FINANCE & WATER
"WHERE'S THE DATA?"
WORKING PAPER

OCTOBER 2010

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Introduction

1.1 The Natural Environment Research Council (NERC) asked Z/Yen Group Limited (Z/Yen) to produce a report to examine the environmental data requirements of the financial community to support investment decisions in the water and water-related sectors. This paper presents recommendations through which such data could be provided by the Centre for Ecology and Hydrology (CEH) and the British Geological Survey (BGS), two of NERC's research facilities.

1.2 CEH and BGS both hold large repositories of digitised data, ranging from river-flow and rainfall, to land cover and groundwater reservoirs. In addition, both bodies have built up a range of models to forecast water scenarios such as drought and reserve depletion up to 2100.

1.3 NERC seeks to engage research centres and financial services professionals in order to maximise use of current data sets and to anticipate demand for further data from the financial community.

1.4 This paper not only seeks to alert the financial services sector to the existing modelling capabilities and data resources of NERC science assets, but also to encourage an active exchange of information which will mutually benefit both scientific research and financial investment.

Critical Issues

2.1 The increasing number of water conservation initiatives around the world is evidence of the growing awareness of the challenges facing water supplies. Freshwater is a finite resource, essential to human survival the global food, feed, fuel and fibre supply and the entire ecosystem. Freshwater can only be engineered through the desalination of saline water, which is costly in monetary, energy and environmental terms, there is no alternative.

2.2 Demand for water is growing due both to increasing population and increasing economic activity. Increasingly, the strains imposed by climatic changes along with high water abstraction rates and on-going contamination pose significant threats to future supplies.

2.3 At present, there are few ways of investing directly in water, with the result that the financial sector's knowledge of water issues and data is limited. The impact of individual stresses on water supply may soon begin to impact directly on investments, as latent interest of water problems becomes more active. The short time frame for these developments (estimated at two to four years in some arid and semi-arid places) makes preparation to deliver accurate hydrological data to the investment community a matter of some urgency. This challenging task will be made all the more difficult by the need to quantify water at a variety of local, regional and international levels of resolution.

2.4 NERC (via CEH and BGS) can deliver data on a variety of spatial levels. Resolution varies by location, with the highest being generally available for the UK, most of Europe and

North America, and the lowest (often based on modelling from partial data) in the developing world. The coverage of predictive models is extensive, but some forms of measurement, such as the replenishment rate of underground aquifers, have a significant error margin. Thus far, NERC has engaged extensively with the insurance industry on UK flooding and with individual multi-national corporations with particularly high water dependence. NERC, however, is actively seeking to share its data and models with the wider universe of capital markets.

Analysis

3.1 Within the financial services community investment managers, insurance providers, credit risk analysts and banks (both commercial and investment) all have a range of interests in water-related financial vehicles. There is a broad distinction to be made between:

- 'investors'- those who directly own forestry assets.
- 'guarantors' - insurers and related risk analysts;
- 'traders' - in which indices and derivatives can be traded either on exchanges or 'over the counter' (OTC).

'Investors' and 'guarantors' require detailed data at a geographical level, directly related to the investment or risk being priced. The ‘traders’ tend to be interested in data sets offering wide coverage at a global or regional level, depending on their particular geographical scope, with consistent but relatively low resolutions and measurement criteria. Although professionals in different financial services may require different geographies for datasets, there is a common understanding that maps and models will be required for water scarcity in the near future.

3.2 'Risk' best describes the interface between hydrological processes and financial services. Water scarcity will appear on financial services’ radar when they pose a risk to investment and returns. Although some large corporations (especially those in water-intensive sectors such as beverages) are beginning to undertake water-footprinting and water stress modelling the quality of the datasets used is uneven, and practical measurement techniques are still in their infancy.

3.3 While the scientific community has built an increasingly sophisticated and comprehensive picture of the world's water resources, financial services professionals are only beginning to define environmental data requirements, which, broadly speaking lie with hydropower and other water-dependent energy generation, industry, agriculture and water (property) rights.

3.4 There is no consensus on either the types of data required by financial services or the immediacy of the requirement itself. Financial services firms are often at least one step removed from the actual data. Such information as they do receive normally arrives from third-party consultants or disclosure by listed companies of their water usage and related risks.

3.5 There is, nonetheless, a strong latent desire to move closer to comprehensive data, and our research has generally echoed the conclusions of a recent report that "global water scarcity is one emerging risk that all companies should be focused on – and one about which investors need information"[1].

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[1]Barton, Brooke, *Murky Waters? Corporate Reporting on Water Risk*, Ceres, (February 2010) page 3.

Conclusions

4.1 The above developments will require a more open and fluid exchange of information between the financial and scientific research communities. While this exchange will become self-sustaining with time, it is not there yet. The scientific community will accelerate progress if it becomes more pro-active, and seeks both potential end users in the financial services sector, and a more prominent position from which to advertise and disseminate its data.

4.2 It is clear that on a two to four year time horizon, a comprehensive suite of data on water supply and demand, backed up by solid scientific observation and modelling, could become a vital component of investment and risk protection processes – and thus a basic requirement of all major financial institutions.

4.3 Given the pace of change, and the increasing stresses on global water resources, we conclude that the dialogue and work to meet those needs ought to begin now. However, this work is not confined to the scientific community in pushing this data out, but also rests on professionals within financial services knowledgeable of the imminent challenges, who must define their needs.

4.4 The core recommendations of this paper are that NERC and CEH take the lead in pursuing developmental partnerships in financial services, and that the two bodies must be proactive in educating the financial sector on the availability of water data-sets and modelling techniques.

2. Introduction

Preamble

The Natural Environment Research Council (NERC) asked Z/Yen to produce a report to examine the environmental data requirements of the financial community to support investment decisions about water and why. This paper presents recommendations on how data could be provided by the Centre for Ecology and Hydrology (CEH) and the British Geological Survey (BGS), two of NERC's research facilities. Numerous datasets and models exist that are being deployed by environmental science to gauge fluctuations in global water supply and demand, but these have generally not yet been accessed by capital markets. This paper focuses on the capacity of CEH and BGS to deliver this material to the financial services industry, and suggests strategies to accelerate the convergence between scientific and financial interests.

NERC is one of the many public institutions pursuing and defining the sustainable use of natural resources. NERC's science assets, such as the Centre for Ecology and Hydrology (CEH) and the British Geological Survey (BGS) have been collecting data and monitoring changes in the environment over time and across the world for over a century. The majority of data collected thus far, however, has remained within the scientific domain. This project seeks to examine how to make it more accessible so that investment decisions can be made based on solid scientific models of likely future hydrological trends.

Measures to mitigate unsustainable use and engender long-term water management are gathering pace in the UK and beyond. After a concerted and growing effort by scientists, governmental institutions, Non-Governmental Organisations (NGOs) and the private sector, governments, companies and citizens are taking increasing account of growing water scarcity. As water features in almost every productive activity, there is a concomitant realisation that careful water management is essential to continued economic growth. Although collaborative events on water between NGOs and water-intensive industries are becoming more commonplace, this paper represents the first step in engaging NERC scientists directly with the financial services sector.

Water has generally been overlooked as an asset class or risk factor by wholesale financial markets. The links between environmental science and financial services are still tenuous, with the exception of the UK insurance market, which has actively been engaged in the development of flood prediction and risk models. As increasing demand from agriculture, industry and demographic growth places increasing stresses on finite freshwater resources, investors will become progressively dependent on water data and models to underpin investment decisions and hedging decisions. Water risks can only be addressed through the quantification of water. In short, there is a clear inability to match water demand with availability, partly because there is so much uncertainty surrounding the amount of water available and partly because society has carried on regardless of supplies available today, let alone those in the future.

Objective

This report was commissioned to explore how hydrological research, datasets and modelling could be exploited to provide relevant information to financial services with particular reference to water-related investments. This paper outlines the scope for NERC's active participation in creating an interface through which its scientific assets and capabilities could best be delivered to financial institutions. This project aims to deliver a series of recommendations which would allow potential data users to engage directly with NERC to develop a commercial package of scientific water information models, to agree on metrics, geographies and levels of resolution, and finally to work jointly to construct tailored information delivery systems to assist in the valuation, management and risk assessment of water-related assets.

