

CLIMATE CHANGE: THE INVESTMENT OPPORTUNITIES TO COME IN ADAPTATION

Much of the focus in dealing with climate change has been on cutting emissions (mitigation), with investment in measures to cope with the changes already built in to the system (adaptation) being the poor relation. But recent scientific revelations suggest that changes to the climate are happening more quickly than previously thought and adaptation measures will be more important in years to come. Opportunities and risks will arise in a number of areas.

New Energy Finance finds that:

- The latest science suggest that the effects of climate change caused by greenhouse gases already emitted will be worse than previously thought.
- Despite this, most of the climate change effort is aimed at mitigation i.e. cutting emissions rather than adaptation i.e. coping with the effects of the changing climate.
- The changes brought about by rising temperatures will have an impact across every sector of the economy, affecting the viability of existing investments in everything from aviation to agriculture.
- Adaptation investment opportunities can often be classified in other ways, ranging from poverty reduction to securing energy and water supplies. Investments from health to infrastructure can be classified as adaptation.
- As the effects of climate change are becoming more evident, climate change adaptation is rising up the political and investment agenda.
- When evaluating opportunities, investors will have to start taking into account factors that are not currently considered important, such as hydrology, ecosystems and soil science.
- While adaptation issues are universal, some sectors will be affected more than others – these include insurance, agriculture, energy, the built environment and most of all – water.

Figure 1. Key impacts of rising temperature

Water	Increased water availability in moist tropics and high latitudes	Decreasing water availability and increasing drought in mid-latitudes and semi-arid latitudes	
	Hundreds of millions of people exposed to increased water stress		
Ecosystems	Up to 30% of species at increasing risk of extinction		Significant extinctions around the globe
	Increased coral bleaching	Most corals bleached	Widespread coral mortality
	Terrestrial biosphere tends toward a new carbon source as: ~15% -> ~40% of ecosystems affected		
Food	Increasing species range shifts and wildfire risk	Ecosystem changes due to weakening of the meridional overturning circulation	
	Complex, localised negative impacts on small holders, subsistence farmers and fishers		
	Tendencies for cereal productivity to decrease in low latitudes	Productivity of all cereals decreases in low latitudes	
Coasts	Tendencies for some cereal productivity to increase at mid- to high latitudes	Cereal productivity to decrease in some regions	
	Increased damage from floods and storms	About 30% of global coastal wetlands lost	
	Millions more people could experience coastal flooding each year		
Health	Increased burden from malnutrition, diarrhoeal, cardio-respiratory, and infectious diseases		
	Increased morbidity and mortality from heat waves, floods and droughts		
	Changed distribution of some disease vectors		
Source: Insight Investment, <i>Managing The Unavoidable</i>			

Introduction

If you ask an investor to name the most promising and necessary areas for investment thrown up by climate change, their response is likely to be some kind of mitigation project – i.e. a technology or project that reduces GHG emissions, ranging from offshore wind turbines to energy efficient light bulbs.

But the science tells us that a certain amount of climate change is already built into the system and adapting to that change is likely to be as important as acting to cut emissions. Indeed, a wave of recent announcements has suggested that our failure to cut emissions means the climate will change more than was previously thought.

The scientific imperative

There have been suggestions that the global economic slowdown of 2008 and 2009 will reduce emissions, temporarily delaying the onset of climate change, but the US National Oceanic and Atmospheric Administration (NOAA) said in March that the growth of CO₂ levels in the atmosphere accelerated in 2008. The concentration of CO₂ reached a global average of 384.9ppm, up 2.2 ppm on 2007, compared with a previous annual increase of 1.8 ppm, the NOAA data showed.

One theory is that GHG levels may have risen partly because the ability of the world's oceans to soak up CO₂ is diminishing, adding to the pressures caused by increasing levels of man-made emissions. Meanwhile, a scientific conference in Copenhagen in March heard that sea level rises will be much higher than anticipated.

Better understanding of how ice sheets melt suggests sea levels will be a metre higher by 2100, according to Professor Stefan Rahmstorf of Potsdam Institute for Climate Change. The estimate is almost double the projection of 20cm to 59cm made in 2007 by the Intergovernmental Panel on Climate Change. He added that unless greenhouse gas emissions were controlled within 50 years, the planet would be locked into rises of "tens of metres". With about a half of the world's population estimated to live within 200km of a coastline, the consequences of such a rise would be huge.

