

# Overview of key messages

The amount of freshwater on Earth is finite, but its distribution has varied considerably, driven mainly by natural cycles of freezing and thawing and fluctuations in precipitation, water runoff patterns and evapotranspiration levels. That situation has changed, however. Alongside natural causes are new and continuing human activities that have become primary 'drivers' of the pressures affecting our planet's water systems. These pressures are most often related to human development and economic growth.

History shows a strong link between economic development and water resources development. There are abundant examples of how water has contributed to economic development and how development has demanded increased harnessing of water. Such benefits came at a cost and in some places led to increasing pressure on the environment and increasing competition among users. Our requirements for water to meet our fundamental needs and our collective pursuit of higher living standards, coupled with the need for water to sustain our planet's fragile ecosystems, make water unique among our planet's natural resources.

Important decisions affecting water management are made outside the water sector and are driven by external, largely unpredictable drivers – demography, climate change, the global economy, changing societal values and norms, technological innovation, laws and customs, and financial markets. Many of these external drivers are dynamic and changing at a faster pace. Developments outside the water domain influence water management strategies and policies. Decisions in other sectors and those related to development, growth and livelihoods need to incorporate water

as an integral component, including responses to climate change, food and energy challenges and disaster management. The analysis of these issues leads to a set of responses and recommendations for action that incorporate the contribution of water to sustainable development.

## **Chapter 1. Getting out of the box – linking water to decisions about sustainable development**

The news media today are full of talk of crises – in climate change, energy and food supplies and prices, and troubled financial markets. These global crises are linked to each other and to water resources management. They arise against a background of continuing poverty for a large part of the world. Unless resolved, they may lead to increasing political insecurity and conflict at local and national levels.

- The 'water box' dilemma must be resolved. Leaders in the water sector – in water supply and sanitation, hydro-power, irrigation and flood control – have long been aware that water is essential to sustainable development, but they do not make the decisions on development objectives and the allocation of human and financial resources to meet them. These decisions are made or influenced by leaders in government, the private sector and civil society, who must learn to recognize water's role in obtaining their objectives.
- Water is essential for achieving sustainable development and the Millennium Development Goals. Properly managing water resources is an essential component of growth, social and economic development, poverty reduction and equity – all essential for achieving the Millennium Development Goals.

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- Water is linked to the crises of climate change, energy and food supplies and prices, and troubled financial markets. Unless their links with water are addressed and water crises around the world are resolved, these other crises may intensify and local water crises may worsen, converging into a global water crisis and leading to political insecurity and conflict at various levels.

Specialists and managers in water supply and sanitation, hydropower, irrigation and flood control have long been aware of this. But they often have a narrow, sectoral perspective that blinds many decisions on water. And they do not make the decisions on development objectives and financial resources needed to meet these broader objectives.

Action is required now. Lives and livelihoods depend on water for development. After decades of inaction, the problems are enormous. And they will worsen if left unattended. But while the challenges are substantial, they are not insurmountable. The Report has examples of how some countries and regional and local governments have solved similar challenges. Recognizing the links between water resources and other crises around the world and between water resources and development, leaders in the water domain and decision-makers outside it must act together now to meet these challenges.

### Part 1. Understanding what drives the pressures on water

Alongside the natural forces affecting water resources are new human activities that have become the primary 'drivers' of the pressures affecting our planet's water systems. These pressures are most often related to human activities and economic growth. Our requirements for water to meet our fundamental needs and our collective pursuit of higher living standards, coupled with the need for water to sustain our planet's fragile ecosystems, make water unique among natural resources.

Drivers should not be considered in isolation of related socioeconomic and political factors or of other drivers. Many natural links also influence how drivers affect changes, directly and indirectly. Water properties are governed by biological, chemical and physical laws that define the quantity and quality of water resources, regardless of human influences, and that are linked in various ways. Superimposed on these natural processes are human activities that intensify these processes

and disrupt the natural balance of water systems.

Economic growth, a principal driver of water use, is affected by a wide range of policy decisions, from international trade to education and public health, while the potential rate of economic growth can be affected by demographic variables such as population distribution (local workforce availability) and social characteristics (workforce capacity and the role of women) and by the availability of new technologies. Water availability is also directly subject to the impacts of climate change, which also can exert additional pressures on the other drivers.