Approach

This paper is being delivered by Z/Yen, with the Financial Services Knowledge Transfer Network as delivery partners on behalf of NERC. NERC's expectations of the outcomes of Finance & Water were as follows:

- to improve working processes between research centres and industry;
- to impact on industry;
- to influence government policy;
- to develop more joint research publications;
- to foster industry enquiries that NERC might fulfil.

A cross-section of the financial services industry was engaged in this project. The project began with a workshop attended by ten specialist financial services professionals and six members of the scientific research community in June 2010. Issues identified at this meeting were pursued through interviews with other members of the financial services community, including financial information service providers, water analysts, experts in the construction industry, water specialists at international development agencies, leading agencies in the field of water disclosure, commodity traders and investment managers. Initial findings were presented six weeks later at a symposium attended by fifty finance and science professionals, all framed around the central question: "Where's the Data?"

Acknowledgements

We would like to thank NERC, CEH and BGS for the opportunity to work together. We wish to thank everyone who participated in the workshop, symposium and interviews for their time, energy, experiences and thoughts. Please see Appendix A for the full list of participating organisations.

3. Critical Issues

Water Availability

Water is the central element in the world's energy, nutrient and carbon cycles. It is also one of the core dynamics in global weather patterns. Smooth interconnectivity between the four earth systems: lithosphere (land), hydrosphere (water), atmosphere (air) and biosphere (vegetation and wildlife) provides the optimum conditions for life to flourish. The disruption of any one mechanism can result in drastic alterations of global climatic conditions. The inter-action between the water cycle and the remainder of the ecosystem is circular, with water being the key element in the development of flora, fauna and weather patterns.

Global water balance is the key to precipitation patterns. As the volume of water on earth is finite, a balance must be maintained between flows of water to and from the lands, oceans and atmosphere. When water evaporates from oceans, lakes, rivers and other surface reservoirs it forms atmospheric humidity. When there is enough water vapour and it cools, the water vapour condenses and forms clouds, which in turn produce precipitation. The combination of precipitation, evaporation, condensation, run-off and infiltration shape the course of the water cycle.

The 'water rich': regions with high and relatively stable rainfall (more than 50cm per annum) throughout the year are capable of supporting (with the correct soil conditions) dense vegetation and hence high biodiversity as well as maintaining moist soil and the permanent flow of larger streams. Natural reservoirs recharge and replenish naturally (except for periods of drought) so the more varied needs of human life are met. These 'water rich' regions, generally located at mid-latitudes will support intensive agriculture with little need for irrigation. Natural vegetation and water-intensive crops, accustomed to high levels of soil moisture, are vulnerable to drought. Yunnan Province, in Southern China, typically a 'water rich' and fertile area, experienced a year-long drought with no rain between the summer of 2009 and a three-month late rainy season. In early 2010 the upper reaches of the Mekong River were said to be flowing at the lowest levels since the worst drought for 98 years in 1993, greatly affecting harvests and food supplies of at least 8.2 million people[2]

The 'water poor': arid and semi-arid regions experience average annual rainfall of 0cm to 50cm. These dry climates are only able to support seasonal surface water flows and reservoirs. Desertification, soil exhaustion and land degradation in Minqin County, Northern China has hit the headlines over the last few years. Higher temperatures and more erratic precipitation patterns, along with high withdrawal rates and diversions of the Yellow River, has prevented the recharge of aquifers and surface water reservoirs. Although variability in rainfall is typical of semi-arid regions, they have always been susceptible to drought. Climate change may make rainfall variation more unpredictable and severe, rendering it more difficult to estimate water levels and guarantee water supplies over even short-term horizons. Over longer time frames, the situation is equally uncertain. While some semi-arid areas might benefit temporarily from increasing flows of melt-water, others could be driven into soil erosion, salinisation, land degradation and desertification, leading to declining agricultural yields in tropical and sub-tropical regions[3].

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[2] http://www.chinadaily.com.cn/china/2010-03/29/content_9653274.htm
[3] Dow, Kirstin and Downing, Thomas E, *The Atlas of Climate Change*, Earthscan (2007)

The hydrologic cycle is essential for economic growth. Surface water in the form of rivers and lakes, along with groundwater and soil moisture, provide the vital input required for plants to grow, and animals and humans to survive. In order to increase agricultural yields and livestock populations to support population growth, mankind has been disrupting the water cycle for at least four millennia by building dams, flood levees and irrigation systems, and abstracting from both groundwater and aquifers. The pace of exploitation accelerated from the 18^{th} century on as a result of the Agricultural and Industrial Revolutions in Europe, which both increased demographic growth and created new water requirements. Over the last half century, globalisation has further increased the burden on water supplies by progressively breaking down Malthusian restraints on life and creating a whole host of industrial and agricultural requirements.

There are three ways to live beyond the natural 'water endowment' of a dry climate. Dry climates can only support marginal food and water supplies. Where mean annual precipitation is low, cities, industries and farmers have either been forced to use artificial means such as irrigation, or to run down the areas' natural 'water-endowment', in three ways:

1. Channelling or diverting water. This is demonstrated starkly in the current state of the Aral Sea, once an immense saline lake straddling Kazakhstan and Uzbekistan. The two rivers feeding the lake were 'cut off' in the 1950s when a mass-irrigation scheme was implemented to grow water-intensive cash crops such as cotton in the region's desert plain.

2. Groundwater abstraction. Where surface water is near exhausted or insufficient, drilling wells and powerful pumps draw water from below water tables; aquifers and other groundwater reservoirs. When groundwater abstraction exceeds recharge rates, the water table is depleted. As the purity of freshwater is easily spoiled, salt-water intrusion in coastal locations and high levels of contamination, render the water too polluted to use even for irrigation. Water in the aquifer below Mexico City was withdrawn to the extent that ground subsidence ranges from 4m to 7m, creating huge and costly engineering challenges.

3. Desalination. Israel and the 'oil-rich' yet 'water-poor' countries of the Middle East invest extensively in desalination projects; an energy-intensive, expensive and ecologically damaging method of producing potable water. Although these plants are being made to run much more efficiently, for example using reverse osmosis techniques, thus reducing costs of production, the waste water outflow is typically 5 – 10ºC warmer than ocean temperatures, releases high concentrations of salt brine and chemicals such as chlorine and anti-sealants, thus modifying the ecological balance of the surrounding coast[4]. The close proximity of many Saudi Arabian desalination plants to the coral reefs of the Red Sea[5] along with sewerage and industrial effluent discharge could contribute to the bleaching and degradation of this fragile ecosystem.

Water Supplies and Use

The natural 'water endowment' of a country is seldom reflected in water rates. Neo-classical economics teaches that as a resource becomes scarcer or the higher the demand, the

[4] http://www.unep.ch/regionalseas/main/persga/pilcher.html
[5] http://www.unep.org/regionalseas/programmes/nonunep/redsea/instruments/r_profile_persga.pdf

more expensive it gets. Due primarily to high levels of regulatory intervention and to common perceptions of access to abundant volumes of water for a low price as a natural right, water pricing does not yet follow normal commodity pricing models. The amount of water available is generally not factored into price, or, to a lesser extent, the allocation of water rights. Utility companies in Western Europe charge their customers the most for potable water, despite the fact that annual rainfall is more than sufficient to meet demand. In contrast, rates are twice as low in water-stressed Australia and four times lower in the drier regions of the USA[6]. Levels of regulation and price control vary, but there is a pronounced tendency for more developed economies to be more interventionist and less developed countries less interventionist. More than 250 major river basins cross national boundaries[7] and groundwater reservoirs are neither aligned with nor confined to national borders. The trans-boundary nature of freshwater supplies complicates allocation of water, as they originate from shared sources and are priced by different regulatory regimes.

Water is neither a commodity nor a pure public good. Water is not easily classified as either a public good or a commodity. Examples exist as a private good, for example through privatisation of water services. The bottled water industry shows it is not just a commodity. Water in advanced capitalist economies has increasingly been allocated through water rights and licenses, although these can differ significantly within some national boundaries (such as differences on a state-by-state basis in the USA). In many less mature economies, urban needs will be subject to some degree of regulation, but rural water distribution is usually driven simply by the ability to withdraw water. Although 80% of the world's fresh-water supplies are owned by public authorities[8], the composition of the water utility landscape is changing, with more countries turning to privatisation of their water utilities such as Chile, New Zealand and the UK.

