Global Framework for Action
to achieve the Vision on Groundwater Governance

March 2016

Groundwater Governance
A Global Framework for Action

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Acknowledgements

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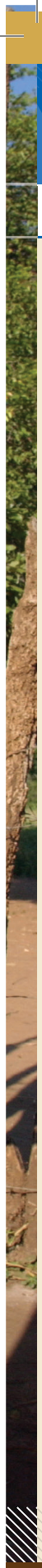


Preface

This document, *Global Framework for Action to achieve the Vision on Groundwater Governance*, is the last one in the long series of documents produced by the project '*Groundwater Governance: A Global Framework for Action*' (2011-2016). It is one of the three key documents prepared during the final phase of the project; the other two are the *Global Diagnostic on Groundwater Governance* and *A Shared Global Vision for 2030*. While the Global Diagnostic looks at the current situation and the Vision expresses the shared aspirations on what to achieve by the year 2030, it is the Global Framework for Action that describes the action required for improving groundwater governance according to the Vision's aspirations. Its purpose is to trigger action and to provide guidance on the main steps to be taken. Perhaps is it therefore the most important one of the mentioned three key documents.

The Global Environment Fund (GEF), the Food and Agriculture Organization of the United Nations (FAO), the United Nations Economic, Social and Cultural Organization International Hydrological Program (UNESCO IHP), the International Association of Hydrogeologists (IAH) and the World Bank, co-operating in this Groundwater Governance project, consider the Global Framework for Action as an essential tool for triggering appreciable follow-up to the project in the form of many initiatives for improving groundwater governance around the world. For these organizations, the urgency of improved governance of the precious and vital resources was already clear from the onset. The many activities, discussions and outputs of the project have confirmed and highlighted this urgency very convincingly; and they have certainly contributed to spreading the message and demonstrating the need for action in virtually all parts of the world.

The project has revealed and documented the enormous diversity around the globe in groundwater conditions, development, management and governance, as well as in geographic, socio-economic and political contexts. A Global Framework of Action therefore is cast necessarily in rather generic terms, but it is believed that what has been presented forms a strong and relevant guidance for improvement of groundwater governance in any particular setting.

The Global Framework for Action starts by briefly characterizing groundwater governance and summarising the rationale for strengthening it, by describing the Groundwater Governance project in terms of processes and outcomes, and by explaining the structure and intended use of the Framework for Action.

It was considered appropriate to dedicate a special chapter to understanding the context, since taking the local context fully into account is crucial for the success of the actions to be taken. Evidently, it is important in each area to identify the main groundwater management challenges to be addressed: for instance, groundwater level declines and storage depletion, salinization of fresh groundwater, pollution, water-logging and groundwater flooding, degradation of ecological functions or the environment, or interaction between groundwater development and other uses of the subsurface. A ‘one size fits all’ response to these issues is unlikely to be effective. Instead, tailor-made approaches should be adopted and tuned to key factors of the local context such as hydrogeological setting, human interactions with groundwater, and political and macro-economic conditions.

It is also important to be aware that improving groundwater governance is a time-consuming process and that initiating many actions simultaneously is usually not feasible nor effective. The framework therefore pays special attention in Chapter 3 to creating an adequate basis for governance. An initial diagnostic analysis will always prove very useful. Further, the processes

of change will benefit from paying due attention in an early stage to leadership, information, awareness raising and involvement of stakeholders at an early stage.

Effective institutions — including organizations and legal frameworks, both formal and informal — form the core of governance. Therefore, building effective institutions, addressed in Chapter 4, is essential. Among the many aspects discussed some emphasis is given to the enforcement of laws and regulations, the capacity of lead government agencies in groundwater governance, the vertical and horizontal linkages in groundwater policy and management, stakeholder engagement, the practice of cross-sector coordination and the special case of transboundary aquifers.

Given the many interdependencies in real life, the Framework of Action underlines the importance of adopting a holistic view, in a separate chapter on essential linkages. This includes not only linking groundwater with the other components of the water cycle (in an IWRM approach), but also linkages of groundwater development and management with sanitation, waste water and waste management, land use, land use practices, energy, use of the subsurface space and exploitation of other subsurface resources. Mainstreaming groundwater in other policies is recommended.

Finances are discussed in the next chapter. A plea is made for securing financing for the basic functions of groundwater management and governance, attention is called to innovative approaches to generating funding and especially to redirecting financing. The latter includes discontinuation of ineffective or even counterproductive funding or incentives, and using the recovered finances for more cost-effective purposes.

The final step in groundwater governance is establishing a groundwater resources planning and management process. It forms the bridge between groundwater governance and management. Chapter 7 summarizes key facets of establishing such a process.

The Framework for Action ends with a call for action. Groundwater is a vital and precious resource on Earth, and firm action to improve groundwater governance very significantly is urgent. The cooperating international organizations GEF, FAO, UNESCO, IAH and World Bank express their sincere hope that the project ‘Groundwater Governance: A Global Framework for Action’ will have the intended global impact and that its call for action is widely heard and responded to.

The Project Steering Committee
Rome, March 2016

Executive summary

This Framework for Action has been prepared to achieve the goals of the Shared Global Vision for Groundwater Governance 2030. It describes the main steps to be taken and is an urgent call for action to all who can make a difference: national and local governments, international organizations, the private sector, civil society, media, educational institutes and professional organizations — but also to well owners, groundwater users and concerned citizens everywhere.

A shared global vision for Groundwater Governance 2030

This is a Vision of a world in 2030 in which countries have taken appropriate and effective action to govern their groundwater in order to reach globally shared goals of social and economic development and avoid irreversible degradation of groundwater resources and their aquifer systems.

There is more freshwater stored underground than anywhere else on the planet. Although not all of this groundwater is readily accessible, groundwater has become a critical element for living for many settlements, cultures and economies as a prime source of water and also as a factor in environmental health and climate change adaptation.

For all too long now, groundwater has too often been 'abandoned to chance' — despite the growing resource utilisation and dependence. Therefore, a Shared Global Vision for Groundwater Governance has been generated through a worldwide process of consultation with groundwater professionals, users and managers. The Vision is an urgent call for systematic action, recognizing that the 'price of doing nothing' will be especially high, in terms of lost freshwater reserves at a time when groundwater storage is critical for sustaining water security and adapting to climate variability.

The Vision aims that by 2030

- there are appropriate and implemented legal, regulatory and institutional frameworks for groundwater that establish public guardianship and collective responsibility, permanent engagement of stakeholders and beneficial integration with other sectors, including other uses of the subsurface space and its resources
- all major aquifer systems are properly assessed, and the resulting information and knowledge are available and shared, making use of up-to-date information and communication techniques
- groundwater management plans are prepared and implemented for the priority aquifers
- groundwater management agencies, locally, nationally and internationally, are resourced and their key tasks of capacity building, resource and quality monitoring, and promoting demand management and supply-side measures are secured
- incentive frameworks and investment programmes foster sustainable, efficient groundwater use and adequate groundwater resources protection.

The Vision and this Framework for Action originate from concerns that whilst we are increasingly dependent on groundwater, the resource and the related aquifer systems are under threat and the governance of groundwater in most cases has not kept up with these challenges. This led five international organizations — the Global Environmental Facility (GEF), the World Bank, the Food and Agriculture Organization of the United Nations (FAO), the UNESCO-International Hydrology Programme (IHP), and the International Association of Hydrogeologists (IAH) — to organize the Groundwater Governance Project. This global initiative to strengthen groundwater governance commissioned 12 thematic papers and a synthesis by leading experts and convened five regional consultations in different parts of the world and a final high level expert meeting. The outcomes of all these activities were integrated in a Global Diagnostic that became the basis for the Shared Global Vision for Groundwater Governance 2030 and this Global Framework for Action to Achieve the Vision on Groundwater Governance.

What needs to be done in a certain place and for a certain aquifer system is very much driven by the local context — the hydrogeology, the level of development and the specific challenges of an aquifer — and also by the capacity of political leadership to deliver, by the overall governance context, and by macro-economic objectives. From the consultation process it was, however, clear that almost everywhere much more needs to be done to strengthen groundwater governance. The steps to be taken need to be adapted to what is feasible in the specific local and national context.

Creating an adequate basis for governance

The first theme for action is to create an adequate basis for governance. This starts with diagnosing the current groundwater governance conditions in the area concerned. This diagnostic helps to define which governance improvements are most relevant and how they may be adapted to local conditions and challenges. Critical in all cases is leadership (usually vested in a dedicated government organization) and political commitment. Other elements that contribute to the foundations of good groundwater governance are provisions for structural acquisition and management of data and information, awareness raising programmes and mechanisms for effective stakeholder involvement.

Building effective institutions

The second theme for action is to build effective institutions. These should have the capacity to look ahead and to plan, to be inclusive and legitimate in the eyes of the stakeholders, and to come to credible and verifiable commitments.

Laws and regulations and effective provision for their implementation are important starting points. They should bring groundwater under public guardianship, and provide for water well development licensing at the appropriate scale, and for controlling localized 'point' pollution. Laws and regulations should also require data sharing and facilitate important processes such as balancing competing or conflicting interests among stakeholders, and coordination with urban and rural land uses and with the management of the entire subsurface space.

As far as government organizations are concerned, it is preferred to have a national unit or a dedicated team that ensures both vertical integration between the national and local level, and horizontal cooperation across different levels and the interface with other sectors. Because groundwater is essentially a local resource, local organizations (including municipalities) have a large role to play. Governments should not endeavour to 'go it alone', but instead seek the systematic engagement of stakeholders. The preferred action is to create permanent mechanisms for stakeholder involvement: this can be in the form of groundwater management associations or fora.

In building effective institutions, transboundary aquifer systems that extend across country or state borders require special provisions. More efforts are required to promote cooperation, starting with building confidence and developing relations between professionals and stakeholders from the neighbouring countries.

