\lambda - 1}{\theta}\ and\ \lambda > 1;\ \theta > 0.$$

The fractal dimensions of fractal random variables $\boldsymbol{X}$ will have to be greater than $\boldsymbol{1}$ for a probability distribution to exist.

To determine if $\boldsymbol{X}$ is fractal, the fundamental theorem of fractal statistics is used, that is; "$\boldsymbol{X}$ is fractal if and only if $\boldsymbol{log\ (x/\theta)}$ has an exponential distribution with the rate parameter $\boldsymbol{\beta = \lambda - 1.}$"

The fractal dimension, $\boldsymbol{\lambda}$, of the data $\boldsymbol{X}$, is $\boldsymbol{\lambda = 1+\beta}$, where the rate parameter $\boldsymbol{\beta = 1/\bar{y}}$ and $\boldsymbol{y = log(x/\Theta)}$.

3.0 Research Design and Methods

The fundamental theorem of Fractal Statistical Analysis (FSA), according to Padua, 2015, "the data set, {X}, is fractal if and only if the log (x/Θ) has an exponential distribution with the rate parameter $\beta = \lambda - 1$." The fractal dimension (λ) of the data X is $\lambda = 1+\beta$.

The exponential distribution of the log of the data set is an indicator of the fractal nature of the raw data. If such condition exists then the raw data together with the log of the data is the subject of fractal analysis. The rate parameter is the statistical proximity measure of the data set, thus β describes the measure of data cluster.

ISO 3166-1 listed 249 countries around the globe. One hundred sixty-nine countries have data with freshwater withdrawals, Table 5, Appendix (UNDP, 2013). Data that deviate from the exponential distribution must have been unnatural, intervened or designed. Data with exponential distribution are verified, its rate parameter and fractal dimension are calculated. The fractal characteristics of these data are examined for its quantitative and qualitative significance.

The paper iteratively tests the statistical distribution of the data set. Data that deviate from the exponential distribution are segregated. The trimmed data are re-assessed. There are three possible options for a data {freshwater extraction};

1.) Taking y = log (freshwater extraction), if data set, {Y}, has an exponential distribution, then data set {freshwater extraction}, is fractal.

2.) If data set, {freshwater extraction}, is exponential in distribution, then let x = e(freshwater extraction) and data, {X}, is fractal.

3.) If neither of the data sets {X} and {Y} is exponentially distributed, then FSA may not be appropriate.

The trimmed and segregated data are examined, respectively, for the fractal characteristics and interventions, issues that cause its deviation.

Figure 1, is the histogram of 169 countries with freshwater extraction. The initial observations show an exponential distribution if the zero and extreme data values are segregated. Table 1 shows the list of segregated 11 countries. The remaining 158 countries are re-assessed. Figure 2.a is the histogram of the trimmed data with an approximately exponential distribution. Figure 2.b verifies the exponential distribution using a line regression with a theoretical exponentially distributed data. The test shows a very strong correlation of 97%. Thus, trimmed data is exponentially distributed. Countries listed in Table 1 are subjected to a case study where relevant issues and impacts are defined for its significance in the current state.

4.0 Results and Discussion

The rates of freshwater extractions of the 158 countries have an exponential distribution, Figures 2.a and 2.b. Thus, data x = e (freshwater extraction) is fractal. The data set {X} has a fractal dimension, $\lambda = 1.585793$, and a rate parameter of $\beta = 0.585793$, Table 2.

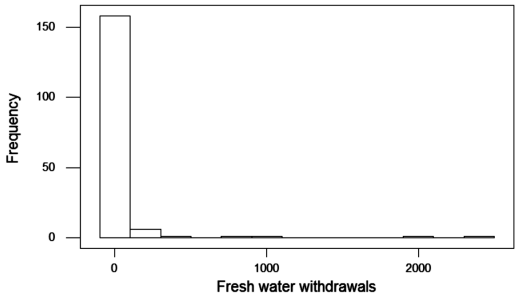

Figure 1. Histogram of all Freshwater Extraction

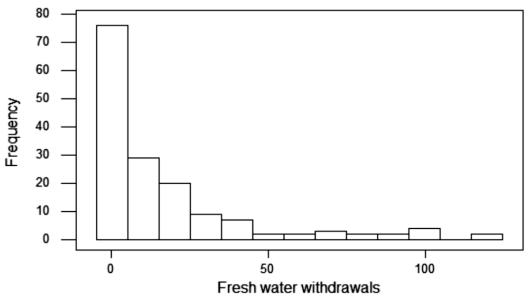

Figure 2.a. Trimmed Data Histogram

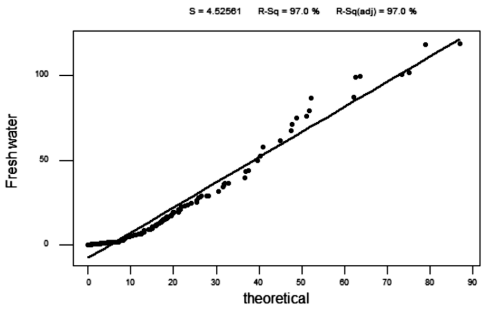

Figure 2.b. exponential distribution verification

Table 1. Countries with extreme freshwater extraction and no data (zero)

HDI RANK	Countries	Freshwater withdrawals
141	Congo	0
155	Papua New Guinea	0
178	Central African Republic	0
185	Congo (Democratic Republic of the)	0
159	Yemen	168.6
48	Bahrain	219.8
36	Qatar	455.2
64	Libya	718
57	Saudi Arabia	943.3
41	United Arab Emirates	2032
54	Kuwait	2465

There is a threshold to drawing fresh water, drawing beyond or limiting the supply increases the risk and problems associated with water management and sourcing, or water scarcity. Careful observations show that the data {***X***} is empathetic to the efforts of the governments to manage its freshwater resources, where ***x = 1*** being the least effort and ***1 < x < infinity*** ranges from slight to extreme effort. The greater the freshwater extraction rate, the higher the efforts to secure and sustain the said resource.