Water as a human right may change the competition landscape. On 28 July 2010[9], the United Nations General Assembly declared access to potable water to be a human right. It is far too early to judge whether this declaration will strengthen the case for universal access to water, but any progress at all will require significant outside intervention in 'water poor' developing nations. Similarly, it is unlikely that there will be significant changes in regulatory regimes in developed countries, in which the huge majority of the population already has access to water services. All this notwithstanding, there is scope for a shift in the competitive dynamics of water supply. The most likely bone of contention is the ability of large private businesses in water-stressed areas to abstract vast quantities of water at the expense of poorer sections of society. One such example is seen in Goa, a densely populated semi-arid region of India, where water scarcity is pitting residents against golfing and hotel resorts[10].

The correlation between regulation and infrastructure is often weak. The water industry in most countries is either a government controlled monopoly or a regulated privatised oligopoly. In both cases, the priorities of governments or their regulators tend to be built around vote-driven policies of low prices and generous supply. The water utilities

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[6] http://www.circleofblue.org/waternews/2010/world/the-price-of-water-a-comparison-of-water-rates-usage-in-30-u-s-cities/
[7] http://www.transboundarywaters.orst.edu/publications/register/register_paper.html#table1
[8] Wild, Daniel et al. "Water Technologies and Infrastructure" in *Investment Opportunities for a Low Carbon World*, Oulton, Will (ed.) GMB Publishing (2009) page 136
[9] http://www.un.org/apps/news/story.asp?NewsID=35456&Cr=sanitation&Cr1
[10] http://www.tourismconcern.org.uk/index.php?page=water-abuse

themselves are either not expected to operate profitably, or allowed margins too thin to support extensive capital investment. This produces parodies in water-rich developed countries, in which a water company is effectively forced into inefficiency, accepting double-digit percentage leakage losses from antiquated distribution networks because it has neither the money nor the incentive to remedy them. The situation in the developing world is variable. Many cities in emerging economies, even economically advanced centres such as Mumbai, have incomplete and inadequate distribution and treatment facilities. Wealthier users often construct their own clandestine wells to complement insufficient or non-existent utility services. Most people in rural areas continue to rely on untreated surface or groundwater, often placing themselves at risk from multiple contaminants. In an attempt to improve services through market mechanisms, the World Trade Organisation (WTO) issued the General Agreement on Trade in Services (GATS)[11], prompting many developing countries to privatise their water utilities. The privatisation of Cochabamba's water supply to Bechtel hit the poorest social strata the most due to a rise of up to 60% in water bill price whilst the volume used remained static.[12]

Per capita water usage varies widely and according to income. The relative availability of freshwater tends to exert less influence on per capita consumption than relative wealth. Texas has one of the highest daily withdrawal rates in the USA, and yet is one of the most arid states[13]. On a more local scale, Las Vegas in Clark County, Nevada is the driest county in the driest state in the USA with an average annual rainfall of 11cm and the country's fastest-growing city. Water scarcity has long been a problem for Las Vegas, with a resident population of 2 million expected to climb to 3 million by 2020[14], plus an influx of almost 40 million tourists a year and a daily water consumption level of 870 litres per person[15]. Although the city has cut its water consumption by 15% per person[16] since water-saving measures were implemented in 2002, water levels in Lake Mead continue to decrease due to unsustainable withdrawal rates coupled with a long-term drought in the region[17]. Decision-makers and business leaders in Las Vegas and elsewhere in drought-stricken regions are beginning to act on the realisation that water will affect competitive positions and bottom-lines[18].

Water use is driven by demand rather than supply. 40% of the world's population does not have access to sanitation or potable water. It is not water supply, however, that actually drives consumption. The key variable is demand, which is broadly correlated to wealth. A stark correlation between average income and water use is seen within both 'developed' and 'developing' economies. One such example is Durham and Middlesbrough in the North-East of England where Northumbrian Water delivers an extra 2,555 litres to the city of Durham with 10,686 households serviced (where only 2% of the population claim state-benefits) compared to Middlesbrough (where 24% of the population claims state-benefits) with 30,322

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11 http://econ.worldbank.org/external/default/main?pagePK=64165259&piPK=64165421&theSitePK=469372&menuPK=64216926&entityID=000094946_01052404350414
12 Shiva, Vandana, *Water Wars,* South End Press (2002)
13 http://www.nrdc.org/globalWarming/watersustainability/
14 http://abcnews.go.com/Nightline/story?id=3012250&page=1
15 http://news.bbc.co.uk/1/hi/sci/tech/4719473.stm
16 http://www.reuters.com/article/idUSTRE52A04P20090311
17 http://www.lasvegassun.com/news/2008/jun/15/equation-no-water-no-growth/
18 http://www.reuters.com/article/idUSTRE52A1XA20090311?loomia_ow=t0:s0:a49:g43:r1:c1.000000:b30328958:z0

households serviced[19]. An example from the developing world is between Costa Rica where average daily water consumption per capita stands at 200 litres[20] (with an average annual income per capita of $7,000[21]) and consumption in Nicaraguan towns of 12 litres per day[22] (average annual income per capita of just over $1,200[23]).

The assessment of embedded water may offer a useful tool for monitoring water use. Early attempts at quantifying corporate water use revolved around 'water foot-printing'. This method was modelled on the 'carbon footprinting' methodologies developed in the past decade. Such 'foot-printing' remains difficult, dependent on wide assumptions that are difficult to test as they involve calculating the amount of embedded water along the entire supply-chain. There is a huge range in the amount of water required to produce various foodstuffs. It takes 15,500 litres of water to produce a kilo of beef, compared to 1,800 litres for a kilo of soya and only 141 litres for 1 kilo of potatoes. The growing of water-intensive crops in arid regions (such as wheat in Saudi Arabia, which requires 1,300 litres of water per kilo) is only possible through what the geographer Anthony Allan has called the 'virtual water trade'. The concept of 'virtual water' is extremely valuable in assessing the misallocation of water resources across the world. In Egypt, for example, cotton has a high embedded water content (11,000 litres per kilo of cotton textile), and production itself is only possible through an unsustainable mixture of groundwater extraction, and capital intensive irrigation.

Agriculture accounts for 70% of global water consumption. A recent report released by the United Nations Environment Programme (UNEP) warns that up to 25% of the world's food production may become lost due to environmental breakdown by 2050 if a 'business as usual' approach is taken.[24] In some areas, agricultural stress is already visible, for example, in Northern India farming can use up to 90% of local water supplies (compared to only 2% in the U.K.). Water abstraction from groundwater aquifers for irrigation is particularly vulnerable. Although groundwater is replenished through the percolation of surface water, abstraction often outstrips natural recharge rates by a considerable margin.

The service industries are using more water. Although they account for a smaller proportion of water use compared to extractive industries and manufacturing[25], service providers are expanding at a relatively higher rate in most economies. In the USA, water use by service-sector buildings (hospitals, hotels, restaurants, schools and offices) accounts for roughly 180 billion litres per day, or equivalent to 12% of total national consumption[26]. The four most water-intensive service sector activities (ranked by order of volume) are bathrooms, landscape watering, kitchens and heating, and ventilation and air conditioning.

In an increasingly water-stressed environment, allocation decisions are required between agricultural, industrial, domestic and other uses. Where rights are allocated formally or informally, the needs of industry and agribusiness are often prioritised over the

[19] Data courtesy of Northumbrian Water (August 2010)
[20] http://www.ticotimes.net/dailyarchive/2009_09/0924092.cfm
[21] http://data.un.org/CountryProfile.aspx?crName=Costa%20Rica
[22] http://www.envio.org.ni/articulo/3558
[23] http://data.un.org/CountryProfile.aspx?crName=Nicaragua
[24] http://www.grida.no/publications/rr/food-crisis/
[25] Waughray, Dominic, and Lee, Sylvia, *The Bubble is Close to Bursting: A Forecast of the Main Economic and Geopolitical Water Issues Likely to Arise in the World during the Next Two Decades,* World Economic Forum Water Initiative (January 2009)
[26] http://www.buildinggreen.com/auth/article.cfm/2008/2/3/Water-Doing-More-With-Less/

needs of poor households. This renders lower income users and downstream ecology subject to volatile water access. Growing populations, affluence and consumptive lifestyles will add to existing stresses. There have already been a few high-profile conflicts for access to reservoirs. Coca-Cola's law-suit over a major operating license in Kerala, Southern India serves as an example of how competition for groundwater can lead to the threat of licenses being revoked. The scramble for natural resources such as water, however, has not been confined to poor regions. In the agricultural plains of Colorado, where surface and groundwater supplies are scarce, land and property is priced and sold on the basis of access to surface water. We are still only in the early stages of overt competition for water supplies. Coherent and enforceable allocation strategies remain the exception rather the rule.

