Human Ecology embraces the principles of natural and moral philosophy.

It draws on knowledge and understanding from the sciences and humanities, to develop and promote holistic, integrative, sustainable initiatives, ideas and development projects to enhance and strengthen people’s relationships with each other and the natural and built environment on which they depend.

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## CONTENTS

### Water

<table>
<thead>
<tr>
<th>Section</th>
<th>Author(s)</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>1. Global water: future challenges</td>
<td>Ian Douglas</td>
<td>4</td>
</tr>
<tr>
<td>2. The Water Cycle</td>
<td>Ian Douglas &amp; Eva Ekehorn</td>
<td>8</td>
</tr>
<tr>
<td>3. Household and community measures to augment water security and sanitation provision</td>
<td>Ian Douglas</td>
<td>10</td>
</tr>
<tr>
<td>4. Fighting Over the Last Drop? A Critique of the ‘Water Wars Thesis’</td>
<td>Peter Hough</td>
<td>15</td>
</tr>
<tr>
<td>5. Re-evaluating Land Use Options in Malaysia for Reducing Flood Risk</td>
<td>Zulkifli Yusop</td>
<td>17</td>
</tr>
<tr>
<td>6. Oceans</td>
<td>Eva Ekehorn</td>
<td>20</td>
</tr>
<tr>
<td>7. Book Reviews</td>
<td></td>
<td>28</td>
</tr>
<tr>
<td>8. Water Websites</td>
<td></td>
<td>32</td>
</tr>
</tbody>
</table>

Membership form
Introduction: Water: the key to life and civilisation

All living things need water. Human societies have developed by skilfully managing water, by collecting it, storing it, cleaning it and disposing of dirty waste water. From harvesting rainwater, to wells and springs, diversion of rivers and the construction of reservoirs and tanks, ancient civilizations found ways of increasing crop yields, ensuring health and cleanliness, draining wastewater out of cities and providing enough to drink in dry seasons. Yet despite millennia of understanding, many people today still lack access to reliable water supplies and adequate sanitation. Many cities do not have piped water available throughout the day. Many of our rivers are over-used as carriers of waste matter and much water drawn from wells is seriously contaminated. The rivers carry great volumes of waste to the oceans, affecting all aspects of marine life, including the fish that are part of the human diet. With the arrival of the new United Nations sustainable development goals, whose targets include achieving universal and equitable access to safe and affordable drinking water for all by 2030, it is timely to take a look at some key water issues in the Commonwealth.

This issue of Human Ecology concentrates on problems of water supply, use and disposal. It begins with a discussion of the future challenges facing all people, from decision makers to families, in ensuring adequate water for growing urban and rural communities. While we have the technology and skills to deliver adequate water everywhere, we are not always capable of organizing societies to do that. Perhaps this is in part because we do not always think about the ways in which all aspects of water use and waste water disposal are interconnected, even though most of us should have been taught about the water cycle in geography and science lessons at school. Just in case we have forgotten, there is a brief summary of the processes and linkages involved in the second article.

The Commonwealth is full of innovative and effective ways of ensuring adequate water supplies, from small village-level schemes to highly technical ways of combining desalination with microfiltration of waste water and supplies delivered from surface water reservoirs to sustain drinking water supplies for advanced urban communities. Ian Douglas explores some of the most successful schemes and ways in which city dwellers sometimes use multiple water sources to meet their needs. Using major rivers or groundwater aquifers that are crossed by international boundaries often gives rise to conflicts, most of which are resolved by having international agreements on the quantity and quality of water to be supplied from upstream to downstream states. However, water wars have occurred in the past: as when pastoralists move into farming areas during droughts. Peter Hough examines the extent to which water wars have occurred in recent times and the prospects for the future.

It is important to remember that the way we use the land affects our water supplies. Even changing one type of tree crop for another alters river flows and water quality. Zulkifli Yusop explores the impact of replacing tropical rainforest with oil palm plantations in Malaysia and suggests that rubber plantations might have greater benefits in some instances, including reduction of pollution and flood risks.

Finally Eva Ekehorn shows the complex issues of contamination of the world’s oceans, from the impacts of waste plastic to unscrupulous fishing techniques. Even aquaculture based in coastal lagoons and inland lakes and ponds is damaging ocean fish stocks and food chains through the excessive removal of krill used as food for farmed salmon and sea bream. The inter-connections between our daily lives, our eating habits and our excessive waste discharges have extensive impacts on our human ecological relationships with each other and with our environment.
1. Global water: future challenges
Ian Douglas, Trustee CHEC

Although the Millennium Development Goal of 90% of people having access to improved water supplies was largely met by 2015, many experts claim that still some 748 million people do not yet use an improved source of drinking water. ‘Improved water sources’ are defined as household connections, public standpipes, boreholes, protected wells, protected springs and collected rainwater. Far more seriously, the target for access to sanitation has not been reached. 2.5 billion people do not use an improved sanitation facility and one billion people still practice open defecation. Even among those with access to improved water supplies about 1.8 billion people drink water contaminated with Escherichia coli, an indicator of fecal contamination. Many of these people are relying on wells and boreholes tapping water from shallow aquifers that are easily contaminated.

Despite this progress in increasing access to drinking water and sanitation, the severity of water problems is likely to grow in the coming decades. Global water demand is largely influenced by population growth, urbanization, food and energy security policies, and macro-economic processes such as trade globalisation, changing diets and increasing consumption all affect global water demands. By 2050, these demands will grow to 55% more than present global water use, as manufacturing, thermal electricity generation and domestic uses expand (Fig. 1). Assuming nothing is done to alter greenhouse gas emissions, by 2030, the world is projected to face a 40% global water deficit. Increasingly people are identifying countries experiencing the greatest water stress from the main influences on future water availability. Such studies reveal the high stresses on many cities in the Middle East and in the SW of the USA and adjacent parts of Mexico.

Competing demands lead to difficulties in deciding how to allocate water supplies between competing uses, particularly those for food production and those for energy. This energy-water-food nexus is a major challenge for all energy, water and food planners and policy-makers. Decisions about future water supplies, future power stations, and agricultural development are made independently of each other. Yet, 70% of our water supplies are used for agriculture. Nearly 13% of energy consumption is for pumping, cleaning, delivering, heating, chilling and disposing of our water. Energy raw materials, such as natural gas and oil are used in producing the fertilizers, pesticides, and farm vehicle fuels needed by food growers. In future, expanding demands for water for electricity generation and manufacturing may lead to increased competition for scarce water resources. The desalinated water used to supply urban areas and grow crops in presently oil-rich arid regions uses far more energy per litre than other water sources. Thus future planning really does require integrated thinking among government departments and utility companies about managing water alongside food security and energy supplies.

United Nations organizations, such as the Food and Agriculture Organization and UN Water, have emphasized the importance of this energy-water-food nexus (Fig. 2). Many governments, however, have yet to establish effective mechanisms for integrated planning and management of these vital resources.

![Predicted growth in global water demand 2000 to 2030](image)

*Based on data in the World Water Report*
The competition for water – between water ‘uses’ and water ‘users’ – may provoke localized conflicts and continuing inequities in access to services, with significant impacts on local economies and human well-being. In many situations water is not used carefully, particularly when large-scale irrigation and power generation projects pay little for each unit of water used. This frequently means that more water is pumped out of rivers or aquifers than is actually required to support the plant growth or cooling needed. Such over-abstraction is often the result of out-dated concepts and patterns of natural resource use and governance, where the use of resources for economic growth is under-regulated and poorly policed. Currently some 20% of the world’s groundwater aquifers are over-exploited. Surface water resources in rivers and lakes are often deteriorating in both volume and quantity through the impacts of unabated urbanisation, inappropriate agricultural practices, deforestation and pollution.

Persistent poverty, inequitable access to water supply and sanitation services, inadequate financing, and deficient information about the state of water resources, their use and management impose further constraints on water resources management and its ability to help achieve sustainable development objectives. Lack of water supply, sanitation and hygiene takes a huge toll on health and well-being and comes at a large financial cost, including a sizable loss of economic activity. Investments in water and sanitation services result in substantial economic gains; in developing regions the return on investment has been estimated at US$5 to US$28 per dollar. Approximately US$5 billion a year (less than one tenth of the US annual defence budget and about the same as the annual defence budgets of India and the UK) over a five-year period would be needed to achieve universal coverage – a small sum given this represents less than 0.1% of the 2010 global GDP.

Women and youth are disproportionately impacted both by water scarcity and the lack of safe drinking water, increasing the vulnerability associated with persistent poverty. Water policies often lack gender perspectives and local knowledge thereby allowing gender inequities to persist, and preventing the adoption of innovative solutions suggested by women. For example, one suggestion indicated that cutting just 15 minutes off the walking time to a water source could reduce under-five child mortality by 11% and the prevalence of nutrition-depleting diarrhoea by 41%. In Ghana, a 15-minute reduction in water collection time increased girls’ school attendance from 8% to 12%. A Bangladesh school sanitation project that provided separate facilities for boys and girls boosted girls’ school attendance by an annual average of 11%

Progress can be made when there is sufficient political will. When apartheid ended, the Government of South Africa prioritized the provision of basic services including, water supply, sanitation and energy services. Ambitious targets were set within a policy framework that included ‘free basic water’ and ‘free basic sanitation’ for households with resources below the social grant amount (approximately US$1 per day). In 2012, 3.47 million and 1.84 million people benefitted from free services for water and sanitation respectively.

The Water and Sanitation Program (WSP), administered by the World Bank since the late 1970s, is one of many projects funded by donor governments to support poor people in obtaining affordable, safe and sustainable access to water and sanitation services. On the international NGO front, WaterAid, which works in 16 Commonwealth countries in Africa, Asia and the Pacific, has funded numerous projects and has been the leading voice in international civil society on policy matters regarding water and sanitation.

The Commonwealth Situation

About 360 million Commonwealth citizens do not have access to clean water. In at least 16 Commonwealth countries, fewer than 90% of the people have access to clean water. Access to adequate sanitation facilities is available to less than 90% of the population in 22 Commonwealth countries. In many developing Commonwealth member states water and sanitation service networks will often exist only in urban areas and the quality of the services themselves is at times, inadequate.