Data {***X***} also present the adverse consequence

and impact of water scarcity to people and the environment. Drawing more water is an indicator of a logistical problem of supply, the greater the rate of extraction the bigger the problem of supply. The lack of fresh water for domestic use is always associated with the lack of hygiene and the consequential health problems. These often led to diseases and epidemics like diarrhea or cholera, if left uncheck could be fatal and widespread. The same impact can be observed on water scarcity to industries and the environment with its exponential effect on the economy or the increasing destruction and deterioration of ecology respectively.

Fresh water is an important and vital resource. The extent of the administrative efforts to secure this resource may be difficult to quantify. However, the delivery and non-delivery of this resource seems to affect the country exponentially. Thus, ***the data {X} characterizes the impact, effect or the repercussions of the lack of a significant and vital necessity. As the need increases the need to solve and address such necessity exponentially increases. Non-action will exponentially impart a negative effect.***

The impact of water scarcity, across the globe is fractal. This impact has a fractal dimension, $\boldsymbol{\lambda} = \boldsymbol{1.585793}$, with a rate parameter or statistical proximity of $\boldsymbol{\beta} = \boldsymbol{0.585793}$. Water scarcity has a high and extreme impact in the regions of Central Asia, Middle East, North Africa and in small island countries, Table 2.

Zero Extractions

Countries listed in Table 1, are from the regions of the Middle East and North Africa except for Papua New Guinea. Countries with zero and near zero extraction data like Democratic Republic of Congo, the Central African Republic, and Papua New Guinea do have abundant fresh water. Despite its immense freshwater resources, these countries have challenges in their respective water sector. Global Water Partnership reports that the abundant water resource in the Central African Republic is unevenly distributed and not well developed. The United Nations Environment Programme (UNEP) reported that the growing population of the Democratic Republic of Congo has an inadequate access to clean drinking water. Estimates by the Rural Water Supply Network have shown non-functionality of about 67% of its water points (Africa et al., 2014).

The Food and Agriculture Organization reported that the water sector in Papua New Guinea was fragmented and poorly coordinated due to a lack of human resources, political interest, and financial constraints. There is a lack of access to clean water and adequate sanitation and lack of finance to invest in essential water services (Papua New Guinea, 2012).

Extreme Extractions

The countries with extreme freshwater extraction like Kuwait, UAE, Bahrain, tables 1 and 2, are comparatively wealthy countries. In response to water scarcity in the region, these countries use desalination plants to supplement majority of its fresh water needs. These countries

Table 2. Water Extractions Rates, Fractal Dimension, Water Stress reports: Medium , High and Extreme water stresses (UNDP, 2013, Gassert, et al, 2013)