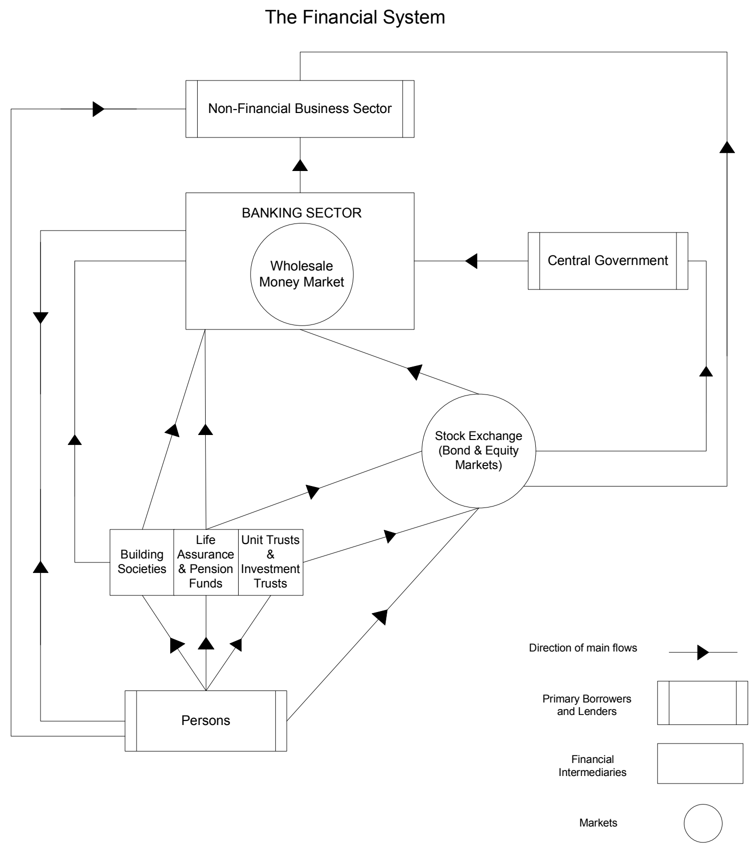
Finance and Risk

Financial awareness of water-related risks is beginning to pick up. The last two years have seen the publication of influential reports, for example, *Watching Water*[27] and *Murky Waters? Corporate Reporting on Water Risk*[28]. The reports themselves are evidence of a growing awareness of the risks and uncertainties inherent in increasing freshwater scarcity. Emerging water initiatives aiming to raise awareness in financial services, such as the Capital MS&L and africapractice roundtable (October 2008) and the collaboration between Lloyd's 360º Risk Insight and WWF (2010) are driven by third sector and private sector organisations. Initiatives involving not-for-profits or corporate social responsibility (CSR) teams, such as CDP Water Disclosure and Water Foot-printing Network address the use of water supplies on a company level, but do not currently address supplies on a basin level.

Unlike most other natural resources, there are very few ways of investing directly in water. Water, unlike coffee, carbon and coal is not in an asset class of its own. While water can be purchased, it is not a tradable commodity, and exposure can only be gained indirectly through water indices or water funds: and directly through equity investment in companies supplying, treating, analysing, managing water or providing related technology. With water having been dubbed "blue gold" by voices within financial services[29], there is considerable scope for the development of new financial instruments, both for investment and for risk management. Investment, however, is still generally limited to privatised water utility companies, water funds financing water utilities and water technologies, and some early water indices.

[27] Levinson, Marc, *Watching Water*, JP Morgan (April 2008)
[28] Barton, Brooke, *Murky Waters? Corporate Reporting on Water Risk*, Ceres (February 2010)
[29] http://www.investorschronicle.co.uk/InvestmentGuides/Funds/article/20100726/6a3182e0-989b-11df-8354-00144f2af8e8/Investing-in-blue-gold.jsp

Figure 1 The Financial System in Outline



Source: Adapted from *How the City of London Works*, William M. Clarke, (2008) 7th Edition

Several water indices already exist. The last decade has seen the launch of a number of quoted indices, including the Palisades global Water Index, the Janney global Water Index, Standard & Poor's global Water Index, and the HSBC Optimised global Water Index. These indices are conventional vehicles composed of varied weightings of quoted companies involved in water and water-related businesses. The most common basket is a combination of water utilities and companies engaged in water infrastructure and technology development.

Water funds have proliferated since the turn of the millennium. The first water fund was launched by Pictet & Cie. in 2000 and there are now more than 100 water funds listed around the world[30]. In addition, many SRI funds, such as Jupiter Asset Management's "Ecology Fund" and F&C's "Stewardship Investment Fund", include water management companies in their portfolio. The selection criteria for water funds are gradually becoming more demanding. Pictet Asset Management have two water funds: the older one holds companies with at least 20% exposure to water either in revenue or profits; while the Pictet Water Opportunities Fund launched in 2010 holds only companies with at least an 80% exposure to water.

[30] http://www.guardian.co.uk/business/2010/aug/08/water-funds-investors-booming-growth

Individual projects are attracting increasing attention from direct investors. Direct investment in water falls into two distinct categories: general portfolio investment, normally in large water utilities and infrastructure providers; and higher risk Private Equity or Venture Capital investment in companies developing water-related technologies. Investment in water itself is not impossible – indeed that is exactly what the acquisition of water rights is – but, generally speaking, the risks surrounding the rights themselves, the control of flows originating elsewhere, and the difficulty of pricing water itself have precluded significant activity. Thus, Social Venture Capital Funds (also known as Social Enterprises), such as Ennovent and Vox Capital, that finance businesses offering sustainable solutions to low-income households, including water purification and wastewater treatment, should be attractive to the bulk of risk capital.

Water investment remains be-devilled by the water pricing issues, and asymmetric regional supply and demand. Water prices are generally set well below cost levels by regulated public and private water utilities. The result is that water utilities do not have the means or the incentive to invest in greater efficiency, and thus are forced to accept very high leakage rates from aged infrastructure. Furthermore, allocation of water to users is often skewed. Where water rights are not underpinned by law or government intervention, mass agriculture, industry and services are often privileged at the expense of households and the wider ecosystem.

Water is subject to the same general risks as other investments, but potential water risks are difficult to quantify. As John Adams made clear, risk itself is often shaped by human perception[31], and hence does not lend itself to consistency across any asset class. This is particularly true of water. Investors financing agriculture in Colorado and energy generation in California may ascribe a higher cost to drought risk than investors located in London financing the same activities in drought-prone areas purely because the former are more familiar with the consequences of supply shortfall. Environmental change, whether anthropogenic or natural, can pose a huge risk to investment, associated supply chains and all dependent revenue streams. The nub of the problem is that risk management is based on prediction, and climate change is disrupting existing predictive models. With the ability of risk analysts to predict the likelihood and severity of weather events disrupted, the need for improved hydrological data and models can only become more acute. Financial risk modelling, in short, will need to be integrated with its scientific equivalent.

- Credit
- Material
- Operational
- Profit
- Regulatory
- Reputation

Financial awareness of water issues is only beginning to crystallize. Although hydrologists have been observing the world's water cycle for decades and environmental literature such as *Limits to Growth*[32] and *Small is Beautiful*[33] has highlighted water scarcity under business as usual scenarios, the growing problems with the global water supply are

[31] Adams, John, *Risk,* UCL Press (1995)
[32] Meadows, Donella H el al., *The Limits to Growth*, Universe Books (1972)
[33] Schumacher, EF, *Small is Beautiful*, Abacus (1974)

relative newcomers on the radar of most financial institutions. As a result, there are currently very few dedicated water analysis functions in the sector. Consequently, there is little capacity in place to assess the problems that water will pose both as a barrier to economic growth and as a risk to existing investments.

