Moving from Information to Knowledge for Water Quality Management Wordwide

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Abstract: In this paper we take a global view of fresh water management at various sector levels and in select nations. We focus on sustainability, water usage, river quality, capital spending and other variables. Our emphasis is on pressing current issues, but also on a long-run perspective. We suggest that (1) the policy process involve identification, evaluation and implementation and that (2) stages of data production involve monitoring, analyzing, and disseminating information. A classification scheme is suggested for categorizing environmental pollution and observing existing laws in various regions and nations. We advocate analysis along two lines: (1) longitudinal data, to note changes over decades rather than years and (2) cross-sectional data for comparing companies and nations of similar size. The emphasis is on improving water quality and in moving from information to knowledge in regard to environmental indicators.

1 Overview of Water Supply

There is as much water in the world as there was a 100 or 1000 years ago, with this permanency based on the hydrologic cycle from runoff to evaporation to precipitation. Total world supply is estimated at 1350 mil km3 a truly high figure. This quantity of water on Earth exceeds the needs of the world's current 7.2 billion persons or even more people. But, as early pioneers in the field recognized, much of the water is unavailable, inaccessible, or unevenly distributed by location or seasons of the year (Biswas 1978, Nace 1969, Ambroggi 1980, Gleick, 1993). In fact, 97% of the figure cited for total supply is saline or ocean water, 2% is frozen or brackish, and only 1% is fresh water. Desalination of ocean water is still a prohibitively costly solution. Of the fresh water, only about one-hundredth of that 1% is in rivers and lakes, many of which are polluted.

Only one-fourth of all precipitation falls on land: the distribution of such rain or snow shows much variation shows much variation by nation and on an annual or seasonal basis. Only one half of the runoff becomes available for use due to lack of storage. To capture either surface or ground water is not easy. Simply, it is not economical to build reservoirs to capture all the runoff due to evaporation or silting. As for dams, their number is on the rise, with China, USA, and Russia leading the way; yet the World Bank refused a big loan toward constructing the Three Gorges Dam for environmental reasons (China built it just the same) and some dams have been demolished recently in USA. Deforestation, melting of glaciers, increased irrigation, and urbanization all contribute to reduced supply. Desalting of ocean water is on the rise, especially in the Middle East, but the total impact has been small so far (UN 2012, UN 2015, WB 2014).

2 Overview of Water Demand

The use of fresh water has been rising worldwide along with population and economic activity. During the four decades between 1960 and 2000, the annual growth rate has been put in the range from 2.8% to 3.5%, though some estimates came in as high as 4%. These figures can be contrasted with world population growth of 1.8%-2.0% and world gross domestic product (in real terms) at 4.2%-5.2%. This gave rise to cautious optimism and indeed growth rates have been reined in for water use during 2000-2014. Water use by major sectors of an economy changes as development takes place; share going to agriculture declines and those to industry and households increase. However, even in highly developed nations, agriculture is often still the major user of fresh water (Barlow 2013, Blewitt, 2008, Gleick 2014). As rainfall decreases and as wells run dry, droughts recur. So the cultivation practices of farmers will have to change greatly as in California and urban areas will likely to restrict usage to as in Sao Paolo just now (Davidow & Malone 2015, Hoekstra, 2013, Molden, 2007, Piper 2014, Romero 2015).

Much of the increased demand for water in the 21st century comes from nations in Latin America, Africa, the Middle East, and South Asia. Several countries in these regions experience shortages of fresh water, have not managed well the demand from various sectors, and as a result are approaching their ‘maximum developable supply’. Indeed, in a just released 2015 report by the United Nations, the planet is said to be "facing a 40% shortfall in water by 2030 unless we improve management of this precious resource." Various agencies are at work examining daily and annual use of water in the three major sectors and in specific operations e.g. rice vs wheat fields, steel vs plastic production, and washing garments vs flushing toilets. Average daily use per capita in households ranges from 50 to 400 liters per day; withdrawal per capita for all uses can be from 400m3 to over 3000 m3 per year (Drinan & Spellman 2012, OECD 2014, UN 2012, UN 2015, World Bank 2014 plus select websites listed in Bibliography).

3 Sustainability and Water Usage

The concept of sustainability has been around for decades (Bruntland 1987, Kahle & Gural-Atay 2014, Tolma 1991) but its practice is more recent. A simple definition: it is development that meets the needs of the present without compromising those of future generations. Related to this definition has been the emphasis on a 'triple bottom line'—dealing with economic, social, and environmental needs. As others have stated: profits, people, and planet. Yet another 'shorthand solution' proposed is espousing 'reduce, reuse, recycle.' But the application of these broad concepts in daily activities of billions, whether at work or at leisure, and in keeping our ecosystem less polluted is truly complex and challenging. That is due to life styles, economic growth, urban overcrowding, overgrazing, and deforestation (DeLange, 2010, Gleick 1993).