rank	Countries	{Y}fesh water extract 2013 %rate /100	$x = e^y$ mean: 1.707089 rate paramtr: 0.585793 FD: 1.585793	data {X}	water stress level report 2013				Fresh water ext/stress level			flood occurrence 2013	drought severity 2013
					no stress	low stress	medium stress	high and ex high	low stress	medium stress	high and ex high		
					50	30	34	37	30	34	37		
101	Greece	0.127	1.135417	1.14			3.27			0.127		2.36	1.08
102	Thailand	0.131	1.139968	1.14		1.70			0.131			3.68	1.04
103	Estonia	0.140	1.150274	1.15			2.75			0.140		1.06	1.53
104	Mauritania	0.140	1.150274	1.15	0.60							2.47	3.79
105	Czech Republic	0.148	1.159513	1.16		1.13			0.148			3.23	2.27
106	France	0.150	1.161834	1.16		1.75			0.150			2.50	1.61
107	United States	0.156	1.168826	1.17			2.89			0.156		3.08	1.54
108	Maldives	0.157	1.169996	1.17								.	.
109	The former Yugoslav Repu	0.161	1.174685	1.17								3.27	1.72
110	Moldova (Republic of)	0.164	1.178214	1.18		1.46			0.164			3.78	1.73
111	Dominican Republic	0.166	1.180573	1.18				5.00			0.166	3.73	0.79
112	Philippines	0.170	1.185305	1.19			3.33			0.170		4.02	0.62
113	Mexico	0.175	1.191246	1.19				3.52			0.175	2.88	1.73
114	Turkey	0.188	1.206834	1.21			3.02			0.188		2.56	1.63
115	Cyprus	0.193	1.212883	1.21				5.00			0.193	0.00	0.15
116	Poland	0.194	1.214096	1.21		1.31			0.194			2.70	2.06
117	China	0.195	1.215311	1.22			2.94			0.195		3.51	1.96
118	Cuba	0.198	1.218962	1.22			3.19			0.198		3.01	0.49
119	Japan	0.209	1.232445	1.23			3.05			0.209		2.98	0.90
120	Germany	0.210	1.233678	1.23		1.90			0.210			2.88	1.90
121	Zimbabwe	0.210	1.233678	1.23	0.64							2.77	2.05
122	Somalia	0.224	1.251071	1.25	0.46							3.79	2.56
123	Swaziland	0.231	1.259859	1.26			3.11			0.231		3.08	1.60
124	Italy	0.237	1.267441	1.27			3.35			0.237		2.62	1.23
125	Sri Lanka	0.245	1.277621	1.28			3.01			0.245		3.73	0.67
126	South Africa	0.250	1.284025	1.28			3.04			0.250		2.84	0.79
127	Mauritius	0.264	1.302128	1.30								.	.
128	Ukraine	0.276	1.317848	1.32			2.10			0.276		2.43	1.58
129	Lebanon	0.281	1.324454	1.32				4.54			0.281	2.76	1.44
130	Bulgaria	0.287	1.332424	1.33		1.27			0.287			3.24	1.65
131	Kazakhstan	0.289	1.335092	1.34				4.02			0.289	1.72	2.43
132	Spain	0.290	1.336427	1.34				3.73			0.290	2.69	1.74
133	Singapore	0.317	1.373003	1.37				5.00			0.317	2.89	1.48
134	Belgium	0.340	1.404948	1.40			3.16			0.340		2.77	1.90
135	Azerbaijan	0.352	1.421909	1.42			3.39			0.352		3.01	1.63
136	Afghanistan	0.356	1.427608	1.43				4.01			0.356	3.71	2.48
137	Armenia	0.364	1.439074	1.44			3.07			0.364		3.26	2.83
138	Korea (Republic of)	0.365	1.440514	1.44				3.54			0.365	3.47	0.79
139	India	0.398	1.488844	1.49				3.58			0.398	3.85	1.62
140	Morocco	0.434	1.543419	1.54				4.24			0.434	2.90	2.14
141	Kyrgyzstan	0.437	1.548056	1.55				4.82			0.437	2.12	2.32
142	Occupied Palestinian Terr	0.499	1.647073	1.65				4.63			0.499	2.95	2.10
143	Algeria	0.527	1.693843	1.69			3.44			0.527		2.79	2.26
144	Sudan	0.576	1.778909	1.78	0.91							3.30	2.94
145	Tunisia	0.617	1.853360	1.85			3.44			0.617		2.62	1.88
146	Iran (Islamic Republic of)	0.677	1.967965	1.97				4.78			0.677	3.24	2.57
147	Malta	0.713	2.040102	2.04				5.00			0.713	0.00	0.00
148	Tajikistan	0.748	2.112770	2.11				3.53			0.748	3.68	2.45
149	Barbados	0.761	2.140416	2.14				5.00			0.761	3.58	0.00
150	Pakistan	0.795	2.214441	2.21				4.31			0.795	3.87	2.48
151	Oman	0.866	2.377382	2.38				4.91			0.866	1.90	3.41
152	Iraq	0.873	2.394082	2.39			3.48			0.873		2.40	2.11
153	Jordan	0.994	2.702021	2.70				4.59			0.994	2.98	2.80
154	Syrian Arab Republic	0.998	2.712851	2.71				3.85			0.998	2.65	2.37
155	Turkmenistan	1.008	2.740115	2.74				4.30			1.008	1.77	2.62
156	Israel	1.019	2.770423	2.77				4.83			1.019	2.89	2.04
157	Uzbekistan	1.183	3.264152	3.26				4.32			1.183	2.74	2.57
158	Egypt	1.190	3.287081	3.29		1.33			1.190			2.53	3.35
159	Yemen	1.686	5.397846E+00	5.40E+00				4.67			1.686	2.94	1.74
160	Bahrain	2.198	9.006982E+00	9.01E+00				5.00			2.198	0.00	0.00
161	Qatar	4.552	9.482186E+01	9.48E+01				5.00			4.552	0.00	2.94
162	Libya	7.180	1.312908E+03	1.31E+03				4.84			7.180	0.03	2.77
163	Saudi Arabia	9.433	1.249395E+04	1.25E+04				4.99			9.433	1.23	2.12
164	United Arab Emirates	20.320	6.681345E+08	6.68E+08				5.00			20.320	1.17	2.92
165	Kuwait	24.650	5.074099E+10	5.07E+10				4.96			24.650	0.56	1.95
	Congo Republic of	0.000	-----	-----	0.43							1.68	1.33
	Papua New Guinea	0.000	-----	-----	0.60							1.61	0.97
	Central African Republic	0.000	-----	-----								2.27	1.09
	Congo (Democratic Repub	0.000	-----	-----	0.01							1.88	1.23

also draw water from the underground, imports fresh water and implements grey water recycling. These practices are also common to other neighboring countries in the region like Israel, Jordan, Iraq, Syria, Libya and others (Amster, Pallant, & Saranga, 2007).

However, these extreme water extraction practices, increased developments, and economic activities have strained the environment and the ecosystem to more than its limits (Hussein, 2011). These are evident in the deterioration of the ecosystem of the Dead Sea, the depletion of the rivers, sinking of the water table (Amster, Pallant, & Saranga, 2007) (Hamoda, 2001). Although programs like the Integrated Water Resources Management are in placed in most of these countries, the rate of extraction continues to increase and negates the recharging of the water table and the rivers. From a report, the increased desalination of seawater for the domestic and development use have increased the gulf's salinity from 32,000 to 47,000 parts per million (Alderman, 2010).

On thorough consideration, these practices in the region will not be sustainable for the countries and the environment. The desert ecosystem is dependent on its underground water. Continuous extraction at these extreme rates lowers the water table, a level desert plants would be unable to reach, and furthers its desertification. Extreme extractions are also manifested by the ground subsidence and sink holes.

Medium and High-Stress Countries

The majority of the countries with high freshwater extraction rates are medium to high water-stressed, Table 2. These countries, according to a report are also flood-prone with medium to high flooding incidence (Gassert, et al., 2013). The list, include countries from different global regions with developed and under-develop status.

Historically the majority of the settlements and urban centers of countries, like Manila, initially are built on the edges of floodplains (Halili, 2004) (Glover, 2004) (Peralta, & Salazar, 1974). The availability of fresh water, livelihood, and means of transportation are often the primary reason for these settlements. Over the years, cities grow, converting the floodplain into urban communities with concrete structures. As a result, seasonal floods became unwelcomed, polluted, and drained to the sea. (Novitski, Smith & Fretwell, 1996) (Holway & Burby, 1990) (Montz, 2000).