Making essential linkages

Establishing linkages to other water resources and to other sectors is a requisite of governance. This is the third theme for action: connections to the management of other water sources and other sectors need to be systematically made. At present the linkages often are not incorporated in policies and plans.

Within the water sector, groundwater is part of a continuous water cycle and needs to be managed in an integrated way with other sources of water. Groundwater and surface water in particular supplement and feed each other; hence water allocation plans should be made accordingly. In mega-irrigation systems there is scope to dovetail surface water supplies and groundwater recharge and usage.

Groundwater governance should also make strong functional linkages to other sectors. Priorities are the urban water sector, because of the effect of pollution from sewerage and waste disposal and the increased reliance on groundwater; the land use and land management sector, which has a large effect on the use and recharge of groundwater as well as being a

major source of pollution; the mining and other sectors that make use of the subsurface; and the energy sector, where the pricing and delivery of energy is a major driver for groundwater use, and where non-payment or below-cost prices can also wreck energy utilities. The key to sustainable groundwater management often lies in the integration of groundwater issues within wider policies — from regulating the use of hazardous substances, to infrastructural planning (such as roads and pavements) to trade arrangements.

Redirecting finances

In many countries, incentive policies and public expenditures at present do little to promote sustainable and efficient groundwater management, and often even do harm. Examples are subsidies that encourage over-abstraction and inefficient use such as growing high water-demand crops in areas where groundwater is under severe stress. The financial resources involved in these subsidies are often very large. They could be freed up to support recharge and promote water use efficiency and pollution mitigation.

There is also, in general, a need to invest much more in groundwater governance. It is important that the basic functions of regulation, planning and monitoring are not under-resourced. Such functions are 'virtuous': they safeguard a shared treasure of enormous value to society and the economy. Part of the cost of these services could be paid through creative approaches to cost recovery such as charging for groundwater use — supported by new systems such as the use of swipe cards or pre-paid systems.

Similarly, there needs to be more investment in groundwater management. Portfolios need to be developed for projects on building knowledge and dissemination of information; user engagement through participatory monitoring; landscape improvement, wetland restoration and recharge projects to augment groundwater replenishment; groundwater substitution projects; dedicated electricity feeder lines to better regulate different groundwater uses; swipe card systems to facilitate the application of groundwater quotas; reduction of pollution loads from effluents and other sources; and protection of recharge zones and, where unavoidable, remediation.

Starting the process of planning and management

The final theme of action is to start the process of planning and management, beginning with priority aquifers where pressures are high and interests large. A systematic process of planning and management can demonstrate that groundwater governance is in action.
The process should start with the identification of suitable management units, then develop

a plan of activities in cooperation with main stakeholders, implement these activities in a systematic and phased way, and ensure that outcomes of the implemented measures are monitored. Special arrangements are required for vulnerable situations — such as non-renewable groundwater systems, fast-growing cities or small island states.

The call for action

The current state of, and dependence upon, groundwater requires a massive effort to strengthen its governance — locally, nationally and where appropriate in transboundary situations. This will require a concerted and coordinated effort from government at different levels, from municipalities and utilities, from the private sector, civil society and international organizations, educational institutes, media and professional associations.

Fortunately there are some inspiring examples to follow — major cities that have managed to control excessive extraction, islands that have safeguarded groundwater quality, and districts that have put in place full monitoring and metering systems for groundwater.

The Shared Global Vision for Groundwater Governance 2030 and the Global Framework for Action to Achieve the Vision on Groundwater Governance call for strengthening groundwater governance. This call for action urges countries, districts, communities, companies, organizations and individuals to safeguard the groundwater resource that is essential to meet their common future goals and to set in place the groundwater governance arrangements that will secure this future for the common good of all.

1. Introduction

1.1 Strengthening groundwater governance — an urgent need

The groundwater revolution of the last half-century has brought enormous socio-economic benefits across the world — and promises even more

Groundwater development has brought enormous benefits in development and improvements in welfare in the last fifty years. It has been the corner stone for agricultural intensification and quality production in important global food baskets. It has been the economic sustenance in a myriad of localities in many countries. It is a prime source of safe water supplies for rural and urban populations and for small and large businesses. Groundwater is serving as a strategic reserve that can be relied upon if other water sources are non-existent or if they temporarily fail.

Development of groundwater has been rapid, outpacing the development of the governance frameworks that should have regulated it, and significant problems of allocation, depletion and quality impairment are emerging

The abstraction of groundwater has steadily increased as has dependence on groundwater. The increase in groundwater abstraction is fourfold in the last fifty years for the world as a whole. The increase is even more pronounced in, for instance, South Asia, the Middle East or North China. Another major trend consists of the steadily increasing threats to groundwater quality, mainly due to anthropogenic pollution sources. These pollution sources tend to be prominent in densely populated areas, in industrial zones and in areas of intensive agriculture. With a few positive exceptions, however, the governance of groundwater has not kept pace with these unprecedented and rapid changes. As a result, part of the valuable groundwater resources may be lost and groundwater-related ecosystems and environment may be damaged. Moreover, in several areas there are opportunities foregone: by better recharge and management of the subsurface space new groundwater reservoirs can be created that were not there before. These are not different from surface storage but they have a number of advantages: they can be very large and they do not lose water to evaporation. Whilst all these issues are known to a small group of persons, they are not common ground among a larger group of politicians or concerned citizens.

Groundwater governance comprises the enabling framework and guiding principles for management of groundwater in line with society's goals

Groundwater governance comprises the enabling framework and guiding principles for collective management of groundwater in pursuit of society's goals of growth, sustainability, equity and efficiency. Governance comprises four essential components: a conducive **legal framework**; accurate and widely-shared **knowledge** of groundwater systems together with **awareness**; an **institutional framework** characterized by representation and leadership, sound organizations and capacity, stakeholder engagement and participation, and working mechanisms to coordinate between groundwater and other sectors; and **policies, incentive structures and plans** aligned with society's goals.

Groundwater governance has characteristics that distinguish it from the governance of surface water resources

Although groundwater governance forms part of overall water governance, the characteristics of groundwater as an 'unseen', largely open-access resource, usually developed and used in an unregulated way (private exploitation is predominant), and the comparatively very slow

flow and transport processes (leading to very large groundwater system reaction times) merit specific governance provisions.

Good groundwater governance is the basis for effective groundwater management

Groundwater governance provides the enabling framework and guiding principles within which groundwater management operates. Management thus comprises the actions taken to control groundwater abstraction and to prevent the degradation of groundwater quality, typically with the objective of ensuring sustainable freshwater provision and preserving desired environmental and ecosystem conditions that depend on groundwater.

Yet almost everywhere, groundwater governance is weak

Across the globe, groundwater has huge social, economic and environmental importance, but little attention has been paid to exploiting and using this precious resource wisely, and to managing and protecting it effectively. Groundwater governance is poor — or even largely absent — in most parts of the world.

Box 1.1

Glossary

Groundwater governance
Groundwater governance comprises the promotion of responsible collective action to ensure control, protection and socially-sustainable utilisation of groundwater resources and aquifer systems for the benefit of humankind and dependent ecosystems. This action is facilitated by an enabling framework and guiding principles.

Groundwater management
Groundwater management comprises the activities undertaken by mandated actors to sustainably develop, use and protect groundwater resources.

Governance of the sub-surface space
Governance of the sub-surface space comprises the regulation of all activities and functions located in the subsurface space to ensure harmonized use and avoid undesirable and irreversible damage.

Therefore, the Groundwater Governance Project developed a Shared Global Vision for Groundwater Governance

The Groundwater Governance Project developed a Shared Global Vision of the desired state of groundwater governance globally by the year 2030. This Vision is of a world in which groundwater, everywhere is governed in a way that balances its important and wide-ranging services for a broad group of present and future stakeholders, and that assures resource sustainability and avoids irreversible degradation of groundwater resources

...and this Framework for Action advocates achievement of the Vision

This Framework for Action advocates groundwater governance to be placed on political agendas and aims to trigger effective action in groundwater management. Improvement of groundwater governance is now essential, both to sustain the achievements that have been made so far and to achieve future goals of social and economic development, while preserving the groundwater resource and the related environment and ecosystems.

1.2 GEF Groundwater Governance Project — process and outcomes

This Framework for Action, the final output of the Groundwater Governance Project, is based on the Global Diagnostic and on the Shared Global Vision for Groundwater Governance 2030

This Framework for Action is the final output of the Groundwater Governance Project. This project was led by a core group of organizations: the Global Environmental Facility (GEF), the World Bank, the Food and Agricultural Organization of the United Nations (FAO), the International Hydrology Program of UNESCO and the International Association of Hydrogeologists (IAH). Among other outputs and activities, the Project produced, a series of **thematic papers** and initiated **regional consultations** in different parts of the world to take stock of the range of situations with regard to groundwater. These consultations culminated in five **Regional Diagnostics** and a **Global Diagnostic**. In addition, a **Shared Global Vision for Groundwater Governance 2030** was developed to guide future action (see below).

There are wide variations in the challenges countries and areas face, and also a wide diversity of governance measures in place

The Regional and Global Diagnostics summarized the diversity of issues identified in the different regions and identified the main groundwater governance deficiencies (Table 1.1). There are huge geographic variations in the status of groundwater governance and also in the overall context and the urgency of improving groundwater governance.