Three major factors cause or contribute directly to environmental damage and specifically to water pollution. First, although degradation occurs in the absence of man-made activities, it is the latter that are responsible for most of the problems. If population and economic-industrial activity were more dispersed then 90% of existing pollution would be eliminated. Second, such non-economic factors as lack of trained personnel, resistance from vested interests, and bungling by bureaucrats loom equally significant to demographic and economic forces. Third, non-point sources such as fertilizer runoff from farms constitute major sources of water pollution, but are almost impossible to monitor or eliminate (Biswas 1978; Gross 1986a; Black & King 2009; Drinan & Spellman, 2012; etc.). The impact of water pollution may be short-run or long-run or both; it may be visible or invisible. But the assessment of damage is a complex undertaking; it has taken years to prove that air pollution results in acid rain and lake contamination far away

3.1 Corporate Sustainability: Case Study of Water Use by Two Giant Mining Firms

The broad definition of sustainability as balancing the needs of the present and future generations must be made more meaningful at the individual, organizational, and public level. In a Dow Jones index, sustainability is defined as a "business approach that creates long-term shareholder value by embracing opportunities and managing risks deriving from economic, environmental developments." The International Council on Mining and Metals stated in 2008 that for mining firms at the project level "investments must be technically appropriate, environmentally sound, and socially responsible." These statements go beyond mere profit goals, but they are sill broad.

We compare two long-established, global mining firms on water usage. They are BHP Billiton (founded in 1885) and Rio Tinto (founded in 1873) that have recorded, respectively, revenues of $67 billion and $48 billion in 2014. Both are multinational in scope and have grown on their own as well as via mergers and acquisitions. Our choice was governed by being asked to deliver a lecture at a major Ecoforum exhibit in Sydney in 2012 on sustainability and water use by resource-based firms (Castrigano & Gross, 2012). Both firms have been criticized in the past, BHP Billiton for air pollutants, Rio Tinto for open-pit mining in Indonesia. However, in regard to sustainability in their use of water they have done better as discussed below.

Both Rio-Tinto and BHP-Billiton developed a corporate sustainability framework as shown here in **Figure 1** and **Figure 2**, respectively. These are concise exhibits that duplicate the broad ideas or definitions given above, so we needed to move beyond that. Accordingly, we examined their annual reports as well as specific environmental reports that the two giant firms had to offer. While we were interested in total water usage, of greater importance was their recycling ratios. We found that both firms are heavy users of water as shown in **Table 1- Part A**, with Rio Tinto using more than twice as much as BHP-Billiton. But on the recycling front, shown in **Table 1-Part B**, Rio Tinto is lagging behind BHP-Billiton (Castrigano & Gross, 2012).

Both promised to do better and to increase recycling rates. We probed further in publications and websites of the two giant firms and in **Table 2** show how they are promoting their achievements to stakeholders, including shareholders and employees, various government agencies and other diverse communities. They do this to build trust among stakeholders and to strengthen their corporate reputation for monitoring agencies. BHP Billiton is practicing sustainability more so than Rio Tinto as we look at a compare their achievements for key performance indicators.

We can also gain additional insights on water conservation by these companies if we examine the individual mining operations. The Olympic Dam mine of BHP Billiton in southeast Australia extracts copper primarily, but uranium is also mined.

A water efficiency initiative established in 2006 targeted reducing water use in three production areas: concentrator, hydromet, and smelter. After one year, total reduction of water usage was 5.5.megaliter per day (1 megaliter = 1 million liters). The Northparkes mine of Rio Tinto, in the same region, extracts copper and gold. Targeted total use of water use was exceeded by 17% in 2006, but the operation was redesigned and water evaporation from surface water was reduced. The company received an award from the Mineral Council for this innovation and later on chose to commercialize it.

3.2 Water Use by Nations and by Key Sectors

Moving beyond the corporate level, we must explore how nations and regions use fresh water and what the distribution of such water is among the three sectors of agriculture, industry, and domestic consumption. While geography is not destiny, the history of civilization over centuries can be described as the clustering of population along major river basins. These basins remain vital today for all three major end use sectors (Ambroggi 1980, Gleick 1993, Black & King, 2009, OECD 2013). In densely populated areas, even small rivers were intensely developed.

Rise of mega-cities and the growth of mega-farms have created major burden for governments. Drought conditions have been reported for Sao Paulo in Brazil, several regions of Pakistan, the state of California, and many other locations around the globe. Water supply has been imperiled by declining rainfall, rising temperatures, and bureaucratic mismanagement. The UN, WHO, OECD and other multinational agencies identified the top ten "water-scarce" and top ten "water-stressed" nations, with a majority in the Middle East. In total, 47 nations face water shortages, 18 are 'water-stressed', and 29 'water-scarce' (Hoekstra 2013, Leahy 2014). Total global water usage was estimated by the UN at about 3800 km3 per year in 2000 (with agriculture around 70%, industry 30%, and households 10%) and to rise to nearly 4900 km3 by 2025.

Fresh water withdrawals (also known as water abstractions) are shown in **Table 3-Part A** for ten nations using recent data from OECD. The statistics are over a considerable period, from 1985 to 2005. This 20-year span reveals cause for optimism for these industrialized countries. Despite population and economic growth, along with urbanization, most of them were able to "hold the line" or even decrease the amount withdrawn. The exception is Turkey; it had the highest rate of growth and experienced rapid industrialization (OECD 2014, UN 2012).