From the hydrologic cycle, floodplains perform a vital function in the recharging of the underground water (Petersen, 1999) (Novitski, Smith, & Fretwell, 1996) (Barbier, 1994). City and urban development disrupt this important function and starve the aquifer with fresh water supply while the demand for fresh water increases. Thus, water crisis and flooding are the results of years of improper land use and resource mismanagement.

The rate of extraction for the Philippines according to data is only 17% of the annual total potential fresh water endowed to the Philippine archipelago while Indonesia is 5.6%. According to data, the Philippines and Indonesia are countries that are under the category of high water-stressed with a high incidence of flooding (Gassert, et al., 2013). While the countries of Bulgaria and Germany extracts more at 28.7% and 21%, data reports show lightly stressed with a low incidence of flooding. Table 3 shows more of these similar data in other countries like Greece, Italy, Dominican Republic, Mexico, United States. To date, the city of Metro Manila, just like many other cities, from time to time suffers water shortages and the same time also experience flooding in its major city centers

(Gilbuena, et al., 2013) (Gilbert, et al., 2013).

The California drought is a similar case that still happens to date. According to reports, the drought is a case of resource mismanagement by environmental policies. A case where water runoffs were diverted from the reservoir to the streams for environmental reasons of which fresh water eventually drains to the sea (Zimmerman, 2015) (Hepler, 2015). Because of the environmental policies the reservoirs did not hold enough water while farmers resort to pumping underground water. From other reports, it is said to be a case of water wastage. California to date suffers one of the worst drought and water crisis and is currently in a state of emergency. The drought is in its fourth year.

Often the treatment of the issues of flooding and water shortage is separate and solutions are independent. Urban life and development of cities built on flood plains and lowlands should embrace floods and develop a system that returns water to the ground (Bouwer, 2002) (Gilbert et al., 2013,). Water impounding system should be in placed where water filters and sips through the ground. The quantity should balance the rate of extraction.

Water Extraction Thresholds

Table 3 shows the thresholds of freshwater extraction rates. At the current circumstance, the threshold for low water stress is approximately 5.63% of total renewable fresh water, 13.70% for medium water stress and 33.10% for High water stress.

At the 5.63%, the data $x = e^{0.0563}$ or water scarcity impact is $x = 1.05792$. The data $x = 1.05792$, is the borderline of no stress to slightly stressed where water scarcity has the least effect. The fractal data $x = e^{0.3370}$ or $x = 1.40074$ is borderline of high water stress where water scarcity begins to have a high and significant effect to administrative efforts and significant adverse effect to people, to the economy and the environment. The least of the extreme water extraction is 168%, Table 2, an equivalent water scarcity impact of $x = e^{1.68}$ or $x = 5.36556$.

Table 3. Extraction Threshold for Low, Medium and High Stress

rank (rate)	Countries	{Y}fesh water extraction 2013 %rate /100	data X (fractal)	water stress report 2013	threshold of extraction rates per stress level		
					low stress	med strs	high strs
					8.000	3.000	6.000
					0.0563	0.1370	0.3370
25	Nicaragua	0.007	1.01	1.01	0.007		
46	Russian Federation	0.015	1.02	1.23	0.015		
47	Canada	0.016	1.02	1.21	0.016		
56	Malaysia	0.023	1.02	2.09		0.023	
61	Guatemala	0.026	1.03	1.01	0.026		
72	Australia	0.046	1.05	3.51			0.046
76	Switzerland	0.049	1.05	1.06	0.049		
95	Viet Nam	0.093	1.10	1.01	0.093		
96	Lithuania	0.096	1.10	1.19	0.096		
98	Korea (Democratic Peop	0.112	1.12	2.06		0.112	
105	Czech Republic	0.148	1.16	1.13	0.148		
113	Mexico	0.175	1.19	3.52			0.175
128	Ukraine	0.276	1.32	2.10		0.276	
132	Spain	0.290	1.34	3.73			0.290
138	Korea (Republic of)	0.365	1.44	3.54			0.365
139	India	0.398	1.49	3.58			0.398
148	Tajikistan	0.748	2.11	3.53			0.748

5.0 Findings

Fresh water is important and vital resource, practically irreplaceable. Ensuring the availability of this resource requires more than just effort and management. On times when and places where water resource is plenty, the efforts are relaxed, and the management is easy. When water resource is scarce, the efforts often are keen, and management could be uncompromising.

1. The rate of freshwater extraction across the globe is exponential in distribution, thus data X, that is,

   $$x = e^{\{freshwater\ extraction\}}$$

   is fractal. The data X has a fractal dimension of $\lambda = 1.585793$, with rate parameter of $\beta = 0.585793$.
2. The data {X} characterizes the impact, effect or repercussions of water scarcity. As the

need for water increases, the need to solve and address such necessity exponentially increases. Non-action will only lead to an exponential adverse effect. The effect could be on the administrative efforts or could be to the health and welfare of the people, to business and the economy or the environment.

3. The current threshold to high water stress is at ***33.70%*** extraction of the total renewable fresh water resource with water scarcity impact of ***x = 1.40074***. Lightly stressed threshold is ***5.63%***. The lowest extraction rate for extremely stressed countries is ***168%*** or a water scarcity impact of ***x = 5.36556***.
4. Countries with high and extreme water stresses, in general, are in water-deprived geographic locations, such as those in the desert regions and small islands. However, some countries are in water stressed because of mismanagement of its natural resources. The most common causes are improper land use, over development, and wastage.
5. Countries with zero extraction data have common issues. These countries have an inadequate infrastructure for potable water processing, access or delivery. These countries also have problems with politics, leadership and security issues.
6. The countries with extreme extractions persisted in the practice through its wealth. Seawater desalination supplies the majority of the fresh water needs. Other sources include underground water extraction often at rates more than nature can recharge, importation and grey water recycling.
7. Underground water is not limitless as most think. It has to be recharged. Years of over-extraction have depleted these reserves, and it continues to happen to date globally. Continued extractions have lowered the water table and are the primary cause of the desertification and environment degradation on the surface.

