Planning for an uncertain future

© FAO/Guilio Napolitano

Demand for water will soar in the coming decades, as the human population swells and becomes both more urban and more affluent. This will lead to increasingly difficult trade-offs between water for food security versus water for energy security. To compound matters, climate change is expected to make water resources less abundant in many places, as well as less predictable. In order to pre-empt the growing risk of future food, water and energy insecurity, many countries are taking the precaution of acquiring large tracts of land abroad and importing 'virtual water' in the form of foodstuffs.

Technological progress should go some way towards reconciling supply and demand but, ultimately, the solution will lie in better water governance. In order to satisfy competing demands, the water, agriculture and energy sectors will need to work together on policy design. In the face of uncertainty, managers will need to learn how to plan not for *one* future but for several. The speed with which we take up these challenges could make all the difference between achieving global sustainability and a future blighted by water scarcity, pollution and flooding for hundreds of millions of people.

These are some of the key messages of *Managing Water under Uncertainty and Risk*. Produced by the World Water Assessment Programme (WWAP), this fourth report in the triennial series was launched by UNESCO on 12 March at the World Water Forum in Marseilles (France), on behalf of the 28 agencies comprising UN-Water. Here, we examine some of the trends highlighted by the report.

How will we feed another 2 billion?

The world population is expected to grow from 7 billion in 2011 to 9.1 billion by 2050. In parallel, economic growth and individual wealth are shifting diets from predominantly starch-based to meat- and dairy-based, requiring more water. Producing 1 kg rice, for example, requires about 3500 litres of water, 1 kg of beef 15 000 litres of water and a cup of coffee about 140 litres. This dietary shift has had the greatest impact on human water consumption over the past 30 years and is showing no sign of abating. The combination of rapid population growth and changing diets may increase the demand for food by 70% by 2050.

The main challenge facing the agriculture sector will not be so much to grow 70% additional food in the next 40 years as to make 70% more food available on the plate. Reducing losses in storage and along the value chain would go some way towards offsetting the need for more production – and water.

Livestock not only provides food, of course, but also wool, hides and other products. It now contributes 40% of the global value of agricultural output. The expansion of land for livestock has created acute environmental concerns. It has led to deforestation in countries like Brazil, for instance, and, in countries belonging to the Organisation for Economic Co-operation and Development (OECD), intensive livestock production has become a major source of pollution. In 2008, 3 350 million ha were used as permanent meadows and for pasture, more than twice the area used for arable cropping and permanent crops.

Recent estimates suggest that nearly 2 billion hectares of land worldwide – an area twice the size of China – are seriously degraded, some irreversibly. Innovative technologies will be needed to improve crop yields and drought tolerance and deliver more efficient ways of using fertilizer and water.

Among these figure water-harvesting technologies and drip irrigation, as well as technologies that recycle grey water in peri-urban agriculture. Grey water is produced by non-sanitary use of water in the home, such as in dishwashing or showering. FAO estimates that 70% of urban households in developing countries already participate in agriculture.

The development of biofertilization techniques would also increase water use efficiency by promoting higher nutrient absorption and crop growth rates (*see box*). Timely agro-climatic information to help deal with increasing climate and rainfall variability, early warning systems and mechanization – which is still lagging behind in many countries – could also lead to an overall increase in water use efficiency.

Agriculture accounts for about 70% of all water withdrawals and as much as 90% in some fast-growing economies. Best estimates of future global agricultural water consumption – including both rainfed and irrigated agriculture – forecast an increase of about 19% by 2050. Much of the rise in water consumption for irrigation will affect regions already suffering from water scarcity.

© Photoshare/Gaurav Gaur

Livestock contributes less than 2% of GDP worldwide, yet produces 18% of greenhouse gases in the form of methane. Critics argue that the disadvantages far outweigh the benefits but others counter that this argument seriously underestimates the socio-economic importance of livestock, particularly in low-income countries.

Global energy consumption will climb steeply by 2035

Global energy consumption will increase by 50% between 2007 and 2035, with non-OECD countries accounting for 84% of the increase. In 2009, 1.4 billion people lacked access to electricity, 20% of the world's population. All sources of energy and electricity require water in their production processes: the extraction of raw materials, cooling in thermal processes, cleaning processes, cultivation of crops for biofuels and powering turbines. Energy is itself required to make water resources available for human use and consumption through pumping, transportation, treatment, desalination and irrigation.

Cuba adopts organic agriculture

The Cuban government responded to a food crisis in September 1993 by turning over much of the 80% of all farmland held by the State to the workers and re-establishing worker-owned enterprises. Although peasants did not own the land, they were allowed to rent it indefinitely free of charge, as long as they continued to meet production quotas for their key crops. Food crops produced in excess of these quotas could be freely sold at farmers' markets. This provided a price incentive for farmers to use new organic technologies effectively, such as biofertilizers, earthworms, compost and the integration of grazing animals. Farmers also revived traditional techniques such as intercropping and manuring in order to increase production yields.