In most Commonwealth countries water is delivered to households and businesses by local government or municipally-owned companies and sourced from nationally or locally owned reservoirs. Because water services are seen as an essential public service and basic right, privatisation is often a contentious issue. The UK is the only Commonwealth country in which water and sewerage operations are fully privatised. Privatisation has only been partially successful in other developed member states where it continues to face strong opposition. In most developing member states privatisation has been largely unsuccessful even in liberalised environments. Many Commonwealth urban water supply systems are inadequate and fail to deliver running water to all consumers 24 hours per day. Several face extreme stress (Table 1).
In Sierra Leone in 2010, approximately 55% of people used an improved drinking water source and 13% had access to adequate sanitation facilities. Such poor access to water and sanitation contributed to the country having the highest infant mortality in the Commonwealth, with 127 infants dying for every 1,000 live births. The lowest infant mortality rate is found in Singapore with only two deaths for every 1,000 live births. Singapore has an excellent sewerage system and all water is treated. The water supply uses river water from neighbouring Malaysia and from reservoirs on Singapore island (Fig. 3) as well as water from desalination plants and wastewater recycling operations. The desalination and recycling enterprises are run by public–private partnerships involving design-build-own-operate (DBOO) mechanisms.

Water and sanitation problems remain severe in India. Many piped urban supply networks using upstream reservoirs have expanded little since 1985 despite great increases in the urban population. No major city in India is known to have a continuous water supply; supplies in some suburbs may only be available for a few hours per day. Sewerage and sanitation systems are even less reliable, 72% of Indians still lack access to improved sanitation facilities. Providing private excreta disposal would be expected to reduce diarrhoea by 42% while eliminating excreta around the house would lead to a 30% reduction in diarrhoea. India still loses up to 500,000 children per year due to diarrhoea.

Since the year 2000 in India, the idea that water management is the exclusive responsibility of government or water utilities has given way to a paradigm involving participatory local management of the resource. Cities have begun to promote decentralized management policies to improve aquifer recharge, such as rooftop rainwater harvesting by individual households, commercial establishments and institutions. Unfortunately, while regulations to promote such activities have been formulated, the support for implementation frequently has been limited to information dissemination rather than enforcement. The future for many cities in India, and their counterparts in other developing Commonwealth countries, may lie in planning in the short term to rely on a combination of high cost high quality continuous piped supply and for low cost decentralized self-supply by individual households and institutions.

In recent decades water demands in many African countries have increased rapidly. In Nigeria where the population is growing rapidly, per capita annual water withdrawals increased from 33 m$^3$ per person in 1995 to 108 m$^3$ per person in 2005. The bulk of this increase in most countries is from irrigated agriculture—primarily in India and sub-Saharan Africa, which will create the bulk of the additional demand to 2030.
Table 1  Commonwealth cites in extreme water stress. The named cites were among the cities listed in the ten most stressed in each category in a study by Jeanerette and Larsen (2006) published in Global and Planetary Change, Vol. 50.

<table>
<thead>
<tr>
<th>Largest urban footprint 2000 (km²) (measures cost associated with gaining supplies)</th>
<th>Most sensitive to climate change</th>
<th>Most sensitive to per capita change in water demand</th>
<th>Most sensitive to projected population change (growth from 2005 to 2015)</th>
<th>Most sensitive to leaving water instream for other ecological uses</th>
<th>Most sensitive to combined scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karachi, Pakistan</td>
<td>Johannesburg, South Africa</td>
<td>Rajkot, India</td>
<td>Rajkot, India</td>
<td>Rajkot, India</td>
<td>Cape Town, South Africa</td>
</tr>
<tr>
<td>Rajkot, India</td>
<td>Freetown, Sierra Leone</td>
<td>Benin City, Nigeria</td>
<td>Johannesburg, South Africa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>East Rand, South Africa</td>
<td>Chittagong, Bangladesh</td>
<td>Douala, Cameroon</td>
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<td>Surat, India</td>
<td>Lagos, Nigeria</td>
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In India, projected annual agricultural water withdrawals per capita for 2030 are almost 800 m³, while in sub-Saharan Africa they average 323 m³, but in South Africa they will be only 150 m³. Irrigated crops mainly responsible for the withdrawals include rice and wheat in India and maize, sorghum, and millet in Sub-Saharan Africa. Many other Commonwealth countries increased their irrigation withdrawals significantly between 1995 and 2005 for example by 24% in Tanzania and by 10% on Bangladesh.

By 2030, the total demand for water in India will grow to almost 1.5 trillion m³, driven by domestic demand for rice, wheat, and sugar for a growing population, a large proportion of which is moving toward a middle-class diet. However, India’s current annual water supply is approximately 740 billion m³. Thus most of India’s river basins could face a severe deficit by 2030 unless concerted action is taken, with some of the most populous basins—including the Ganga, the Krishna, and the Indian portion of the Indus—facing the biggest absolute gap between water supply and demand.

Total demand in South Africa in 2030 is predicted to be 17.7 billion m³ in 2030, 34% of which is household demand. However, the current supply in South Africa, of 15 billion m³, is already severely constrained by low rainfall, limited underground aquifers, and considerable reliance on water transfers from neighbouring countries. South Africa faces making tough trade-offs between agriculture, key industrial activities such as mining and power generation, and the needs of large, rapidly growing urban centres. To this forecast, based on assumptions from present-day climatic conditions, have to be added possible impacts of climatic change. For example, an ‘average’ projection of climate change for South Africa by 2030 suggests a slight decrease in supply, but a more pronounced increase in crop demand that would increase the gap between supply and demand by 30%. Cost-effective measures could improve the efficiency of water supply, agricultural efficiency and productivity improvements. In addition efforts to conserve water in domestic and industrial situations would be able to reduce the supply and demand gap and make cost savings.

The challenge of future water involves new technologies, respect for traditional water users, anticipating climate change, acting both locally and globally, reducing waste of water through leakage and over-irrigation, ensuring that water and sanitation are extended to those still without access and a wide community understanding of water as a finite resource, than can be re-used with care and should always be protected from contamination and pollution. In acting to manage the water, energy, food nexus governments need to promote integrated management of not only the water itself, but also its involvement in energy and food production. We have much of the knowledge and technology required, we need the will and common sense to apply it effectively and fairly.
About 360 million Commonwealth citizens do not have access to clean water. In at least 16 Commonwealth countries, fewer than 90% of the people have access to clean water. Access to adequate sanitation facilities is available to less than 90% of the population in 22 Commonwealth countries. In many developing Commonwealth member states water and sanitation service networks will often exist only in urban areas and the quality of the services themselves is at times, inadequate.

2. The Water Cycle
Ian Douglas & Eva Ekehorn, Trustees CHEC

Life without water is impossible.
All known forms of life depend on water.

The water cycle, or the hydrological cycle (Fig. 1), describes the continuous movement of water in all its forms: vapour, liquid and ice, around the earth in the lower atmosphere. The basic cycle of water begins with the heat from the sun causing water to evaporate from oceans and lakes and to be transpired by plants. The transpiration from plants can be seen as the plant breathing. As plants open their pores to take in carbon dioxide for photosynthesis, water vapour is released, cooling the plant. The movement of that vapour in the atmosphere may produce clouds, which in turn, depending on temperature and air movement may develop precipitation in the form of rain, snow or hail. The rain or snowmelt water takes pathways into the soil or over the land surface into rivers, joining the surface flows from the land and draining into lakes or oceans whence the cycle continues by evaporation of the water back to atmosphere. The cycle is continuous, but any molecule may take just hours to years to move from one part of the cycle to another. Much groundwater, such as that under the Sahara desert, is thousands of years old.

Adding or subtracting heat makes the cycle work. If heat is added to ice, it melts. If heat is added to water, it evaporates. Evaporation turns liquid water into water vapour. If heat is taken away from water vapour, it condenses. Condensation turns water vapour into a liquid. If heat is taken away from liquid water, it freezes to become ice.

Human influence on the water cycle

In agriculture, humans divert the water cycle for the special purpose to growing crops for food and other plants such as cotton. While many crops are grown using just the rain that falls on to the fields, much cultivation depends on artificial watering, whether to grow vegetables or flowers in an urban garden or allotment, or to large scale production of rice or wheat for trade (Fig. 3). Irrigation may simply involve abstraction of water from a nearby river or diversion of water flowing from a spring (Fig. 2). Often it involves water stored in a distant reservoir and released into rivers or channels under strict rules (Fig. 3 &4). Elsewhere water may be pumped from underground aquifers, many of which hold water accumulated in different climatic conditions thousands of years ago. In many cases the pumping lowers the groundwater table, often causing
competition between people with shallow wells and those who can afford to sink ever deeper boreholes.

Fig. 2 The hydrological cycle in an agriculture area using both surface and groundwater

The drinking water for many people around the world comes from rivers into which has flowed water from rain that has entered streams that form the channel network of a rivers catchment area. Some of the rain falling over the catchment area sinks into the ground and enters the groundwater aquifer. This groundwater can provide a source of drinking water, accessed by building wells or be drilling boreholes to reach water a greater depths. Water is channelled from these sources to provide water supplies for human settlements from farms and small villages to sprawling megacities (Fig. 5). Water is pumped from dams through pipes to water filtration plants and reservoirs, whence a network of water mains and supply pipes carries it to individual homes, schools and businesses.

Many people collect rainwater from their roofs to use to augment any piped water supplies. Some rain water runs off into storm drains, local streams and creeks and thence reaches rivers. Most rivers eventually flow into oceans. Oceans are also becoming a source of drinking water for many people around the world by using a water treatment process called desalination. Desalination is a way of turning salty ocean water into drinking water.

Another source of water is recycled water which is made by treating (cleaning) wastewater in a wastewater treatment plant or water recycling plant. This water can have many uses and is an important water source. Increasingly such water is being used to irrigate parks and gardens. In some cities the waste water purification process is so effective that the recycled water is safely added to the drinking water supply. The structures that store water, the pipes that move water, and the raw and waste water works that clean and treat water are all part of the urban water cycle.

Fig. 3 Rice terraces, Banaue, Philippines (photo: Eva Ekehorn)
Fig. 3. The Lake Argyle Reservoir in northern Western Australia holds water from the Ord River to supply irrigated farmland nearer the coast.