Fresh water use by three end-user sectors shows variability among industrialized nations as seen in **Table 3-Part B.** These figures are averages for the 2008-2012. Notably, **agriculture** takes a large share in these countries and the sector accounts for much more, 85% to 95%, of fresh water withdrawal in emerging economies e.g. in India, Iran, Iraq, Kazakhstan (OECD 2012, UN 2015). This is because reuse or recycling of water is largely impractical in agriculture. A major report conducted in

2007 focused on whether there was sufficient water for agriculture to produce food for nearly 7 billion people then and the forecasted 9 billion persons by 2050 (Molden, 2007). The conclusion was that this would be possible only with reduced irrigation and major changes such as moving away from water-intensive produce and meat production.

'Virtual water' refers to water used to produce commodities, such as wheat, cotton, fruit and produce; when the product is shipped, such water is considered as an export. California is said to export over 20 trillion liters of virtual water even as it suffers from drought. How can this be? It is due to misallocation, mispricing and mismanagement. Water transfers among distant points is cumbersome and regulated. Farmers planted almond groves when price for almonds was high and water use was cheap (almonds, pistachios, berries all require intensive irrigation). Some municipalities have rules against sale of ground water. But now changes in irrigation practices, municipal rules as well as market incentives are advocated (Davidow & Malone 2015). Molden's report, cited above, also called for similar policy changes globally on agricultural water use.

Water use in **industry** -in manufacturing, mining, and utility operations- is rising in importance in both industrialized and emerging economies. There are major variations among nations as to what percentage of the total use is taken by the industry sector. At one point, UN agencies predicted sharp increases in this sector due to higher electricity generation and manufacturing activity, but there has been a slowdown in both in all regions. In the developed nations there is a strong trend to recycling in process industries and n developing nations steps are taken to adopt new technology in regard to water intake, consumption, and waste load handling. Much of the **capital spending** on these is on equipment for more efficient water and wastewater treatment and more recycling. In addition, **operating expenses** are also being cut; for example organic coagulants are replacing inorganic ones. The former cost 10 times more than inorganics, but they are 15 times more efficient; far lower quantity is needed and far less solid waste is precipitated. This phenomenon gathered momentum over the years (Duncan & Gross 1995, Gross 1986b).

In an analogy to the concept of 'virtual water' or 'exported water' for agricultural commodities (fruit, produce, grain) and the raising of livestock, the concept of 'water footprint' is advocated in the manufacture of all products ranging from plastic bottles to steel, from paper to linen napkins. Many calculations have been carried out for different countries and different operations. For example, in case of a plastic cola bottle, about 5 liters of water are needed to make a half-liter bottle; but there is additional water needed for packaging and shipping which brings the total footprint to 175 liters (Leahy 2014). Large soft drink and water bottling firms are engaged in a strong dispute around the world; conservationists advocate less bottling, more use of tap water, and 'thermos' type or reusable containers (Hoekstra 2013). Further, it is said that poor dry countries in Asia and Africa should not sell 'water-rich products' to wealthy wet nations.

In regard to **domestic** use, progress has been made via conservation and pricing measures; still, its share of the total has risen due to growth in population, urbanization, and adoption of new lifestyles. Variables that come into play are income, tradition, price, and water/sanitation facilities. Per capita daily use varies widely in the 10 to 450 liter per day, but these numbers have shown a steady slow rise as people acquire appliances and as the middle class is growing in China, India, and other major developing nations. However, in industrialized countries most consumers respond positively to water-saving measures and even to proposed price increases charged by public and private utilities. A report in water prices charged in major European cities show a wide range from \$2/m3 in Wroclaw to \$3/m3 in Budapest, \$4.50/m3 in Amsterdam, and \$9/m3 in Copenhagen, but residents proved capable of adjustments (OECD 2013 citing IWA).

4 Expenditures and Achievements on Water Treatment

At this point we tackle the dual question: (1) how much is spent for battling water pollution and (2) what can be achieved in improving water quality, both locally and globally. These are complex questions that cannot be answered easily, in part because the cleanup task is tied to sovereign nations, different climates, rivers crossing national boundaries and past public policies along with regulatory enforcement. However, we can now make at least a partial assessment in regard to efforts and expenditures as well as subsequent results by taking a long-run view.

For the past half-century, under prodding by environmentalists, governments, and enlightened business interests, progress has been made in devoting efforts and funds toward reining in water pollution problems. Visible evidence such as the infamous Cuyahoga river fire incident of 1969 in Cleveland, Ohio and subsequent laws such as the U.S. Clean Water Act contributed to an upsurge in spending on water cleanup tasks. Business opportunities arose in marketing ‘air and water purification’ equipment around the world (Gross, 1986a). An early monograph on past and projected water pollution control spending in 30 nations was developed (Gross 1986a). In creating a framework, the author espoused the idea of using both the top-down method of utilizing aggregate data from government censuses and trade associations as well as the bottom-up method of combining data from major equipment producers (Duncan & Gross1995).