Table 1.1

Key deficiencies identified in the 'Global Diagnostic'

- Inadequate leadership from government agencies
- Lack of awareness of long-term risks
- Lack of knowledge of the resource and its status
- Non-performing legal systems
- Insufficient stakeholder engagement
- Poor integration with related national policies

Some types of groundwater occurrence deserve special attention in terms of groundwater governance and management

First are the world's intensely irrigated areas that depend on groundwater, exclusively or in conjunction with canal supplies from surface water sources. Second are the **large urban areas using groundwater or located above aquifers**. In these areas, hydrological systems have changed with the expansion of build-up area, unprecedented pollution is observed and at the same time the demand for water is high and rising fast, creating extraordinary pressures. Third are **small island states**, most of them extremely vulnerable due to geographic factors and their heavy dependence on often slim and fragile groundwater resources. Fourth are **transboundary aquifer systems**. Groundwater resources shared between countries or other administrative units are often not yet well assessed and understood, but in some cases issues over abstraction and pollution are already emerging.

Almost everywhere, groundwater depletion and aquifer degradation are apparent, and there is a need to review and strengthen governance and management provisions in the very near term.

Though some countries, some regions and some cities are addressing the challenge of groundwater management adequately, there is almost everywhere a need to improve groundwater governance. In many areas, continual but sometimes unnoticed deterioration of groundwater systems in terms of both quantity and quality is occurring. In addition, there are challenges of allocation between sectors (often between agriculture and municipal needs) and amongst users, with frequently skewed and inequitable access to groundwater, particularly amongst rural users. In many countries, these problems are now pressing, and there is a need to review and strengthen governance and management provisions in the very near term.

The Shared Global Vision sets out some key requirements for strengthening groundwater governance:

The Groundwater Governance Project developed a Shared Global Vision for Groundwater Governance 2030 setting out the desired state of groundwater governance globally by the year 2030. This Vision is of a world in which groundwater everywhere is governed in a way that balances its important and wide-ranging services for a broad group of present and future stakeholders, and that assures resource sustainability and avoids irreversible degradation of groundwater resources. Key requirements of good groundwater governance, as envisaged in the Vision, are summarized in Table 1.2. The Vision calls upon countries to take appropriate and effective action to govern their groundwater resources properly and to prevent irreversible degradation. The Vision makes an appeal to all stakeholders to support these processes.

Table 1.2

The Shared Global Vision: key elements of good groundwater governance

- Accurate and widely-shared **understanding** of groundwater systems
- An effective **legal system** in which groundwater is under public control
- **Leadership** nationally and locally for the resource, with **empowered government agencies** having appropriate authority, personnel and finance for the task
- Mechanisms to facilitate and nurture **stakeholder participation**
- **Co-management with surface water and land-use**, and **coordination with related sectors** (such as urbanization, agriculture and energy) to address issues and risks
- Structured programmes for the elaboration and implementation of priority **management action plans**, based on sound scientific evidence.

1.3 The Framework for Action — How it will contribute

The Framework is action-oriented, setting out a structure for action and specific steps on five themes that can be taken by stakeholders

The Framework for Action is a call for action to be taken by various actors inside and outside the groundwater community: not only national governments and their water agencies, but by all stakeholders and institutions in a position to make a difference. It aims to set out an overarching structure for action, together with initial steps and achievable objectives as a process towards achieving the Vision on Groundwater Governance. From the consultation process it was clear that almost everywhere much more needs to be done to strengthen groundwater governance. What is done and when in a certain place has to take into account what is there already and what is feasible in the short and medium term. The steps to be taken towards strengthened groundwater governance need to be adapted to what is possible in time and space. The Framework for Action proposes activities on five themes:

- Initial steps to establish an adequate basis for groundwater governance (Chapter 3)
- Strengthening institutions in groundwater governance (Chapter 4)
- Creating linkages with main interrelated areas of human action and policy (Chapter 5)
- Redirecting finances for effective groundwater management (Chapter 6)
- Establishing a process of groundwater planning and management (Chapter 7).

The Framework also emphasizes the importance of understanding and adapting governance to the local context

Since provisions and actions should be adapted to the local context, priorities and opportunities, it is essential to understand the local context properly. Therefore, the chapters dealing with the five themes are preceded by a chapter dedicated to understanding the context (Chapter 2).

A final chapter of the Framework emphasizes the need for all stakeholders to act in order to improve governance and spells out what each category of stakeholder may do

The document is intended for use at different levels — local, country, regional and global — with active, strategic supporting roles for regional and international players. The last chapter (Chapter 8) of this Framework for Action describes the actions to be taken by different groups of stakeholders, the ultimate message being that broad and active engagement is required and is at the heart of effective groundwater governance.

2. Understanding the context

2.1 Specific focus for action — main groundwater challenges

The most immediately evident groundwater challenges are the physical ones, largely related to depletion through over-pumping, to pollution, and to degradation of the aquifer and its ecological and environmental functions

Groundwater management and the related governance arrangements are designed to meet agreed objectives and to address specific challenges. Typical physical and technical challenges identified in the Global Diagnostic on Groundwater Governance are:

1. *Depletion of stored groundwater*. Caused by a persistent and significant imbalance between groundwater recharge and abstraction, depletion is accompanied by falling groundwater levels, with impacts such as higher groundwater abstraction cost; wells and springs falling dry; reduced base-flows in rivers and streams; ecosystems and the environment affected; loss of the aquifer's buffer capacity; and eventually physical exhaustion of the aquifer and loss of the resource.

2. Salinization of fresh groundwater. Increasing salinity levels in groundwater are caused by a range of processes, sometimes associated with intensive exploitation of groundwater near saline groundwater bodies (e.g. seawater intrusion in coastal zones or up-coning of deep salt water) or with increased evaporation in zones where groundwater levels have become shallow due to excessive infiltration of surface water or rising salt concentrations in infiltration from irrigated land increased salinity limits the suitability of groundwater for practically all functions.
3. Pollution. Widespread and persistent groundwater pollution occurs in many parts of the world. Common causes include leaching of agro-chemicals; the infiltration of urban and industrial effluents; and disposal of untreated waste. Pollution not only reduces the value of groundwater as an extractable resource, but it also affects groundwater-related ecosystems.
4. Degradation of ecological functions and the environment. Falling water tables may curtail the availability of soil moisture, change local micro-climates, dry out groundwater-dependent ecosystems, reduce spring and base flows and, in some ground conditions, trigger land subsidence.
5. Water-logging and groundwater flooding. Waterlogging can be a natural condition sustaining wetlands, but it can also be produced by land and water use, in combination with wet meteorological conditions. Waterlogging happens especially in flat, low-lying areas. Waterlogging and related groundwater flooding may bring health risks for humans and livestock, damage property and reduce agricultural yields.
6. Uncontrolled interaction between different human activities in the subsurface. There is a rapidly growing pressure on the entire subsurface space of which aquifers are an important part. Pressures stem from: mining; underground construction (pipelines, subways, parking space etc.); underground storage of various substances (including hazardous material); and the development of energy sources (ranging from conventional oil and gas to shale gas and coal bed methane exploitation and geothermal energy). All these activities can affect groundwater and may damage aquifers or the groundwater they contain. On the other hand, groundwater abstraction may have negative impacts on various uses of the subsurface space and on the exploitation of subsurface resources.

There are also challenges of inequitable allocation of groundwater, of potential conflict between sectors or inefficient use

In addition to the evident physical challenges, socio-economic and broader policy issues also arise. There may be local issues of inequitable allocation, where larger farmers or those with capital have appropriated what may be viewed as a common resource by drilling wells. In some locations, farmers have developed a resource that might later have been the prime source for water supply in a nearby city. A further but linked issue is that groundwater use in agriculture may be artificially stimulated and sustained, for example by subsidized energy for pumping, such that farmers have no incentive to invest in maximizing water productivity.

Often behind the challenges, lie failings in governance and demand management that send the wrong signals to users

In many countries, weak demand management policies drive poor use of the resource. Globally, the most common failure of governance has been the absence of effective regulation that has allowed competitive over-pumping to develop.

Over-abstraction — and the resulting 'tragedy of the commons' — have also commonly been fostered by incentives that result from both market and policy failures

To a significant extent, the over-abstraction of groundwater reflects the incentives that users face resulting from both market and policy failures. Groundwater aquifers are a shared common pool resource — that is a resource that is used jointly by a number of users. As a result, the benefits of abstracting water from the common aquifer accrue to the individual, but the costs and consequences of a diminished supply of water impact all users of the aquifer. The result is the familiar 'tragedy of the commons' — where each user extracts more of the resource than is optimal and desirable. The problem is usually made worse by a lack of information and data on the status of aquifers, with the result implying that there is often a large element of uncertainty in determining when unsustainable levels of abstraction have been reached. In some cases policies tend to promote over use and even abuse of the resource. For instance, where, as often, the energy used for pumping is subsidized there will be a greater incentive to use more water.

Weak regulation has also led to negative externalities, for example in pollution of groundwater

In addition, where sanitation regulations and infrastructure are weak, groundwater supplies have been rendered unusable by pollution and by contamination from either industrial sources or household waste water. Addressing these externalities will be key to more efficient and sustainable management of ground water resources.

In addition to these challenges there are supply-side opportunities that are missed

As groundwater use has soared, there has been growing scope for investment in recharge infrastructure and programmes such as dams, terracing or watershed management. These investments need, however, to be made within a coherent governance framework and in managed aquifers.

It is these physical and socio-economic challenges which set the agenda for improved groundwater governance

These main challenges occur in variable degrees and in a diversity of ways in different places: each of them may be a critical challenge at some locations and less important elsewhere. Together with a number of other parameters of the local context (outlined below), they set the agenda for action, which has direct implications for the governance requirements and options at each particular location. Hence, for improving groundwater governance it is important to understand the local context.

2.2 Key facets of the local context

Factoring in the local context is essential, as the resource, the socio-economy and the institutional context vary widely

Although the Global Diagnostic found widespread shortcomings in governance, there is no single solution or formula that will addresses all groundwater challenges in all places. Hence an understanding of the local context is essential, considering its various dimensions, in particular the hydrogeological setting (2.3); human interactions with groundwater (2.4); and the overall political and macro-economic conditions (2.5).