The result of these combined and interacting forces is a continuously increasing demand for finite water resources for which there are no substitutes. When water resources of acceptable quality can no longer be provided in sustainable quantities, the outcome can be overexploitation of aquatic ecosystems. The ultimate losers are the exploited aquatic ecosystems and the organisms (including humans) dependent on them for survival and well-being.

### Chapter 2. Demographic, economic and social drivers

Human activities and processes of all types – demographic, economic and social – can exert pressures on water resources and need to be managed. These pressures are in turn affected by a range of factors such as technological innovation, institutional and financial conditions and climate change.

*Demographic drivers.* Population dynamics (growth, gender and age distribution, migration) create pressures on freshwater resources through increased water demands and pollution. Changes in the natural landscape associated with population dynamics (migration, urbanization) can create additional pressures on local water resources and the need for more water-related services.

*Economic drivers.* Growth and changes in the global economy are having far-reaching impacts on water resources and their use. Growing international trade in goods and services can aggravate water stress in some countries while relieving it in others through flows of 'virtual water' (water embedded in products and used in their production, particularly in the form of imported agricultural commodities).

*Social drivers.* Social drivers are mainly about individual rather than collective actions and about the way people think and act on a day-to-day basis. Social drivers influence

human perceptions and attitudes about the environment, including water resources, in turn influencing the pressures people exert on water through water demands and uses. Changes in lifestyles represent one of the principal drivers of change. They reflect human needs, desires and attitudes (as illustrated in consumption and production patterns), which are influenced by such social drivers as culture and education and by economic drivers and technological innovation; the rapid global rise in living standards combined with population growth presents the major threat to the sustainability of water resources and the environment.

### Chapter 3. Technological innovation

Technological innovation is driven largely by both human wants and needs. It can create both positive and negative pressures, sometimes simultaneously, resulting in increased or decreased water demand, supply and quality. One of the most unpredictable drivers, technological innovation can create rapid, dramatic and unexpected changes, both in pressures and solutions. Impediments to the dissemination of technology must be overcome for developing countries to benefit from innovations developed in richer countries.

### Chapter 4. Policies, laws and finance

Efforts to implement water management effectively and efficiently and to properly inform the decision-making process are facilitated by the adoption of water resources management laws, policies and strategies that reflect links between water and the social and economic sectors. Good examples can be found in many countries.

But even if all the necessary policies and laws are in place, development of water resources will not take place without adequate funding of infrastructure and the institutional and human capacity of the sector.

*Policies and laws.* Effective policies and legal frameworks are necessary to develop, carry out and enforce the rules and regulations that govern water use and protect the resource. Water policy operates within a context of local, national, regional and global policy and legal frameworks that must all support sound water management goals.

Legitimate, transparent and participatory processes can effectively mobilize input for designing and implementing water resources policy and create a strong deterrent to corruption. Corruption remains a poorly addressed governance issue in the water domain. It can lead to uncontrolled pollution of water sources, overpumping and depletion

of groundwater, lack of planning, degradation of ecosystems, weakened flood protection, urban expansion leading to heightened water tensions, and other harmful effects.

*Finance.* Although water is often described as a 'gift of nature', harnessing and managing it for the wide variety of human and ecological needs entail financial costs. While there may appear to be many financing options for water resources development, governments still have only three basic means of financing them: tariffs, taxes and transfers through external aid and philanthropy.

Policy-makers need to make political decisions on socially and environmentally acceptable trade-offs among different objectives and on who bears the costs of such compromise. Commitments have been made by the donor community to increase assistance to the broad water sector, but this has led mainly to an increase in allocations for water supply and sanitation in dollar terms (although its share of total official development assistance has stagnated at 4%), and the percentage of total aid allocated to the water sector remains below 6% and has been declining.

### Chapter 5. Climate change and possible futures

The external drivers of change, strongly connected, create complex challenges and opportunities for water managers and decision-makers in government, the private sector and civil society. Climate change and variability, while seldom the main stressors on sustainable development, can impede or even reverse development gains.

*Climate change.* There is evidence that the global climate is changing and that some of the change is human-induced. The main impacts of climate change on humans and the environment occur through water. Climate change is a fundamental driver of changes in water resources and an additional stressor through its effects on external drivers. Policies and practices for mitigating climate change or adapting to it can have impacts on water resources, and the way we manage water can affect the climate.