Since 1980, many additional reports appeared on global, regional, and national markets for water pollution control equipment from various sources, especially by large market research agencies such as Datamonitor, Euromonitor, The Freedonia Group, and IBISWorld. **Table 4** reveals a 20-year span of past and projected statistics on major countries and regions. Total demand globally for water treatment equipment rose from about \$29 billion in 2007 to over \$38 billion in 2012 and projected to grow to over $53 billion by 2017 (The Freedonia Group, 2013). Annual growth rate for the world should rise from 6% during 2007-2012 to 7% during the 2012-2017 period, showing dedication on the part of industrial firms and municipalities to tackle water pollution in their respective countries. Filtration, membrane, and disinfection equipment will continue to be in high demand for supply water to households and process water for industrial use, even as water-saving devices in homes and recycling ratios in factories are on the rise.

Water and wastewater equipment are widely used by government and manufacturing entities, but they cannot be easily used in agriculture. Irrigation and accompanying cultivation steps that provide water for the growing of grain and produce on farms are not amenable to reuse or recycling; wastewater from livestock cannot be cheaply cleansed. Thus, there is flow of contaminated water from land into rivers and lakes. Furthermore, pesticides used on large farms and agri-businesses become part of the runoff. This key problem –called non-point source-has been around for many decades, but became more acute with intensive irrigation and livestock production. Dispersal of farm operations and cutbacks in pesticide use are costly, cumbersome, and not easily enforced. But all users of water should practice source not end-of-pipe solutions.

There is evidence on hand that that cleanup efforts, expenditures and legislation are working in regard both water and wastewater treatment. Numerous measures for gauging the extent of water pollution exist. For drinking water these are turbidity, pH values, lack of toxic chemicals, etc; for wastewater it is suspended solids, pH, BOD, lack of metals, etc. To be sure even in 2014 around the globe, over 1.2 billion people lacked access to potable water and over 2.2 billion did not have access to indoor sanitation (UN 2015). Many metrics show improvements; here we focus on BOD or biological oxygen demand. **Table 5** lists several major rivers, mostly in Europe, with practically all of them showing an improvement on this measure (the lower the better). Our emphasis is on Europe since it is the leading continent in regard to environmental action; but included are data from Japan, Turkey, and USA. The general improvement between 1970 and 2005 is encouraging and cause for optimism. It is notable that major rivers, such as the Rhine and the Danube, that cross several national borders show good results (OECD and UN data).

5 Framework for Classification, Legislation, and Action

To build an information to intelligence framework for understanding environmental degradation and for analyzing and improving the situation is no easy task. The old-fashioned, simple view that factories emit visible smoke and dirty water, that industrial leaders ignore these, and that the solution lies in strict legislation is gone. The causes and effects of pollution are many and varied, while remedies are equally numerous and complex—as seen in **Table 6**. The reason for such complexity is that all human activities –both work and leisure related- cause physical degradation. The resultant effects can be mild and dangerous, but are neither easily measured nor easily tackled. In the short run solutions are in ad hoc economic, legal, and technical advances. In the long run, changes must be made in lifestyles, cultural values, and social conditions.

Three major factors cause or contribute directly to environmental damage and specifically to water pollution. First, although degradation occurs in the absence of man-made activities, it is the latter that are responsible for most of the problems. Concentration is really the problem; if population and/or economic-industrial activity could be dispersed evenly over land, then 90% of existing pollution would be eliminated. Second, such factors as lack of trained personnel, resistance from vested interests, and bureaucratic bungling are at least as significant as economic failures. Third, nonpoint sources, such as fertilizer and pesticide runoff from agriculture, are hard to monitor and even harder to eliminate (Gross 1986, Duncan & Gross 1995).

The impact of pollution is likely to be both short or long run or both; it may be visible or not; and assessing damage, actual or potential, is no small task. Yet in an era emphasizing sustainability it is mandatory to consider solutions for health and wellness. At the same time, the notion of 'triple bottom line' cited earlier and a cost-benefit analysis can lead to economic payoffs. Among the short run solutions suggested are: incentives (barriers or subsidies), regulation or licensing, and more efficient treatment facilities. Economists in the past recommended levying discharge fees and establishing regional or river basin management authorities. A consensus is emerging that overly strong regulation is unfair, inefficient, and self-defeating.

As to legal and administrative approaches to water pollution control, we have constructed yet another framework as shown in **Table 7**. Common law –as practiced in the UK-US milieu with emphasis on precedent- has always been concerned with the use of property by both individuals and organizations and its impact on neighbors. This is applicable and appropriate in regard to the use of rivers and the notion of 'riparian rights' that avoids harm to those downstream. In practice this means: (1) setting limits on specific pollutants, (2) agreement on threshold standards, and (3) negotiations on actual and potential harm (Gross & Scott, 1980, Gureusway & Leach 2012).