Public policies also supported urban organic agriculture. Through the Programa Nacional de Agricultura Urbana (1994), Havanans were encouraged to transform their vacant lots and backyards into small farms and grazing areas for animals. This resulted in 350 000 new, well-paying jobs – out of a total workforce of 5 million –, annual production of 4 million tons of fruit and vegetables and a city of 2.2 million inhabitants self-sufficient in food.

Cuba's transition to organic agriculture has ensured food security and a steady income for the population under a trade embargo. The lack of chemical pesticides should also have a positive long-term impact on Cuban health.

Source: WWAP (2012) Managing Water under Uncertainty and Risk.

© Yanet Toirac/UNESCO La Habana

Vegetable garden in Havana

Forest ecosystems could be a casualty of land conversion to grow biofuels, unless policy-makers and managers recognize that these ecosystems do not consume water but rather supply and recycle it – making them an extremely valuable resource.

Even investment in clean energies to mitigate climate change will affect water, as biofuels and hydropower are both water-intensive. Demand for energy from renewable resources should rise by 60% by 2035. Biofuels are already an increasingly prominent component of the energy mix, as exemplified by the 2007 EU target for biofuels to constitute 10% of transport fuel by 2020. This target has been hotly debated, as it acts as a driver for land conversion from food to biofuel production, placing upward pressure on food prices and, in some cases, leading to the conversion of forest ecosystems to grow biofuels.

A number of international organizations highlight the water–food–energy nexus as illustrating the most difficult choices, risks and uncertainties facing policy-makers today. Examples abound of the various intended or unintended consequences of favouring one pillar over the other, such as food security over energy security. For example, the OECD's International Energy Organization predicts that 'at least 5% of global road transport will be powered by biofuel [by 2030] – over 3.2 million barrels per day. However, producing those fuels could consume 20–100% of the total quantity of water now used worldwide for agriculture if the production processes and technology don't evolve.

Another example is shale gas, a form of natural gas found in fractures in sedimentary rock (shale) deep underground. Although shale gas promises access to new reserves of fossil fuels, it is slightly more water-intensive than conventional gas because its extraction method – hydraulic fracturing (fracking) – injects millions of litres of water into each well. If current policies do not change, shale gas production should expand in Asia, Australia and North America, despite its environmental drawbacks.

Another inefficient technique is desalination, which causes pollution and oversalinization of the immediate coastal ecosystem. Desalination is also energy-intensive, demonstrating another trade-off between water supply and energy production. Solar-powered desalination plants, currently being tested in Saudi Arabia and elsewhere, may provide a more suitable avenue for sun-drenched countries.

There is obviously an urgent need to harmonize water and energy policies, which often overlap, yet are often made in different government departments or ministries. Water is used to cool power plants in the USA, for example, where it represents 40% of the country's industrial water use. This proportion is expected to reach 30% in China by 2030.

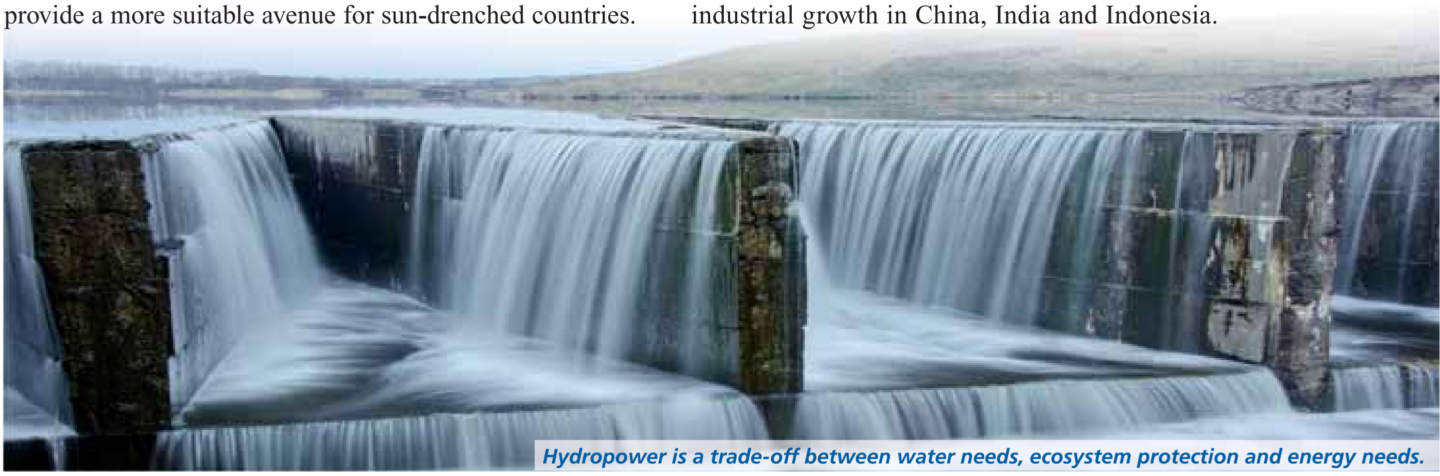
Industry is cleaning up its act

On a global scale, industry uses relatively little water (about 20% of total withdrawals, *see map*) but it does require an accessible, consistent supply of adequate quality. It is estimated that only about 30–40% of this water is actually used for industry, the balance being used for various forms of power generation.