Public policy, so far dominated by mitigation, could benefit from a better balance between mitigation and adaptation. Carbon is a measure of the anthropogenic causes of climate change – water is a measure of its impacts. The international community also has to balance investing for tomorrow's likely problems of greater climate variability and global warming against investing for today's problems of climate variability to

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prevent losses from droughts and floods. While both are vital, focusing on today's problems can also create greater resilience for dealing with the problems of tomorrow.

*Possible futures.* Each of the external water drivers is dynamic and continues to evolve, as do the direct and indirect pressures they exert on water resources. Thus, it is difficult to draw a comprehensive picture of the future by examining each driver independently. Because the drivers can have even more of an impact on future water resources collectively than they can individually, future scenarios that consider these interactions offer a more holistic picture. Existing global water scenarios are outdated, incomplete or sectoral and do not fully incorporate each of the external drivers. The evolution of the drivers and the logic behind their storylines need to be examined and possibly redefined in view of developments both inside and outside the water sector that have occurred over the past decade.

### Part 2. Using water

History shows a strong link between economic development and water resources development. There are abundant examples of how water has contributed to economic development and how development has demanded increased harnessing of water. Steadily rising demand for agricultural products to satisfy the diverse needs of growing populations (for food, fibre and now fuel) has been the main driver behind agricultural water use.

The effects of water-depleting and water-polluting activities on human and ecosystem health remain largely unreported or difficult to measure, and the need grows stronger for effective protection of ecosystems and the goods and services they produce – on which life and livelihoods depend. As competition among demands on water increases, society will need to respond with improved water management, more effective policies and transparent and efficient water allocation mechanisms.

#### Chapter 6. Water's many benefits

Water has always played a key role in economic development, and economic development has always been accompanied by water development. Investment in water management has been repaid through livelihood security and reductions in health risks, vulnerability and ultimately poverty. Water contributes to poverty alleviation in many ways – through sanitation services, water supply, affordable food and enhanced resilience of poor communities faced with

disease, climate shocks and environmental degradation. Water of the right quality can improve health through better sanitation and hygiene and, when applied at the right time, can enhance the productivity of land, labour and other productive inputs. In addition, healthy freshwater ecosystems provide multiple goods and services essential to life and livelihood.

The importance of water services is especially apparent in societies where normal social life and political structures have broken down. In these fragile states the government cannot or will not deliver core functions to most of its people, including the poor. While each fragile state is fragile in different ways and for different reasons – war, post-conflict recovery, major natural catastrophe, prolonged mismanagement and political repression – a striking commonality in reports from aid agencies is the prominence of water and sanitation in relief and reconstruction programmes. The rapid restoration of viable water services is often a crucial ingredient of nation-building in these fragile states.

#### Chapter 7. Evolution of water use

While most of the old challenges of water supply, sanitation and environmental sustainability remain, new challenges such as adaptation to climate change, rising food and energy prices, and ageing infrastructure are increasing the complexity and financial burden of water management. Population growth and rapid economic development have led to accelerated freshwater withdrawals.

Trends in access to domestic water supply indicate substantial improvement in the past decade, putting most countries on track to achieve the water supply target of the Millennium Development Goals. However, sanitation is lagging well behind, and most sub-Saharan African countries and many rural areas still show unsatisfactory records for both water supply and sanitation.

Steadily increasing demand for agricultural products to satisfy the needs of a growing population continues to be the main driver behind water use. While world population growth has slowed since the 1970s and is expected to continue its downward trend, steady economic development, in particular in emerging market economies, has translated into demand for a more varied diet, including meat and dairy products, putting additional pressure on water resources.

After agriculture, the two major users of water for development are industry and

energy (20% of total water withdrawals), which are transforming the patterns of water use in emerging market economies. Water and energy share the same drivers: demographic, economic, social and technological processes put pressure on both energy and water. The recent acceleration in the production of biofuel and the impacts of climate change bring new challenges and add to the pressures on land and water resources.

Freshwater ecosystems provide an extensive array of vital services to support human well-being. A variety of economic and recreational activities such as navigation, fisheries and pastoral activities depend on direct use of water in healthy ecosystems. Yet some environmental services receive inadequate policy attention and are endangered by the way development sectors use water.