Going further, we have seen the emergence of broad statutory steps that affect all media-- air, water, and solid waste. Transferring pollution from one medium to another is a temporary or localized solution as natural resources are connected. Much in the news these days is carbon tax to control air pollution; but the record so far is mixed and its adoption is still widely debated. In water and specifically river pollution the trend is toward river basin management as practiced in France and Germany. Just now, in mid-March 2015, Egypt, Ethiopia, and Sudan finally agreed to better management of the Blue and White Nile and the construction of a large dam.

Other frameworks have been suggested for classifying water pollution problems and solutions. At a major environmental information forum, sponsored by Environment Canada in 1991, two conceptual frameworks were proposed. The first one by T. Friend of Statistics Canada proposed two routes, a material-energy balance and a stress-response system that includes "preventive, curative, and conservation steps." The second framework, proposed by Nishioka and Moriguchi, at the same forum, put the emphasis on (1) stages of policy process—identification, evaluation, and implementation and (2) stages of data production—collection, analysis, and dissemination. Their 3x3 matrix makes a contribution by relating policy to data (see details on both in Gross & Duncan 1996, Chapter 6). A third, recent and comprehensive framework suggests a complex information network "allowing contributions by all players and building a web of trust" along with creation of website (wqin.org), database, collaboration tools and a user interface (Dalcanale et al. 2010). The ideas discussed have merit, but the website is currently not functional.

Much progress has been achieved in regard to environmental data collection and analysis by the major agencies of the United Nations, including WHO, UNESCO, UNICEF, et al; but the key player is the UN Environmental Program. Specifically, UNEP sponsors GEMS which is the Global Environment Monitoring System Water Programme. It is dedicated to providing water quality data of "the highest integrity, accessibility and interoperability with more than 4100 stations with 4.9 million records, and over 100 parameters." The UN also sponsored an inter-agency mechanism called UN Water; it just issued, on March 20, 2015, its latest World Water Development Report (UN 2015). Another major agency on the global water scene is OECD with its Factbook 2014 focusing on economic, environmental, and social statistics. The OECD has been the fountainhead for economic data for many decades for Western nations, but it has now broadened its scope of collection. The World Bank in its annual World Development Report also contribute to the dialogue as do many other public and nonprofit agencies (see websites cited).

6 Summary, Conclusions and Recommendations

In this paper we offered a short, guided tour of the global situation regarding water quality. The discussion focused on water supply and water demand in a worldwide setting, then exploring the relation between sustainability and water usage. This was followed by a case study of corporate sustainability—a comparison of water use and recycling practices of two giant mining firms. In the next section we considered fresh water withdrawals by nations and its use by the three key sectors of agriculture, industry, and households. Spending on water treatment equipment and the resultant river quality levels were analyzed. Finally, we considered classification schemes for tackling water pollution along with legal and administrative steps to achieve higher water quality on a worldwide basis. We think that both cross-sectional and longitudinal analyses are needed. The challenge is to make progress on the cleanup front and to develop meaningful databases for use by analysts and policy-makers. Combining our two final tables with comparisons across and over time can constitute a viable framework for those who generate, analyze, and disseminate data. In moving from information to intelligence or know-how, the key is reducing the numerous data points in quantity while upgrading quality.

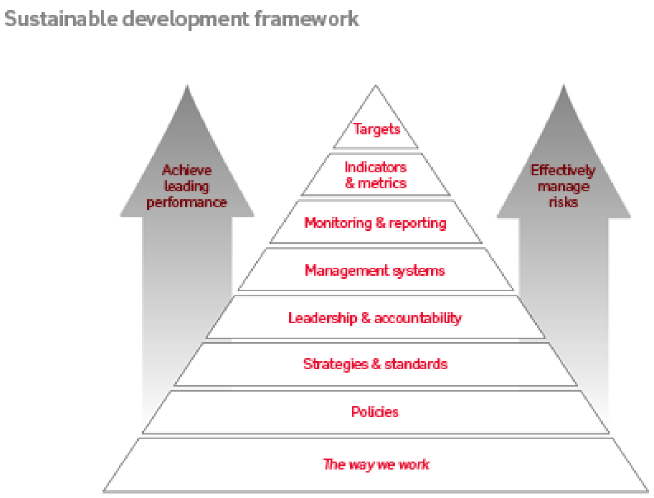

Figure 1
Rio Tinto's Sustainable Development Framework
Source:http://www.riotinto.com/annualreport2010/performance/our_approach.html