6.0 Conclusion

Fresh water is one resource that is vital to all forms of life. It is renewable; the source is abundant but the useful quantity is limited and at the current technology, it is expensive to process. Its rate of use is a good indicator to how life flourished, develop, spread across the globe. Its availability is demonstrative of other natural renewable resources, has thresholds and limits.

Fractal statistics analysis determined the rate of freshwater extractions across the globe as exponential in distribution. The distribution indicates that the spreading of people and development is exponential across regions. It also showed that the progression of life is determined by how much resources can sustain. It also established that extreme extractions and extreme developments come with a relative high cost, financially, and, or at the expense to natural or environmental resources.

FSA also determined the fractal data of the freshwater extraction rates. The significance of the fractal data is in the quantitative measure of the impact of water scarcity. How water scarcity affects the administrative efforts, society, economy and the environment, and the consequence of non-action or non-delivery of the necessity.

Other significant issue: Pumping underground water should cease where it is necessary. Water regulates the land temperature. Desertification occurs on the land surface when water is too low

for plants to reach and surface temperature soars. Drawing the water out on the surface increases the evaporation rate. These will be useful to people for a while, but without the measures to replenish it underground water could easily be depleted. Measures to recharge underground water must be assured and should be part of the urban development planning.

7.0 References

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Appendix:

Table 4. Freshwater Extraction of 169 Countries (UNDP, 2013)

rank	Countries	% Fresh water withdrawals	rank	Countries	% Fresh water withdrawals	rank	Countries	% Fresh water withdrawals
1	Congo	0	58	Ghana	1.8	115	Dominican Republic	16.6
2	Papua New Guinea	0	59	Luxembourg	1.9	116	Philippines	17
3	Central African Republic	0	60	Malaysia	2.3	117	Mexico	17.5
4	Congo (Democratic Republic of	0	61	Burundi	2.3	118	Turkey	18.8
5	Iceland	0.1	62	Costa Rica	2.4	119	Cyprus	19.3
6	Gabon	0.1	63	Uruguay	2.6	120	Poland	19.4
7	Paraguay	0.1	64	Georgia	2.6	121	China	19.5
8	Equatorial Guinea	0.1	65	Guatemala	2.6	122	Cuba	19.8
9	Liberia	0.1	66	Myanmar	2.8	123	Japan	20.9
10	Panama	0.3	67	Bangladesh	2.9	124	Germany	21
11	Fiji	0.3	68	Slovenia	3	125	Zimbabwe	21
12	Bolivia (Plurinational State of)	0.3	69	Romania	3.2	126	Somalia	22.4
13	Sao Tome and Principe	0.3	70	Antigua and Barbuda	3.3	127	Swaziland	23.1
14	Cameroon	0.3	71	Ecuador	3.6	128	Italy	23.7
15	Sierra Leone	0.3	72	Nigeria	3.6	129	Sri Lanka	24.5
16	Mozambique	0.3	73	Argentina	4	130	South Africa	25
17	Bhutan	0.4	74	Albania	4.4	131	Mauritius	26.4
18	Angola	0.4	75	Madagascar	4.4	132	Ukraine	27.6
19	Suriname	0.5	76	Australia	4.6	133	Lebanon	28.1
20	Cambodia	0.5	77	Ethiopia	4.6	134	Bulgaria	28.7
21	Uganda	0.5	78	Austria	4.7	135	Kazakhstan	28.9
22	Benin	0.5	79	Nepal	4.7	136	Spain	29
23	Croatia	0.6	80	Switzerland	4.9	137	Singapore	31.7
24	Colombia	0.6	81	Hungary	5.4	138	Belgium	34
25	Guinea-Bissau	0.6	82	Tanzania (United Republic of)	5.4	139	Azerbaijan	35.2
26	Venezuela (Bolivarian Republic	0.7	83	El Salvador	5.5	140	Afghanistan	35.6
27	Brazil	0.7	84	Indonesia	5.6	141	Armenia	36.4
28	Guyana	0.7	85	Malawi	5.6	142	Korea (Republic of)	36.5
29	Nicaragua	0.7	86	Senegal	5.7	143	India	39.8
30	Guinea	0.7	87	Trinidad and Tobago	6	144	Morocco	43.4
31	Norway	0.8	88	Jamaica	6.2	145	Kyrgyzstan	43.7
32	Belize	0.8	89	Djibouti	6.3	146	Occupied Palestinian Territory	49.9
33	Comoros	0.8	90	Mali	6.5	147	Algeria	52.7
34	Bosnia and Herzegovina	0.9	91	Cape Verde	6.8	148	Sudan	57.6
35	Gambia	0.9	92	Niger	7	149	Tunisia	61.7
36	Chad	0.9	93	Belarus	7.5	150	Iran (Islamic Republic of)	67.7
37	Peru	1	94	Burkina Faso	7.9	151	Malta	71.3
38	Brunei Darussalam	1.1	95	Haiti	8.6	152	Tajikistan	74.8
39	Chile	1.2	96	United Kingdom	8.8	153	Barbados	76.1
40	Latvia	1.2	97	Kenya	8.9	154	Pakistan	79.5
41	Honduras	1.2	98	Eritrea	9.2	155	Oman	86.6
42	Togo	1.2	99	Viet Nam	9.3	156	Iraq	87.3
43	Lao People's Democratic Repub	1.3	100	Lithuania	9.6	157	Jordan	99.4
44	Slovakia	1.4	101	Denmark	10.8	158	Syrian Arab Republic	99.8
45	Mongolia	1.4	102	Korea (Democratic People's Rep	11.2	159	Turkmenistan	100.8
46	New Zealand	1.5	103	Netherlands	11.7	160	Israel	101.9
47	Ireland	1.5	104	Portugal	12.3	161	Uzbekistan	118.3
48	Sweden	1.5	105	Greece	12.7	162	Egypt	119
49	Finland	1.5	106	Thailand	13.1	163	Yemen	168.6
50	Russian Federation	1.5	107	Estonia	14	164	Bahrain	219.8
51	Canada	1.6	108	Mauritania	14	165	Qatar	455.2
52	Botswana	1.6	109	Czech Republic	14.8	166	Libya	718
53	Rwanda	1.6	110	France	15	167	Saudi Arabia	943.3
54	Namibia	1.7	111	United States	15.6	168	United Arab Emirates	2032
55	Lesotho	1.7	112	Maldives	15.7	169	Kuwait	2465
56	Zambia	1.7	113	The former Yugoslav Republic o	16.1			
57	Côte d'Ivoire	1.7	114	Moldova (Republic of)	16.4			