Professor Katharine Richardson, who chaired the scientific steering committee for the conference, said it was now almost impossible for the world to achieve the UN target of preventing global temperature rise exceeding 2C. "We can forget about the 2C," said Professor Richardson in an interview. "We are now facing the situation where we have to avoid a 5-6C rise in temperature."

Investment implications

According to a report for a group of UK investors, including Insight Investment, USS, Henderson Global Investors and Railpen, "The world's climate is changing with immense, albeit still poorly understood, implications for investors." The changes, some of which are already starting to be observed, include changes in prevailing weather patterns and changes in extreme weather events.

Average temperatures are rising and heatwaves are becoming more common; rainfall patterns are changing, with increased risk of flooding and drought. Both of these phenomena have been seen recently in Australia, which has had to contend with massive bush fires on top of a prolonged drought.

Glaciers are melting, which will have profound effects on water supplies in locations ranging from the Indian sub-continent to North and South America. Permafrost is thawing, affecting building foundations and potentially releasing billions of tonnes of previously locked away methane. Sea levels are rising; storm surge heights are increasing; and the intensity of storms is increasing, all of which will affect millions of people. Most affected initially will be people in major deltas such as the Nile Delta in Egypt, the Ganges-Brahmaputra Delta in Bangladesh and India, and the Mekong Delta in south-east Vietnam. However, this is not just a developing world problem. New York, London, Sydney, Hong Kong and Shanghai are all under threat, too.

Meanwhile, a number of analysts say that when it comes to oil prices, it was the recent \$100 fall in the price that was the blip, rather than the price rise seen in 2008. "The price would not have risen to the levels we saw last summer if producers had been able to put any more on the market," says Marc Brammer of Innovest Strategic Value Advisors. "It was \$147 a barrel – if they could have sold any more, they would have."

With current policies to abate energy-demand growth, spare capacity could return to the low levels witnessed in 2007 as soon as 2010 to 2013, adds a report from McKinsey Global Institute, risking a second spike in oil prices that could cost oil-importing countries \$1.5 trillion and even more if oil prices more than double. MGI forecasts that 90% of demand growth would come from developing regions. "So there will be an unfortunate dovetailing between the impacts of climate change and the nature of oil markets," says Brammer. "At the same time that we need to re-organise what we do, the energy that we use is going to be extraordinarily expensive."

Figure 2: Investment Implications of Climate Change

Potential Climate Change Impact	Potential Questions Facing Companies
Increasing Temperatures	<p>Will facilities be able to cope with higher temperatures?</p> <p>Will there be a need for more investment in air-conditioning (e.g. for IT equipment and data rooms)?</p> <p>Will work practices need to change to reduce exposures of staff to higher temperatures? For example, will there be constraints on construction activities during the hottest hours of the day?</p> <p>Will the Mediterranean continue to be a popular tourist destination? How will this impact on airlines and the travel industry more generally?</p> <p>Will changing weather patterns lead to changing patterns of consumer demand for items such as hot/cold drinks, clothing, furnishing and fittings, white goods?</p> <p>Will the nature of agricultural activities change (e.g. will the UK become a significant wine producer)?</p>
Increasing severity of storms and other extreme weather events	<p>Will new building designs and standards need to change to make them more resistant to storm damage? Will existing buildings need to be altered to make them more storm-proof?</p> <p>Will extreme weather events impact on transportation systems?</p> <p>Will such interruptions impact just-in-time delivery systems (e.g. for retailers)? Do companies need to develop new approaches for product transport and distribution?</p> <p>Will insurance premiums rise to reflect increased risks of property damage and other losses from extreme weather events such as the UK floods in the Summer of 2007?</p>
Changes in Rainfall Patterns	<p>Will power companies have sufficient cooling water to operate their plant safely and efficiently? For example, during the 2003 heat wave, French nuclear power generation had to be severely curtailed as river water levels were too low and the water itself was too warm.</p>

Note: http://www.insightinvestment.com/global/documents/mliterature/367922/managing_the_unavoidable.

Source: Managing the Unavoidable

In the shade

Yet time and again, climate change commentators say that the need for adaptation is overshadowed by mitigation efforts. "Adaptation is a hard sell in the current economic conditions," says Dr Lis Gibson, Partner in Deloitte's general insurance actuarial department.

"Adaptation is very important, but the main problem is – 'What is it?' says Mike Bess, head of policy and strategy at project developer Camco. "You get a different answer from everyone you ask."