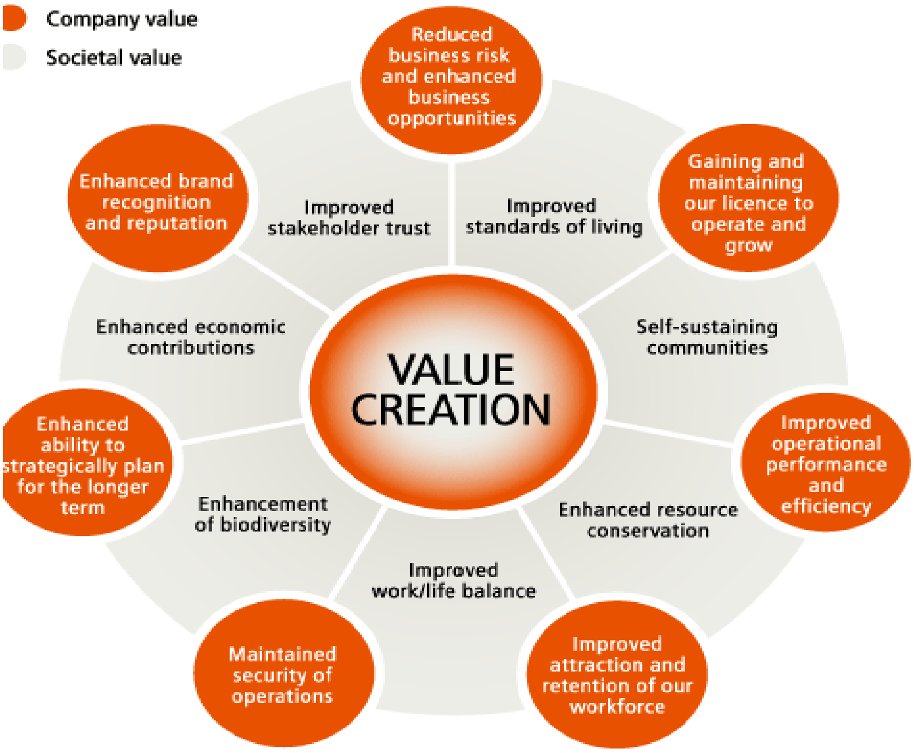

Figure 2

BHP Billiton's Sustainability Framework

Source: http://www.bhpbilliton.com/bbContentRepository/docs/fullSustainabilityReport2008.pdf

Part A: Comparison of Rio Tinto and BHP Billiton on Total Water Usage

Year Ended:	**2010**	**2009**	**2008**	**2007**	**2006**
TOTAL WATER USED (in ML)					
Rio Tinto	747,500	740,000	1,458,824	984,000	1,015,385
BHP Billiton	387,234	400,000	411,364	354,348	367,391

Part B: Comparison of Rio Tinto and BHP Billiton on Recycled Water Volume

Year Ended:	**2010**	**2009**	**2008**	**2007**	**2006**
RECYCLED WATER (in ML = megaLiters)					
Rio Tinto	299,000	259,000	248,000	246,000	264,000
BHP Billiton	182,000	168,000	181,000	163,000	169,000
RECYCLED WATER (as a % of Water Used)					
Rio Tinto	40%	35%	17%	25%	26%
BHP Billiton	47%	42%	44%	46%	46%

Table 1
Water Usage by Two Major Mining Firms in Australia
Source: Rio Tinto, annual reports; BHP Billiton sustainability reports; authors' work.

	Rio Tinto	**BHP Billiton**
Sustainability discussed in annual report	Yes	Yes
Annual Sustainability Report, separate from annual report, with more detailed strategies and results	No	Yes
Key Performance Indicators (KPI's) for Sustainability	Yes	Yes
Measurement and reporting of KPI's	Yes	Yes
Number of KPI's Achieved / Stated for 2010	3 / 5	10 / 13
Management Systems Achieved / Stated for 2010	-	1 / 1
Safety Achieved / Stated for 2010	1 / 1	1 / 2
Health Achieved / Stated for 2010	1 / 1	2 / 3
Environment Achieved / Stated for 2010	1 / 3	4 / 5
Community Achieved / Stated for 2010	New for 2011	2 / 2
Listed on the Dow Jones Sustainability Index (DJSI)	Yes	Yes
Rank on the DJSI for 3/31/2011 for Asia Pacific Region	10th	1st

Table 2
Comparison of Rio Tinto and BHP Billiton in Proving Sustainability to Stakeholders

Source: Rio Tinto, annual reports; BHP Billiton Sustainability reports, 2006-2010; and authors’research .
Note: Portions of this and previous table are based on invited lecture by R. Castrigano and A. Gross at Ecoforum Sydney, March 2013.

Part A: Fresh Water Withdrawals (bil m3) in Major Countries, 1985-2011

Country	1985	1990	1995	2000	2005	2011
Australia	14.6		24.1		19.3	14.1
Canada			47.3		42.0	
France	34.9	37.7		32.7	33.8	
Germany			43.4			
Hungary	6.3	6.3	6.0	6.6	4.9	
Japan	87.2	88.9	88.9	87.0	83.4	
Poland	16.4	15.2	12.9	12.0	11.5	11.9
Spain	46.3		33.3	36.5	35.7	
Turkey	19.4	28.1	33.5	43.7	44.7	
USA	464.7	462.3	466.1	482.6	483.0	

Part B: Fresh Water Withdrawals in Major Sectors, Select Countries, 2008-2012

Country	Agriculture	Domestic	Industry	Total (% and bil m3)	
Australia	74	16	11	100	22.6
France	12	18	69	100	31.6
Germany	12	12	76	100	32.3
Japan	63	19	18	100	90.0
USA	40	14	46	100	478.4