Water is becoming a critical factor in companies' choice of location for their economic activities. In water-stressed regions, companies are becoming aware of how their 'water footprint' could impede their operations or damage their reputation with local communities. Another issue concerns the release of toxic waste from industrial enterprises; this remains a major threat to the provision of safe water to populations in developing countries.

There is a need to decouple industrial development from environmental degradation by moving towards cleaner production processes like zero discharge via the adoption of advanced technologies. Effluent that would otherwise be discharged could be recycled or sold to another user. Many industries are finding that water of lesser quality may be adequate for their needs and that reducing water consumption can be an economical way of saving costs; that in turn can be good for business, especially in light of the risk of future water scarcity.

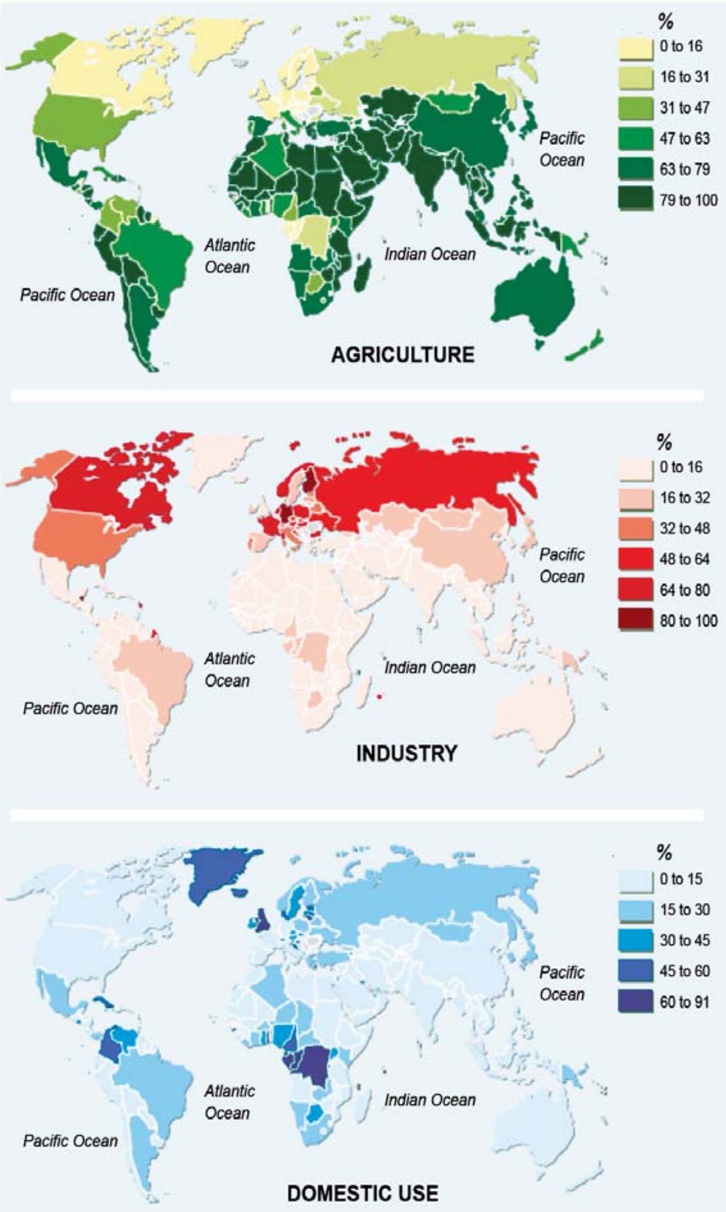
Industry will find itself competing more and more for limited water resources as demand and consumption increase in all areas. According to the United Nations, if present consumption patterns continue, two-thirds of the world's population will live in water-stressed conditions by 2025. Lack of water is already a major constraint to industrial growth in China, India and Indonesia.



© Shutterstock/ded pixto

Hydropower is a trade-off between water needs, ecosystem protection and energy needs.

Global freshwater use by sector at the beginning of the 21st centry



Source: WWAP (2012) Managing Water under Uncertainty and Risk, *with data from World Resources Institute*

Although the world is on track to meet the Millennium Development Goal target of halving the proportion of people without access to safe drinking water by 2015, sub-Saharan Africa and the Arab region are lagging behind. The same target for basic sanitation currently appears out of reach, as half the population in developing regions still lacks access.

Fewer urban dwellers have access to clean water and sanitation than in 2000

The main source of human demand comes from urban communities requiring water for drinking, sanitation and drainage. The urban population is forecast to nearly double to 6.3 billion in 2050 from 3.4 billion in 2009.

The number of people in cities who lack access to a clean water supply and sanitation is estimated to have grown by 20% since the Millennium Development Goals were established in 2000. WHO estimates that the overall economic benefits of halving the proportion of people without sustainable access to improved drinking water and sanitation by 2015 would outweigh the investment cost by a ratio of 8:1. For instance, diarrhoeal diseases are estimated to kill more than 1.5 million children under the age of five every year. Studies have shown that the provision of improved sanitation and safe drinking water could reduce diarrhoeal diseases by nearly 90%.