Another issue is that – while it is possible to define mitigation projects by the simple criterion of whether they cut emissions or not – adaptation is more difficult to pin down. Part of helping people to become more able to adapt to climate change is about poverty reduction or sustainable development, while many of the impacts are more to do with demographic trends than the climate changes themselves – for example, the trend to over-develop coastlines in both developed and developing countries is one of the reasons sea level rise will affect so many people.

On top of that, one single aspect of climate change can have manifold consequences across many different sectors of the economy and its effects will vary from region to region. For example, higher temperatures in Europe will hit Alpine ski resorts because of lack of snow and the Mediterranean because of increasingly frequent and severe droughts. But resorts in Northern Europe will benefit as the Mediterranean becomes increasingly uncomfortable for holidaymakers.

For these reasons, adaptation is an area that requires – and is likely to receive – more attention from policymakers at all levels, from the largest transnational bodies such as the UN down to municipal authorities. The UN has created an Adaptation Fund, which will receive 2% of the proceeds of CER funding from the CDM mechanism.

Case Study 1. 2003 European Heatwave

A severe heatwave over large parts of Europe in 2003 raised summer temperatures by 3 to 5°C in most of southern and central Europe. There was also a drought that contributed to the estimated 30% reduction in gross primary production of terrestrial ecosystems over Europe. This reduced agricultural production and increased production costs, generating estimated damages of more than EUR 13bn. The hot and dry conditions led to many very large wildfires, in particular in Portugal. Many major rivers (e.g., the Po, Rhine, Loire and Danube) were at record low levels, resulting in disruption of inland navigation, irrigation and power-plant cooling. The extreme glacier melt in the Alps prevented even lower river flows in the Danube and Rhine. The excess deaths due to the extreme high temperatures during the period June to August may amount to 35,000. Economically, the drought created stress on health, water supplies, food storage and energy systems.

Note: <http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-xccc.pdf>

Source: IPCC

In Australia, which is seeing the impacts of climate change earlier than most countries, the Rudd government has recently committed AUD 10m over four years to research the effects of climate change on areas such as water resources, human health, emergency services, infrastructure and biodiversity. The government has also provided AUD 44m to establish the CSIRO Climate Adaptation National Research Flagship to support scientific solutions to help Australia to adapt more effectively to the impacts of climate change and variability and to inform national planning, regulation and investment decisions.

In Europe, the EU has produced a Green Paper that charts the potential disruptions to energy infrastructure, power production and consumption and sets out a four-action approach at Community level:

- Early action in areas from agriculture to trade, backed by EU policies and available Community funds.
- Integration of adaptation into existing EU external actions, in particular its promotion in developing countries.
- Intensified climate research, in particular on the impacts of global warming, and technological innovation.
- Involving all segments of society, business and the public in the further development of adaptation strategies.

However, the Green Paper acknowledges: "Market forces alone are unlikely to lead to efficient adaptation because of a certain degree of uncertainty in the climate projections and lack of financial resources" and so, as one analyst put it, "how does the public good of adaptation get paid for? That is still a big issue."

The UN Development Programme has projected that annual adaptation investment needs will be \$86bn by 2015. The World Bank, together with the Netherlands and the UK, is undertaking a study on the economics of adaptation, examining countries' vulnerability to impacts of climate change, adaptive capacity and the adaptation deficit (the degree to which each country is not well adapted to current climate). Next, adaptation costs will be estimated and extrapolated to estimate costs at the national level and for all developing countries.

A different way of thinking

According to the UNFCCC, "there are no new empirical data or analyses yet available (although some work is under way) that allow a meaningful update of the estimates of financial flows and investment needs for adaptation".

For investors, though, it is clear that investing in adaptation requires a different way of thinking and a new blend of expertise, says James Cameron, vice-chairman of investment bank Climate Change Capital. "To improve ecosystem resilience, we need investment in natural systems, in restoring wetlands, managing agricultural land and preserving forests. It requires much more focus on hydrological systems, and soil quality rather than what value we can extract from the soil."

No-one knows what to do yet, says Brammer of Innovest. "When they come, the impacts are very sudden, as with Hurricane Katrina or the bush fires in Australia. When the crisis happens, it reveals whatever weaknesses exist in the system. So if you see a weakness in the system, that is an opportunity," he adds.