Water will become a mainstream investment and risk issue on a two to four year time horizon. Water is a new subject for most financial professionals. Hitherto it has been dealt with as a separate 'green' issue pertaining only to sustainable-responsible investment (SRI) or corporate social responsibility (CSR). Mainstream investors, such as large pension funds, have yet to factor water risks into their investment decisions. Such institutions do have the capacity to respond quickly to the developing water shortage issue. Action, however, will require combining SRI, investment valuation, predictive modelling and risk analysis in an integrated fashion.

Water data suffers from short time runs and patchy coverage. The quality of water data available to the financial sector professionals is generally good in terms of both time series and coverage for Europe and North America. Data for Brazil, the Middle East and the more developed regions of India provides at least a reasonable basis for decision making. In China, almost all of Africa, the bulk of South and Central America, and Southeast Asia, coverage is poor to non-existent, and investment depends either on project-specific due diligence or scientific modelling. There is an additional problem that water shortages themselves are the product not just of abstraction rates, but also of unpredictable weather patterns and poorly understood aquifer replenishment rates. Investment, even on a short time horizon is fraught with risk.

Water stress is already an issue for a multitude of goods and service providers. As discussed earlier in the paper, water is embedded in practically all goods and services. Although investments in agricultural produce are the most exposed, almost all investments are exposed to some degree through supply-chains. Those requiring larger volumes, such as hospitals, and producers of semi-conductors and textiles, are at most risk. Nestlé's Arrowhead brand of bottled spring water has recently been the subject of widespread criticism as a result of the Arkansas[34] River running dry at its mouth due to over-abstraction. Although Nestlé has rejected claims that the Arrowhead brand will be abstracting unsustainable volumes of water, and the Nestle Waters' North America website claims that data is monitored on a daily and monthly basis under its "Water Monitoring Programmes"[35], this data is not made available to the public.

Agribusinesses are already feeling the effects of water scarcity and competition. Floral Management magazine reported in its August 2010 issue that 43% of the US state of Georgia's greenhouse growers have closed due to the impact of a four-year drought on water supplies in this typically wet state. One of the main concerns of hydrologists has been the rising demand for water-intensive bio-fuels over the last decade. This has led to the conversion of cultivated land and diversion of water resources to grow sugar cane and corn. This in turn has affected the production of other food, fibre and feed crops. For labour-intensive agriculture, the cost and availability of labour has been a primary factor dictating

[34] http://coloradoindependent.com/58242/nestle-ok%E2%80%99d-to-turn-arkansas-river-springs-into-bottled-water-product
[35] http://www.nestle-watersna.com/Menu/Environmental/WaterResources/Sustainability/Water+Monitoring+Programs.htm

where production occurs. It is thus often the case that crops are still grown in places where natural water supplies are low but labour is inexpensive. Water intensive and labour intensive crops such as asparagus are grown in the arid coastal valleys of Peru, which requires year-round irrigation[36] in a region ranking highly on water stress indices[37]. As water scarcity becomes more of an issue for producers, it should become a primary cost and location driver. There are also a host of ways to employ more efficient irrigation techniques and technologies, but all significant changes will involve not simply corporate action, but political acquiescence, which might be difficult to obtain in areas where current agricultural practices are tightly interwoven into socio-economic structures. For an in-depth review of agriculture and water see *Watering Scarcity*[38].

Managing Sustainability

Escalating competition for finite natural resources will lead to financial sustainability converging with environmental sustainability. If a water-intensive operation is carried out in a water-stressed or water-scarce area, as is the case in central Argentina where soya is grown on a mass-scale for export, that revenue stream is exposed because one of the essential inputs, water, is under increasing stress. In a similar way to unsustainable soya-farming on cleared rainforest land, where the soil types become depleted of nutrients within a few years of deforestation, the effects of unsustainable water use may take some years to feed through to profit margins, thus affecting competitive positions. In the words of Kim Jeffery, CEO of Nestlé Waters North America stated on Bloomberg Businessweek, in reference to the 14,000 acres his company owns and the 100 springs it abstracts from; "The way we stay in business is by taking care of those natural resources…"[39]

Sustainable water management initiatives are rare at both corporate and legislative levels. Corporate and political action lags far behind comparable environmental policies on greenhouse gases. Despite companies with water-intensive operations such as PepsiCo, Inc. (food and beverages) and InterfaceFLOR (carpets) taking action to reduce their ecological footprints, these are the exceptions among the 80,000+ parent Multinationals with some exposure to water[40]. The result is that in many places, humans appropriate 60% to 90% of natural productivity[41], leaving insufficient natural resources for the other species on this planet.

It is possible to invest in water supplies without that supply being sustainable. Although environmental benchmarks such as the Business and Biodiversity Offsets Program (BBOP), Extractive Industries Transparency Initiative (EITI) and Initiative for Responsible Investment (IRI) are evidence of growing concern of industries' impact on and relationship with the ecosystem, there is no standardised sustainability check for water supplies. This simple fact renders the quest for sustainable management highly problematic. Given that the majority of water funds do not attempt to measure the sustainability of their portfolio, the funds are not following the imperfect metrics of 'green' or 'ethical' funds and therefore stakeholders have no way of knowing whether the water has been sourced sustainably. Shareholder pressure can

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[36] http://www.progressio.org.uk/sites/default/files/Drop-by-drop_Progressio_Sept-2010.pdf
[37] http://www.iwmi.cgiar.org/assessment/FILES/pdf/publications/ResearchReports/CARR2.pdf
[38] Klop, Piet and Vos, Peter, *Watering Scarcity*, World Resources Institute and Rabobank (2008)
[39] http://feedroom.businessweek.com/index.jsp?fr_story=91d368815839e7ad01f747723c5a3ced4b5ef753
[40] Figure taken from the *World Investment Report - Investing in a Low Carbon Economy*, United Nations Conference on Trade and Development (report issued July 2010)
[41] Hoffman, Steve, *Planet Water*, John Wiley & Sons, Inc. (2009) page 26

exert considerable influence in directing a company's environmental credentials, as is being seen with the post-Deepwater Horizon disaster[42]. As discussed earlier in the paper, countries or regions with limited freshwater supplies have adopted artificial means of enhancement, the most common being desalination. Water-intensive activities such as hydroponic agriculture can continue regardless of freshwater availability.

The potential for efficiency gains, through technology advances, behavioural and regulatory changes is significant. At the most basic level, water metering of all consumers, whether domestic or institutional, offers a cheap and effective means of curbing excessive consumption. Other technologies range from basic and inexpensive systems such as the simple cistern 'Hippo' water-saver, to advanced root-feed irrigation methods based on soil moisture sensors. More small-scale farmers are moving towards older and more traditional agricultural methods, with a positive knock-on effect on water supplies. *The Economist*[43] has reported that farmers in Northern India with co-operative smallholdings are reducing dependence on fertilisers and pesticides in favour of biological boosters and controls. Farmers using 'organic' methods emphasise growing certain species of flower that attracts pollinators or leaving shrubs and trees to attract locust-eating birds. Most of the innovations introduced through the 19th and 20th centuries were not only water-intensive but also often polluting, sometimes resulting in eutrophication of surface water or the lethal contamination of groundwater. Unfortunately, non-existent or short-sighted regulation continues to hinder the efficient and sustainable use of water, even in the most advanced nations. Water rights in Colorado, assigned a century ago, act as a disincentive to use water efficiently, because they can be reallocated if farmers do not use all their allowance. The result is that it is commonplace to see irrigation undertaken at the hottest time of the day when evapo-transpiration is highest. In addition, the price of water is so low that there is little incentive to become more efficient.

Disclosure initiatives are beginning to influence commercial awareness and transparency. The Asia Water Project: China (AWPC) and the Carbon Disclosure Project Water Disclosure (CDPWD) were launched in 2010 and 2009 respectively. AWPC's main interface is through its website where manufacturing and extractive companies operating in China can keep abreast of issues such as water quality, and changes in the regulatory environment. AWPC is intending to set up websites devoted to other Asian countries with similar regulatory and environmental challenges. CDPWD is in the first year of data collection on water use by the 300 of the global 500 companies with the most water-intensive operations. Disclosure of this sort may be an important step, but it alone will not solve water stress issues.