2.3 The hydrogeological setting

The hydrogeological setting is a key determinant of governance needs

Hydrogeology differs significantly from place to place. It determines to a large extent the nature, extent and persistence of groundwater resource management challenges (as listed in Section 2.1). Moreover, hydrogeology sets the scene for groundwater governance.
The character of the aquifer systems, the way aquifers interact with surface water, the level of contemporary recharge, the vulnerability to pollution — all have a bearing on the modalities of groundwater governance that may be appropriate and feasible in a certain place.

The character of the aquifer may indicate the best governance approach....

In some cases, the most important governance instrument may be the incentive structure. For instance, large alluvial aquifers sustain many thousands of individual groundwater exploiters. This multitude of users make it hard, if not impossible, to establish a formal regulatory regime. Governance of such systems is possible — but typically by creating a common knowledge base that encourages informed groundwater abstraction and use rather than trying to regulate directly the behavior of a multitude of often small individual exploiters.

...or through local self-management

In the contrasting case of a relatively localized hard-rock aquifer where the population of exploiters is much smaller and where the effect of what a single person does — either in groundwater exploitation or in enhancing recharge — can be more easily monitored, there is more likely to be the basis for cooperation among the local groundwater exploiters which could make self-management and self-regulation the best approach.

In other cases, a high level of interaction with other water resources may indicate that conjunctive management is required

Another example of hydrogeological conditions setting the boundaries for governance is how in a certain place aquifer systems interact with surface water. This interaction can go both ways (shallow groundwater systems being recharged by streams or irrigation canals, and vice versa) — the relation changing between seasons and along the course of a stream. In such cases surface water and groundwater systems should be managed conjunctively.
In other areas where there is little interaction between surface water bodies and the

underlying aquifer, governing groundwater can be stand-alone, unless both types of water interact significantly in satisfying local water demands.

Many aquifers are regularly recharged — and recharge can be enhanced — while others contain non-renewable groundwater resources ('fossil groundwater'). Different rules need to be applied to management of regularly replenished groundwater resources from those applied to the 'mining' of groundwater storage reserves

The level of contemporary recharge is an important facet too. Rainfall, local run-off or floods actively recharge many aquifers, and recharge may be enhanced by planned recharge programs. In some successful landscape-wide recharge programs, 'new' groundwater resources have been created. By contrast, some deep aquifers are no longer replenished and contain only 'fossil' groundwater. The exploitation of these fossil groundwater reserves requires a different set of rules and arrangements, as the water resource is non-renewable.

Management practices will also vary according to aquifers' vulnerability to pollution

Groundwater systems also differ in their exposure to pollution pressures and vulnerability to pollution. Shallow unconfined aquifers tend to be more vulnerable to pollution than confined aquifers underneath a low permeability overburden, while aquifers with large rock interstices (e.g. karstic limestone) are more vulnerable than those composed of rock that have only micro-scale open spaces.

2.4 Human interactions with groundwater

The nature and intensity of human interactions with the groundwater systems form the second dimension of the local context that influences the groundwater governance provisions that are desired and their feasibility. Often, it is the close link between land ownership (which is often exclusively private) and groundwater access that confounds attempts to govern groundwater use. De-coupling land and water tenure may be desirable in order to advance regulation, but is difficult to achieve in practice where land and groundwater use is so closely bound by custom, tradition and, in some cases, by law.

The higher the socio-economic importance of groundwater the greater the need for management — and the more challenging the political economy

Human interaction with groundwater has a number of facets. First of all is the local *socio-economic* significance of groundwater. The higher the local significance, the greater the need for workable groundwater management and governance. The economic significance of groundwater use also affects the stakes and vested interests that may either stand in the way of governance reform or create pressure for change. The economic significance also affects the finances that can be raised to invest in governance provisions and arrangements. The diversity of interests of users — their affiliations, the varying nature of their stake in the resource, their capacity for collective action and adaptation — influences the way cooperation and regulation will take shape.

The more intense the exploitation and the greater the number of abstractors, the more likely problems are to emerge necessitating higher levels of management

Second, closely related to the socio-economic significance of groundwater, is the local *intensity of groundwater abstraction* for different purposes (domestic use, agriculture, industry, mining) and the related number of groundwater users. More intensive abstraction usually leads to many challenges (Section 2.1). The presence of a very large number of groundwater exploiters poses difficult challenges of an administrative and regulatory nature, and may require governance arrangements different from those in case of small numbers of exploiters.

Where human activity creates a high risk of pollution, specific governance responses are needed

Third is the occurrence of human activities that may lead to *pollution of groundwater resources*. If the risks are high, then high priority should be given to governance arrangements required for pollution control. But attempts at controlling pollution to aquifers from land — whether as a point source (a factory outlet) or from broad land treatment with fertiliser and pesticides — is still dependent upon appealing to many private landholders who may have strong incentives to hide polluting activities.

Where groundwater development and use is advanced and complex, clear governance arrangements will be a high priority

Fourth is the *stage of development*. This refers not only to the intensity of groundwater exploitation (compared with the potential of the groundwater systems), but also to the degree of development of water supply and sanitation infrastructure, wastewater treatment provisions, waste management practices etc. Where a socio-economy is highly dependent on groundwater for multiple uses, governance provisions need to be similarly advanced.

2.5 Political and macro-economic conditions

The effectiveness of groundwater governance will reflect the soundness of overall governance in a country and the level of engagement of political leadership

Whatever directions groundwater governance takes, it is not isolated from the overall system of governance in a country and the political system that prevails. Trust in the state, the acceptance and authority of the public administration, the links between the centre and regions, the mechanisms of control, respect of the legal and regulatory systems, the ability to raise budgets — all these factors determine the groundwater arrangements that can be promoted. The capacity of political leaders at both national and local level to understand natural resource management issues and to conceive and deliver governance systems that provide for long term sustainability and equitable allocation of resources and risk will vary considerably. Good groundwater governance requires both overall good governance and far-sighted political commitment.

Groundwater governance will also be influenced by the relative contribution of groundwater to different economic sectors and segments of the population

A key influence on the groundwater drivers in any economy is the relative contribution of groundwater and aquifer services to specific economic sectors — public health, agriculture, mining, industry, energy. This macro-economic setting will condition the perspective of users and determine the range of available governance options. For instance, a poor rural economy highly dependent on shallow groundwater access for potable water supply and income generation will present a very different opportunity for the application of subsidies to control groundwater use compared with a predominantly high income urban population dependent upon thermal power to de-water mines and service processing industries. These relative

economic interests can provide as much variability as the hydrogeological dynamics upon which a groundwater governance initiative is predicated.

Transboundary aquifers require international agreements and cooperation

A special political setting is present in the case of transboundary aquifers, the aquifers crossed by national borders, or by borders between states in federal countries. Governing transboundary aquifers requires cross-border co-operation and special legal arrangements between the corresponding neighbouring countries.

Macroeconomic policy, the overall rate of growth and social transition, rapid urbanization — all these can create particular challenges for groundwater governance, which needs to be integrated with overall economic policy

The structural role of groundwater in the larger economic system needs to be emphasized. The **price of energy**, for example, is a key determinant of both groundwater use and fertilizer production. Hence energy policy not only creates an intensified demand for groundwater, but also generates higher levels of potential groundwater pollutants. Another example is the **pace of urbanization** and the case of the often fast-growing mega-city: these create an intensified demand for water in the surrounding area and are at the same time a source area for high levels of groundwater pollutants. In general, macro-economic drivers have a large effect on how groundwater is exploited and it is important to ensure that groundwater governance arrangements fit within the overall macroeconomic policy framework (see below, chapters 5 and 7).

3. Creating a basis for governance

Main recommended action points:

- **Conducting an initial groundwater governance diagnostic.** An initial diagnostic **will** assess the current groundwater governance situation in the area concerned in order to provide guidance to next steps (Section 3.2)
- **Identifying, fostering and developing leadership.** The main components are: (a) defining which entity is or should be entrusted with leadership in groundwater governance; (b) declaring and formalizing this leadership; and (c) creating the boundary conditions for making it successful (Section 3.3)
- **Making provisions for data, information and knowledge.** These provisions include mechanisms, arrangements, staffing and tools for: (a) systematic data acquisition (time-independent data and monitoring); (b) on the basis of acquired data, adequate generation of information and knowledge on groundwater and its context; (c) sharing data, information and knowledge (voluntary and legally binding arrangements) (Section 3.4)
- **Conducting awareness raising programmes** on groundwater and its management (targeting public sector, private sector and the local population at different levels) (Section 3.5)
- **Making provisions for stakeholder involvement** in groundwater management. Structured processes, events and tools facilitate participation. (Section 3.6)

For any specific country or area, these actions have to be tuned to the local context. Hence, priorities, approaches and levels of activity will be area-specific.

3.1 The general conditions for good governance

Chapter 1 (Table 1.2) highlighted the key elements of groundwater governance. Several of these elements reflect **general conditions** for good governance: political commitment and leadership; knowledge and awareness; and stakeholder involvement. These conditions are essential to good groundwater governance. This chapter discusses ways in which these general conditions may be put in place.

A starting point for putting in place these general conditions — as well as consequent development of groundwater governance systems — is to take stock of the current state of governance. This may be done by conducting a *groundwater governance diagnostic* (see Section 3.2). This diagnostic produces a picture of the current local groundwater governance situation, its deficiencies and its context, including the challenges and opportunities that may function as a trigger for improving groundwater governance. This allows other fundamental steps for creating an adequate basis to be planned and designed.

In some cases the diagnostics may reveal that the general conditions and governance system are already in place, but in most cases there are likely to be at best some gaps or need for improvement. Measures to improve the setup need to be tailored to the local context and their implementation planned as a coherent package.