Efforts are being made to provide sanitation facilities but many social programmes are incompatible with the needs of women. For example, a lack of segregated toilets in schools can directly affect how frequently pubescent girls attend school.

It is estimated that over 80% of wastewater worldwide is not collected or treated and urban settlements are the main vectors of pollution at the source. The public needs better information on the impact of its consumption on the quantity and quality of water resources. Tools are being developed to manage the growing urban demand for water, particularly integrated urban water management, which links freshwater, wastewater and stormwater management within a common resource management structure.

A silent revolution at the pump

Over the past 50 years, the rate of global groundwater abstraction has at least tripled, significantly boosting food production and rural development. Today, groundwater abstraction accounts for about one-quarter of all water withdrawals worldwide, nearly half of all drinking water and about 43% of water used in irrigation. The growing use of groundwater has also considerably modified local and global water cycles, environmental conditions and ecosystems.

Groundwater has enabled people to settle and survive in dry areas where rainfall and runoff are scarce or unpredictable. It is crucial for the livelihoods and food security of over 1 billion rural households in the poorer regions of Africa and Asia and for domestic supplies of much of the population elsewhere in the world.

Specific challenges for the world's regions

Africa

Sub-Saharan Africa uses barely 5% of its annual renewable freshwater. Coverage of the drinking water supply in rural areas had grown to 47% by 2008 but remains static at just over 80% in urban areas since 1990. Only 31% of the population uses improved sanitation facilities; although the proportion practising open defecation is declining, the actual number increased from 188 million people in 1990 to 224 million in 2008.

From the mid-1990s to 2008, the number of malnourished persons grew from 200 million to 350–400 million. Since the mid-1960s, agricultural production has increased by an average of less than 2% annually, while the population has grown at a rate of 3%. Drought affects GDP growth in one-third of countries.

Only one in four Africans has access to electricity. Hydropower supplies one-third of Africa's energy but could meet all the continent's electricity needs. Only 3% of renewable water resources are currently exploited for hydroelectricity. African countries have begun to address transboundary water issues related to hydrodevelopment, such as through power pools like the South African Power Pool and West African Power Pool.

Arab States and Western Asia

About two-thirds of available surface water originates from outside the region, leading to conflict with upstream countries at times. Past conflicts have created hordes of internally displaced persons and destroyed water infrastructure in places like Iraq, Kuwait and Lebanon, absorbing resources needed for rehabilitation. To defuse potential conflict over water resources, attempts have been made to share scarce waters across the region. The League of Arab States has created the Arab Ministerial Water Council and adopted an Arab Water Security Strategy.

Water scarcity has spawned concerns about food security. Imported foodstuffs, particularly grain, account for a sizeable amount of virtual water consumption in this region. Local cereal production has been boosted by the rise in groundwater use for irrigation. However, as aquifers are drawn down, pumping water is becoming increasingly expensive and unsustainable. The economic cost of poor quality water in the Middle East and North Africa ranges from 0.5% to 2.5% of GDP. Water governance urgently needs strengthening to deal with these challenges.

Climate change should raise temperatures, increase soil aridity and shift seasonal rainfall patterns. This can already be seen in Syria and Tunisia, for instance. The region should also expect more frequent floods and droughts, less snowfall and snow melt in some mountainous regions and sea-level rise and water salinity in coastal aquifers.

Asia and the Pacific

The region is experiencing rapid urbanization, economic growth, industrialization and extensive agricultural development. Two-thirds of the world's hungry live in Asia.

Between 1990 and 2008, 1.2 billion people gained access to safe drinking water, raising the total proportion of Asians from 73% to 88%. China and India together account for three-quarters of the total. However, Asia is also home to 72% of the 2.6 billion people worldwide who do not use improved sanitation facilities.

The region is the most vulnerable to natural disasters, with much of the population living in coastal and flood-prone areas. The Pacific's small island states are particularly vulnerable to tropical hurricanes, cyclones and earthquakes and would be highly exposed to sea-level rise from global warming.

A number of countries are shifting from an emphasis on the short-term development of water infrastructure to a more strategic approach that recognizes the ecological impact of economic development.

Europe and North America

North Americans are the highest per capita water users in the world, consuming 2.5 times more than Europeans. About 3.5 planet Earths will be needed to sustain a global population mimicking the current lifestyle of the average European or North American. However, pockets of water deprivation do exist, particularly among indigenous people: more than 10 000 homes on reserves in Canada have no indoor plumbing and the water or sewer systems are substandard on one in four reserves. In Europe, some 120 million people lack access to safe drinking water and even more to sanitation.

An important problem in Europe and North America is the pollution of water courses by agrochemicals, namely nitrogen, phosphorus and pesticides. While legal frameworks exist to regulate this problem, in the drainage basins of the Mediterranean Sea, the East Atlantic Ocean and the Black Sea, anti-pollution enforcement is lagging.

In terms of transboundary water management, the European Union's Water Framework Directive (2000) and more recent directives on standards and groundwater represent the only supranational water arrangements in the world.

The IPCC predicts that summer flows will decline by up to 80% in Southern Europe and some parts of Central and Eastern Europe by the 2070s. Europe's hydropower potential is expected to drop by an average of 6% over this period. In North America, climate change will cause heightened competition among users for over-allocated water resources.