Fig. 4. Irrigated farmland of the Ord River irrigation area in northern Western Australia

(Photos: Maureen Douglas)

Fig. 3. The urban water cycle
In the 1940s this writer’s grandparents lived in a cottage in a village in Oxfordshire, England where they had two water supplies, one a well sunk into the chalk below the cottage with a hand pump and the other a rainwater tank. Their sanitation was an outside bucket latrine which grandfather emptied into a pit 50 m away at the end of his long garden. The soft water from the rainwater tank was used for washing; the hard water (due to the calcium dissolved from the chalk) was used for all other purposes.

Rural villages like this one now have piped water supplies and have been connected to sewerage systems. However, many people in rural areas of the UK, Australia and Canada, still rely on rainwater collection and wells for their water and have septic tanks systems for their sanitation. In European Union countries, including the Commonwealth countries of Cyprus, Malta and the UK, drinking water and waste water standards set by EU directives have led to vast improvements in water supplies and waste water collection and treatment since 1965.

Malaysian rural water supplies

Progress in water and sanitation has also been good in many other parts of the Commonwealth. Most rural areas of Malaysia, save for remote areas in the Borneo states, now have safe water supplies. Even some longhouses in the rainforests of Sarawak have been provided with specially designed small-scale drinking water treatment facilities (Fig. 1).

![A packaged water treatment plant of the type being supplied to longhouses in Sarawak (Photo from Aquakimia).](image)

This type of river water treatment project, as installed at the Tuai Rumah Muna Enemang Longhouse in Sarawak, shows that engineered solutions to water supply problems in rural areas need not be prohibitively expensive. This project was entirely self-funded by local residents without outside financial assistance, with affordable family contributions of around US$ 1.50 per month. However, the local residents’ traditional attitude to conserving water means that on average they use less than 20 litres per day per person. This compares to the residents of Malaysia’s capital, Kuala Lumpur, where the daily water consumption per capita is more than 350 litres.

Adequate river water is not available at all rural settlements in Sarawak. Many coastal settlements near the mouths of big rivers and on sandy beach ridges have only shallow lenses beneath the houses from which water can be obtained using shallow wells. To make such water supplies more secure, Sarawak’s scientists and engineers designed a form of horizontal well, using a buried perforated pipe laid parallel to the ground surface in a trench about two metres deep (Fig. 2). This enhanced the flow into the well, enabling more water to be drawn from it and reducing the risk of the water level in the well dropping below the level of the pump.

In other places in rural Sarawak, village water supplies have been enhanced by rainwater harvesting. In addition to householders collecting water from the roofs of their own house, rain falling on the Balai Raya (village hall) as collected in a large tank which was kept as an emergency supply in the event of drought. Despite many parts of Sarawak having an average a rainfall of over 5000 mm per year, long dry spells do occur, especially during El Nino events, such as those of 1992 and 2015. At such times permission is given to take water from the Balai Raya tank. Another government scheme in Sarawak in the 1990s set out to provide each eligible village household in areas without a good piped water source with two rain water tanks (with a combined capacity of 1635 litres), each with a gutter, inlet sieve, down-pipe and outlet taps. Not all villages had a full complement of tanks installed. Of those supplies only about 35% were installed correctly of a hardwood stand with gutter, downpipe, inlet screen and outlet tap. However, such an approach to support reliable household level access to water has greatly helped to improve the health of villagers.

Elsewhere in Malaysian Borneo, examples of using rainwater harvesting to augment urban supplies
occur. In Sandakan, Sabah, people adopted the rainwater harvesting approach after 1984 because the flow of treated water from the State Water Board’s plant became inadequate with water rationing being imposed. In other parts of the Commonwealth, rainwater harvesting is commonplace. Around many Australian country towns, people live in houses on one hectare plots of land, beyond the limits of piped town supplies. The water from the roof is collected and stored in a large underground tank of 20,000 to 50,000 litres capacity, depending on mean annual rainfall and anticipated daily consumption of water. In extremely dry periods, people may have to buy water from the town supply and have brought to the property by tanker.

Fig. 2 The site of the horizontal well, indicated by the line of concrete well heads in the centre of the picture, at Kampong Loba, Sarawak (Photos: Ian Douglas)

**Rainwater harvesting around the Commonwealth**

Droughts in Australia since 2000 have led state agencies to encourage city dwellers to install small rainwater tanks to reduce use of water from the town supply for non-drinking purposes. Increasingly new homes and business and industrial premises are being fitted with rainwater harvesting facilities to reduce the need to use high quality drinking water for activities such as flushing toilets, washing cars and watering gardens.

In some villages of eastern Rajasthan, India, rainwater harvesting structures, called johads, comprising a low wall made from mud, or cement are used to collect water. The check dam is located in the flow of monsoon runoff to hold back pools of rainwater and allow it to infiltrate into the soil and so recharge local shallow aquifers, increasing the groundwater available during future dry periods. Tarun Bharat Sangh (TBS), a leading rainwater harvesting organization in India, has been revitalizing johads in eastern Rajasthan for over 20 years. TBS organises villagers to construct, and use harvested rainwater structures, but does not decide who will donate the labour, and how much each household should contribute. Like many other NGOs in India, TBS focuses on community-initiated development, requires full participation in decision-making by women, and seeks a return to indigenous technologies, believing that community ownership of any water resource scheme is preferable to reliance on water supplied by a private company.

Rainwater harvesting is integrated with use of shallow ground water in many small island states. Across the islands of Kiribati, in the Pacific Ocean, most households extract groundwater through private wells and on South Tarawa households also have access to a piped water system which uses shallow groundwater from two freshwater lenses in highly permeable sands 2 to 5 metres below the ground surface. The sustainable yield of the lens on South Tarawa of approximately 54 litres per person per day (l/p/d) can meet the non-potable needs of householders. The sustainable yields in excess of 100 l/p/d in the less densely populated outer islands can meet provide all householder water requirements. As sea levels rise sea water will penetrate further in the freshwater lenses, reducing the amount of good quality drinking water under the ground.

During droughts on the outer islands households also use standby wells located away from the coast in bushland areas. They also obtain rainwater from churches or neighbours with tin roofs. On South Tarawa, households switch from using the piped water supply which is rationed during droughts to using private wells, getting rainwater from neighbours or churches and purchasing water from the water utility’s tanker service provided by the water utility. Nevertheless, some are likely to use possibly contaminated well water to meet potable needs. This existing adaption through using multiple water sources will become more intense with sea level rise and climate change.
Water supplies in large cities

Adaptation of a different form is found in many mega-cities of the Commonwealth. For example, many large Indian cities, including Delhi, Mumbai and Chennai, already rely in part on inter-basin water transfers. Such strategies involve reconciling the needs of different communities, but increasingly those of rapidly growing industrial cities outweigh those of poor rural areas. At the building level, legislation requiring all properties above a certain size to harvest rain water has been passed in Banglalore, Ahmedabad, Chennai, New Delhi, Kanpur, Hyderabad and Mumbai. The Bangalore legislation requires every new house to have a rainwater harvesting system in order to get a drinking water connection. The rainwater is used to recharge boreholes, to recharge groundwater by infiltration, or for flushing toilets, watering gardens or washing cars. However, in Delhi, so much groundwater was being abstracted privately, to overcome issues with both quality and quantity of municipal supply, that boring tube wells was practically banned by the Delhi Jal Board, the body that gives borehole approvals. Local private water selling is widespread in India, as elsewhere in Asia, Africa and Latin America. In poor cities that suffer from both water quality and water delivery issues, a two tiered system often develops, where richer residents can afford to buy clean water from private vendors while poor residents either endeavour to clean polluted surface water or buy “pure” water in plastic bottles or sachets to drink at a high price from local vendors. In Onitsha (Nigeria), the poor might be spending 18% of their income on water during the dry season. Poor people who buy sachets of water from local vendors face the risk that it may be of poor quality, cholera outbreaks often being linked to such water. Most households increase storage, with tanks for the middle class and plastic bottles, jerry cans, or stone jars for poorer households but health risks may arise from contamination of water during household storage.

Providing water for the rural poor in African and Asian Commonwealth countries

Appropriate technology is being applied by many rural people in partnership with NGOs and government agencies to provide community based water supplies. Water is provided through three main methods:

- Wells, dug by hand, are a common way of accessing water - but the supply can be unreliable and sometimes the well itself can be a source of disease.
- Gravity-fed schemes are used where there is a spring on a hillside. The water can be piped from the spring down to the villages.
- Boreholes can require more equipment to dig, but can be dug quickly and usually safely. They require a hand or diesel pump to bring the water to the surface.

In addition to locating new sources of water, some strategies help to reduce the need for water. These include:

- rainwater harvesting
- using waste water to irrigate crops
- improving irrigation techniques
- growing crops which need less water
- minimising the loss of water by evaporation

Work of this type is widely carried out by WaterAid, a UK-based charity. In the Chittagong Hill Tracts of Bangladesh, the one hilly area of predominantly low-lying country, WaterAid and local partners help villagers to construct gravity flow water schemes. These tap water at sources in the hills and pipe it to villages below. This has drastically saved time for women who might have spent 30 to 40 minutes carrying water several times a day and has also reduced the incidence of water-related diseases. In low-lying areas of the country prone to monsoon flooding, WaterAid is helping communities to construct water and sanitation facilities that are more resilient to disasters and the impacts of climate change.

In Africa, WaterAid has worked both with national level partners and with local communities. In Rwanda, it works closely with the government to ensure water, sanitation and hygiene stay on the agenda and plans are carried out in an effective, integrated way. It has developed schemes to map water sources and monitor water flows and usage to improve the efficiency of water management across the nation. At the local level, WaterAid supports local partners in using low-cost and sustainable technologies to help
community schemes to provide life-changing safe water and toilets. In Ghana, community-led solutions and systems are put in place to help empower local communities and people so that they can help themselves to take the first steps out of poverty.