First amongst the general conditions is effective political commitment and leadership related to groundwater governance

Leadership is an essential prerequisite to good governance. Where it exists, it should be nurtured. Where it is absent, steps should be undertaken to fill the gap. Section 3.3 of this chapter discusses the challenges of political commitment and leadership.

The second general condition is that sufficient data, information and knowledge should be available and accessible to all

Decisions taken by leaders, in cooperation with other actors, need to be based on proper knowledge and understanding of the local conditions; hence, it is important to ensure that sufficient data, information and knowledge are available and accessible to all. Making provision for data, information and knowledge is the subject of Section 3.4 below.

Awareness and stakeholder involvement are also key general conditions

Sufficient momentum in groundwater governance develops only if government agencies and local stakeholders alike are fully aware about groundwater and if local stakeholders are involved in managing their groundwater. Therefore, conducting awareness raising programmes on groundwater (see Section 3.5) and making provisions for stakeholder involvement in groundwater management (see Section 3.6) are amongst the initial steps required to create an adequate basis for groundwater governance.

The general conditions will lay the basis for the key elements of groundwater governance systems — interconnected policies, effective institutions and an incentive structure adapted to objectives — that will be addressed in subsequent chapters

Ensuring that these general conditions are in place or are being developed lays the groundwork for groundwater governance systems themselves. Groundwater-specific governance systems themselves are then discussed in the following chapters: effective institutions (Chapter 4); interconnected policies (Chapter 5); and the incentive structure (Chapter 6).

3.2 Conducting an initial groundwater governance diagnostic

An initial groundwater diagnostic includes a stocktaking of the governance situation — actors, legal framework, policies and plans, available knowledge — together with an assessment of gaps and opportunities

The process of strengthening groundwater governance can be triggered by several factors — a clear future vision of the role for groundwater management or a crisis that brings groundwater challenges onto the political agenda. Similarly undertaking a diagnostic can be a trigger for change. The diagnostic should take stock of groundwater governance in the geographic area concerned and describe its current conditions and status, with particular emphasis on identifying strengths, gaps and other shortcomings, and opportunities for improvement. Content-wise, attention has to be focused on **actors** (public and private sectors, individual groundwater users and the general public) and their roles (leader, implementing official or partner, stakeholder, etc.); **legal frameworks**; **goals, principles, policies and plans**; and **knowledge, information and awareness**.

Stocktaking and assessment take into account the local context — hydrogeology, socio-economy, macro and political economy — and the specific groundwater management challenges of the area

As discussed in Chapter 2, all this should be viewed and judged against the **local context**: (i) the hydrogeological setting — Section 2.3; (ii) the socio-economic situation — see Section 2.4; and (iii) political and macro-economic conditions — see Section 2.5. The results should be evaluated in relation to the groundwater management challenges in the area concerned (see Section 2.1). Examples of important items and questions to be addressed in such an initial groundwater governance diagnostic are shown in Table 3.1. The outcomes of the diagnostic may indicate key pathways for enhancing groundwater governance. It will be useful to update the diagnostic and come to a common set of indicators that will assess the state of the art in a country. This may relate to a minimum code of conduct for groundwater governance that compares where countries are and the progress they have made (see also Chapter 8).

3.3 Identifying and developing leadership

Leadership is an essential component of good groundwater governance and requires both vision and the ability to deliver on that vision

Setting up and maintaining groundwater governance requires leadership at central and local level. Leadership has essentially two components: the ability to **conceive and commit** to a clear vision and action plan; and the capacity to **deliver** on that plan. The entity or person assuming leadership has to be **aware of** and **knowledgeable about** groundwater in the area concerned and should have a **vision** on its potential, on current and potential threats, and on how to address these. To deliver on the vision, leaders require the **capability** to put groundwater management onto the agenda, to identify the main issues to be addressed, to mobilize essential stakeholders and to organize the overall groundwater management process, with positive interaction amongst actors. Political support is indispensable for strong leadership. Raising political support requires that decision-makers are convinced, and this requires clear policy messages based on reliable information, and presented in a clear way. It is important to focus on area-specific challenges or on opportunities that may trigger progress, and to link action on groundwater to tangible benefits in popular sectors such as improved public health or poverty reduction and increases in incomes.

Table 3.1 Sample diagnostic questions

Initial groundwater governance diagnostic: examples of questions to be addressed

Subject	Sample diagnostic questions
Actors	Which actors play a role in groundwater governance and management?
	Is any of them formally entrusted with leadership in groundwater management? Which actor?
	What is the interest, capacity and quality of the political leadership concerning groundwater?
	Does this leading agency have sufficient capacity, budget, support and knowledge for its task?
	Which categories of stakeholders are involved in groundwater management? In what roles?
	Is cooperation between the different actors (very) good, reasonable, poor or non-existent?
	How about awareness among different groups of actors? Any ongoing action on the subject?
Legal framework	Are dedicated laws available in support of groundwater management?
	What aspects do they address: groundwater ownership, abstraction, pollution, etc.?
	What specific regulations are in use on control of abstractions, pollution, etc.?
	How effective are these regulations in practice?
Goals, principles, policies and plans	Do policies exist that are applicable to the management of this area's groundwater?
	If so, which objectives do they pursue and which challenges do they address?
	Does a groundwater management plan exist for the area or aquifer considered?
	If so, what challenges does it address? Which local challenges are not included?
	Are policies and management plan interlinked with surface water and other policy areas?
	Does public finance, including subsidies, support or undermine sustainable groundwater use?

Table 3.1

(Continued)

Subject	Sample diagnostic questions
Knowledge, information and awareness	To what extent has the groundwater system considered been assessed?
	What monitoring data exist and on what aspects (water levels, abstraction, water quality, etc.)?
	What monitoring programmes are ongoing? Variables monitored, resolution in time and space?
	Which organization is responsible for data acquisition, data management and dissemination?
	Has this organization sufficient and capable staff, budget and other means for its job?
	Are data, information and knowledge on groundwater publicly available? In what form?
	Is information on groundwater adequately shared among public agencies and also between the public and private sectors?
Local context (see Chapter 2)	Which issues have been identified as groundwater management challenges, and which ones could be used as triggers for improving groundwater governance? (Section 2.1)
	What is the hydrogeological setting of the area considered? (Section 2.3)
	Role, services and significance of groundwater in the area? (Section 2.4)
	Overall socio-economic characteristics of the area and their impact on groundwater? (Section 2.4)
	Stage of development of water and groundwater exploitation, use and management?
	Is overall governance and political leadership conducive to groundwater governance? (Section 2.5)
	Does a country or provincial vision on groundwater exist?
	Do large cities play or aspire to a special role in groundwater governance or management?
	Are there transboundary issues? (Section 2.5)
	Are there developments in the broader economy likely to impact on groundwater? (Section 2.5)

Leadership may arise from several sources...

If the initial groundwater governance diagnostic shows that no real leadership exists yet on the subject, then it has to be nurtured. The initiative to change can come from different corners — community spokesmen, religious leaders, non-government organizations, business leaders or water utility managers who see their resource base undermined.

...but typically an agency is mandated to take the lead

Generally, a government agency is entrusted with leadership regarding groundwater management, thereby receiving an appropriate legally defined mandate and resources to fulfil the corresponding tasks. The assigned government agency may be affiliated with a ministry focusing on a specific water-using sector (such as public water supply, or irrigation) or may be a 'user neutral' agency for water or groundwater management (see Section 5.2 below).

Political support is essential, and champions can make a big difference

An agency entrusted with the overall leadership can only play its role effectively if it has sufficient capacity as well as political and legal support. In addition, this role will be easier to play if the key person in charge is recognized as being charismatic, knowledgeable, dedicated and influential (a 'champion'). Likewise, the constructive engagement of stakeholders and the presence of champions among the leaders of cooperating entities contribute to the overall quality of groundwater governance: it takes 'two to tango'.

Once the entity to be entrusted with groundwater governance leadership has been defined (and possibly also the entities that should have delegated leadership at a secondary level), then due attention should be paid to support it effectively and develop it for optimum performance. This is further discussed in Chapter 5.

3.4 Organizing data collection, information generation and knowledge sharing

Good aquifer management requires good information

How to develop, use, control and protect the groundwater resources of a given area optimally? It is evident that meaningful answers to this question cannot be given without having access to a basic suite of **data and information** on the local groundwater systems (character,

quantity, quality, recharge, development, uses etc.); the **setting** (socio-economic, ecological, political, etc.); and the **processes of change and governance processes** that are taking place or that may take place in the future. Knowledge based on sufficient and reliable data and information is thus essential to guide groundwater exploitation, management and protection. In many countries this knowledge and the underlying data and information are insufficient or missing, even in relatively advanced countries. A cost-benefit assessment should be done of what information is most required. Significant investments may be needed to generate the information needed for groundwater management and to ensure that it is not just available, but also reliable.

Information will include both snapshots of static features and monitoring of dynamic changes

Broadly, two types of information can be distinguished. The first one comprises a **'static' description** of the systems considered: groundwater systems (aquifers and aquitards) and the interlinked physical environment and human communities. Such information is usually collected during **assessment studies** and is presented and accessible in the form of reports, maps and databases. The second type captures **dynamic, time-dependent features** by **monitoring activities**. The direct outputs of a monitoring programme are time series of time-dependent variables, such as groundwater levels, groundwater quality parameters, volumes of groundwater withdrawn, groundwater used for different purposes, demography, etc. The rapid development of new techniques, including remote sensing, can make a difference in providing real-time and impartial information.