Latin America and the Caribbean

The region's population grew by over 50% between 1970 and 2009, although birth rates are now declining rapidly. The urban population has tripled over the past 40 years, with a trend recently towards the rapid growth of intermediate and small cities as opposed to larger ones before. An estimated 35% of the population (189 million people) still live in poverty, 14% of whom are desperately poor.

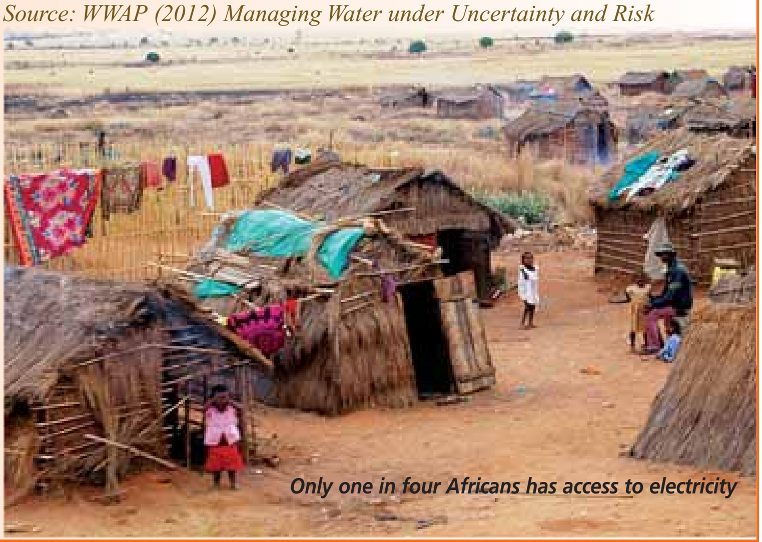
Many countries have benefited from the surge in global demand for minerals, food, timber, fish and tourism, as they are dependent on the 'virtual' export of water via these goods and services.

Although most countries enjoy good coverage for improved water and sanitation, almost 40 million people still lack access to improved water and nearly 120 million access to proper sanitation facilities. Most of them are poor rural dwellers.

The region has 61 basins and 64 aquifers that cross national borders. Many countries have entered into transboundary water agreements, typically to manage hydropower, but political obstacles have often led to conflict. Examples of agreements for managing shared groundwater are few and far between.

With relatively weak water management capabilities, the region's poorest countries in Central America, the Caribbean and the Andes will be at greatest risk from the impact of climate change. On the positive side, lessons learned from adapting to the consequences of El Niño events have driven technological innovation and capacity-building that should help to deal with climate change.

Source: WWAP (2012) Managing Water under Uncertainty and Risk

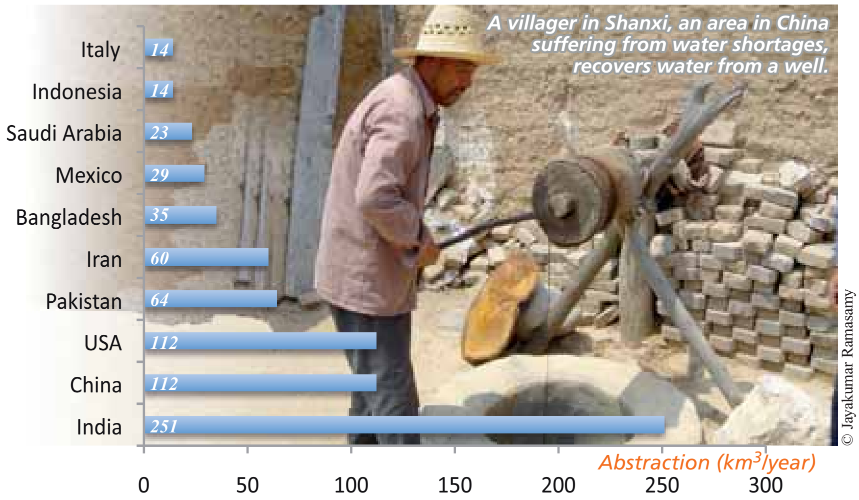


Only one in four Africans has access to electricity

Groundwater depletion is so intensive in some arid and semi-arid zones that the aquifer is unable to replenish the water. Examples are the Highland Plains and Central Valley aquifers in the USA, the north-west India plains aquifers, the North China Plain aquifer and the Australian Great Artesian Basin. Meanwhile, the availability of fossil (non-renewable) water contained in large aquifer systems on Earth that have received little replenishment for millennia has reached critical limits in some hotspots, such as the Middle East and Western USA. With 273 of the world's aquifer systems crossing national borders, growing competition for groundwater will no doubt put the solidity of existing transboundary agreements to the test.

A study by Döll (2009) concludes that groundwater recharge is likely to increase in the northern latitudes by the 2050s but decrease by 30–70% or more in certain currently semi-arid zones, including the Mediterranean, northeastern Brazil and south-western Africa.