Key sectors

Insurance

However, some things are known and certain sectors are beginning to deal with the issue. Insurers have long been at the forefront of the climate change debate, because they are the front line when it comes to paying the costs. The United Nations Environment Programme Finance Initiative says that "on one scenario, disaster losses could reach over \$1 trillion in a single year by 2040."

Munich Re's Natural Catastrophes 2006 report stated that "capital markets have not been spared the consequences of increasingly frequent and violent natural catastrophes. On the contrary, results and share prices are affected by resulting raw material shortfalls, damage to production sites and business interruption. In addition, sectors such as agriculture, tourism, and healthcare are starting to feel the gradual effects of climate change. Ultimately, economic performance as a whole suffers."

Property and casualty insurance will be in the front line of the response to the physical impacts of climate change and it is a factor that will increasingly have to be taken into account in pricing. In some areas, such as floodplains, properties may become uninsurable, or insurers may insist on flood protection measures before cover is provided. An example of this can be seen in Florida, where the State government has become the biggest residential insurer because private insurers have withdrawn from the market following repeated catastrophic hurricanes.

Insurers have an important role to play in encouraging adaptation measures by either withdrawing cover or massively increasing prices. "High insurance premiums (or at the extreme, unavailability of cover) in particular high-risk areas send strong price signals that could deter new construction in these areas, thereby limiting the long-term economic losses from climate change," says F&C.

Insurers can also lobby policymakers to implement adaptation policies. In the UK, for example, the industry agreed to continue to provide property cover if the government invested in flood defences. In return, regulators are starting to impose more conditions on companies. The National Association of Insurance Commissioners has adopted a mandatory requirement for large US insurance companies to disclose annually their exposure to climate change-related risk. Under the new requirement, any insurance firm with more than \$500m in premiums will be required to complete an annual survey detailing its exposure to climate change-related risks such as extreme weather, as well as the geographic region in which its exposure lies and what actions it is taking to address the risk, such as scaling back coverage in the region or raising prices. The association hopes the requirement will address the climate change-related uncertainty currently straining insurance firms' risk models.

Insurers are some of the biggest investors in the world, and some of them are beginning to consider the impact of climate change on their investments. This is a trend that is most advanced in Europe, says Vicki Bakshi of F&C, with US companies much further behind. "Many US companies do not even mention climate change in their accounts despite the recent severe weather events in the US."

Even in Europe, Bakshi says, "many insurance groups that are looking at the way they do business are not looking at how they manage their investments because different teams of people are involved". F&C looks at adaptation as an issue across its entire investment portfolio and it has a climate fund established in 2007, which looks for investment opportunities in both mitigation and adaptation. On the adaptation side, one area ties in with the core insurance business – investing in companies that help property owners to minimise damage from extreme weather.

There is also the opportunity to create new products to profit from the changes climate change will bring, such as expanding coverage in emerging markets as they start to get hit, insuring renewable energy projects and providing catastrophe insurance – but the key is to get the pricing right, which is not easy when "the past is no longer a useful guide to the future," says F&C.

Agriculture

Agriculture is another area where climate change will have obvious impacts, although those will vary from region to region. A recent paper from the European Commission said farmers must think how to adapt to climate change in coming decades, altering their practices to cut greenhouse gas emissions, make agriculture more resilient and keep land in use.

The uneven effects of climatic change were likely to widen regional differences across the European Union's farmland and increase economic disparities between rural areas, the Commission said in the draft paper. Southern and south-eastern EU states from Portugal to Bulgaria are set to be hit by a combination of large temperature rises and reduced rainfall in irrigation-dependent areas that already face water scarcity.

Central Europe will see higher rainfall in winter and much less rain in the summer, but some regions may see longer growing seasons that will increase yields and the range of crops, while farmland in western European and Atlantic areas of the EU will face not only more extreme weather events but also rising sea levels. In the Baltic region, violent storms and flash floods will combine with melting permafrost but longer growing seasons could lead to increased yields.

However, in aggregate, the global food market is likely to be heavily affected because it is a sector that operates on tight margins and small changes can have a large effect on prices.

There will be opportunities for companies such as Monsanto, Syngenta and Plant Health Care, which are working on developing drought-resistant crops and pesticides, while other companies working in the irrigation sector, such as Lindsay and Amiad, are also well-placed.