Information needs to be converted to knowledge in order to enable stakeholders to take informed management decisions

Professionals with relevant expertise are required to *convert the information into knowledge*. This knowledge provides guidance to decision-makers and other stakeholders, thus enabling informed decisions to be made and stakeholder behavior to adapt. Sophisticated methods and techniques may be needed to analyze the related aspects, but the answers should be presented in a form that makes the messages understandable for those addressed (decision-makers, planners, local stakeholders, the general public). The analysis carried out and the data used should be documented in a degree of detail that enables other professionals to verify and — if necessary — expand the analysis.

The resulting information and knowledge should be shared widely with all stakeholders

For achieving maximum impact and reducing costs, the data and the results of their interpretation and analysis should be *shared* as widely as possible. This requires an open-minded attitude from the 'owners' of data and information, and the implementation of *effective data/information sharing* activities. The latter may include negotiations amongst different entities to exchange data; the development of web pages and on-line databases; reports targeting specific groups of actors; dedicated publications in groundwater-related journals; brochures and other publications; articles and messages in newspapers, on radio and television, or disseminated via other mass media. Where applicable and feasible, institutions, including private parties, should be legally obliged to make their data and information publicly available.

The four information and knowledge tasks — data acquisition, analysis, information sharing, and dissemination of useful knowledge — are key steps to guide groundwater management

In summary, regarding area-specific information and knowledge, four main tasks can be distinguished: (a) **collecting** basic data; (b) **storing, processing, interpreting and analyzing** these data; (c) **sharing** the acquired data and information; and (d) **translating and disseminating** the results of interpretation and analysis in the form of tailor-made messages that give guidance to optimal development, use, management and protection of the groundwater resource and the interconnected environment and ecosystems. Establishing a **dedicated agency or department entrusted with all groundwater information and knowledge tasks** under one roof (and with full government support) is likely to contribute to these tasks being carried out systematically and coherently rather than in a fragmentary and haphazard fashion.

3.5 Undertaking awareness raising programmes

Awareness of the nature and challenges of groundwater is essential to guide decision makers and to motivate all stakeholders to align their behavior with the objectives of good groundwater management

Few people have a basic understanding of groundwater: its invisible presence inside geological formations below ground surface, its dynamics, its potential and the threats it is exposed to. Even fewer people have any knowledge of the local groundwater conditions in

the area where they live. However, most people depend on groundwater in one way or another, and the majority of them should be aware about what is at stake, either because they have to take decisions on groundwater withdrawal, use, control and protection, or because they are users or polluters who need to be motivated to align their behavior with the objectives of groundwater management.

Awareness is thus a key component of groundwater governance for decision takers, for well owners, and for water consumers

Awareness-raising on groundwater is crucial for good groundwater governance. Acquired knowledge on the local groundwater conditions, as discussed above, can be used to develop tailor-made messages for awareness-raising among different categories of actors.
Good examples may inspire and should be the basis for learning on how to move forward. Planners need to be enabled to develop realistic plans and to compare the pros and cons of alternative management strategies. Awareness of decision-makers should be raised to such a level that they experience a sense of urgency for groundwater management and are able to take well-informed decisions. Local stakeholders and the general public need to understand why certain management measures are being implemented, to what extent they are supported by legal frameworks, how individuals can contribute by changing their individual behavior, what benefits can be achieved by concerted and consistent groundwater management action, and what problems may arise when refraining from any groundwater management intervention.

Awareness and awareness-raising need to change as the underlying issues change

Awareness-raising requires dedicated action targeting the different categories of actors in different ways and at appropriate moments. It is a never-ending activity because aquifer conditions will change, new issues may arise, priorities may change and new inexperienced actors will appear. Its focus will, however, shift over time, often from emphasis on creating motivation for groundwater management in general to focussing on new issues or providing feed-back on the observed impact of interventions. Responsibilities for awareness-raising activities rest in the first place with the entity entrusted with leadership in groundwater governance and management.

...and messages need to be targeted at stakeholders and behaviors which impact on the main problems and challenges

Awareness campaigns on groundwater have been conducted in only a few countries but they have proved effective in developing new leaders and champions and in convincing

stakeholders — particularly well owners and water consumers — of the need for improved governance and management. Awareness and capacity building may also engage stakeholders whose role is crucial but who may not have been hitherto engaged. An example is the need to train lawyers in application of the regulatory framework. In each case, creativity is needed to define the media and formats that fit the current local situation and which can be tailored to inspire people to change their behavior and start new initiatives. Therefore, awareness campaigns should not overlook targeting those that are active in the mass media and education: they are essential the spread the messages.

3.6 Facilitating stakeholder engagement

There are many stakeholders in groundwater but they may have conflicting interests

Groundwater is interlinked with many facets of every-day's life (water supply, energy, food, industry, land use, ecosystems, the environment, mining, use of the subsurface). In turn, each groundwater system is exposed to many independent actions, by numerous individuals and entities, be it in the form of groundwater withdrawal, drainage, water and wastewater disposal, land use practices, polluting activities, nature conservation or environmental protection activities. The private sector is particularly important, because much groundwater use and pollution is related to private behavior, ranging from farmers to beverage companies and other major consumers. All these individuals and all these entities are stakeholders, but their stakes are of a varied nature, and their demands and interests regarding groundwater may be competing or even conflicting. Companies, for instance, may face a range of different obligations — social responsibility, reducing risk exposure, shareholder pressure etc. A particular challenge is to reach out to smaller stakeholders and to devise stakeholder processes that are inclusive, in order to ensure that the interests of poorer people are represented.

Best practice shows that stakeholder involvement through information and participation helps get acceptance of the inevitable trade-offs and helps align individual behavior with common goals

Good groundwater governance should provide a common ground and attempt to define and establish a sustainable 'best compromise' between the varying demands and interests. This requires the different categories of stakeholders to articulate their demands and preferences. It is for this reason that involving the stakeholders actively in different stages of

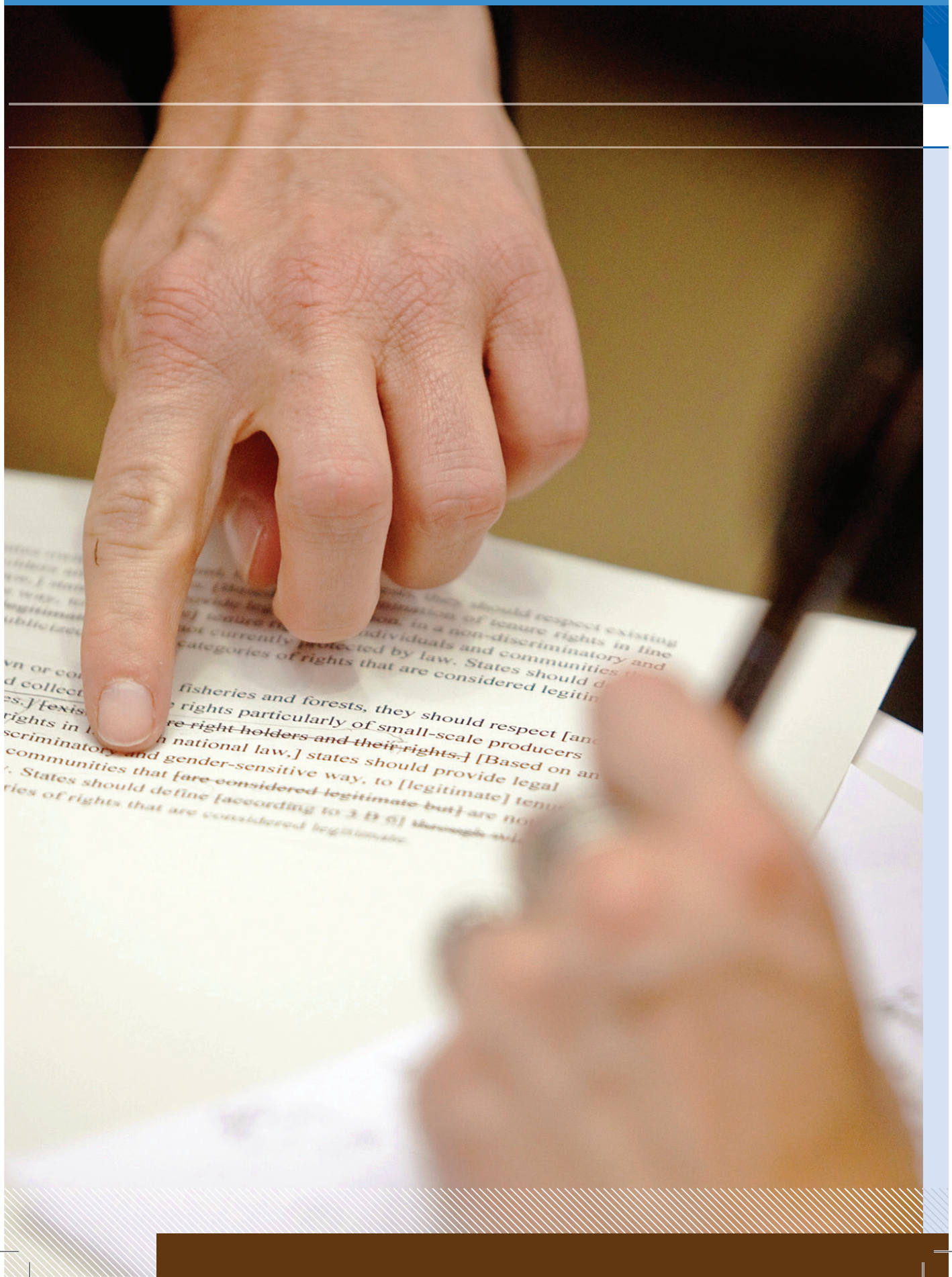
the groundwater management process will potentially lead to better policies and local action plans on groundwater (see 5.3 below), it will enhance their understanding of the compromises to be accepted and it will help align individual behavior with the common goals adopted for local groundwater management and the measures selected for its implementation.