Top 10 groundwater-abstracting countries, 2010



About 72% of the global groundwater abstraction (1 000 km^3/ year) takes place in these ten countries. Of the total, about 67% is used for irrigation, 22% for domestic purposes and 11% for industrial purposes. Estimates of the global volume of stored groundwater range from 15.3 million km^3 to 60 million km^3 [Source: Data from IGRAC (2010), Aquastat (2011) and Eurostat (2011).]

A booming trade in virtual water

The term 'virtual water' refers to the volume of water used in the production of a good or service, the most water-intensive being agricultural produce. Countries engage in water trading through the products they import rather than through the physical transportation of water itself, which is a difficult and costly exercise. The virtual water trade could represent 20% of food consumed globally by 2020.

Some water-poor countries have become net importers of virtual water. Imported grain accounts for a large share of virtual water consumed in the Middle East and North Africa, which was already importing 50 million tons of grain annually by 2000. If countries in Europe and elsewhere have also become net importers, this is not because they are water-poor but simply because it satisfies consumer tastes for imported foodstuffs and other products. Rich nations are tending to maintain or even increase their consumption of natural resources but are exporting their footprint to the producer. For example, 62 % of the UK's water footprint is virtual water embedded in agricultural commodities and products imported from other countries.

The virtual water trade can either improve or worsen the state of a country's water resources. It can provide opportunities for water-rich developing countries to stimulate their economies by exporting greater amounts of food, as long as they can afford the infrastructure to harness the water and there are no artificial barriers in international trade. Unfortunately, many countries still require some kind of financial support to develop this infrastructure and remain competitive on global markets.

Another troubling issue concerns developing countries that are water-scarce and whose people are too poor to buy imported food. As with most globalization processes, the virtual water trade could further marginalize the world's poorest.

A growing appetite for large land acquisitions

In their efforts to ensure domestic food security, a number of countries are investing in agricultural land abroad (*often referred to as 'land grabs'*). The report defines 'land acquisition' as the gaining of tenure rights to large areas of land through purchase, lease, concession or other means.

In developed countries, domestic law protects domestic stakeholders and governments and sets obligations for all investors. When this is not the case, as in many developing states, a weak or incomplete domestic legal base on social, economic or environmental issues can allow international contracts and treaties to enjoy much more liberal rights and entitlements. This is particularly relevant to foreign investments in agriculture, where domestic land tenure rights, water rights, environmental management regimes relating to chemicals, labour law on farms and so on can be weak or absent.

Some of the most active investors in large-scale transnational land acquisitions are oil-rich but food-insecure Gulf States, land-scarce, populous Asian countries and developed countries. Non-state investors include Western food producing, processing and exporting companies new actors attracted by biofuel demand and opportunities related to investment funds

Saudi Arabia, one of the Middle East's largest cereal growers, announced in 2007 that it would be cutting cereal production by 12% a year to reduce the unsustainable use of groundwater. In order to protect its water and food security, the government issued incentives to Saudi corporations the following year to lease large tracts of land in Africa for agricultural production. Saudi investors have already leased land in Egypt, Ethiopia, Kenya and Sudan. India is growing maize, sugarcane, lentils and rice in Ethiopia, Kenya, Madagascar, Senegal and Mozambique to feed its domestic market, while European firms are seeking 3.9 million ha of African land to meet their 10% biofuel target by 2015.

The past is a poor guide to an uncertain future

The report innovates by establishing scenarios for how the world's water resources may evolve in the decades to come. Traditionally, past climate records have offered water managers a fairly reliable guide to future trends, thereby helping them to predict extremes like drought and floods, as well as other threats to water security. However, the past is becoming a less reliable guide to the future as humanity as a whole embarks on a trajectory it has never encountered before: a growing demand for water, even as climate change looks set to threaten its availability.

© Shutterstock/Markus Gebauer

A home in the Australian State of Queensland during megafloods last year. Two billion people are expected to be vulnerable to flooding by 2050, owing to population growth in floodprone lands, climate change, deforestation, wetland loss and rising sea levels.

In order to assess the risks and consequences of different development paths, the World Water Assessment Programme has come up with a World Water Scenarios Project. Before constructing three scenarios for the future, the experts surveyed first identified the most likely drivers of change, both positive and negative:

Greater use of water in agriculture
Between 1961 and 2001, water use for agriculture increased by nearly 100%. It will most likely increase another 100% by 2040.

Deforestation will not disappear
Regions may seek to increase their agricultural areas by continuing to expand deforestation, albeit more slowly. This development is more likely to occur than a slowing of expansion of agricultural lands as a result of ecological concerns.

Climate change will increase water stress
The number of people at risk from water stress is likely to reach 1.7 billion before 2030 and 2.0 billion by the beginning of the 2030s. A 50% increase in delta land vulnerable to serious flooding is likely by the early 2040s.

Most people will have access to safe drinking water and sanitation
As a result of infrastructure development, 90% of the global population will probably have reasonable access to safe drinking water and 90% to appropriate sanitation facilities by the beginning of the 2040s. (*See also below* Demographic growth will not let up)

Rainwater harvesting will become widespread
It is likely that rainwater harvesting will be widely adopted between 2020 and 2030, in combination with simple, cheap ways of purifying the collected water.

Better use will be made of affordable technology
Better use of affordable technology by agriculturalists to check crops and soil moisture will increase the efficiency of irrigation schedules.