Table 5. Water Extraction Rates, Fractal Dimension, Water Stress reports (UNDP, 2013, Gassert, et al, 2013)

rank	Countries	{Y}fesh water extract 2013 %rate /100	$x = e^y$ mean: 1.707089	rate paramtr: 0.585793	FD: 1.585793	data {X}	water stress level report 2013				Fresh water ext/stress level			flood occurrence 2013	drought severity 2013
							no stress	low stress	medium stress	high and ex high	low stress	medium stress	high and ex high		
							50	30	34	37	30	34	37		
1	Iceland	0.001	1.001001			1.00	0.14							0.06	0.59
2	Gabon	0.001	1.001001			1.00		1.56			0.001			0.65	1.07
3	Paraguay	0.001	1.001001			1.00	0.01							3.29	1.21
4	Equatorial Guinea	0.001	1.001001			1.00	0.54							0.04	0.58
5	Liberia	0.001	1.001001			1.00	0.27							1.93	0.67
6	Panama	0.003	1.003005			1.00	0.42							2.76	0.83
7	Fiji	0.003	1.003005			1.00								.	.
8	Bolivia (Plurinational Stat	0.003	1.003005			1.00	0.68							3.15	1.97
9	Sao Tome and Principe	0.003	1.003005			1.00								.	.
10	Cameroon	0.003	1.003005			1.00	0.11							2.16	1.33
11	Sierra Leone	0.003	1.003005			1.00	0.51							1.64	0.77
12	Mozambique	0.003	1.003005			1.00	0.82							2.96	1.26
13	Bhutan	0.004	1.004008			1.00	0.45							4.66	0.91
14	Angola	0.004	1.004008			1.00		1.54			0.004			1.72	1.79
15	Suriname	0.005	1.005013			1.01	0.25							1.41	1.43
16	Cambodia	0.005	1.005013			1.01	0.44							3.87	0.66
17	Uganda	0.005	1.005013			1.01								3.63	1.45
18	Benin	0.005	1.005013			1.01								3.64	1.54
19	Croatia	0.006	1.006018			1.01	0.02							3.04	1.28
20	Colombia	0.006	1.006018			1.01	0.33							3.72	1.59
21	Guinea-Bissau	0.006	1.006018			1.01	0.17							1.04	1.54
22	Venezuela (Bolivarian Re	0.007	1.007025			1.01			2.30			0.007		2.73	1.28
23	Brazil	0.007	1.007025			1.01	0.91							3.08	1.09
24	Guyana	0.007	1.007025			1.01		1.78			0.007			2.40	0.79
25	Nicaragua	0.007	1.007025			1.01		1.01			0.007			3.64	0.83
26	Guinea	0.007	1.007025			1.01	0.06							1.11	1.05
27	Norway	0.008	1.008032			1.01	0.40							1.31	1.69
28	Belize	0.008	1.008032			1.01		1.35			0.008			2.65	0.82
29	Comoros	0.008	1.008032			1.01				5.00			0.008	1.63	0.00
30	Bosnia and Herzegovina	0.009	1.009041			1.01	0.02							3.60	1.33
31	Gambia	0.009	1.009041			1.01	0.42							1.49	2.11
32	Chad	0.009	1.009041			1.01	0.52							2.95	2.54
33	Peru	0.010	1.010050			1.01			3.20			0.010		2.82	3.39
34	Brunei Darussalam	0.011	1.011061			1.01	0.01							2.28	1.00
35	Chile	0.012	1.012072			1.01			3.21			0.012		2.55	2.11
36	Latvia	0.012	1.012072			1.01	0.35							1.82	1.80
37	Honduras	0.012	1.012072			1.01	0.07							3.63	1.17
38	Togo	0.012	1.012072			1.01	0.12							3.12	1.20
39	Lao People's Democratic	0.013	1.013085			1.01	0.01							3.92	0.88
40	Slovakia	0.014	1.014098			1.01	0.20							3.79	2.06
41	Mongolia	0.014	1.014098			1.01				4.05			0.014	1.33	1.57
42	New Zealand	0.015	1.015113			1.02		1.35			0.015			1.70	0.71
43	Ireland	0.015	1.015113			1.02			2.92			0.015		2.21	1.18
44	Sweden	0.015	1.015113			1.02		1.30			0.015			0.35	1.71
45	Finland	0.015	1.015113			1.02	0.98							0.21	2.46
46	Russian Federation	0.015	1.015113			1.02		1.23			0.015			2.00	2.02
47	Canada	0.016	1.016129			1.02		1.21			0.016			1.93	1.67
48	Botswana	0.016	1.016129			1.02		1.36			0.016			2.06	2.70
49	Rwanda	0.016	1.016129			1.02								3.61	1.78
50	Namibia	0.017	1.017145			1.02		1.88			0.017			2.07	3.30
51	Lesotho	0.017	1.017145			1.02				3.97			0.017	3.33	2.32
52	Zambia	0.017	1.017145			1.02	0.08							2.48	1.81
53	Côte d'Ivoire	0.017	1.017145			1.02	0.04							2.27	1.10
54	Ghana	0.018	1.018163			1.02	0.11							3.00	1.08
55	Luxembourg	0.019	1.019182			1.02			2.51			0.019		3.10	1.67
56	Malaysia	0.023	1.023267			1.02			2.09			0.023		3.07	0.77
57	Burundi	0.023	1.023267			1.02								3.35	1.61
58	Costa Rica	0.024	1.024290			1.02		1.94			0.024			3.05	0.65
59	Uruguay	0.026	1.026341			1.03	0.86							3.04	1.06
60	Georgia	0.026	1.026341			1.03		1.51			0.026			3.60	2.10
61	Guatemala	0.026	1.026341			1.03		1.01			0.026			3.52	0.72
62	Myanmar	0.028	1.028396			1.03	0.30							3.22	0.92
63	Bangladesh	0.029	1.029425			1.03	0.65							4.94	0.78
64	Slovenia	0.030	1.030455			1.03	0.03							3.55	1.37