Table 1. Estimates of adaptation investment needs in 2015 from the 2007/2008 Human Development Report

Category	Costs in 2015 (\$)
Climate proofing development	\$44bn
Adapting poverty reduction to climate change	\$40bn
Strengthening disaster response	\$2bn
Total	\$86bn

Note: <http://unfccc.int/resource/docs/2008/tp/07.pdf> page 23

Source: UNFCCC

The effects on agricultural land will also have a profound effect on biofuels markets. The stresses on food production will further limit the opportunities for fuels based on edible products or grown on land suitable for food production. Fuels that require a large supply of water will also suffer, while those – such as algae – that can make use of waste or brackish water will be better-placed.

The built environment

"The value of property and infrastructure that will be affected by climate change is massive," says Michael Riley, equity analyst at SAM. Virtually all forms of infrastructure will be affected, from electricity generation and transmission lines to roads to ports to schools.

Infrastructure investments may be expensive but they are cheaper than the damage extreme weather events can bring. In Hurricane Katrina, buildings in New Orleans that had been "hurricane-proofed" sustained 20% of the damage that hit those that had not.

"Every heavy, fixed asset industry is affected because infrastructure is long term," says Andreas Knoerzer, head of sustainable investment at Bank Sarasin. "If you have recently invested in huge plant and have not taken adaptation into account, then value is at risk."

Some infrastructure investments are obvious adaptation plays, such as flood defences and dykes while others are less obvious. Climate-proofing roads will be important, for example, because as temperatures increases, tarmac is more likely to melt while underground rail systems will need investment in cooling systems, says Gibson of Deloitte.

Buildings will need more cooling as warming takes hold, but the sector will have to focus on two issues – reducing the amount of energy used to provide cooling and reducing the heat output from air conditioner exhausts, which exacerbates the heat island effect in urban areas. This will benefit companies that use innovative building materials such as Kingspan and Owens Corning and technologies that can reduce energy usage in providing cooling, such as heat pumps.

There are also some innovative glazing technologies from companies such as Pilkington Glass, including windows with a film of water in to remove the heat of the sun, reflective glazing and solar control glass, which filters out much of the heat-transferring infra-red radiation while allowing in visible light. Reducing the energy consumption of appliances within buildings will also be a focus, boosting companies that offer energy efficiency products.

However, many of the responses to climate change will come at the design stage, with better orientation, passive cooling and heating systems and the like. The construction industry will also have to respond to the signals sent by insurers and government in terms of where properties are located, the type of communities they are part of, and the technologies and materials they incorporate, to make them more resilient to more extreme weather events.

Energy

Energy is usually seen as a mitigation issue because of its huge contribution to emissions. But the sector faces a number of adaptation issues as well. Climate change will alter the effectiveness of various types of energy generation and infrastructure assets, according to Tony Ward, of Ernst & Young.

In extremes of temperature, transmission lines become more prone to outages while sub-stations may be vulnerable to flooding and storms. The biggest issue, though, is the impact on the efficiency of generating assets. Gas-fired power stations work optimally at 8-10°C, Ward says. "They are essentially giant jet engines. If temperatures exceed 20-25°C, the air becomes less dense and gas-fired power station become substantially less efficient. They could lose more than 10% of their capability."

Taking this into account might improve the economics – and the politics – of CCS and other clean coal technologies in future. More carbon-friendly forms of generation are not immune, either. While wind becomes paralysed by extended periods of high pressure, nuclear and hydro are both limited by the availability of water. In the heatwave of 2003, France was unable to use some of its nuclear reactors because there was either not enough water for cooling, or the power plants were unable to return it to rivers at sufficiently low temperatures. Because it uses many of the same rivers for hydro, it suffered an unfortunate correlation between the availability of hydro and nuclear power, Ward adds.

The increasing unreliability of power supplies will prove a boon for suppliers of back-up power such as Aggreko and Chloride, says Bruce Jenkyn-Jones, chief investment officer at Impax. The likely trend towards more decentralised energy has an adaptation component, making consumers less dependent on large-scale, distant sources of power that are vulnerable to weather-related disruption. This will boost a range of emerging clean energy technologies such as flywheels, capacitors, batteries and fuel cells that are already developing in other areas such as power storage and electric cars.