Demographic growth will not let up
Estimates put the world population at almost 8 billion by 2034, 9 billion by the early 2050s and over 10.46 billion beyond this. Population growth could overwhelm past gains in water and sanitation accessibility, particularly in developing countries where recent improvements in access to water supply and sanitation could be negated.

Demand for water will grow
The demand for water in developing countries could increase by 50% over 2011 levels. Over 40% of countries, most of them low-income countries or situated in sub-Saharan Africa and Asia, could experience severe freshwater scarcity by 2020. An important risk is that unequal access to water will create new economic polarities and give rise to political tensions.

Information sharing will improve
The development of online forums on water issues could help reduce the asymmetry of information between user, provider and policy-maker. Networked co-ordination at the national level to share information and best practices between local water agencies could be achieved in at least 95% of countries between 2020 and 2030. There is concern that resistance from government and vested interests in responding to these information flows could prevent the necessary flexibility, participation and transparency in governmental policy-making.

Three possible futures

In one possible future, the statusquo continues. Growth in food demand resulting from population growth and changes in nutritional habits combines with greater urbanization to push up demand for water dramatically. Expanding human settlements encroach on fragile or marginal lands and there is increased deforestation and pollution. Climate change results in less water availability in many regions, exacerbating economic polarities between water-rich and water-poor countries, as well as between sectors or regions within countries. Much of the burden is likely to fall on the poor.

In a second possible future, technological advances are fully exploited, particularly the trend towards desalinization. Technological developments in agriculture lead to sizeable water conservation, while those in urban water production and waste handling contribute further to reducing absolute water withdrawals and waste. Rapid uptake of these technologies is paired with a growing acknowledgment of water scarcity among the population.

A third possible future extrapolates current demographic and technological trends, together with a set of potential policy interventions. A legally binding international agreement to combat climate change is in place by 2040, along with significant funding for awareness-raising and adaptation in low-income countries. Recognition that the greatest impact of climate change will be felt through water fosters high levels of investment in water infrastructure, leading to reductions in waste, a more sustainable water supply and broader coverage by the sanitation network.

Investment in water management, conservation and sanitation reduces poverty, thanks to the development of solid property regimes, documented land tenure arrangements and clearly established water rights and allocation systems. Subsidies encouraging inefficient use of land, water and fertilizers, which creates a bias in favour of high-water users, are gradually replaced by flexible, index-based insurance schemes that allow producers to make short-term cropping decisions based on climate variability and extremes. Water-basin institutions and decentralized authorities are given more power and resources to manage water effectively within countries. This promotes a local, climate-responsive allocation of water among users, facilitated by well-regulated pricing and innovative water rights trading mechanisms.

Source: WWAP (2012) Managing Water under Uncertainty and Risk

There may be unforeseen negative consequences in many of the African states where these transactions are taking place. For instance, India has purchased 1 million ha of land in Ethiopia, one of the most food-insecure countries in the world. Poorly regulated foreign investments in lands that could otherwise be used to feed local populations could potentially have devastating consequences on the fragile state of domestic food security.

Other consequences include the displacement of populations, the dispossession of land, potential conflicts and instability as various groups are uprooted. There are also considerable negative environmental consequences, as large-scale industrial agriculture requires fertilizers, pesticides, herbicides and large-scale transport, storage and distribution. Many of the states where 'land grabs' are taking place also have weak governance structures, with little legal protection for local communities and no benefit-sharing mechanisms.

To implement its biofuel policy, China has invested heavily in land in Indonesia, Thailand, Malaysia, Mozambique and the Democratic Republic of Congo, among others. By 2020, the Chinese government anticipates that 15% of China's transport energy needs will be met by biofuels. As part of a massive plan to reduce greenhouse gases, China will replace 12 million tons of oil with 2 million tons of biodiesel and 10 million tons of bioethanol each year. Despite the positive goal of investing in 'green and clean' energy, China's interventions have caused deforestation, threatened biodiversity via monocultures, increased food prices and decreased food stocks: the International Monetary Fund estimates that that the rise in demand for biofuels accounted for 70% of the hike in maize prices and 40% of that for soya bean prices between 2006 and 2008. The interventions have also caused population displacement as land is converted into plantations, and water scarcity. The amount of water required for biofuel plantations is particularly devastating to regions where water is already scarce, as in West Africa. For example, 1 litre of ethanol from sugarcane requires 18.4 litres of water and 1.52 m^2 of land.

The lack of any supranational regulating or monitoring mechanism for land acquisitions has enabled the acreage of transnational land acquisitions to rise from 15–20 million ha in 2009 to more than 70 million ha in 2012. Africa consistently appears to be the prime target for these deals, with sub-Saharan Africa accounting for two-thirds of their acreage. It is typical for there to be no explicit mention of water in the disclosed land deals. In the few cases where water is referred to, the amount of permitted water withdrawals is not specified. Evans (2009) quotes the Chief Executive Officer of packaged food manufacturer Nestlé as saying, 'with the land comes the right to withdraw the water linked to it, in most countries essentially a freebie that increasingly could be the most valuable part of the deal. And, because this water has no price, the investors can take it over virtually free.' The consequences of this trend are harmful for the rural poor when they are forced to compete for scarcer water with actors who are more financially powerful and technically better equipped (*see interview, page 15*).