[42] http://www.marketwatch.com/story/green-shareholder-pressure-seen-on-the-rise-2010-08-08
[43] Grimond, John, "A special report on water: For want of a drink", *The Economist* (May 2010)

4. ANALYSIS

Data Considerations and Constraints

Hydrology is the measurement and modelling of water flows and their impact on landforms both above and below the earth's surface. Water metrics embrace volume, flows, load, speed, depth, and contamination. A simple example would be the use of rainfall-runoff modelling to calculate fluctuations in river flow speeds and volumes. Assessing levels of contamination is one of the few areas of hydrology where globally consistent indicators do not yet exist[44]. Although the quality of water data varies widely across various geographies, the metrics for hydrological processes and fluvial flows are generally agreed. Furthermore, satellite technology advances make it possible to use remote sensing to verify and measure both surface water and groundwater reservoirs, hence driving increasingly rapid progress in measuring and verifying both surface water flows and groundwater reservoirs.

CEH has a comprehensive suite of water research tools. The water programme focuses on three research streams: variability and change in water systems, eco-hydrological processes, and water management science. Inputs derived from remote sensing, global and regional time series and datasets are used for modelling and mapping. The CEH water programme captures, collects and holds data on the entire water cycle, including river flows, soil moisture, precipitation and contaminants. CEH can model water scenarios from now up to 2100 for any given location, forecast water supplies in space and time, be they held in groundwater or surface water reservoirs, and assess water quality. The Water and Global Change[45] (WATCH) project is designed to forecast future global water cycles and the state of related water resources and vulnerabilities, taking into account wider socio-economic developments. For any given project, CEH produces 'ready-to-reference' maps and wall-charts detailing the results of datasets and models used.

CEH and BGS also have access to data gathered by other scientific institutions on all five continents. Over 600 water-related projects are being funded by NERC for 2010 alone. One example is TWINLATIN, which uses the Global Water Availability Assessment (GWAVA) model to calculate changes in water availability in South America, incorporating abstractions for domestic, agricultural and industrial supply[46]. Joint programmes such as XEROCHORE (an Exercise to Assess Research Needs and Policy Choices in Areas of Drought) pools expertise from across Europe to forecast the probable range of hydrological events and the impact of extreme events such as flash flooding[47]. By incorporating meteorological, geological, ecological, biogeochemical and oceanographic datasets (amongst others), it has proved increasingly possible to monitor and model inter-connected water-related processes.

CEH licenses data to a number of organisations, in both the private and public sectors. Experian and Equifax – two global information services providers have obtained licenses from CEH to use its data to underpin the development of scientific data products. Environmental and engineering consultancies such as Entec also use licensed CEH data for analytical purposes. Public-sector bodies, including the Department for International

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[44] http://archive.wri.org/page.cfm?id=198&z
[45] http://www.eu-watch.org/nl/25222764-Info_for_Policy_Makers.html
[46] http://nora.nerc.ac.uk/9420/1/FINAL_WP2_D2.1_D2.2.pdf
[47] http://www.feem-project.net/xerochore/

Development (DFID), the Department for Energy and Climate Change (DECC), the Department for the Environment and Rural Affairs (DEFRA), the Department for Transport (DFT), and the European Commission (EC) have all utilised CEH water data. Some of the most pressing research currently in hand involves CEH and the EC working together on ecosystem services and tipping points.

Extreme environmental events are becoming more frequent and less predictable. Hydrologic uncertainty, triggered by climate change, is raising the probability of catastrophic losses in water-related industries. Consequently, CEH and BGS have engaged in an increasing number of collaborative ventures with corporate entities to improve risk assessment. Much of this work is based on a long-term relationship with the UK insurance industry working on flood patterns. With the frequency of severe floods increasing, CEH has been able to provide the industry with dynamic forecasting models which have allowed it to broaden its suite of water-related insurance products, and to price them according to location. Some of CEH's closest partners have gained market advantage through their ability to offer more refined and finely priced products. Such success should serve as a model for other segments of the financial services industry as they seek to improve their interface with the scientific community.

CEH performs water footprinting and ecosystem services calculations. As water scarcity has begun to their operations, a growing number of large companies are approaching CEH to work on water foot-printing exercises to measure their overall usage. Ecosystem services (best defined as those resources such as coral reefs or freshwater aquifers, which have both an ecological value and a human benefit) are covered by CEH's biodiversity and biogeochemistry programmes within which they "undertake scenario testing to estimate risk to ecosystem services of changes in landscape structure."[48] *The Economics of Ecosystems and Biodiversity* (TEEB) study for business report was launched at the first global Business of Biodiversity (GBOB) symposium on 13 July 2010. CEH's role is to calculate the real environmental 'cost' of what these 'services' appear to provide for free. The corporate sector is only just beginning to understand the significance of this work, which has to date largely concerned only scientists and environmental pressure groups.

Internet-accessible water data remains thin. Technological advances such as remote sensing and GIS (Geographical Information Systems) coupled with broadband internet have revolutionised scientific and societal understanding of the planet. NERC's own water-relevant datasets can be accessed online through four portals: the Environmental Data Portal (EDP)[49], the Information Gateway (IG)[50], One Geology (OG)[51] and the NERC Open Research Archive (NORA)[52]. NORA provides the most comprehensive holding of hydrological data, and covers areas outside the UK. Beyond NERC, there are a multitude of other sources, including Landsat data (provided by USGS in conjunction with NASA), Google Earth, the Rivers in Crisis programme (a collaboration between four American, one Swiss, one Hong Kongese and three Australian academic and research institutions)[53], the International Water Management Institute (a research centre supported by public and private

[48] http://www.ceh.ac.uk/sci_programmes/BioDiversity/BiodiversityObjectiveBD-3.3.html
[49] http://www.edp.nerc.ac.uk/dppp/pages/home.jsp
[50] https://gateway.ceh.ac.uk/
[51] http://www.onegeology.org/
[52] http://nora.nerc.ac.uk/
[53] http://www.riverthreat.net/index.html

institutions world-wide)[54] and recently released FAO (Food and Agriculture Organisation of the United Nations) agricultural, water and related data[55]. In most cases, these products provide little more than verification of where a river or lake is located, and proxy data, the quality of which declines with distance from economic and urban centres. Cisco has recently issued an international call for data for its *Planetary Skin*[56] project, the pilot of which is to record forest cover, with a *Water Skin* planned for the future. Outside scientific circles, we are a long way removed from a comprehensive picture of global water resources.

Potential Data Needs

The investment community has yet to define its data needs. Given the fact that financial sector awareness of the key issues surrounding water exposure is low, it is scarcely surprising that the sector is only beginning to develop its water parameters and metrics. Steps forward are most likely to take the form of individual joint projects with scientific institutions to meet investment or financial instrument-specific needs. Although wide-ranging qualitative tools are being developed, for example by the United Nations Environmental Programme Finance Initiative[57] (UNEPFI), there is already a general recognition that a quantitative assessment of water risks and returns will require detailed hydrological data. There is a wealth of such data, but the financial services community is as yet largely unaware of its existence, location or usefulness. The potential areas of interest can be broken down under ten broad headings as illustrated in Table 1 below.

Table 1 Summary of data needs per sector

WATER DATA	Agriculture	Hydropower	Industry & Energy	Insurance Sector
Precipitation	✓	✓		
Water rights	✓	✓	✓	✓
Flow rates	✓	✓		
Flooding	✓	✓	✓	✓
Surface water volumes and abstraction	✓		✓	✓
Groundwater volumes and abstraction	✓		✓	✓
Desalination	✓	✓		
Quality	✓		✓	✓
Evapo-transpiration rates	✓	✓		✓
Effluent discharge	✓		✓	✓

One possible structure for understanding the data requirements of the financial services is set out below. In the same way that for any significant asset, an auditor expects seven typical

[54] http://www.iwmi.cgiar.org/index.aspx
[55] http://www.fao.org/corp/statistics/en/
[56] http://www.planetaryskin.org/
[57] http://www.unepfi.org/publications/water/index.html

pieces of evidence, COD-VERB can be used to help determine the value of a water-intensive or water-related asset.[58]

- **accurate understanding of the Cost of the asset:** How much has it cost to acquire? How much does it cost to maintain? What are the indirect costs?
- **confirmation of Ownership of the asset:** Is there a clear legal title? Is it clear what is covered by that title?
- **some Disclosure of the importance of the asset:** Is there a published disclosure of the asset's utility? Is it based on robust foundations?
- **ability to confirm the Value of the asset:** Is there a defensible valuation methodology? Are the scientific metrics aligned with their financial equivalents?
- **evidence of the Existence of the asset:** Is there an accurate audit of the asset's existence, location, and particulars? Are control procedures in place to deal with any changes in the asset's composition?
- **clear lines of Responsibility for the asset:** Is the management system for the asset clear-cut? Are lines of accountability clear?
- **measurable Benefit from the asset:** How are the benefits of the asset measured? How can it be exploited to increase competitive advantage or shareholder value?