Many other international and local NGOs are carrying out similar work. One important aspect has been to encourage and enable women, the fetchers and carriers of water in most societies, to play a key role in decision making. CHEC, with financial support from the Commonwealth Foundation, has facilitated a series of workshops in East Africa on gender-mainstreaming in integrated water resources development (Fig. 4). These have involved the training of trainers who have returned to their communities or agencies with new ideas on participatory decision-making and involving the whole community in improving water use and management.

Much good work has been done to improve access to water in the Commonwealth. Progress has been made with sanitation. However, while people still have to walk for twenty minutes to get water from a muddy river or still have to defecate in the open, much still remains to be done

Fig. 3 Participants at a CHEC-CIANEA sponsored gender-mainstreaming workshop sponsored by Commonwealth Foundation in Kampala Uganda in 2010 (Photo courtesy Patricia Kabatabazi)
4. **Fighting Over the Last Drop? A Critique of the ‘Water Wars Thesis’**

*Dr Peter Hough, Middlesex University*

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**Much has been written about the risk that climate change might lead to heightened competition for water, especially along international rivers. However major agreements to share and manage international water supplies co-operatively continue to be struck.**

**This risk of water wars may not be as great as some scientists and politicians suggest.**

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**The water wars hypothesis**

Towards the end of the domination of international relations by the Cold War in the late 1980s, many scholars began to suggest that future insecurity might be more about resources than ideology. Before he became UN Secretary-General, the Egyptian politician Boutros-Ghali said in 1985 that ‘The next war in the Middle East will be fought over water, not politics’. Shortly after this, the Canadian Homer-Dixon claimed that Environmental scarcities are already contributing to violent conflicts in many parts of the world. These conflicts are probably the early signs of an upsurge of violence in the coming decades that will be induced or aggravated by scarcity.

Homer-Dixon identified two phenomena, emerging from changes in the three factors - the supply of resources; the demand for resources; and changes in the distribution of resources - as the key links between environmental scarcity and social unrest: ‘resource capture’ and ‘ecological marginalization’. Resource capture occurs when elites within a state respond to falls in supply or rises in demand by appropriating more resources for themselves and leave the poorer sections of society to bear the brunt of scarcity. Ecological marginalisation is said to occur when population growth and / or changes in access to resources for certain groups produce migrations that cause the over-exploitation of resources in certain areas.

Many others have linked resource, food and water scarcity with war and a subsequent strand of the resource war literature has emerged specifically in relation to climate change. For example, one study claimed that the civil war in Sudan - most notably in Darfur- which had flared up in parallel with the onset of extreme droughts – arose because ‘when crops fail, people may take up a gun simply to make a living’.

The US and the UK governments paid attention to these arguments, including setting up strategic assessments of the likelihood of conflicts over resources creating insurgency and international instability. Nevertheless, despite its influence on the thinking of some governments and academia, this vision of environmental scarcity as a military security matter has been criticized. People suggested many examples of conflicts over water such as that over the Senegal River that were more about ethnic and class conflict than access to river water.

Water wars are not a novel phenomenon. The great historian of water use, Gleick points out that such conflicts actually go back 5,000 years and lists a number of them including an ancient ‘dambuster’ raid by Alexander the Great of Greece against Persia between 355 and 323 BC. Access to resources has always been a source of conflict since ‘who gets what’ is the fundament of political contention but there is no obvious correlation between scarcity and war to be mapped out over time.

**Water wars scepticism**

The central assumption that changes in the balance between resources and people create political problems is viewed as flawed logic by resource war sceptics. It is easy to link droughts in Sudan to the Darfur Crisis but such events are unfortunate facts of life in the Sahel and the responsibility for the bloodshed lies squarely with the Janjaweed insurgents and the Sudanese government for giving a green light to their murderous campaigns.

Despite a spate of publications warning of the likelihood of conflicts fought to secure freshwater supplies, particularly in the arid and volatile Middle East, no war of this kind was fought in the twentieth century and it has played little part in Arab-Israeli hostilities. Historical data reveal that in the period 1950 to 2000, of the 1831 international political interactions over water, none had produced war and only 507 instigated a dispute (two thirds of these disputes were purely verbal and only 37 had any armed dimension). In contrast 1228 of those international water interactions produced cooperative responses including 157 treaties. There is no evidence that fighting over depleting resources is in any way a
distinguishing feature of the contemporary world. Indeed, scarcity may even be a source of greater peace by giving a spur to more cautious and cooperative diplomacy.

Several examples of peaceful sharing of international river waters exist. The Helmand River Agreement of 1973 occurred when Iran gave trade concessions to the Afghan government in order to guarantee water supplies. Relations between Syria and Turkey improved rather than deteriorated after a diplomatic dispute over the effects of the latter’s South Eastern Anatolian damming project on the Euphrates in the late 1980s, culminating in a 1987 bilateral accord guaranteeing downstream Syria a specified share of water. Syrian concerns on this issue were channelled through the European Union and the World Bank instead of ratcheting up the stakes vis à vis Ankara and this multilateralism worked in their favour given the Turk’s western orientation. In 1989 a reassured Syria then struck a similar deal of their own with their downstream riparian neighbouring state, Iraq, over the Euphrates.

Conclusions

Securing access to water is becoming more critical with parts of the world experiencing dwindling supplies of this most precious of commodities. It does not follow from this, though, that the people most affected will be forced to fight over it. Responsible management and cooperation is a more rational and fruitful political response to scarcity than conflict. Democratization and interdependence leaves room for optimism that we are not entering an era of water wars. Democracies are forced to confront resource allocation questions as a matter of course and, increasingly, act on environmental degradation even if no obvious human side-effect is apparent. In addition, democracies (and some non-democracies) long ago came to the conclusion that resources are more easily secured through trade and common management than conflict. There is a compelling pessimistic logic to the water wars thesis but it does not stand up to much academic scrutiny. Equally, though, it could be dangerous to entirely dismiss the possibility that the thesis could come to have some relevance in the future on the basis that it is not yet supported by evidence. Resource allocation is fundamental in all politics, with desperation or bloody-mindedness sometimes being expressed through political violence. It would be foolish to entirely dismiss the possibility that increased water scarcity due to global warming could yet see the resource wars scenario become a reality. However, there is much scope for optimism that common resources can be managed amicably by most states in the present state system.

5. Re-evaluating Land Use Options in Malaysia for Reducing Flood Risk
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Since 1965, Malaysia’s landscape has become dominated by tropical rainforest, oil palm (*Elaeis guineensis*) and rubber (*Hevea brasiliensis*). Large scale conversion of forest took place mainly after independence in 1963 for the establishment of rubber and oil palm plantations\(^1\). However, the success of the rubber industry peaked around the 1970s. Rubber’s share of the Malaysian Gross Domestic Product (GDP) steadily declined as Malaysia shifted economic activities towards services and manufacturing. Yet in the following decades the GDP contribution from the palm oil industry increased, prompting the government to encourage plantation estate companies and smallholders to replace rubber trees with oil palm. Malaysia’s second Industrial Master Plan (1996-2005) urged Malaysian firms to develop and produce more value-added downstream products. This initiative was so successful for the palm oil industry that the demand for crude palm oil nationally exceeded the supply. This led in turn to the expansion of oil palm plantations in Sabah and Sarawak. By 2013, there were only 1.1 million hectares (ha) of rubber left compared to 5.2 million ha of oil palm.

The palm oil and rubber industries have significantly altered the landscape of the country. Within four decades, the forested area had been reduced from 60% to about 45% of the total land area of Peninsular Malaysia (13.16 million ha) whereas areas planted with oil palm increased from 2% to 19.2% by year 2010 (see Figure 1). On the other hand, areas planted with rubber declined from 13% to 5.6% over the same period. In Sarawak and Sabah, large areas of rainforest were cleared for new oil palm plantations\(^2\).

The creation of plantation ecosystems may lead to adverse hydrological and environmental impacts especially during the initial stage of land clearing of forests and the replanting of old trees. Replanting to replace less productive old trees is necessary every 25 to 30 years. In tree removal operations, it is important to minimize damage to the remaining trees by using directional felling and minimizing ground disturbance.

How does land cover affect flooding?
Severe floods hit three states in the east coast of Peninsular Malaysia in December 2014. This raised concern as to whether present land management policies and practices were supporting sustainable development within the affected river basins effectively. The huge floods both rose quickly and also carried unusually high loadings of sediment. Although, the main cause of these floods was extreme and prolonged rainfall, the flood impacts could have been reduced if the best forestry and plantation activities management practices had been fully implemented.

Forests play an important role in regulating flow and in reducing flood risk. However, many

Fig. 1 The contrast between rainforest in the foreground and the regular lines of the oil palm plantation on the other side of the Segama River near Lahad Datu in Eastern Sabah, Malaysia (Photo: Ian Douglas)
scientists claim that the role of forests in this regard is often over-emphasised and that more attention should be paid to other factors such as high rainfall intensity, and the spatial extent and duration of storms\(^3\). Two key arguments are put forward: 1) for large storms (of over 100mm rainfall in a few hours) that cause floods the difference in interception loss (the amount of water held up by the foliage of plants) between forest and non-forest vegetation is not likely to exceed a few percent of rainfall and therefore is not likely to be a significant factor, and 2) forest removal is often but not always associated with a reduction in soil infiltration rates (the speed with which rainwater soaks into the soil). When forest logging is followed by secondary growth the landscape may rapidly return to the way it functioned hydrologically before logging\(^4\).

Although enhancement in catchment response to rainfall following forest removal is expected due to increase in soil moisture, most of the larger increases are associated with small to medium storms that do not produce floods. Typically large storms over disturbed or logged tropical forest catchments catchment only increase soil moisture by about 10%. Thus as storm sizes increase, soil factors often become more significant than vegetation cover in controlling stormflow\(^1\).

Floods usually occur when there is too much rain in too short a period, especially when it coincides with the end of rainy season where soils have already been wetted up by preceding storms. Maintaining infiltration opportunities by minimizing compaction during forest harvesting might be able to reduce floods associated with small and medium storms. However, under very intense storms, basin response is governed almost entirely by soil water storage opportunities rather than topsoil infiltration capacity or vegetation cover\(^3\).