The current pace of land acquisitions and the related concessions of water rights to investors also carry great threats for transboundary co-operation in many river systems, including those of the Nile, Niger and Senegal basins.

The vitual water trade can enable water-rich developing countries to stimulate their economies by exporting greater amounts of food.

The way forward

Water and land have become vitally strategic resources, more interlinked than ever before. Confronted with competing demands, policy-makers are faced with a dilemma: how can they ensure food security without penalizing energy security, or satisfy both industrial and agricultural demands for water?

The key to rational management will be to consider different uses of water alongside each other, including domestic use, land management, agriculture, mining and energy production. The best way to do this is to create a structure within which competing interest groups – such as water utilities, farmers, industry and mining, communities and environmentalists – can hammer out coherent strategies for meeting future challenges and uncertainties. To be fully inclusive, a broad group of stakeholders should also be involved in the rule-setting process for the management of both domestic and transboundary water resources. Combine these twin elements and you have what is called integrated water resource management.

Water management has always been underpinned by uncertainty but global trends in demography, consumption patterns, industrial development, migration and climate change are driving the level of uncertainty to unprecedented levels, exacerbating risk. Integrated water resource management offers stakeholders the flexibility they need to be able to adapt strategies for water management when the future doesn't go according to plan.

This will be the challenge for water authorities: to move from planning for one defined future to the use of plans that are responsive to a range of possible future scenarios, all uncertain but presenting varying degrees of probability. In this new paradigm, technical specialists will need to interact with government decision-makers and society more broadly, on the basis of reliable, objective information and data about the state of water resources and how they are used and managed.

As part of preparations for the Rio+20 conference this June, the UN Commission on Sustainable Development invited UN-Water to conduct a global survey last year to determine the extent of progress towards sustainable management of water resources using integrated approaches. Preliminary findings from over 125 countries show that 64% of respondants have developed plans for the implementation of integrated water resource management, as recommended in the *Johannesburg Plan of Implementation* (2002), and that 34% are at an advanced stage of implementation. The only cloud on the horizon is that progress appears to have slowed in countries with a low and medium Human Development Index since an earlier survey in 2008.

This article has been compiled by the editor from Managing Water under Uncertainty and Risk*, the Fourth World Water Development Report, with grateful thanks to the report team.*

To read or purchase the full report, see page 24

Venice *will* succumb to sea-level rise, the question is when

The newly published report of a workshop run by UNESCO's Venice Office on 22–23 November 2010 has concluded that 'the planned mobile barriers (MOSE) might be able to avoid flooding [of the World Heritage site of Venice and its Lagoon] for the next few decades but the sea will eventually rise to a level where even continuous closures will not be able to protect the city from flooding. The question is not if this will happen, but only when it will happen.'

In order to avoid flooding, the Italian authorities have authorized the construction of an underwater barrier system, referred to as the MOSE Project, which should be operational by 2014. During the project planning phase, three scenarios for sea-level rise by 2100 were considered: 16.4 cm, 22.0 cm – the scenario recommended for the MOSE project – and a pessimistic scenario of 31.4 cm. Today, even the pessimistic scenario is considered overoptimistic.

The Intergovernmental Panel on Climate Change (2007) forecast global sea-level rise of 18–59 cm to 2100 but excluded ice melt from its calculations, as this parameter could not be modelled. Observed global sea-level rise actually exceeded the model projections for the period 1961–2003 by 50% and for 1990–2008 by 80%.

Other uncertainties stem from the insufficiently understood dynamics of heat uptake by the oceans, which causes oceans to swell and thus sea level to rise, as well as from the variety of possible scenarios for future carbon emissions and the consequential heating of the atmosphere.

Some recently published papers give higher estimates of global sea-level rise: Vermeer and Rahmstorf (2009) give a range of 75–190 cm, Horton *et al*. (2008) a potential lower limit of 54–89 cm and Jevrejeva *et al*. (2010) a range of 60–160 cm. Looking farther ahead, the Delta Committee (2008) gives a range of 1.5–3.5 m for the year 2200, while the German Advisory Council on Global Change (2006) estimates sea-level rise of 2.5–5.1 m by 2300. 'This means that sea-level rise will be governed in the coming centuries by a delayed response to 21st century anthropogenic (human-induced) warming.'

As for sea level in the Mediterranean, it has shown strong variability over the past century, rising by approximately 1.2 mm/year, which is 'significantly lower than the global average.' Based on measurements from tide gauges, it even dropped a few centimetres between 1960 and 1993 before rising 4–5 cm between 1993 and 2000, after which there was no change.

One factor affecting regional sea level is atmospheric pressure: a drop in pressure of 1 millibar (mbar) is equal to about a 1 cm rise in sea level. A rise in atmospheric pressure linked to the North Atlantic Oscillation was responsible for the drop in sea level in the Mediterranean between 1960 and 1993. Climate models indicate that atmospheric pressure could rise in future in the Mediterranean, causing a drop of 2 cm by 2100, or -0.2 mm/year on average.