The table below gives an idea of how data would help underpin investment decisions exposed to water risk. Given the difficulties presented as water is not a traded asset or commodity, and has no proxy value, the following datasets are an approximation:

Table 2 Data requirements for a water-intensive or water-related asset

MARKETS	**Investors**	**Traders**	**Guarantors**
Cost	cost price of water per litre for each country; reservoir longevity under a variety of scenarios	cost price of water per litre for each country measured against water rates paid; reservoir longevity under a variety of scenarios	cost price of water per litre for each country; reservoir longevity under a variety of scenarios
Ownership	information detailing water rights and changes in legislation	information detailing water rights and changes in legislation	information detailing water rights and changes in legislation
Disclosure	transparency on importance of water to investments	transparency on utilities and companies underpinning indices and featuring in portfolio	client transparency on water exposure and relevant water data to verify this information
Valuation	changes in water supply and effect on output and returns	changes in water supply and effect on output and returns	changes in water supply and effect on output and returns
Existence	surface water volumes; groundwater volumes – data to cross-check	surface water volumes; groundwater volumes – data to cross-check	surface water volumes; groundwater volumes – data to cross-check
Responsibility	'real-time' monitoring of reservoirs	'real-time' monitoring of reservoirs	'real-time' monitoring of reservoirs
Benefit	long-term supplies of water available under a variety of abstraction scenarios	comparative analysis of water scarcity for each utility	comparative risk assessments

[58] Harris, Ian and Mainelli, Michael, "All Important Information", *Charity Finance*, (April 2002) pages 26-27.

The data requirements of investors, guarantors and traders overlap. Traders are those buying and selling indices and portfolio shares. Guarantors are those insuring or re-insuring any project or company. Investors fund project finance on behalf of institutional investors such as wholesale banks. In general, all three user groups will need hydrological data to verify physical existence and regulatory compliance. As risk is the main dynamic through which the three connect, the primary concerns revolve around risk assessment and legality. While there will be a general requirement for transparency on pure information issues, each party's needs will be specific to geographical location, industry and time horizon. Their needs are specific to the investments they are making, and will be provided by a combination of the traded markets and the guarantors, and by the investor's own due diligence and management procedures. They will thus make variable demands on scientific data providers.

Water risks cannot be isolated within a specific country or region. The data required by each investor or risk manager will depend on the geographical reach of the water-related assets involved. Their requirements are likely to be complicated by two factors: the mobility of water itself, and the fact that water sources frequently cross multiple national or jurisdictional borders. These complications apply as much to risk assessment as to asset ownership. Unexpected water stress can arise because of weather changes in an area distanced from the manager's asset portfolio. It is thus inevitable that the demand for robust hydrological data will mushroom beyond original investment areas. Indeed, large portfolio investors, like large corporates, are probably already in a position where they will need at least basic information and forecasts for the greater part of the world.

The financial services industry will access most information via third parties. "Value-adding resellers" such as field experts, consultants and commercial information providers are currently the most widely used sources for environmental data. Much of the data available to these providers, however, is insufficient both in terms of coverage and quality. Datasets for countries such as India are generally incomplete and may not span a period longer than the previous five years. One commercial information provider is already supplying environmental, social and governance (ESG) information as part of its standard data package, and although the current users are mostly in SRI roles, the firm already foresees the need to carry water data within this package to meet wider investment demand. The corporates and utilities whose shares make up the bulk of water funds do gather data for their own purposes, but at present there is limited disclosure, largely because of limited demand. As environmental and financial sustainability converge, and as water-related risks become more apparent, posting such information will become an accepted requirement. The process can be accelerated by approaching scientific institutions directly for their own hydrological data.

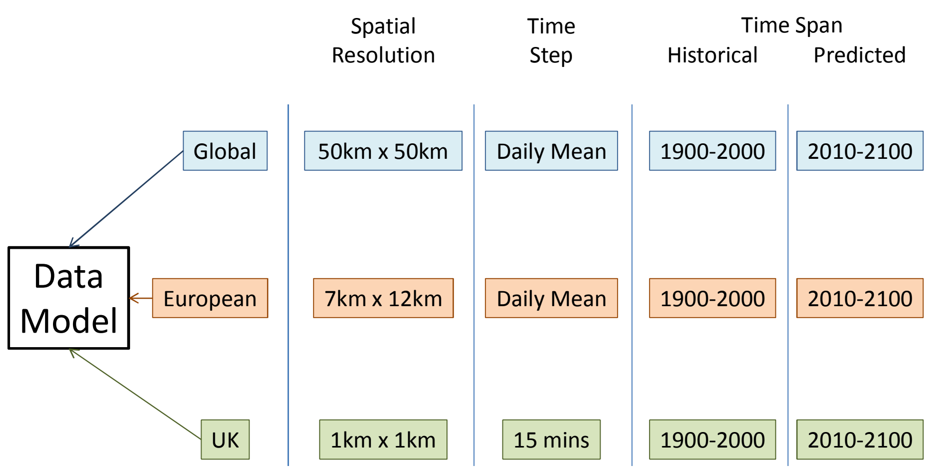
NERC has yet to develop a public profile with the majority of the financial services community. Science and finance have long been inter-related disciplines. Until recently, however, the relationship revolved around tradable agricultural and mineral commodities with market and supply-driven values. The development of the carbon market was something of a step-change, and any extension into the field of water will require a change of similar magnitude. The first step, as has already been stressed, is to make investors aware of the availability and importance of hydrological data. As touched upon earlier in the paper, NERC already has in place a number of web gateways. Recent additions to the website such as the Information Gateway are an important step towards improving accessibility. CEH and BGS could, however, accelerate knowledge transfer and awareness of water sustainability issues by improving the packaging and transmission of their data. Website visitors need to be immediately made aware of the fact that CEH and BGS hold datasets which are continuously expanding, whether measuring groundwater levels in Nevada, river hydraulics in the Yangtze, or flooding around the Ganges.

A collaborative effort with existing projects aiming to achieve a 'water snapshot' could pay strong dividends. Several pan-national initiatives such as the UNESCO World Water Assessment Programme (WWAP)[59] are already contributing to a global picture of water resources. By joining the network of scientific institutions corroborating with NASA/Cisco/Google on 'open source' initiatives, NERC would raise its profile and maximise the utility of its data, without stretching a tightening budget. Making consistent and comparable global data-sets both accessible and meaningful to those outside of the scientific research community would dramatically improve the use of environmental data for financial investment and risk management purposes.

A Global Water Snapshot

Another, admittedly more costly option would be to develop a more sophisticated 'snapshot' of the global water picture.