The nature of stakeholder involvement needs to be adapted to the local context

Stakeholder involvement can come in many forms and intensities. Variants run from a rather passive involvement, where stakeholders are simply informed on what the government is going to do, to the other extreme where stakeholders are more or less self-regulating without significant interference of government agencies. Variants-in-between may include stakeholders being consulted, or involved as co-developers of plans or as actors with delegated implementation tasks. City mayors for instance can take a leading role and have done so in some fast developing cities. They face large and increasing challenges (sourcing, quality, loss of recharge areas, private drilling, disposal) but also increasingly use resources from beyond their boundaries. This causes cities to increasingly negotiate with other areas and be a driver for improved governance and innovative groundwater management. Those acting as leaders in groundwater governance should define which stakeholder participation model fits best the local situation, and how this model may evolve over time.

Stakeholder involvement requires substantial outreach and is best supported by a permanent, mandated agency

Creating stakeholder involvement or stakeholder participation is supported by awareness-raising programmes and by targeted communication events. For each particular case, a feasible and efficient approach has to be found for establishing effective stakeholder involvement and for keeping it alive and productive on a permanent basis. In order to ensure a consistent, partnership approach over time, it is preferable to embed the responsibility for coordinating stakeholder involvement firmly within national organizations rather than leave it to occasional projects. Arrangements for stakeholder involvement are discussed in detail in Chapter 4 (4.3).


fisheries and forests, they should respect [an
rights particularly of small-scale producers
re right holders and their rights.] [Based on an
national law,] states should provide legal
and gender-sensitive way, to [legitimate] tenu
communities that [are considered legitimate but] are no
States should define [according to 3 4 5 6] through sui
ries of rights that are considered legitimate.

4. Building effective institutions

Main recommended action points

- Provide a regulatory framework consistent with the fundamentals of groundwater governance (Section 4.1)
- Strengthen the capacity of government to implement, administer and enforce groundwater legislation and regulations (Section 4.2)
- Secure national leadership through a national groundwater unit (or dedicated team in a larger environmental or water-resource agency), and vertical integration of national and local level of government (Section 4.2)
- Provide such unit with specialist staff of specific training in groundwater resource evaluation and management, environmental policy formulation, and national and international groundwater law (Section 4.2)
- Facilitate conjunctive management through consolidation or coordination of surface water and groundwater responsibilities, and through the removal of institutional and regulatory obstacles (Section 4.2)
- Pursue integration of the responsibilities for groundwater resource conservation and quality protection, but if these functions are separate establish a mechanism for collaboration between the responsible sister agencies (Section 4.2)
- Engage with stakeholders via regulatory mechanisms and financial support, and consider promotion of formal groundwater management associations (Section 4.3)
- Provide for cross-sector coordination of policies, starting with an inventory of uses of the entire subsurface space, and provide consistent regulatory mechanisms, in closely related fields such as rural land use, urban construction, environmental health, hydrocarbon exploitation and mining activities (Section 4.4)
- If the circumstances allow, negotiate treaties/agreements for collaboration over groundwater shared across the political boundaries of countries, or of states or provinces forming a federal country (Section 4.5)

Introduction

Institutions are at the core of groundwater governance. They provide the enabling environment for groundwater management. Effective institutions will have the ability to plan for the future. They have legitimacy in the eyes of stakeholders, are inclusive, and are characterized by credible and verifiable commitments. To move to effective groundwater governance is a step-wise process. Different countries have different starting points and varied capacity to progress. For the purposes of this analysis, five components of a sound institutional structure are identified and discussed:

- Responsive groundwater **laws and regulations** to achieve the required level of control over resource use and potentially-polluting activities [4.1]
- Sound **organizational design** with adequate **capacity** for policy making and public administration of resource use and pollution protection [4.2]
- Mechanisms for permanent **stakeholder engagement and participation** to foster socially-responsible attitudes and actions on groundwater as a 'common-pool' resource [4.3]
- Procedures for **cross-sector coordination and co-management** to allow groundwater issues to be adequately addressed in the policies and practices of linked sectors [4.4]
- Institutions for the management of **transboundary groundwater** [4.5]

Although effective institutions are essential for good groundwater governance, in many countries they are weak which has negative results for the resource itself and for the economy in general

An adequate institutional set-up is a critical prerequisite for satisfactory groundwater governance and for promoting effective groundwater management and protection. It is clear that almost everywhere much more needs to be done to build effective institutions. The steps taken need to adapt wisely to what is possible in a specific location and time.
The Vision on Global Groundwater Governance developed within the current programme, clearly identified that deficiencies in this respect have often been the root cause of past management weaknesses. The result has been widespread degradation of groundwater resources and missed opportunities to conserve good quality groundwater reserves.

Because there is often a perception that groundwater is a private resource and because top-down regulation is consequently difficult, institutional structures have to engage with private stakeholders as well as public actors

A unique characteristic of groundwater is that, although it is generally legally a public resource susceptible of top-down management and regulation, in practice use rights and management decisions are frequently decentralized and exercised by water well owners. The reasons for this vary but are typically: historical — people have simply drilled wells on their own initiative; and technical — as groundwater can be accessed over vast geographical areas, it is often impossible for governments to quantify, allocate and regulate use rights and usage.
The corollary is that almost everywhere, institutions for groundwater governance have to include both public and private stakeholder interests. At the same time, the government cannot entirely abdicate its role as custodian of groundwater in view of the public good aspects of the resource.

The balance between public and private stakeholders will depend both on local conditions and the stage of aquifer development and on the overall governance framework in the country

Groundwater governance has thus to balance the roles of the public administration and of private stakeholders to promote socially responsible use and protection of the resource base. The balance differs — according to the hydrogeological, socio-economic and politico-institutional realities of the specific aquifer system under consideration (see Chapter 2).
The balance sought will also be influenced by the overall stage of development of the aquifer — whether there is still scope to develop groundwater resources for a variety of purposes (as in parts of Sub-Saharan Africa) or whether the pressure on the resource is very severe (as in many countries in the Middle East and Asia). Overall governance in the country will also play a role — the level of respect for regulations, the degree of inclusiveness of institutions, the transparency and contestability of contracts etc.

More generally, institutional set-ups will need tailoring to the local context, as well as being adaptive to change and uncertainty

Given the wide diversity of context, there is no 'one size fits all' for groundwater governance: specific success stories only give an insight into what might work in certain situations at a given cost. What is clear however is that almost everywhere there is still much to gain from building effective institutions.

Particular consideration is required to setting up collaborative institutions for transboundary groundwater

The governance of groundwater flows in aquifers that cross the boundaries of countries or of state/provincial jurisdictions in federal countries (like Argentina, Australia, Brazil, Canada, India and USA) calls for special transboundary institutional and legal provisions.

4.1 Responsive laws and regulations

Laws and regulations that incorporate societal goals, and set an enabling and regulatory framework for achieving those goals, are a fundamental component of groundwater governance

In the abstract, laws and regulations regarding groundwater would normally target societal goals of sustainable and efficient development and use and equitable sharing of benefits. Typically, therefore, laws and regulations would make four basic provisions:

1. Groundwater to be brought into the public domain
2. Licensing of water well construction and groundwater extraction
3. Control of 'point-source' pollution of groundwater,
4. A requirement for transparency and sharing of data collected by all groundwater users, private and public

*Ideally groundwater should be **brought into the public domain**, although this may pose considerable legal and practical challenges*

The nature of groundwater as an open-access resource — anybody can drill into it anywhere — and as a non-exclusive good — 'my neighbor can pump out the groundwater if I don't' — leads to incentives for the well-owner to drill as many wells as possible and to pump out the maximum groundwater. This behavior is inconsistent with the societal goals of sustainability, efficiency and equity. The case is therefore strong for bringing groundwater into the public domain to enable the state to assign use rights and to regulate abstractions in line with goals. This could require cutting links that typically exist or are assumed between private land rights and groundwater rights, and transitioning groundwater from private to public property. Where, as often, the lion's share of groundwater has already been appropriated by private

users, the legal steps may be tough — yet empirical evidence shows that lawmakers can be quite creative, and that the few known challenges to expropriation have failed.

Even more challenging than the legal steps are the practicalities. There are few examples of states recovering control of groundwater by top-down action once extensive unregulated development has occurred. Typically, co-regulation and self-regulation by users must complement top-down action by governments.

To accompany legal provision for management of groundwater in the public interest, a regulatory regime needs to be developed

The ideal regulatory regime would be based on perfect knowledge of the characteristics of the resource, and would assign and regulate use rights. Typical instruments include licensing water well construction and setting levels for groundwater extraction, with limitations dictated by practicality and administrative expediency in regard to certain well-types. For example, little or no regulation would be required for shallow hand-dug waterwells or other groundwater used only for supplying domestic and subsistence needs.

A regulatory framework for groundwater abstraction and use must be adaptive to changing circumstances

To facilitate adaptation to changing supply and demand conditions, regulation needs to incorporate flexibility. For example:

- Groundwater abstraction/use rights may not be granted in perpetuity, and may be subject to periodic adjustment in response to local or global change (or if in perpetuity they should be expressed as a proportion of an overall variable allocation depending on conditions)
- Groundwater abstraction and use rights may be subject to forfeit without compensation if they are not used
- Rights discovered to cause environmental damage may be terminated

Again the challenge is implementation. Only in socio-economic situations with high standards of governance or control can regulation of innumerable wells be effectively practiced. Elsewhere, self-regulation or co-regulation on a participatory basis may be a necessary adjunct to top-down regulation by public agencies (see 4.3 below).