Comparisons of plantations of oil palm of differing age in Malaysia have suggested that older plantations may have lower infiltration rates than newly established or replanted plantations which usually have a good cover crop that can protect the soil against raindrops and surface erosion for at least 5 years. As the palms grow taller and the canopy becomes denser, the cover crop gradually dies off due to limited sunlight. In addition, the use of harvesting machinery both suppresses the cover crop and compacts the soil encouraging water to flow over the ground surface towards streams. Observations on rubber plantations in Hainan, China and northern Thailand confirm these Malaysian findings on the effects of tree crops with good ground cover and well-developed foliage in regulating storm water flows\(^5\).

### Soil erosion and muddy rivers

Many rivers in Malaysia and in SE Asia generally, are muddy, especially after rain. Even in undisturbed forest they become muddy during the heaviest rain storms when river banks collapse and occasionally large trees fall down exposing the soil around their roots. The sediment can affect water intakes further downstream, contaminate water supplies, and greatly disturb both freshwater and inshore fisheries (Fig. 2). Disturbance of the ground by machinery, during logging operations, access route construction and land clearance for plantation development and urban construction greatly aggravates the sediment problem.

![Fig. 2](image)

The detailed measurements of river sediment transport made in several part of Malaysia show that the steeper the ground, the greater the amount of soil erosion during a given storm. For example, a study at Jengka, Pahang showed that soil loss from a recently abandoned logging road on a 30% slope was about 50 times higher than in a nearby undisturbed site and also that a logging road on a gentle slope (10%) produced only a half soil loss than on a steeper slope (30%). Sediment yields vary with geology, generally being lower in tectonically stable areas on granite, metamorphic rocks and sandstones and higher on most volcanic rocks and friable marls and mudstones\(^6\).

In the 0.44 km\(^2\) Baru catchment at Danum Valley in Sabah the highest erosion rate were observed within two years of logging through erosion of logging and feeder roads, skid trails, log landings and disturbed terrain. Initial recovery of streams occurred within 3 to 5 years after logging with sources of sediment limited to unsurfaced feeder roads and log landings. However, this recovery was punctuated by extreme hydrologic events and biogenic decay of
logs used for bridge construction and culverts, and the failure of debris dams. Extreme events have led to renewed sources of sediment from landslides and their scars. Even 21 years after logging operation, the erosion rate measured using the erosion bridge technique which surveys ground surface level change, still exceeded primary forest values at landslide scars and unsurfaced road sites. These repeated phases of extreme erosive events produce cumulative watershed effects (WCEs) whose assessment is crucial because the cumulative impacts of individual local disturbances get larger downriver as the size of its catchment area increases. WCEs can result from individually minor but collectively significant actions taking place over a period of time. They include the impacts of widespread forest removal, followed by poor cultivation practices and rampant soil degradation, which may enhance flood risk in the downstream.

**Managing tree plantations to avoid erosion and cope with climate change**

In terms of managing plantations, the aim has to be to minimize the opportunities for surface water to collect into small channels and begin to form little streams that can erode the surrounding soil. In general, rubber plantations have good undergrowth if weeding by herbicide is minimised. Oil palm plantation has shorter rotations (20-25 years) and generally poor undergrowth in mature plantation due to light competition, compacted harvesting paths and the dense plantation road network (6.5% of the area). These compacted areas are permanent sources of overland flow and sediment during storm events.

Although undergrowth under rubber plantation for timber (LTC) is dense and effective in regulating overland flow and erosion, the short rotation (15 to 20 years) will lead to intense and frequent disturbance. Moreover, the hydrological impact of replanting LTC is expected to be more severe compared to rubber for latex because the former is grown on steeper slopes. It is also hypothesized that a site frequently affected by disturbance (replanting) will have a longer recovery period in the subsequent rotation because of depleting soil nutrient status.

In view of the lower hydrological impact of planting rubber trees for latex it may be advisable to consider reconveting oil palm plantation into rubber especially on hilly areas. In fact, this move has economic justification in view of a more often volatile palm oil price than rubber. Thus increasing investment in rubber could act as a safety net when palm oil prices crash. In the past, the motivation to replace rubber plantation by oil palm was purely economic.

While good management practices in forestry and plantation could help reduce impact of regular flooding, the main cause of major floods is always climatic or prolonged heavy rainfall over large parts of a catchment. Climate change and land cover change remain increasing threat for Malaysia’s rivers and water supplies.

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1 Mohammad and Sarjiman. 2007
5 Albert et al. 2009
Introduction

The oceans are vast and appear to go on for ever. Water covers 70% of the Earth’s surface and to call it the Blue Planet would seem apt. Whilst humans have lived by and traversed the oceans for centuries, our knowledge about life and chemistry in the oceans is still limited. The deep sea, down to 11,000 m in the deep trenches, is of course even less explored, but with new technology our knowledge of the oceans is slowly increasing.

Oceans are an essential source of life. The oceans contain 97% of all water and act as the ‘reversed lungs’ of the Earth’s water cycle through the evaporation of water into the atmosphere and its subsequent falling on land where it provides living creatures with drinking water. The oceans provide us with half the oxygen we breathe. They also act as a buffer on temperature fluctuations and regulate the climate. The oceans are all connected and water moves constantly, with surface water sinking at turning points and continuing to flow in the depths of the sea.

So will this seemingly unlimited source of sustainable ecologies be able to cope with the stresses from an industrial world inhabited by 8 to 9 billion human beings? Well, it appears that it cannot. There are many ways human populations have an impact on the water, its chemistry and its organic life. We have done so for a long time, but are now becoming more aware that the ocean is not infinitely resilient to human encroachment. This paper is an attempt to highlight the interaction between humans and the oceans and the consequences of this interaction.

Long term changes in the oceans

The oceans absorb 30% of the CO$_2$ from human activities. Over millennia the rate of absorption has changed, due to shifting continents and long term changes in the Earth’s climate, but it is now accelerating due to the burning of fossil fuels and the consequent increase in CO$_2$ in the atmosphere. The oceans are becoming increasingly more acidic, dissolving calcium that creatures require. Many crabs and crustaceans depend upon it to build protective shields, and coral reefs require calcium for their construction. A lack of calcium could subtly but significantly damage the ability of life to thrive on the sea-bed.

However, that is not the only threat to the oceans and its living organisms.

In 2003 the UN specialised agency International Maritime Organisation (IMO) defined four major threats to the ocean and the marine life. They were, in no particular order: 1) aquatic invasive organisms in ballast water; 2) land-based sources of marine pollution; 3) over-exploitation of living marine resources and 4) physical alteration of coastal and marine habitat$^1$.

In the new Sustainable Development Goals discussed in the UN in 2015, the Goal 14 is ‘to Conserve and sustainably use the oceans, seas and marine resources for sustainable Development’. One of the facts is as much as 40% of the world oceans are heavily affected by human activities, including pollution, depleted fisheries, and loss of coastal habitats. The first target (14.1) states: “by 2025, prevent and significantly reduce marine pollution of all kinds, particularly from land-based activities, including marine debris and nutrient pollution”$^2$.
Today, half the world’s population lives within 60 km of the sea, and three-quarters of all large cities are located on the coast. Humans have always lived along the Earth’s waters. They have used materials from timber trunks to reed floats to go exploring, to fish or to trade. The differential impact of today’s huge steel container ships, however, is potentially irrevocable. In the contemporary ‘Anthropocene’ period, the human-ecological relation between humans and nature is defined by the often unseen damage that industrial technologies cause beneath the surface of the oceans.

**Ballast water**

Since the beginning of the construction of steel ships in the mid-1800, ships have been designed with ballast water tanks which maintain the ship’s stability in varying loading conditions (Fig. 3). The water for the ballast tanks is pumped in at ports where the ship has unloaded its cargo. This water may contain many various species of which some can survive the trip to the next port where the ship upload new cargo. The ballast water is then pumped out in the new environment. If the surviving species are able to stay alive in the new environment and even thrive in the new ecosystem; then the system can change considerably. This unforeseen transportation of life can subtly disturb the integrity of indigenous ecologies of ocean life.

![Fig. 3 Ballast water tanks, IMO (with permission)](image)

The Asian phytoplankton algae Odontella (*Biddulphia sinensis*) was first recorded in the North Sea, having been brought there in ballast tanks. It was not until 1970 that scientific studies began to clarify the links between ballast water and surviving species, and that policy stakeholders started to engage with the need to prevent species being accidentally transported across the world. Regions such as the Black Sea and the waters surrounding the USA and Canada in particular faced a serious array of invasive species which when brought to the attention of the IMO led to international policy action. New technologies and new rules on how to discharge ballast water are now in place, and new conventions on ways of handling and treating ballast water from source to end were adopted in 2004. The ratification process (30 nations needed to get the convention into law) has now reached over 45 states and the convention is expected to be ratified in 2015 and thus become law. Nevertheless, implementation of the law has involved many hurdles. Old ships can be exempt, and new ships are fitted with technologies that remain at an experimental stage of their development. It remains a long process to ensure all ships are in line with the convention.

The case of ballast waters demonstrates that when international consensus is created around key issues, policies can be adopted. The challenges that face the oceans, however, are almost too broad and all-encompassing for targeted policies to address at once. Even when policies are laid down, ensuring their implementation requires major resource commitments at national and international levels.

**Land-based sources of marine pollution**

As long as populations along the coasts were tiny and waste was mostly from humans or organic waste, the dumping of waste matter into the sea could be dealt with by nature’s own way of breaking down organic materials by bacteria. But with the increasing of dense coastal populations in towns and cities, the waste ejected into the oceans is proving too much for ecosystems to cope with and it creates problems which require carefully planned solutions. As a brief historical note on coastal or riverine cities, the Harappa culture in the Indus valley which peaked in 2000 BC had an elaborated urban planning with a drainage system to cope with its creation of waste. Today, the discarding of sewage waste is remains a major challenge for coastal cities.