### **Chapter 8. Impacts of water use on water systems and the environment**

The pattern and intensity of human activity have disrupted – through impacts on quantity and quality – the role of water as the prime environmental agent. In some areas depletion and pollution of economically important river basins and associated aquifers have gone beyond the point of no-return, and coping with a future without reliable water resources systems is now a real prospect in parts of the world.

While the intensity of groundwater use, partly encouraged by subsidized rural electrification, has led to the emergence of many groundwater-dependent economies, their future is now threatened by aquifer depletion and pollution. Prospects for relaxing use of these key aquifers, remediating water quality and restoring groundwater services to ecosystems look remote unless alternative management approaches are developed.

Our ability to maintain the environmental services we depend on has improved but remains constrained by an incomplete understanding of the magnitude and impact of pollution, the resilience of affected ecosystems and the social institutions that use and manage water resources systems. A failure to monitor the negative impacts of water use on the environment and institutional weaknesses in many developing countries prevent effective enforcement of regulatory provisions.

Relevant information about pollution loads and changes in water quality is lacking precisely where water use is most intense – in

densely populated developing countries. As a result, the often serious impacts of polluting activities on the health of people and ecosystems remain largely unreported. Still, there are signs of progress in how pollution and the risks of pollution can be mitigated and trends in environmental degradation reversed.

### **Chapter 9. Managing competition for water and pressure on ecosystems**

Competition for water and shortcomings in managing it to meet the needs of society and the environment call for enhanced societal responses through improved management, better legislation and more effective and transparent allocation mechanisms.

Challenges include wise planning for water resources, evaluation of availability and needs in a watershed, possible reallocation or storage expansion in existing reservoirs, more emphasis on water demand management, a better balance between equity and efficiency in water use, inadequate legislative and institutional frameworks and the rising financial burden of ageing infrastructure.

Water management choices should emerge from informed consultation and negotiation on the costs and benefits of all options after considering basin interconnectivity, relationships between land and water resources, and the consistency and coherence of decisions with other government policies.

### **Part 3. State of the resource**

The uneven distribution over time and space of water resources and their modification through human use and abuse are sources of water crises in many parts of the world. In many areas hydrologic extremes have increased. Deaths and material damage from extreme floods can be high, and more intense droughts, affecting increasing numbers of people, have been observed in the 21st century. Worldwide, water observation networks are inadequate for current and future management needs and risk further decline. There are insufficient data to understand and predict the current and future quantity and quality of water resources, and political protocols and imperatives for sharing data are inadequate.

### **Chapter 10. The Earth's natural water cycles**

Water resources are made up of many components associated with water in its three physical states (liquid, solid and gas). The components of the water cycle (rainfall,

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evaporation, runoff, groundwater, storage and others) therefore all differ in their chemical and biochemical qualities, spatial and temporal variability, resilience, vulnerability to pressures (including land use and climate change), susceptibility to pollution and capacity to provide useful services and to be used sustainably. A consequence of this variability is that while human pressures have resulted in large modifications to the global hydrologic cycle, the directions and degrees of change are complex and difficult to ascertain. The uneven distribution of water resources over time and space and the way human activity is affecting that distribution today are fundamental sources of water crises in many parts of the world. Adding complexity, climate change and variability also influence the water supply, demand and buffering system, although their precise impacts can be difficult to isolate.

### Chapter 11. Changes in the global water cycle

Most climate scientists agree that global warming will result in an intensification, acceleration or enhancement of the global hydrologic cycle, and there is some observational evidence that this is already happening. While trends in precipitation have been noted in some parts of the world, in other areas precipitation patterns have remained about the same within the period of observed data. Changes have been observed in snow cover extent and snow water equivalent and in the frequency with which precipitation falls as snow. More than 15% of the world's population live where water resources availability depends heavily on snowmelt from ephemeral snowpacks or perennial glaciers. Despite the evidence of temperature changes, there is little evidence of detectable changes in evaporation and evapotranspiration.