Table 2. Solar power generation water use, by technology

Technology	Project	Nameplate Capacity (MW)	Litres/MW/year	Water Use (litres/MWh)
Crystalline Silicon PV	SunPower High Plains II	250	13,815,077	27.7 (twice a year wash)
Thin-film PV	OptiSolar Topaz	550	4,317,222	3.9 (once a year wash)
Parabolic trough STEG (water cooling)	FPL Beacon	250	1,973,582,400	3719.7
Heliostat and tower STEG (air cooling)	Brightsource Ivanpah	400	123,348,900	125.4

Source: New Energy Finance

Use of water in production or operation will be a key limiting factor, with Vestas already selling itself as a producer of energy that uses no water during operation. Solar technologies do use water, however, with many PV facilities needing access to ultra-pure water and many installations needing a supply of water for cleaning.

Water

The real key to adaptation is water, to the extent that James Cameron, vice-chairman of Climate Change Capital says we will know we are getting to grips with climate change when hydrologists and soil scientists are paid the same as investment bankers.

For virtually every sector of the economy, a clean and sustainable supply is vital, and many of the impacts of climate change will be related to changes in the availability of water. However, there is a flip side – the increase in the number and frequency of extreme weather events such as floods, droughts and hurricanes will take a huge toll on consumers, businesses, buildings, supply chains and less tangible factors such as business confidence.

Finally, rising sea levels will demand a range of responses – from improved sea defences to abandonment of certain areas that could include some of the most economically-productive tranches of land on earth in places such as New York and London.

This will provide opportunities for construction companies and other infrastructure companies, but they will also labour under stricter legal requirements and standards. Impax's Jenkyn-Jones suggests companies such as the Dutch group Boskalis, which builds dykes and also has a dredging business, will be busy, while storm water management groups such as Hydro International will also have plenty of work.

The provision of water infrastructure is a growth area and will benefit companies ranging from Singapore-based Hyflux, which makes water treatment systems to Geberit, whose products improve water efficiency. Those involved in leak detection, such as Canada's Pure Technologies, should also see strong demand. Even simple pipemakers such as Northwest Pipe can expect to see the benefit.

Changes to global hydrology will put a premium on companies able to deliver safe, reliable supplies of water, which will provide benefits for the makers of desalination equipment – however, these are usually large infrastructure providers such as GE and Veolia, although Jenkyn-Jones highlights the potential of Energy Recovery, a company that makes pressure exchangers for desalination plants.

The key to the further growth of desalination is cutting the amount of energy expended in the process, so companies that come up with more efficient desalination processes will be rewarded by the market. A recent report from Lux Research says that the cost and energy intensity of desalination continues to fall, with costs expected to drop 25% in the next 10 years.

Desalination of brackish underground reservoirs under deserts may become a crucial factor in the viability of solar thermal technologies by providing the necessary water for cleaning the mirrors, Lux adds.

VCs will steer clear of desalination and focus instead on areas such as metering, leaving opportunities for those banks that survive the shake-out to bring new desalination technologies to market. "During the next five to 10 years, technology risk will be wrung from novel membranes such as those promulgated by Porifera, Stoneybrook Purification, HTI (for Forward Osmosis), DAIS (for membrane distillation), as well as purveyors of alternative desalination technology including Oasys Water, QuantumSphere, Altela, Apaclara, and Puraq," Lux says. "At the same time, early VC investors will be under pressure to liquidate investments

Case Study 2. The Murray-Darling river basin, Australia

Three and a half million Australians depend on Murray-Darling river basin, which is also the breadbasket of the country, producing everything from wheat to wine grapes. But the last two years have seen the lowest inflows into the Murray River since records began 116 years ago. Australia's state governments have agreed water-sharing arrangements, and water is now rationed between government and private-sector users in a system of allocations ranked from 'high-security' drinking water to 'low security' water for cotton farming. There are restrictions on watering lawns and filling swimming pools. More households are using shower water and dishwater in the garden, and installing efficient showerheads, taps, and rainwater tanks.

Farmers use about three quarters of the Murray-Darling's water. Now farmers' rations have been slashed. They can, however, save unused allocations for the following year. Farmers can also trade their water. Strict rationing has also forced cotton and rice growers to retrench. 2008 year saw the smallest rice crop ever, closed mills, and lost jobs. By contrast, last year's grape crop was estimated to be near record levels, despite less water. Vineyards have introduced more drought-tolerant vines and used more drip irrigation.

Source: Allianz

as the ends of their funds' lives near, flooding the market with increasingly viable technologies at fire-sale prices."

Knowledge is power

Underpinning all of the above areas and many more will be the need for knowledge. Climate change will have different effects in different places and knowing what will happen where will be vital to the success of individual projects, including those in clean energy.