In the UK, rudimentary sewage treatment plants were installed in cities from the mid-19th century. The Great Stink from the heavily polluted River Thames in London in 1858 forced the government to act, leading to the building of sewage systems by Bazalgette. This system took waste away from populated areas, but it was still dumped at sea without treatment. Most UK cities and coastal towns had huge ocean outfalls until after 1945. Only in the 1980s did Liverpool’s 53 ocean outfalls begin to be connected and were fed into a treatment works. Later developments to this system included using sewage to fertilise farmlands, thus reducing the solids discharged to the oceans. Today, the UK’s use of
anaerobic treatment means that waste water from urban areas now can be clean when it enters the sea. However, these systems are not used uniformly across the world’s urban areas. Far too much of untreated sewage is still pumped into the oceans\textsuperscript{7}. Many countries in the world have no treatment at all. During the 1980s, Monte Carlo for instance continued to pipe its untreated sewage out into the Mediterranean, although in long-distance pipes so as not to directly pollute the beaches\textsuperscript{8}. Such systems fail to meet the EU’s criteria on waste water management.\textsuperscript{9}

**Plastic**

A relatively new problem that affects the oceans is plastic waste. Although oil based plastics have been used for less than 70 years, in recent decades it has become an increasing problem for ocean life. Worldwide, plastics production is currently at staggeringly high levels, having increased from 1.7 million tonnes a year in the 1950s, to 299 million tonnes in 2013\textsuperscript{10}. Anyone walking along a beach in Europe has inevitably seen rubbish blown up on the sand and that rubbish is now primarily plastic: containers, cups, bags, wrappers and bottles (Fig. 4).

It is estimated that in 2010 more than 5 trillion pieces of plastic entered the sea, weighing over 250,000 tons, much floating on or near the surface but most disappearing under water\textsuperscript{11}. Plastics containing oil do not decompose in water but instead break apart into micro pieces. In the ocean gyres - massive vortexes rotating with the wind and currents - plastic parts and other debris form huge zones or conglomerates, sometimes several meters deep. There are five major gyres in the ocean, the largest in the North Pacific. It is estimated that only 5 – 10 % of the plastic we produce is recovered\textsuperscript{12} (although much is still in use), and even if much ends up in landfills, there it is degrading and washed into groundwater and eventually into the sea.

Not all plastic rubbish emanates from plastic bags or wrappers; some also comes from the unlikely source of facial cleanser, toothpaste or body scrubbers. Today some manufacturers use small microbeads\textsuperscript{13}, roughly 3,000 per tube\textsuperscript{14} instead of residues of nut shells or other biodegradable resources, which are seen as too expensive. As these beads are tiny, less than 1 mm, they pass through the sewages system and into the ocean, where they are taken for food by phytoplankton and zooplanktons. Even if some are excreted, some stay in the intestines and as the creatures are in the bottom of the ocean food chain, they are eaten by predators that in turn ingest the particles. Eventually the particles will end up in fish that might be served on our dinner plates. This has not gone on for many years, but some estimates states that now over 470 million beads enter the ocean every day\textsuperscript{15}.

This particular problem has now been highlighted and manufacturers are pledging not to – or have stopped – using microbeads. Many countries are willing to impose new legislation against the use of microbeads. For instance, Australia has done so and California is on its way with new legislation. The campaign to stop microbeads is creating an impact, and shows what can be achieved when civil society mobilises scientific research on human-ecological interactions.\textsuperscript{16}

Plastic particles act as sponges for waterborne contaminants such as pesticides\textsuperscript{17}. Invertebrates, fish and birds often eat the small particles. A report – “Sources, fates and effects of micro plastics in the marine environment - a global assessment” – was published in 2015 by the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), an advisory body that assists the United Nations on scientific aspects of marine environmental protection\textsuperscript{18}. The report states that micro-plastic can now be found anywhere in the oceans: After entry into the ocean micro plastics can become globally distributed and have been found on beaches, in surface waters, seabed sediments and in a wide variety of biota (invertebrates, fish, birds, mammals), from the Arctic to Antarctic. They become concentrated in some locations such as ocean gyres, following long-distance transport, but also close to population centres, shipping routes and other major sources.\textsuperscript{19}

The consequences of this inclusion of plastic particles, and their contamination, in oceanic food chains have not yet been fully explored. That something has to be done about it is becoming consensus in the scientific and even in the political...
environment. In a report from UNEP in 2009 one suggestion was:

National action plans or strategies should be based on development, implementation and enforcement of national legislation for waste management that includes marine litter, enhancement of national institutional mechanisms, strengthening of public, governmental and private sector partnerships, raising public awareness and education; and development of a framework for engaging key stakeholders and partners.20

In this context, it seems difficult to clear up our shores, let alone the oceans themselves. Countries around the globe have volunteers cleaning up litter on beaches through organisations such as Ocean Conservancy. The statistics on how much is removed are stunning. As an example, a clean-up along a 79 km stretch of South Africa coast in North, West and East Cape Provinces some 90,732 items were picked up by 7,532 volunteers, in all weighing over 10.25 tons21 (Fig. 4).

![Fig 5](image)

A clean up is also necessary in the Grand Union Canal, London (photo Eva Ekehorn)

The best solution would be to deal with the problem at its source: re-use, recycle, and reduce plastic consumption. Plastic must also be replaced with bio-degradable material whenever possible.

Countries in northern Europe are recycling nearly 100% of their plastic waste, mostly by incinerating the plastic, and generating electricity. Yet it is not only a top down solution that is needed – bottom up action on plastic is required to ensure recycling becomes a normal aspect of everyday life. Facilities for recycling are becoming increasingly available as legislation and the awareness of the litter problem increase, especially in Western Europe. However, even here, individuals have to be educated and supported to recycle; “Recycling is not an option – it is a responsibility” is a slogan stated on the sides of some recycling trucks in London. The willingness to change the way we use plastic should be strengthened through education that emphasises the harmful effects of its use.

**Over-exploitation of living marine resources**

According to the Marine Conservation Institute22, the way we fish has contributed to the over-exploitation of marine life. In addition, some fishing methods destroy or damage the very seafloor habitats where fish and many other species reside. Among all fishing techniques, bottom trawling - a fishing method that drags a large net across the sea floor - is the most destructive to our oceans, sometimes leaving up to 4 km long trails on the sea bed and severely damaging the seafloor ecosystems. The net indiscriminately catches every object it encounters. When the net is lifted on board the ship, much of the by-catches - fish, sea turtles, seabirds and marine mammals - are dumped overboard, usually dead or damaged. In cases of emergency, a ship might cut off its nets, but the nets released will continue to trap fish for years to come.

An example of the consequences of over-fishing is the loss of cod on the Grand Banks on the eastern shores of the Canada where overfishing caused the ecological system collapse.

When the Italian John Cabot first explored the Grand Banks he said it was so full of fish that you could just scoop them up with a bucket. In the 1600s English fishermen said the sea was so full of cod that it was hard to row a boat through them. The location of the Grand Banks at the northern edge of the warm Gulf Stream where it meets the cold Labrador in shallow water on the Banks creates an ideal place for all kinds of fish, shellfish and other marine species. The cod industry flourished there, feeding not just Canada, but Europe and more distant countries (Fig 6).

Contemporary industrial scale fishing has relied on high catches involving bigger ships with larger trawling nets, and in 1968 some 800,000 tons of fish, mostly cod, was taken out of the sea23. However, by 1974, this catch had fallen to 300,000 tons around Newfoundland. Fishing continued but it was not until late 1980s when, in spite of local fishermen’s warnings, scientists begun to realise that the cod population was in serious trouble. Fishing zones were being introduced, but this increased fishing instead of keeping it under control24. In 1992 the Canadian Government finally acted and imposed a total ban on cod fishing on the Grand Banks which caused a collapse of the Newfoundland fishing industry. By 2012 stocks in the Grand Banks near Newfoundland
and Labrador had recovered by 69% since 2007, but they were still only 10% of their original size.

The cod have not returned. The ecosystem on the Grand Banks has changed. Shrimps and crabs are now the major catch source for the fishing industry. As stated in The British Sea Fishing website:

The intensive bottom trawling that had taken place in the Grand Banks was seen as a major factor. It was thought that the constant trawls had torn up the seabed to such an extent that marine life could no longer be supported in the area. The shellfish and seaweed beds which had supported crustaceans, molluscs and small fish had been destroyed and without them there was nothing for the cod to feed on.

The Grand Banks is unfortunately not the only one of over-fishing. Today, species such as Bluefin tuna, sharks and rays are nearly extinct in the Mediterranean and certain varieties of salmon and sturgeon in the Atlantic just as examples. There are other threats to sea living creatures. Dynamiting the coral reef to stun the fish is also practised, although illegal. The explosives used are not only killing fish, but also destroy flora and fauna. It takes very long time to heal the coral reefs. International waters are hard to control and illegal fishing continues widely.

Physical alteration of coastal and marine habitat

The large human populations living along the world's shorelines are constantly changing the coasts and adjacent shallow seas. Ports are now focal points in an interconnected global economy, defined by flurries of human activities: mining, construction and tourism (Fig. 7). As such, coasts are a clear manifestation of human relations with nature in the Anthropocene. Natural ecosystems including mangroves, marshes and coral reefs along the coast are vulnerable to these human undertakings. Yet these ecosystems also act as a critical line of defence for the coastline and many fulfil roles as breeding grounds for creatures.

In tropical and sub-tropical coasts, mangroves form an important forest protecting coastlines against storms, currents, waves and tidal surges. They are also a haven for fish and birds seeking food and shelter. In many areas they are under serious threat. Oil spills, logging, clearance for oil pipes, urban development and shrimp farming; all pose a threat to the aquatic mangroves and the complex ecosystems that depend on them. Mangroves also play an important role in facilitating agriculture, as they allow water to drain off the land. (Fig. 8)
Whilst clearly under threat, it is important to note that mangroves can be replanted and work is being done to highlight the need to do so (Fig. 7). CHEC led workshops in 2012 and 2013 that trained civil society from West Africa on mangrove protection, but lacks the resources to replicate this initiative across the Commonwealth. Other bodies are also taking important steps to protect mangrove reserves. National parks can protect mangrove forests, by applying indigenous knowledge and adopting Ramsar conventions. Ramsar is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

Beaches are important sites for many species that symbiotically maintain the health of the beach ecosystem for other life forms. In tidal flats (Fig. 9) lugworms play a key role, aerating the sediment and helping maintain it for a large variety of other marine organisms. However, a lugworm cannot see the difference between micro-plastic and food, but when it eats too much plastic, it suffers from stress and cannot do its job properly, and this is also true for mussels. Mussels also play an important role in marine ecosystems by filtering water, which removes bacteria and toxins. They are also a source of food for a variety of birds.