Table 5. Water Extraction Rates, Fractal Dimension, Water Stress reports, continued

65	Romania	0.032	1.032518	1.03	0.84							3.68	2.02
66	Antigua and Barbuda	0.033	1.033551	1.03				5.00			0.033	3.58	0.00
67	Ecuador	0.036	1.036656	1.04		1.86			0.036			3.23	2.64
68	Nigeria	0.036	1.036656	1.04	0.29							3.10	1.99
69	Argentina	0.040	1.040811	1.04			2.51			0.040		2.45	1.64
70	Albania	0.044	1.044982	1.04		1.90			0.044			2.73	1.07
71	Madagascar	0.044	1.044982	1.04		1.25			0.044			2.62	0.91
72	Australia	0.046	1.047074	1.05								2.66	1.07
73	Ethiopia	0.046	1.047074	1.05	0.61							3.24	1.44
74	Austria	0.047	1.048122	1.05	0.32							3.29	1.79
75	Nepal	0.047	1.048122	1.05			2.40			0.047		4.49	1.18
76	Switzerland	0.049	1.050220	1.05		1.06			0.049			3.17	1.71
77	Hungary	0.054	1.055485	1.06	0.49							3.48	2.06
78	Tanzania (United Republi	0.054	1.055485	1.06		1.50			0.054			3.12	1.43
79	El Salvador	0.055	1.056541	1.06		1.49			0.055			3.75	1.00
80	Indonesia	0.056	1.057598	1.06			3.26			0.056		3.14	1.00
81	Malawi	0.056	1.057598	1.06	0.11							3.33	1.38
82	Senegal	0.057	1.058656	1.06	0.21							2.47	3.65
83	Trinidad and Tobago	0.060	1.061837	1.06				5.00			0.060	2.23	0.70
84	Jamaica	0.062	1.063962	1.06				5.00			0.062	3.51	0.02
85	Djibouti	0.063	1.065027	1.07			3.39			0.063		2.95	1.12
86	Mali	0.065	1.067159	1.07	0.20							2.61	2.90
87	Cape Verde	0.068	1.070365	1.07								.	.
88	Niger	0.070	1.072508	1.07	0.11							3.45	3.72
89	Belarus	0.075	1.077884	1.08	0.59							2.61	1.98
90	Burkina Faso	0.079	1.082204	1.08								3.29	1.75
91	Haiti	0.086	1.089806	1.09			2.38			0.086		3.88	0.59
92	United Kingdom	0.088	1.091988	1.09			2.63			0.088		3.40	1.34
93	Kenya	0.089	1.093081	1.09	0.68							3.81	1.62
94	Eritrea	0.092	1.096365	1.10			3.02			0.092		2.55	2.73
95	Viet Nam	0.093	1.097462	1.10		1.01			0.093			3.80	0.67
96	Lithuania	0.096	1.100759	1.10		1.19			0.096			2.36	1.80
97	Denmark	0.108	1.114048	1.11	0.95							0.00	0.46
98	Korea (Democratic People	0.112	1.118513	1.12			2.06			0.112		2.99	1.17
99	Netherlands	0.117	1.124119	1.12		1.73			0.117			2.46	1.76
100	Portugal	0.123	1.130884	1.13			3.34			0.123		2.40	1.37
101	Greece	0.127	1.135417	1.14			3.27			0.127		2.36	1.08
102	Thailand	0.131	1.139968	1.14		1.70			0.131			3.68	1.04
103	Estonia	0.140	1.150274	1.15			2.75			0.140		1.06	1.53
104	Mauritania	0.140	1.150274	1.15	0.60							2.47	3.79
105	Czech Republic	0.148	1.159513	1.16		1.13			0.148			3.23	2.27
106	France	0.150	1.161834	1.16		1.75			0.150			2.50	1.61
107	United States	0.156	1.168826	1.17			2.89			0.156		3.08	1.54
108	Maldives	0.157	1.169996	1.17								.	.
109	The former Yugoslav Repu	0.161	1.174685	1.17								3.27	1.72
110	Moldova (Republic of)	0.164	1.178214	1.18		1.46			0.164			3.78	1.73
111	Dominican Republic	0.166	1.180573	1.18				5.00			0.166	3.73	0.79
112	Philippines	0.170	1.185305	1.19			3.33			0.170		4.02	0.62
113	Mexico	0.175	1.191246	1.19				3.52			0.175	2.88	1.73
114	Turkey	0.188	1.206834	1.21			3.02			0.188		2.56	1.63
115	Cyprus	0.193	1.212883	1.21				5.00			0.193	0.00	0.15
116	Poland	0.194	1.214096	1.21		1.31			0.194			2.70	2.06
117	China	0.195	1.215311	1.22			2.94			0.195		3.51	1.96
118	Cuba	0.198	1.218962	1.22			3.19			0.198		3.01	0.49
119	Japan	0.209	1.232445	1.23			3.05			0.209		2.98	0.90
120	Germany	0.210	1.233678	1.23		1.90			0.210			2.88	1.90
121	Zimbabwe	0.210	1.233678	1.23	0.64							2.77	2.05
122	Somalia	0.224	1.251071	1.25	0.46							3.79	2.56
123	Swaziland	0.231	1.259859	1.26			3.11			0.231		3.08	1.60
124	Italy	0.237	1.267441	1.27			3.35			0.237		2.62	1.23
125	Sri Lanka	0.245	1.277621	1.28			3.01			0.245		3.73	0.67
126	South Africa	0.250	1.284025	1.28			3.04			0.250		2.84	0.79
127	Mauritius	0.264	1.302128	1.30								.	.
128	Ukraine	0.276	1.317848	1.32			2.10			0.276		2.43	1.58
129	Lebanon	0.281	1.324454	1.32				4.54			0.281	2.76	1.44
130	Bulgaria	0.287	1.332424	1.33		1.27			0.287			3.24	1.65
131	Kazakhstan	0.289	1.335092	1.34				4.02			0.289	1.72	2.43
132	Spain	0.290	1.336427	1.34				3.73			0.290	2.69	1.74
133	Singapore	0.317	1.373003	1.37				5.00			0.317	2.89	1.48
134	Belgium	0.340	1.404948	1.40			3.16			0.340		2.77	1.90