Climate change is being superimposed on an already complex hydrologic landscape, making its signal difficult to isolate, and yet making its influence felt throughout the water supply, demand and buffering system. Data limitations in record length, continuity and spatial coverage contribute to the uncertainty, while natural climate variability and multiyear variability associated with large-scale atmospheric circulation patterns influence the interpretation of many trends in ways that are not yet fully understood.

Despite the limitations of global datasets, many studies have shown changes in runoff and streamflow. Many have focused on low (drought) or high (flood) extremes. Except in regions with flows affected by

glacier meltwater, the general conclusion is that global trends are not present or cannot be detected at this stage, although climate change-related trends are evident in some regions. Groundwater resources have been heavily used for human supply and agriculture for many years. While many groundwater abstraction schemes access fossil water (water unrelated to current conditions), renewable groundwater resources depend on highly variable recharge volumes.

It is thus realistic to expect future recharge regimes to reflect changes in the driving hydrologic processes (such as precipitation and evapotranspiration) that might result from anticipated climate changes. It is increasingly clear that the assumption of statistical stationarity is no longer a defensible basis for water planning.

Among the consequences of a changing hydrologic cycle is its interaction with the terrestrial carbon cycle. The terrestrial biosphere may have taken up roughly 25% of anthropogenic carbon emissions during the last century; it is unclear how long this can continue.

### Chapter 12. Evolving hazards – and emerging opportunities

Water-related hazards can be naturally occurring or anthropogenic. Hazards can result from too much water (floods, erosion, landslides and so on) or too little (droughts and loss of wetlands or habitat) and from the effects of chemical and biological pollution on water quality and in-stream ecosystems. The natural variability of water resources and changes, whatever the cause, can provide opportunities for management strategies to respond to potential climate change threats by implementing more resource-sustainable policies and practices.

In many places climate-related water events have become more frequent and more extreme. In developing countries extreme floods can result in many deaths, while in developed countries they can result in billions of dollars in damages. More intense droughts in the past decade, affecting an increasing number of people, have been linked to higher temperatures and decreased precipitation but are also frequently a consequence of the mismanagement of resources and the neglect of risk management. The increased exposure to potential climate change hazards has led to more awareness of water resources management.

Changes in flow and inputs of chemical and biological waste from human activity have altered the water quality and

ecological functioning of many of the world's rivers. Global warming is expected to have substantial effects on energy flows and matter recycling through its impact on water temperature, resulting in algal blooms, increases in toxic cyanobacteria bloom and reductions in biodiversity.

In areas of increasing water stress groundwater is an important buffer resource, capable of responding to increased water demands or of compensating for the declining availability of surface water.

### Chapter 13. Bridging the observational gap

Worldwide, water observation networks provide incomplete and incompatible data on water quantity and quality for properly managing water resources and predicting future needs – and these networks are in jeopardy of further decline. Also, no comprehensive information exists on wastewater generation and treatment and receiving water quality on a regional or global scale. While new technologies based on satellite remote sensing and modelling present opportunities, their value is limited by our ability to ground-truth and validate the simulated information.

Management of the world's water resources requires reliable information about the state of the resource and how it is changing in response to external drivers such as climate change and water and land use. There is little sharing of hydrologic data, due largely to limited physical access to data, policy and security issues; lack of agreed protocols for sharing; and commercial considerations. This hampers regional and global projects that have to build on shared datasets for scientific and applications-oriented purposes, such as seasonal regional hydrologic outlooks, forecasting, disaster warning and prevention, and integrated water resources management in transboundary basins.

Improving water resources management requires investments in monitoring and more efficient use of existing data, including traditional ground-based observations and newer satellite-based data products. Most countries, developed and developing, need to give greater attention and more resources to monitoring, observations and continual assessments of the status of water resources.

### Part 4. Response and choices

We have many of the answers. Across the planet we have already shown that it can

be done! But there is no one-size-fits-all solution. The best mix of responses to a country's development objectives and policy priorities to meet its water challenges depends on the availability of water in space and in time and the country's technical, financial, institutional and human capacities – its culture, political and regulatory frameworks, and markets.

Options within the water domain are distinct from those outside it. Leaders in the water domain can inform the processes outside their domain and implement decisions for the water domain; but it is the leaders in government, the private sector and civil society who determine the directions that will be taken. Responses outside the water domain strongly affect the macro changes that influence how water is used and allocated. They also make water adaptation measures more (or less) effective and less (or more) costly.