Exploitation of the oceans for non-organic resources (oil, minerals)

Deep sea drilling for oil and gas has been a central technique for oil extraction since the late 1800s. In the mid-1900s drilling began in water deeper than 30 meter and by the millennium deep sea drilling at depths up to 500 m had become possible, such as in the Golden Triangle between Brazil, the Gulf of Mexico and western Africa (Fig. 10). This type of drilling is now used in India, the South China Sea and in the Caspian Sea.

Oil spills are a nearly unavoidable outcome of this oil exploration. Serious spills have occurred through drilling, such as the Deepwater Horizon in 2010, and also during the transport of oil, such as Exxon Valdez in 1979 and Amoco Cadiz in 1978. The oceans provide a certain degree of cleaning up after oil, as there are microbes that feed off it, especially in warmer waters. That is not enough sufficient to clean up an entire spill, however, which – as many of us are familiar with from TV images broadcast after accidents such as the Deepwater Horizon - can kill birds, fish and many other species. Human intervention to stop the spread of the oil slicks is, of course, absolutely necessary. With exploration companies looking at the Arctic Ocean for new well sites, the potential risks from an oil leak in this much harsher environment should not be taken lightly.

The seabed of oceans contains many minerals, formed from crystallisation of elements in the water and from flows in the volcanic activity along the continental plate boundaries. Gold and diamonds are harvested on the continental shelf outside southern Africa, and trials have been undertaken at greater depth for modules of manganese, iron and cobalt, sometime to a depth up to 4,000 m. Back in the early 1980s there was great commercial interest in manganese nodules and cobalt crusts. This initial euphoria over marine mining led to the International Seabed Authority (ISA) being established in Jamaica, and the United Nations Convention on the Law of the Sea (UNCLOS) being signed in 1982 – the “constitution for the seas”. Since entering into force in 1994, this major convention has formed the basis for signatories’ legal rights to use the marine resources on the sea floor outside national territorial waters.
New interest has emerged in the possibility of mining rare minerals in the very deepest hydrothermal vents on the sea floor where the fluids are rich in diamonds, gold, iron sand, and rare earth elements. In 2014 a Canadian company, Nautilus Minerals, signed an agreement with Papua New Guinea to extract minerals from Solwara 1 in the Bismarck Sea to harvest 1.6 million tonnes ore containing copper and gold. Nearly 20 other licences are in place for similar deep sea mining. The environmental impacts of such extractive industries are very uncertain as the organisms living at these depths are not very well known, but complex ecosystems persist, even at the depth of 4,000 m. How to restore the ecosystems at this depth after mining stops is being investigated through cooperation between the industry, the International Seabed Authority and scientists, such as Dr Cindy Lee Van Dover, Duke University Marine Laboratory, an expert on deep sea trenches, and organisations against mining such as Deep Sea Mining Campaign.

Noise

Another emerging problem is noise. Many Cetaceans, such as whales and dolphins, communicate by sound or ‘songs’ that can be heard for miles under water. But there is now noise interference from ships’ propellers, sonars on military submarines, drilling and extraction of gas, oil and minerals. These noises can distract whales from their course and possibly cause the beaching of the animals. Noise can also be used to scare animals, such as harbour porpoises, away from fishing nets, although the effect of the ‘ringers’ and ‘pingers’ used by fishing boats are not well known.

The establishment of offshore wind farms has highlighted the noise problem, but there is a willingness to adjust the timing of the building of the bases for the wind turbines, something which can create much disturbing noise, to accommodate fish breeding and migration. Some major shipping routes should be - and already have been - moved away from important marine mammal habitats.

Conclusions

Threats to the oceans are many, as described above. However, there is an increasing understanding of the particular challenges they pose and policies are being developed to tackle them.

In fishing, especially, marine protection areas are set up to protect habitat and breeding grounds. Consultations are taken worldwide, including engagement with local fisherfolk, with control given to local areas which can improve the viability of the protection zones. The European Union (EU) Fisheries Policy is formulated in cooperation between fisheries, politicians and scientists and is regularly updated; latest changes being approved in January 2014. Similar rules are, and should be, adopted globally. This is where the Commonwealth as an international broker can play a major role in global sustainability.

When it comes to pollution of the sea many steps have already been taken to control and to limit the impact waste has on the ocean. EU’s Urban Waste Water Directive, implemented in 1991, is dealing with planning, regulating, monitoring and information about urban waste in Europe and this will contribute to less waste dirty water being sent to the oceans. Again, these policies are in place in many parts of the world, and there is much to be learnt from the implementations of such rules.

Plastic in the ocean is also coming higher up on the agenda for policy makers and international organisations. Manufacturers of plastic are increasingly involved in trying to lessen the effects of their output by cooperation in education for recycling. The cosmetic industry is increasingly abstaining from using microbeads from their products.

Much of these changes are due to an increasing activism from local and international organisations, working locally or collaborating with people affected by the problems.

The ocean is not infinite – there is a limit to what it can cope with. As human beings are very dependent on the ocean for our life, we should take care of it. It is not just for food and water, but for the pleasure of being able to enjoy a clean beach, swim in clear water and let the distant horizon of the sea inspire our curiosity of what is far away and beyond what we can see (Fig. 11). Many threats have been mentioned here and it is a bleak picture, but there is also hope in the way our awareness of our impact on the oceans has increased. Calls for actions to tackle the consequences must be taken now. Action cannot be taken only at one level but at all levels, from government to individuals - the political or on ground level – but we should all act together.
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This edited volume from John Richard Wagner gives us entirely new but critical insights into the contestation of water resources around the globe. Underpinning the theoretical approaches of the various authors is Wagner’s key point: that water is a Maussian “total social fact”, but also a “total ecological fact” – water is neither purely ecological nor purely social, but transcends categorisation according to the bifurcated domains of scientific and social scientific enquiry. Bruno Latour’s Actor Network Theory (ANT) grows ever increasingly popular, and clearly not without reason. Wagner usefully mobilises ANT to emphasise that water is a non-human agent that has an impact on “the social” as a composite “socioecological” system (Wagner 2013: 8); its meanings and effects transcend its place in “nature”. The articles of the book mobilise this broad, but underlying conceptual focus in a range of instances, exploring the contamination of water supplies, the contested privatization of water resources, and environmental degradation. In this sense, the book is not only about water as “more than nature”, but about the deep sense of crisis that has come to define water issues on the Blue Planet.

Of particular note is Fabianna Li’s excellent contribution which exposes the way multiple theories of water compete in contests between mining companies and local communities. Li describes how a mining company in Yanacocha, Peru was able to abide by minimum water standards, whilst polluting canal water that townspeople relied on for drinking. Because of the different grades of water standards, and as the minimum standard did not include water for drinking, the mining company was able to meet legal requirements. This was despite the radical change in the appearance of the water, and a decline in its quality that profoundly affected the local community. Replacement pumps to provide them with drinking water did not deliver sufficient water. Pumping water was not the same as having a canal with good water quality. In short, Peruvian irrigation law contains a fundamental weakness that the mining company was able to exploit: the minimum standard of water quality does not include water for drinking. Ultimately, the local community was no longer able to use its primary and easily-accessible source of water.

In contrast to Li who describes how “the canal users and engineers seemed to be talking about the same thing – water quantity and quality – but from different sets of assumptions”, I wonder whether the assumptions of the engineers were contingent upon an institutionalised disregard for extra-legal, non-empirical forms of measuring water quality. Their assumptions about necessary water quality have their foundation in a legal framework that favours exploitation of natural resources at the expense of local communities, and by simultaneously disregarding their modes of knowledge; how they know their water. Modes of knowledge are non-equivalent (Li 2013: 30), but when one knowledge regime is enshrined in law, we must ask how incommensurable epistemologies and ontologies are arranged and privileged at the expense of others. Social anthropologist Bruce Kapferer (2011) has offered a brilliant insight into how ideology arranges root ontological assumptions that might usefully be drawn upon here. The implications of Li’s findings can then be seen to be much broader than the local contexts she describes, and directs us towards the way ontologies of water become foregrounded and embedded in legal frameworks introduced by policy-
makers. The commodification of water does not happen in an empty vacuum but according to the onto-political shifting of various regimes of understanding. In Li’s example, we see how an ontological distinction between water as a “natural” material to be harnessed and the society that uses it becomes imbricated with capitalist logic of quantification and commodification that itself rests upon this distinction.

The technological determinism of water policy in Peru – that water quality can be quantified and graded – reminds us that scientifically-premised policies so often dislodge the epistemological and ontological premises of communities whose day-to-day lives involve interacting and using water. Here, I am thinking of communities of fisherfolk in small island states, or the townsfolk who used the Yanococha canal. As anthropologist Eduardo Viveiros de Castro has recently called on us “moderns” to do: can we alter our own understandings of “Nature”, to live in harmony with the land as non-moderns have done? As Bruno Latour has it, how can we – in a modern world defined by exploitation of “raw materials” as “resources” – get back that sense of respectful awe with which we used to apprehend Nature? Rather than dislodging non-modern forms of epistemology – such as ways of knowing canal water based upon human-ecological interaction – how can we foreground them in our ongoing attempts to protect the planet from the worst effects of human industrial development? Arguably, this should be the question that defines climate change policy in the 21st century.

Elsewhere in the book, we glimpse the forms of sociality that coalesce around water resources. In a Palestinian village, women – perhaps surprisingly – fondly recalled the time before the introduction of a piped water system as one where they had spent time at the village well, sharing stories and taking a break from their working days (Nefissa Naguib). Whilst we see the ways in which water exists simultaneously as a social and ecological material, I would suggest that the volume could say more about the “shifting” and “foregrounding” - the emergence - of particular knowledges of water; the way that ways of knowing water emerge from complex assemblages of capital, ecologies, values and ethical systems. Nevertheless, this fantastic set of articles takes us much further in the useful destabilisation of our modern ontological assumptions about “natural” resources and the (g)local politics of sustainable development.

Additional references


1 In his 2014 Maralyn Strathern lecture, anthropologist Eduardo Viveiros de Castro suggested that we moderns need to learn from Amerindian peoples whose world has already come to an end, and did so over 200 years ago.