Table 3
Fresh Water Withdrawals in Select Nations
Source: Part A= OECD Factbook 2013; Part B = Worldbank.org/indicator & CIA Factbook 2013

						% annual growth	
Item	**2002**	**2007**	**2012**	**2017**	**2022**	**12/07**	**17/12**
World Pop (mil)	6240	6627	7018	7395	7755	1.2%	1.1%
$ equip/capita	3.24	4.34	5.46	7.21	9.34	--	--
Total Eqp Demand20245	28765	38300	53350	72400	5.9	6.9	
North America	7080	9045	11930	15990	20780	4.8	6.0
USA	5860	7760	9760	13010	16830	4.7	5.9
Canada & Mex.	1254	1685	2170	2980	3950	5.2	6.5
Western Europe	5910	7360	8360	10560	12970	2.6	4.8
Asia-Pacific	4425	7455	10980	16580	24400	8.1	8.6
China	865	2180	3780	6520	19560	11.6	11.5
Japan	1890	2490	2980	3590	4220	3.7	3.8
Other Asia-Pac	1670	2785	4220	6470	9620	8.7	8.9
C & S America	815	1155	1610	2270	3110	6.9	7.1
Eastern Europe	840	1235	1830	2590	3610	8.2	7.2
Africa-Mideast	1175	2115	3590	5360	7530	11.2	8.3

Table 4
World Demand for Water Treatment Equipment by Major Regions/Nations
(in mil current $ except as noted)

Source: E. Park, The World Water Treatment Equipment Market (Cleveland: The Freedonia Group, 2013)

Note: See also related publication, A. Gross, World Water Pollution Control Equipment (Cleveland: Predicasts, Inc, 1980)

Country	**River**	**1970**	**1975**	**1980**	**1990**	**1995**	**2000**	**2005**	**2010**
Austria	Donau				3.80	3.00	1.20	1.90	
Czech Rep.	Morava				7.90	4.22	3.65	4.40	2.19
France	Loire					4.00	4.30	3.80	
	Rhone					1.30	2.00	1.40	
Germany	Rhine	7.0	7.9	7.5	3.3	3.0	3.0		
	Elbe				9.60	5.40	7.21	6.60	4.00
	Donau				2.80	2.80	2.10	2.35	1.60
Hungary	Duna				3.10	2.10	1.60		
	Tisza				1.50	1.90	2.80	3.51	1.92
Italy	Po				3.60	2.50	1.90	1.30	
Japan	Tama	6.8	7.1		4.60	3.80	2.00	1.50	
Netherland	Rhine	3.1	3.2	3.1	1.6	1.9			
Poland	Wisla				6.00	4.20	3.80	3.18	3.00
	Odra				7.00	4.50	4.60	5.44	7.30
Spain	Ebro				2.30	13.60	5.00		
Slovakia	Hornad				6.60	5.70	2.90		2.50
Turkey	Gediz				10.60	31.00	3.70	5.20	
UK	Thames				2.90	1.80	1.70	5.20	
	Mersey	20.2	9.5		4.4	3.7	2.8		
USA	Delaware	3.2	3.5		1.23	2.62	3.67	3.23	
	Mississippi				1.85	1.15	1.48	1.85	4.95

Table 5
River Quality in Selected Countries (BOD levels)

Source: Gross (1986); OECD (1979 and 2013) and other multinational agencies, 2012

Table 6. Key facets of environmental pollution.

Causes/classification schemes	Impact/effect	Remedies/solutions
I. Natural vs manmade occurrences A. Natural: 1. Volcanic eruptions 2. Soil erosion, topsoil removal 3. Nutrient runoff from land	I. Public health attacks A. Respiratory ailments B. Digestive ailments C. Communicable diseases, etc.	I. Cultural & social change A. Change lifestyle, consumption patterns B. Change social/cultural values C. Change underlying attitudes
B. Man-made: 1. General a. Growth of population b. Industrialization c. Urbanization d. Acquisitive lifestyle 2. Specific a. Factory & auto emissions b. Plant & household wastewater c. Oil tanker spillage d. Nuclear waste e. New chemicals	II. Economic damages A. Damage to human productivity B. Damage to animal health and productivity C. Damage to vegetation, plant life D. Damage to materials, corrosion, etc. E. Damage to recreation facilities, etc.	II. Scientific, technical & industrial changes A. Change pollution from one medium to another B. Change assimilative capacity of the environment C. Neutralization or offsetting reactions D. Utilization of effluent/waste E. Switch to new materials & processes F. Limit production of new/untested chemicals
II. Economic vs noneconomic failures A. Economic: 1. Consideration of air & water as free goods 2. Reluctance to spend on "nonproductive goods" 3. Lack of financing, tax base 4. Lack of subsidies, incentives B. Non-economic: 1. Lack of professional & technical personnel 2. Poorly designed legislation, enforcement, jurisdiction 3. Resistance from vested interests III. Point vs Nonpoint Sources A. Point: specific factories, cars, households B. Nonpoint: untraceable emission/effluent IV. All other classification schemes A. On basis of degradability B. By type of medium emitted to air, water, etc. C. On basis of toxicity	III. Noneconomic impact A. Aesthetic & psychological impact B. Social & cultural values C. Disruption to lifestyle(s)	III. Legal, political, & economic changes A. Regulation by the government 1. Outright ban 2. Across the board or point by point regulation 3. Environmental impact statements filing B. Economic subsidies 1. Public spending on treatment facilities 2. Subsidy to individuals, groups C. Economic & other incentives 1. Levy fee on discharges—issue "permits to pollute" 2. License dischargers D. Adjustment of administrative machinery 1. Retain existing boundaries 2. Establish basin or regional authority 3. Establish new ministries or coordinating bodies or "pollution management agencies" 4. Allow suits by individuals and groups

Sources: Primary work by the author based on literature cited and field interviews.