This will drive demand for the services of consultants, particularly those that can offer planning advice as well as strategic guidance. Companies such as Stantec, RPS, Tetratex and WS Atkins should benefit from this trend, along with niche information providers such as the UK's Met Office.

The digitisation of the green knowledge economy will also be a major factor, says Roberto Siagri, president of technology research group Eurotech. "Digital technologies and computers can improve the measurement, control and regulation of the processes we put in place to create energy. Improvements in technology will mean we can do much more with much less."

Companies such as Canadian group Carbonetworks will also benefit from the thirst for knowledge. Its software gives companies a view of their carbon emissions, allowing them to take action to improve their climate robustness and increase their efficiency. Co-founder Stephen Mooney says that the need for greater awareness of climate impacts will lead to an increase in the carbon footprinting of products as undertaken in the UK by Walkers Crisps and Boots. This will highlight climate-related supply chain risks and allow companies to respond accordingly.

Outlook

Adaptation has been underplayed so far in the debate on climate change. Some people see it as accepting the inevitability of climate change; others struggle to see the financial benefits of avoided climate change impacts, not least because the benefits do not necessarily accrue to the companies taking action and because there are real limits to adaptation (i.e. the negative impacts of climate change cannot be completely eliminated). Another factor is that much of the necessary activity needs to take place in the poorest countries of the world. "Adaptation lacks the clear focus point that mitigation has," said one analyst, "and it is not clear what the funding mechanisms are."

Dealing with adaptation takes clean energy investors into some unfamiliar areas, such as the effects of climate change on particular locations, soil health, ecosystems and hydrology. However, it is vital that investors take issues such as these into consideration both as a risk factor and in terms of the opportunities they present across almost every sector of the economy. The UNFCCC estimates that up to \$171bn of additional investment is needed in adaptation by 2030 and many commentators say that adaptation will rise up the agenda but that what will force that change is a series of "climatic Pearl Harbors" that focus attention on particular areas of weakness. "I expect that every time there is a major weather event, there will be a step change in thinking about adaptation," says Deloitte's Gibson. "However, it is likely to stay in second place to mitigation. Adaptation is too big, too ugly and too expensive. There is always something more pressing to spend the money on."

Table 2. Additional investment and financial flows needed for adaptation in 2030, by sector

Sector	Areas/Adaptation measures considered	Global cost (\$ 2005)	Proportion needed in developing countries (percentage)
Agriculture, forestry and fisheries	Production and processing, research and development, extension activities	\$14bn	50
Water Supply	Water Supply Infrastructure	\$11bn	80
Human Health	Treating increased cases of diarrhoeal disease, malnutrition and malaria	\$5bn	100
Coastal Zones	Beach nourishment & dykes	\$11bn	45
Infrastructure	New Infrastructure	\$8bn-130bn	25

Note: <http://unfccc.int/resource/docs/2008/tp/07.pdf>

Source: UNFCCC

Selected Companies Mentioned in this Report

Company	Ownership	Relevant Sub-activities
Climate Change Capital	Private/family-controlled	Finance & Investment
Munich Re	Quoted – Deutsche Borse	Insurance, reinsurance, asset management
F&C	Quoted – LSE	Asset management
Plant Health Care	Quoted – AIM	Biotechnology
Amiad,	Quoted - AIM	Irrigation, water filtration
Lindsay	Quoted – NYSE	Irrigation, water pumps
Monsanto	Quoted – NYSE	Biotechnology
Syngenta	Quoted – SWX	Biotechnology, agricultural research
Kingspan	Quoted – Irish Stock Exchange	Insulation and construction products
Owens Corning	Quoted – NYSE	Building products, composite materials
Pilkington Glass	Subsidiary	Glass products
Aggreko	Quoted – LSE	Power generation products
Chloride	Quoted – LSE	Uninterruptible Power Supplies
Boskalis	Quoted – Euronext	Dredging, maritime infrastructure
Hydro International	Quoted – LSE	Stormwater and wastewater management
Hyflux	Quoted – Singapore Stock Exchange	Water treatment
Geberit	Quoted – SWX	Water efficiency
Pure Technologies	Quoted – TSX	Water monitoring technology
Stantec	Quoted – NYSE	Infrastructure consultancy
Carbonetworks	VC/PE-funded	Emissions management
RPS	Pre-institutional funding	Planning and environmental consultancy

Source: New Energy Finance

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