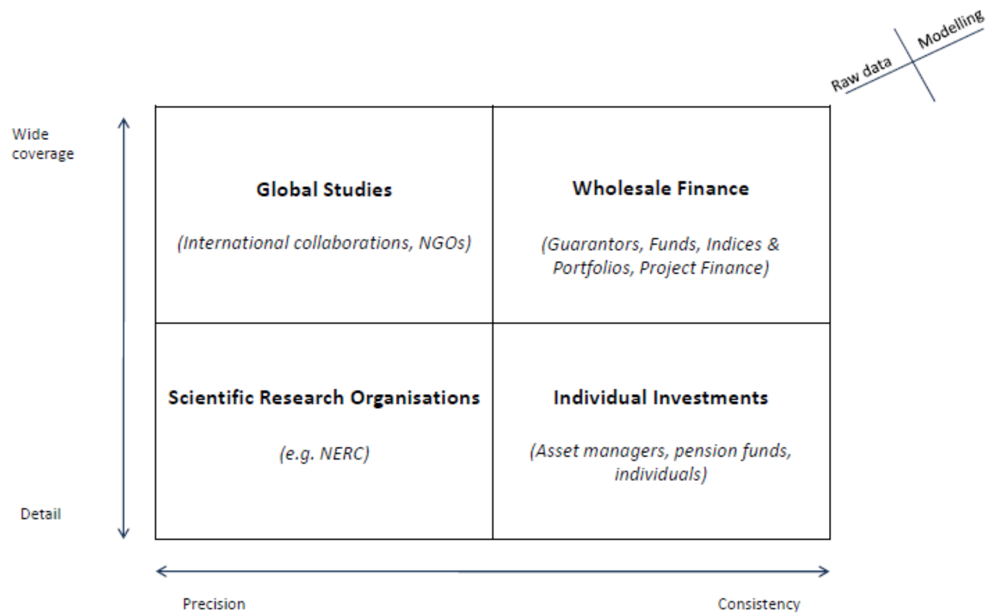
Figure 2 Data Model Dimensions (source: Neil Runnalls, CEH)



The quality of hydrological data currently available from various public and private organisations varies at a regional, national and global level. Figure 2 above encapsulates NERC's modelling capabilities. Luckily, most hydrological metrics are already well-established, but work needs to be done by earth observation scientists and hydrologists to work towards a single, standardised model designed to facilitate investment decisions. Inputs from the financial services community itself will be vital to success. We recommend that financial services professionals and NERC scientists should collaborate to produce robust hybrid metrics to allow informed participation in the financial response to water shortages. As demonstrated by Figure 3 overleaf, coverage and precision requirements will vary depending on the nature of the investment. While an individual investment will require extremely precise metrics, for example, the basic need of the financial community at large is for consistency to allow comparative valuation, trading, and appropriate levels of risk hedging.

[59] http://www.bbc.co.uk/news/science-environment-11435522

Figure 3 'Global Water Snapshot' Matrix



5. CONCLUSIONS

There is a wide gap between the scientific and financial communities, in terms of both awareness of the severity of the water scarcity issue, and understanding of data and predictive model requirements. While individual water-dependent corporates are addressing water stress problems, financial services awareness of the issues involved can best be described as latent. We expect, however that this situation will change quickly and estimate that the time horizon over which financial services will become dependent on hydrological data and forecasts could be as short as two to four years. Water is a finite resource, and water-related risks are mounting under the accumulating pressures of economic and demographic growth. Many existing investments are at risk of being degraded or even undermined by water stresses.

Critical Issues

1. While water is a global resource, its uneven distribution makes supply and demand dynamics regional or even local challenges. While some countries are all but immune from water stress in anything but the most climate scenarios, others are already in crisis, with others rapidly approaching the same point of inflection. Predicting future water shortages has also become more difficult as a result of the, as yet poorly understood, effects of climate change on weather patterns.

2. Data on existing water resources and their depletion, together with rigorous predictive tools will be a critical requirement for the financial services industry. A collection of scientific information and tools will be required to meet two mainstream requirements: the assessment and preservation of investment value; and the construction of the appropriate risk

protection and hedging instruments to cover the inherently non-predictable future course of the supply/demand equation.

3. Given its current low state of awareness, the financial services community will first need to be stimulated into a state of *knowledge*, that water is finite and potentially a very serious issue, and then into *action* to remedy its severe information deficit. The competitive advantages fashioned from hedging water risks should be emphasised.

4. The increasing rate of supply depletion will produce a growing demand for stress-indicator maps on a local and regional scale to support credit analysis and portfolio allocation. As NERC and other institutions are already producing a host of maps projecting water scarcity on a continental and global scale, it may be that online sign-posting for easy reference could be a significant step towards satiating users' needs.

5. Taking data-provision further, e.g. a 'Global Water Snapshot', would require more work, but could become commercially viable if partnerships are sought with major financial institutions. As individual institutions will be operating on different geographical horizons – ranging from the continental all the way down to a single site measured in hundreds of square hectares, information provision and model design will need to be multi-functional, particularly with regard to resolution and time horizon.

6. The current profile of both NERC as an institution and the scientific data it produces is extremely low in the financial services sector. Few of those attending seminars or interviewed separately were aware of the organization's mission, capabilities and existing products. NERC's low profile is as much a product of the financial services communities' limited awareness of the immediacy of the issues involved as it is a symptom of the early stages of NERC outreach programmes.

7. To most market participants outside of the insurance industry, environmental data (other than that closely related to the carbon market) is still in the domain of sustainable responsible investment (SRI), and, as such, does not influence mainstream investment and risk management activities.

8. The level of response generated by the work programme, as demonstrated by high attendance at the workshop and symposium as well as an enthusiastic response to interviews does indicate a significant level of latent interest. This could solidify into real demand for data as the stress on natural resources moves investor focus from SRI to economic and financial sustainability. Water data and predictive tools could, in short, become essential.

9. Past experience with the insurance industry suggests that exposure to data will increase appetite for more data, and will stimulate both analytical innovation from within the financial services sector, and the willingness to invest in data and model generation.

Recommendations

1. NERC can accelerate the demand for data by adopting a more pro-active approach to raising awareness of both the availability of its data and its willingness to collaborate in joint ventures to develop specific applications. Specifically, NERC should enhance the visibility and accessibility of its scientific products through multi-media channels (websites being a

key interface with potential data-seekers), begin to develop its own 'subscriber' lists, and establish an on-going presence in the City through a series of workshops.

2. To foment dialogue, and thus tease-out the detail for data requirements, an interactive and showcase-style workshop-based approach should itself stimulate opportunities to pursue pilot projects with interested financial services counter-parties. This in turn will increase the rate of knowledge transfer, although by no means will be an 'overnight' job.

3. As water is a global issue with multiple local variations, NERC should either consider developing its own 'Global Water Snapshot' product or seek an agreement a commercial entity embarking on a similar course (e.g. Google/Cisco) to improve the accessibility, quality and resolution of data.

4. NERC should take the lead in establishing benchmark standards for the measurement of the most important water data sets and the development of modelling metrics. It is critical that these standards meet the primary financial markets requirement for consistency. Estimates and models should both be conservative, with a clearly established error margin, and the metrics themselves should only be revised at infrequent intervals, say every three or five years.

5. NERC should pursue relationships with financial information service providers who can channel data to underpin the infrastructure required to develop indices, identifiers and registries. Joint ventures in partnership with financial services information providers would allow data to be disseminated in a structured format.

Based on the findings of this project it is concluded that:

- *the most productive way for NERC to move forward would be to establish individual joint ventures with partners interested in developing particular indicators or products relating to current and future water resource stress points – continuing work and dialogue already in-train through existing outreach programmes;*
- *water's unique status as a finite resource, and its connectivity with most significant productive activity, suggest that NERC should prioritize it over its other areas of expertise in seeking to accelerate knowledge transfer to the financial services sector;*
- *NERC could champion the development of an enhanced 'Global Water Snapshot' tool, by seeking commercial partners to collaborate with funding;*
- *NERC should actively exploit the 'early-starter' market advantage enjoyed by its early partners to widen its own franchise;*
- *as the rest of the sector realizes the acuteness of its water data requirements, NERC must already have in place the suite of products to enable it to move into wide engagement with the major financial services information providers and rating industries.*

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7. APPENDIX

Contributing Organisations

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Acclimatise
Asia Water Project: China
Bank of America Merrill Lynch
Bloomberg LP
Brewin Dolphin
British Geological Survey
BT Pension Scheme Management Ltd
Carbon Disclosure Project
CDP Water Disclosure
Centre for Ecology and Hydrology
Chair of the Liberal Democrats' International Relations Committee
City of London Corporation
CIX
Climate Exchange PLC
Davis Langdon
Daiwa Capital Markets
Deutsche Bank Research
EnviroMarkets
Environmental Finance
Herbert Smith LLP
Hermes Equity Ownership Services Ltd
HSBC
Illiquidx Ltd
JP Morgan Chase & Co.
London School of Economics
Markit Environmental Registry
McKinsey
Mercer
Morgan Stanley
Natural History Museum
Rabobank International
Royal Bank of Scotland
Schroder's
Standard Chartered
Sustainable Development Unit
Tower Group
TVE
UBS
UKSIF
UNEP FI
University of Edinburgh
University of Leeds
University of Surrey
US Embassy London
University Superannuation Scheme
WSP Environmental