Table 5. Water Extraction Rates, Fractal Dimension, Water Stress reports, continued.

135	Azerbaijan	0.352	1.421909	1.42		3.39		0.352		3.01	1.63
136	Afghanistan	0.356	1.427608	1.43			4.01		0.356	3.71	2.48
137	Armenia	0.364	1.439074	1.44		3.07		0.364		3.26	2.83
138	Korea (Republic of)	0.365	1.440514	1.44			3.54		0.365	3.47	0.79
139	India	0.398	1.488844	1.49			3.58		0.398	3.85	1.62
140	Morocco	0.434	1.543419	1.54			4.24		0.434	2.90	2.14
141	Kyrgyzstan	0.437	1.548056	1.55			4.82		0.437	2.12	2.32
142	Occupied Palestinian Terr	0.499	1.647073	1.65			4.63		0.499	2.95	2.10
143	Algeria	0.527	1.693843	1.69		3.44		0.527		2.79	2.26
144	Sudan	0.576	1.778909	1.78	0.91					3.30	2.94
145	Tunisia	0.617	1.853360	1.85		3.44		0.617		2.62	1.88
146	Iran (Islamic Republic of)	0.677	1.967965	1.97			4.78		0.677	3.24	2.57
147	Malta	0.713	2.040102	2.04			5.00		0.713	0.00	0.00
148	Tajikistan	0.748	2.112770	2.11			3.53		0.748	3.68	2.45
149	Barbados	0.761	2.140416	2.14			5.00		0.761	3.58	0.00
150	Pakistan	0.795	2.214441	2.21			4.31		0.795	3.87	2.48
151	Oman	0.866	2.377382	2.38			4.91		0.866	1.90	3.41
152	Iraq	0.873	2.394082	2.39		3.48		0.873		2.40	2.11
153	Jordan	0.994	2.702021	2.70			4.59		0.994	2.98	2.80
154	Syrian Arab Republic	0.998	2.712851	2.71			3.85		0.998	2.65	2.37
155	Turkmenistan	1.008	2.740115	2.74			4.30		1.008	1.77	2.62
156	Israel	1.019	2.770423	2.77			4.83		1.019	2.89	2.04
157	Uzbekistan	1.183	3.264152	3.26			4.32		1.183	2.74	2.57
158	Egypt	1.190	3.287081	3.29		1.33		1.190		2.53	3.35
159	Yemen	1.686	5.397846E+00	5.40E+00			4.67		1.686	2.94	1.74
160	Bahrain	2.198	9.006982E+00	9.01E+00			5.00		2.198	0.00	0.00
161	Qatar	4.552	9.482186E+01	9.48E+01			5.00		4.552	0.00	2.94
162	Libya	7.180	1.312908E+03	1.31E+03			4.84		7.180	0.03	2.77
163	Saudi Arabia	9.433	1.249395E+04	1.25E+04			4.99		9.433	1.23	2.12
164	United Arab Emirates	20.320	6.681345E+08	6.68E+08			5.00		20.320	1.17	2.92
165	Kuwait	24.650	5.074099E+10	5.07E+10			4.96		24.650	0.56	1.95
	Congo Republic of	0.000	-----	-----	0.43					1.68	1.33
	Papua New Guinea	0.000	-----	-----	0.60					1.61	0.97
	Central African Republic	0.000	-----	-----						2.27	1.09
	Congo (Democratic Repul	0.000	-----	-----	0.01					1.88	1.23