Table 7. Legal and administrative aspects of environmental pollution.

Definition/ determination of pollution	Primary legislative and administrative approaches	Levels of legislation and/or administrative structure	Facets of individual rights and action
I. Traditional definitions & views A. Alteration of the existing environment B. Right of the territorial sovereign (no extraterritorial effects recognized) C. Damage to humans, property, environment D. Interference with others right to use the environment E. Exceeding the assimilative capacity of the environment II. Nontraditional definitions or views A. "Label substitution" or specification of harmful substances emitted or discharged B. Combination of approaches, i.e., any two or more of the above	I. Comprehensive environmental policy and laws e.g., Australia, Colombia, France, Greece, Ireland, Japan, Malaysia, Portugal, Sweden, UK, US II. Specific environmental (medium) policy and laws e.g., Austria, Canada, Finland, W. Germany, Italy, Norway, Spain, Switzerland, Turkey III. Combination environmental policy and laws ("mixed systems") e.g., Belgium, selected provinces in Canada, Mexico, New Zealand IV. Natural resource legislation e.g., Algeria, Czechoslovakia, Cyprus, Israel, Libya, Peru, Poland, USSR V. Other Systems A. Protection of certain living or natural organisms e.g., Syria B. Specific discharge or emission prohibitions e.g., Egypt Note: Comprehensive laws coexist with specific medium (air, water) laws in many countries i.e., these are not exclusive categories, but indicate main approach	I. Supranational and international organizations and agreements A. Global e.g., UN, UNEP, UNESCO, UNCTAD, WHO, FAO, IMCO, WCJ, WMO, IGOC, Earthwatch B. Regional e.g., OECD, EC, CMEA, Rhine Catchment Basin Danube Countries C. Bilateral e.g. Canada–US, Mexico–US, two country tribunals II. National level government A. 1. New department or ministry e.g., Canada, Denmark, E. Germany, Norway, Japan, UK 2. Old department or ministry with extended jurisdiction e.g., Netherlands, Nigeria B. Coordinating body e.g., Algeria, Chile, France, Israel, W. Germany, Morocco, Spain, Syria III. State or provincial government/ organization A. 1. New department or agency 2. Existing political boundaries and bodies B. Coordinating committee for local government	I. Judicial proceedings (hearing of lawsuits brought against the activity complained of) A. Where the acts complained of have threatened the plaintiff B. Where the plaintiff has sustained no "direct" injury II. Administrative proceedings A. Extent to which a public hearing is required before administrative rule-making B. Individuals' right to participate in hearings concerning the environment C. Challenging admin. action concerning the environment D. Needed improvements

Sources: Primary work by the author based on literature cited and field interviews.

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Select websites for associations, governments, and multinational agencies;

http://www.awra.org

http://www.fao.org/nr/water/aquastat/main/index/.stm

http://www.epa.gov/scitech/swguidance/standrads/criteria/

http://www.globalreporting.org

http://www.stats.oecd.org/wbos/Index.aspx?

http://www.smartwatermark.org/

http://www.unep.org/gemswater/Globalnetwork/

http://www.waterforlifedecade/quality.shtml

http://www.water.worldbank.org

http://www.worldwater.org/conflict.html

http://www.worldwatercouncil.org/

http://www.who.int/water_sanitation_health/

For full name, location and main mission of the organizations behind websites, see list below:

American Water Resources Association (Middleburg, VA, USA)—education, research

Food & Agricultural Organisation (Rome, Italy) –food and farm issues, health, safety

Environmental Protection Agency, US Gov. (Washington, DC)- regulation, policy

Global Reporting Initiative (Amsterdam, Netherlands)- education, research, compliance

Organisation for Economic Cooperation & Development (Paris, France)- research, statistics

Smart Approved WaterMark (Sydney, Australia)- education for households, research

United Nations Environment Programme (Nairobi, Kenya)- policy, advocacy, education

Water for Life Decade 2005-2015 an interagency coordination program of the UN

World Bank (Washington, DC)- major economic policy, financial assistance, statistics

Worldwater –> Pacific Institute (Oakland, CA, USA)- research, protection, equity

World Water Council (Marseille, France)- conservation, protection, policy, research

World Health Organisation (Geneva, Switzerland)- health, wellness, prevention, research

Management, Enterprise and Benchmarking in the 21st Century
Budapest, 2015