Many countries face multiple challenges but have limited financial and natural resources and implementation capacities. Countries need to fully use synergy opportunities and to make trade-offs and difficult decisions on how to allocate among uses and users to protect their water resources. To achieve results, many actors need to participate in these decisions.

### Chapter 14. Options inside the water box

There are many practical examples of solutions within the water domain. Some options show particular promise. Preparing institutions to deal with current and future challenges requires support for institutional development through such reforms as decentralization, stakeholder participation and transparency, increased corporatization where feasible and fair, partnerships and coordination (public-private, public-public, public-civil society), and new administrative systems based on shared benefits of water, including when water crosses borders. Decision-makers need to consider the influence of water law, both formal and customary, including regulations in other sectors that influence the management of water resources.

Decision-making is improved by consulting with stakeholders and ensuring accountability in planning, implementation and management as well as building trust within the water and related sectors and fighting corruption and mismanagement. Strengthening organization structures and improving the operating efficiency of water supply utilities will help to improve service

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quality and increase the coverage and density of connections, while also boosting revenues and creating a more viable financial base to attract further investment.

Innovation and research are critical for developing appropriate solutions. And greater institutional capacity and human capacity are needed, both within the water domain and in areas or sectors outside the water domain. Capacity development can occur through traditional forms of education, on-the-job training, e-learning, public awareness raising, knowledge management and professional networks.

Sound management accountability and good governance within the water sector contribute to creating a favourable investment climate. This should include new approaches such as payment for environmental services.

### **Chapter 15. Options from beyond the water box**

Dealing with risk and uncertainty has long been a routine challenge for water resources managers and policy-makers across sectors and the world. However, issues like climate change and demographic dynamics have made the risks greater and the task more complex. Risk management is now much more important – indeed essential – to analysis and decision-making.

Drivers and policies outside the water sector have more impact on water management than do many policies championed and implemented by water-related ministries. Identifying trade-offs and synergies between water and other policy sectors can enhance policy impacts in all sectors and avoid some adverse effects on water. Because governments, civil society and business leaders make decisions every day that can affect water, it is important to identify where such decisions can also lead to improvements in water sector management and in water sector and environmental services.

Examples of win-win situations abound – whether created by governments, communities or businesses – that point to promoting deliberate cooperation between water and non-water actors and integrating water issues into external decisions. International organizations, notably the UN system, can provide support and expertise to governments, help civil society build capacity and catalyse leadership in the private sector.

### **Chapter 16. The way forward**

Water and water systems must be managed to achieve social and economic

development objectives and to sustain development. Water resources, properly managed, are critical to the survival and well-being of individuals. They can ensure equity and security in water and sanitation for families, businesses and communities. And they can ensure adequate water for food, energy and the environment as well as protection from floods and droughts.

Decision-making on water requires seeking synergies and selecting appropriate trade-offs. It also requires distinguishing between short-term ‘fire-fighting’ – responding to the urgent issues of the day – and long-term strategic development. Developing multi-purpose water schemes and reusing water wherever feasible can lessen the need for trade-offs by enabling the same volumes of scarce water to deliver multiple outcomes.

The donor community can incorporate water into the broader frameworks of development aid and focus assistance on areas where it is needed most – in sub-Saharan Africa, in Asian and Latin American slums and in states recovering from conflict. Recent G-8 efforts in this direction are promising.

The chief executives of the UN agencies, following the example of their joint discussions of and collective responses to climate change, can convene to examine the role of water, water systems and water management in development and environmental services, providing direction to agencies and advice to member countries.

The World Water Assessment Programme and its partners are working to help reduce uncertainty, facilitate decision-making and accelerate investment by highlighting the links between socioeconomic development and investment in water management capacity and infrastructure in other sectors.

The challenges are great, but unsustainable management and inequitable access to water resources cannot continue. We might not have all the information we would like to have before acting, but we do know enough now to begin to take significant steps. Actions must include increased investment in water infrastructure and capacity development. Leaders in the water domain can inform the processes outside their domain and manage water resources to achieve agreed socioeconomic objectives and environmental integrity. But leaders in government, the private sector and civil society will determine the direction that actions take. Recognizing this responsibility, they must act now!