2 As Maralyn Strathern once showed, our modern notions of nature-culture are contingent. They allow social scientists and human ecologists to abstract “culture” or “society” as human creations that are formed out of the givens of a natural world (1980: 216). Amongst the Hagen of Papua New Guinea, the distinction between nature and culture, Strathern found, is not like our own. Mbo (domestic) and romi (wild) are not opposed hierarchically, as a (human) culture that absorbs and transforms nature (ecology), but are used to describe any one thing, whether a person or an object.
This is a very wide, interesting and informative book on all aspects of water, a medium which is abundant but not always well understood.

The author lets us follow explorers and scientists as they slowly develop our knowledge. He takes us to the creation of our planetary system, to the origin of water, to the origin of life. Water is, or has been, everywhere, even on the planets and moons. He describes how we humans under all stages of our development have depended on water. The management of water has changed landscapes and shaped society itself.

He is also very personal, describing his own observations and experiences on expeditions, including seasickness on one journey to Antarctica.

We all know that water in a pipe may rupture the pipe if it freezes. We do not so often reflect upon the fact that water is the only medium which expands, forcefully, when it solidifies. This expansion is also the reason why ice floats on water. A stone, thrown into flowing lava stream from an erupting volcano, sinks in the lava, contrary to the ice on water.

Water is also an extraordinary medium in that it transforms easily between solid, liquid and gas forms under our normal environmental conditions. Water is the most abundant single substance in the biosphere, covering about 71% of the surface of the planet. Most of it, 97%, is salty and slightly more than 2% is ice. The fresh water is in lakes, rivers, in the soil or in aquifers. There is also a small amount of water in the atmosphere.

Although the amount of water on earth is enormous only about 1% of it is available for human use, and we share it with all other living beings. Some 90% of the water in the oceans exists below 400m depth.

The movement of water in and around the oceans and the ways it interacts with the atmosphere are at the heart of the Earth’s climate and weather, as the author explains. The oceans absorb and distribute the sun’s energy, dispersing nutrients and gases in a way that makes the world habitable. The hydrosphere is a profound, symbiotic link between the physical body of the planet and all of the life upon it.

Parts of the oceans’ area are covered by ice, which floats on the water surface. The ice sheets of Antarctica are built from billions of years of snowfall. The snowflakes trap air between them, incorporating tiny pockets of the atmosphere, each one a perfectly preserved record of the air at the time the snow fell. Scientists dig out a timeline of ancient climates in the form of long cylinders of ice.

All domains of life contain water. Adult humans consist of 60 – 70% water on average. A human foetus in its first months is about 95% water.

With the increase in the number of people in the world the strain on water supply increases. More than half the world’s population now live in cities, with associated necessary infrastructure and control. Over 1 billion people in the world today have no easy access to safe drinking water, and more still lack proper sanitation.

Most of the fresh water used by society is for agriculture, about 70%. The author states some figures for ‘water footprint’. Most of the water we use is hidden. We are told that it takes nearly 200 litres of water to grow the coffee beans for one cup. It takes 100 litres to make the two slices of bread for a sandwich. To produce 1kg of beef takes 15,000 litres.

In Moby Dick Herman Melville lets the hero raise the question of whether hunting of whales can seriously threaten the survival of the species. He concludes that the oceans are so enormous that whatever man does it has no influence. Now we know that this is not true.

The activities of man do change the oceans. Increasing temperatures, increased acidity, changing salinity are just a few of the many physical effects we can see. Their impacts reach deep into marine and coastal ecosystems that have evolved. Increasing amount of manmade waste and debris float into - and around – the oceans. Much of this is not biodegradable, such as plastic. It enters into the food chain with consequences we do not yet fully comprehend. In addition we drain many aquifers, lakes and rivers.

On the positive side is that we now become more and more aware of how much we must change our ways. Although the author states that his book is not primarily about climate change, nevertheless it pervades all the problems he addresses.
Part of FWR’s work is to disseminate research in the public domain on all aspects of water. This small booklet highlights the role of water in food production, especially in the UK, but also stretches beyond to the virtual water used throughout the food supply and distribution system.

Water is vital for all life and is essential to the production of any of the food we put on the table. The report contains numbers for the volumes of water in today’s agriculture, not only including the rainfall and from the soil (green water) but also from aquifers, streams and lakes (blue water). As water today is already under stress in many parts of the world, an increasing population will increase the stress further and conflicts over its use for various purposes in society will increase.

Agriculture is by far the biggest user of water in the world. Nearly 70% of all water is used for irrigation, in addition to rainfed agriculture (authors’ stress). With an increased global appetite for meat, this water use will increase. Some water is ‘consumed’ into farm products, i.e. removed from the environment and no longer available, but some water such as the water used in fish farms is not ‘consumed’ in the same way.

The water footprint, introduced in 2003 by Prof Arjen Hoekstra, analogous to the “ecological footprint for land areas, is elegantly introduced. A water footprint considers the total freshwater volume required across all stages in the production chain, both direct and indirect, i.e. all the water needed for producing all inputs into the production process. This can help industry to target waste. (For more information about water footprints see: www.waterfootprints.org).

The main part of the booklet is dedicated to agriculture in UK and its use of water. Estimates made by Defra indicate that 184 million m³ of water was used on land and on farms. Livestock takes 41% and irrigation of crops 38%, leaving the rest for washing down of produce, spraying, leakages and other agriculture use. Of the livestock, dairy farming takes the major part. Of crops, potatoes, both as a main crop and as early potatoes, take over half the irrigation. Rainfall is the main source, but to get a good crop, irrigation can use streams and public water supply.

Waste in food production is a big issue. ‘Over eating, and throwing away food is like leaving the tap running’

Household waste accounts for roughly 4% of UK’s total water footprint, including 17 million tonnes of CO₂ equivalents. With the globalisation of the food supply, the UK is also trading in virtual water, some from countries under water stress, thereby exerting pressure on water environments around the world. Only 38% of the UK agricultural related water footprint is sourced within the UK.

The report ends by highlighting threats to water security and what can be done to prevent conflicts and economic development. Water stewardship is increasingly used locally to solve conflicts, but governments and industry are supporting and driving for common understanding and actions for water resilience.

This report is of great interest for wanting to understand the use of water for our food we put on the table and eat and what action we can take for future security.

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Compiled by Ian Douglas and Peter Lockwood

**UEA Water Security Research Centre**
A world-renowned institute studying water security from a combined natural and social scientific perspective, the Water Security Research Centre studies the various drivers and constraints that influence the management of water. Its publications section lists its published research work. [https://www.uea.ac.uk/watersecurity](https://www.uea.ac.uk/watersecurity)

**Global Water Footprint**

**World Water Assessment Programme (WWAP)**

**UN Water**
UN Inter-agency mechanism on Freshwater issues, including sanitation. The website includes information and statistics on a number of water issues in the post-2015 agenda. [http://www.unwater.org/home/en/](http://www.unwater.org/home/en/)

**United Nations Global Environment Monitoring System (GEMS) Water Programme**
The UN tool for providing water quality data to be used in water assessments. It can also show the water quality index by country. [http://www.gemstat.org/](http://www.gemstat.org/)

**Global Water Partnership**
International organisation set up by The World Bank, UNDP and SIDA to promote integrated water resource management (IWRM) for a water secure world. GWP’s website is an excellent resource for practitioners seeking to explore partnerships and projects in water across the world. [http://www.gwp.org/en/](http://www.gwp.org/en/)

**Global Water System Project (GWSP)**
The GWSP seeks to answer fundamental question about how humans are changing the global water cycle, and how these changes feedback upon societies. The GWSP has several useful products related to water management including publications, databases and videos. [http://www.gwsp.org/](http://www.gwsp.org/)

**Pacific Institute**
American research institute dedicated to solving problems related to water shortages, habitat destruction, and global warming. Their work covers a broad range of issues, including the human right to water and the water-energy nexus. [http://pacinst.org/](http://pacinst.org/)

**Ocean Conservancy**
Working for a healthy and thriving ocean. The Ocean Conservancy campaigns for ocean protection and scientific innovation to sustain the planet’s oceans. [http://www.oceanconservancy.org/](http://www.oceanconservancy.org/)

**Water Footprint Network**

**Foundation for Water Research (FWR)**
An independent, membership based charity dedicated to education and information exchange. Based in Marlow, Buckinghamshire, UK, it was founded in 1989 and its mission is to advance the education of the public in science, engineering and management of water through specialist forums, reviews of current knowledge, publishing and information support. [http://www.fwr.org/about.html](http://www.fwr.org/about.html)

**Commonwealth of Nations: Water and Sanitation**
Most of Commonwealth country water supplies are public sector concerns. This website provides information of public and private sector water supply organisations by country, including the provision of bottled water. [http://www.commonwealthofnations.org/sectors/business/water_and_sanitation/](http://www.commonwealthofnations.org/sectors/business/water_and_sanitation/)

**Environment Canada**

**WaterAid**
A major charity helping to overcome the water and sanitation crisis in many parts of the world: details of problems and solutions. [http://www.wateraid.org/uk](http://www.wateraid.org/uk)

**World Water Development Report 2015**

**WWF**
The Living Blue Planet report provides the most accurate picture of the state of the ocean--and the results are not good. [http://ocean.panda.org.s3.amazonaws.com/media/Living_blue_planet_report_2015_08_31.pdf](http://ocean.panda.org.s3.amazonaws.com/media/Living_blue_planet_report_2015_08_31.pdf)
Old Faithful geyser was named for its frequent eruptions — which number more than a million since Yellowstone became the world’s first national park in 1872. Old Faithful erupts about every 60-110 minutes depending on the duration of the last eruption, shooting water up to 140 feet into the air on average. It reminds us that water, as geothermal steam, as exploited in New Zealand and other countries, is a source of energy with low greenhouse gas emissions. Geothermal plants emit about 5% of the carbon dioxide, 1% of the sulphur dioxide, and less than 1% of the nitrous oxide emitted by a coal-fired plant of equal size, and certain types of geothermal plants produce near-zero emissions.

(Photo Eva Ekehorn)
Membership Form 2016

Commonwealth Human Ecology Council

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