Information is essential to groundwater management, and all groundwater stakeholders should be legally obliged to share all data on the resource and on abstractions and uses

It is a truism that 'what you cannot manage what you cannot measure' and this is a particular challenge in the case of groundwater, partly because of the inherent difficulty of quantifying this unseen resource, and partly because its use is spread over sometimes huge areas and millions of points of abstraction. The law may therefore oblige transparency of data collected by all groundwater users, private and public, and require waterwell drilling contractors, groundwater consultants, drinking water-supply companies, and groundwater users in general, to make available all hydrogeological data they collect, including reporting on abstractions. Extending transparency to the different actors (including the private sector) engaging in specific activities (like oil or gas drilling and mining operations) which come in contact with groundwater, reinforces the point.

It is not just good laws and regulations but their implementation and enforcement by all stakeholders that will make for good groundwater governance

Laws which fail on one or more of the above criteria are among the root causes of poor groundwater governance. But no matter how responsive groundwater laws are (on paper at least) to these fundamentals, it is their acceptance, implementation, administration, and enforcement that eventually make the difference. In this context, the capacity of government officials, of local users and of potential polluters to internalize the prescriptions and directions of the law is critical to the ultimate effectiveness of governance arrangements, and must be carefully nurtured.

4.2 Establishing Sound Institutional Design and Government Capacity

There are different points of departure, but stronger organizations are almost everywhere required

Almost everywhere stronger organizations are desirable. Different degrees of institutional maturity in different countries serve as a reality check, however — often there are fragmented organizational responsibilities, lack of technical leadership, limited local know-how, or funding constraints. These realities may limit the pace of progress.

Public agencies alone cannot manage groundwater for the common good — institutions typically need to be inclusive of all stakeholders

The implementation of groundwater governance provisions, through resource management and protection, needs to be viewed as a cooperative initiative between the public administration and local stakeholders, with the balance between 'imposed regulation' and 'delegated responsibility' evolving according to local hydrogeological and socioeconomic circumstances.

Lead organizations are required at central and lower levels, with provision for stakeholder participation

National leadership on promoting effective groundwater governance is critical, as is ownership of the corresponding management tasks at the level of provincial or local agency offices, to which authority and responsibility for day-to-day implementation would normally be delegated. It is essential for the provincial or local agency to secure full stakeholder engagement at the appropriate scale.

Typically, a dedicated and properly funded groundwater unit or team at each level should assume leadership in coordinating policy, financing and management

A national or state groundwater unit (or dedicated team in a larger environmental or water-resource agency) is essential to achieve the required leadership to assure the adequacy of enabling policies, legislation, funding arrangements, programme priorities and efficient coordination. Another key function at national or state level will be the mobilisation of adequate finance to fund the hardware of agreed demand-side and supply-side management and of pollution abatement measures. It is also important that finances are allocated to the level where the services need to be performed. It must be recognized that such a groundwater unit will need political stature as well as specialist staff with specific training in groundwater resource evaluation and management, and environmental policy formulation, with the back-up support of staff trained in water law.

Lead agencies need capability to mobilize and engage all stakeholders in sustainable groundwater management

A cadre of trained water law and institutional specialists is needed not only to support the delivery of groundwater-related services by government, but also to assist the private sector to engage in the sustainable development and use of groundwater resources.

*The ideal institutional set-up would integrate linkages and functions of groundwater management **vertically** between the national level and the local level, and **horizontally** at each level with other sectors and agencies impacting on groundwater*

Line management and communication are facilitated if the provincial/local agency responsible for day-to-day groundwater resource administration and quality protection is part of a unified national organization. Where this is not the case, or re-alignment would take a major institutional reform to establish, an explicit mechanism for **vertical integration' between national and local** level will be required. Figure 4.1 shows an ideal institutional set-up in which groundwater policy, planning and implementation functions are assigned to each appropriate level within a vertically integrated structure, and **horizontal linkages** at each level provide for inter-sectoral and inter-agency coordination, joint planning etc. Every country will be different, but the schematic presentation in Figure 4.1 provides a useful checklist of the functions required and of the ways in which the linkages might be structured.

Local level agencies need particular strengthening and motivation for their front-line tasks of regulation and management (data, planning, awareness, stakeholder participation)

Contrary to the current situation in many countries, more professional capacity needs to be **concentrated at local level** where the work is by its nature labour intensive and requires considerable professional judgment, especially given widespread constraints on data. A critical mass of professional and technical staff is required, with experienced leadership. The work of these professional staff will also involve a substantial data management task and the corresponding skill base will need to be developed through **in-house training and capacity building**. **Capacity building, adequate motivation** through good management and career development, and the right **incentive structure** are essential.

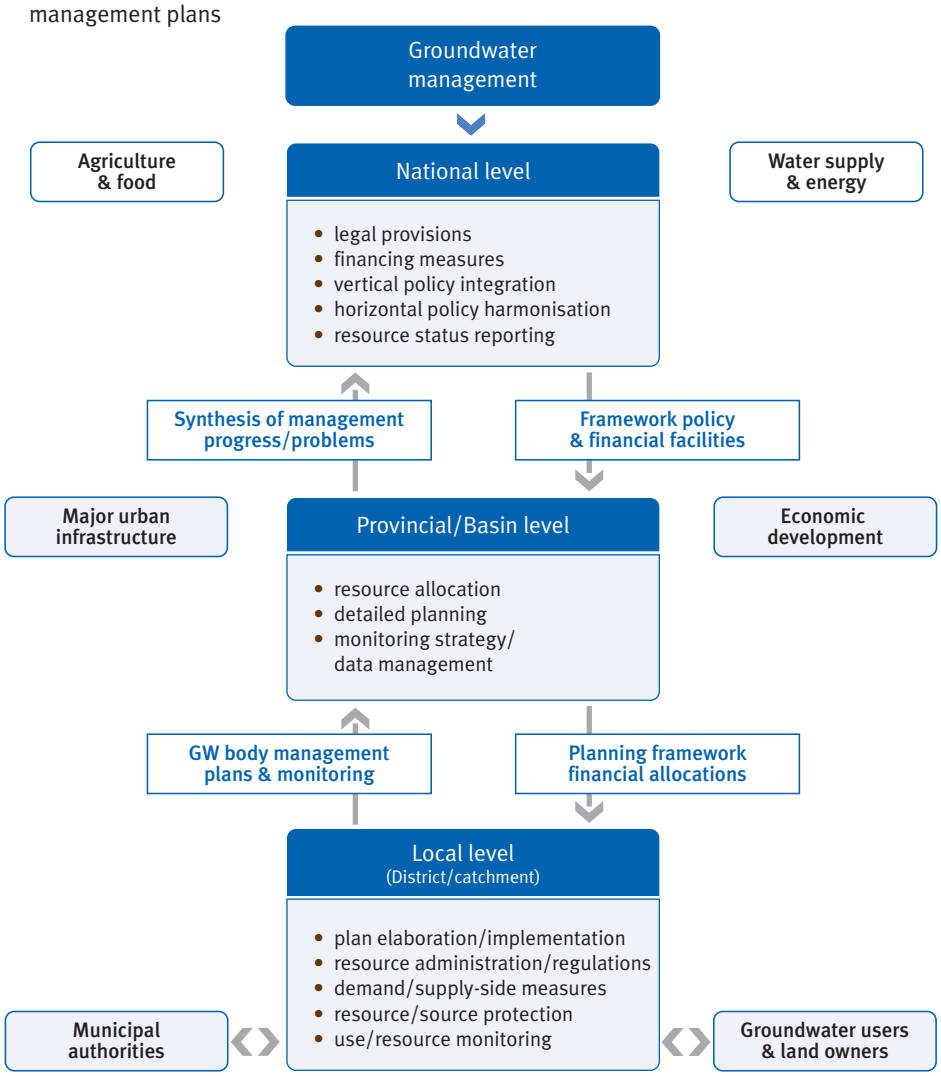
Best practice suggests the separation of regulatory functions from management functions — but in practice this can be hard to achieve

There is a strong case for **separating regulatory functions** like licensing and charging from other functions like resource evaluation, planning, awareness, stakeholder participation or data management functions. In practice, however, this often proves difficult, in part because resource evaluation and regulation must go hand in hand, but mainly because the staffing requirements become too onerous.

Figure 4.1

Groundwater Governance — Linkages for management planning

Indicating the process of 'vertical integration' between national and local government usually required and the parallel need for 'horizontal policy integration' to harmonize management plans



Although ideally basin organizations should take full responsibility for groundwater management within their IWRM mandate, in practice they largely manage surface resources, so that cooperative mechanisms with groundwater agencies are needed

The role of **basin organizations** in groundwater governance depends on their mandate and effectiveness. In practice, basin organizations focus on management of surface water, which is clearly easier. However, the separation of management of surface water from that of groundwater runs counter to IWRM best practice, particularly as the base flow of rivers in many cases comes largely from groundwater. Ideally, basin organizations should assume full local responsibility for groundwater management and protection, including land management for groundwater recharge and conjunctive management of surface and groundwater resources. Whilst in some cases their remit and capacity will readily allow this, in other cases (especially many international/interstate basin organizations) their mandate and capacity are so constrained as not to allow this. In the latter case, explicit mechanisms will be required to ensure communication between basin-level and national or local offices dealing with groundwater at the aquifer unit or sub-catchment level.

Institutional set-ups should facilitate conjunctive management of surface and groundwater

One aspect of the need for integrated water resource management is that groundwater resources often need to be managed on a **conjunctive basis** with surface water. This can best be achieved where either there is a basin organization or where the national and local government agencies responsible for groundwater and surface water are part of the same ministry or organization, and where a facilitating legal and regulatory environment is in place. Conjunctive management will also require allocation decisions e.g. reallocation of surface water from agriculture to municipal uses, or conservation of deep groundwater resources as a reserve for future municipal supply. Where the management of surface and groundwater are not under one roof, and institutional and legal/regulatory impediments to conjunctive management exist, a restructuring may be indicated, for example, to establish a water resource apex agency.

The institutional set-up also needs to ensure joint management of both quantity and quality aspects of groundwater

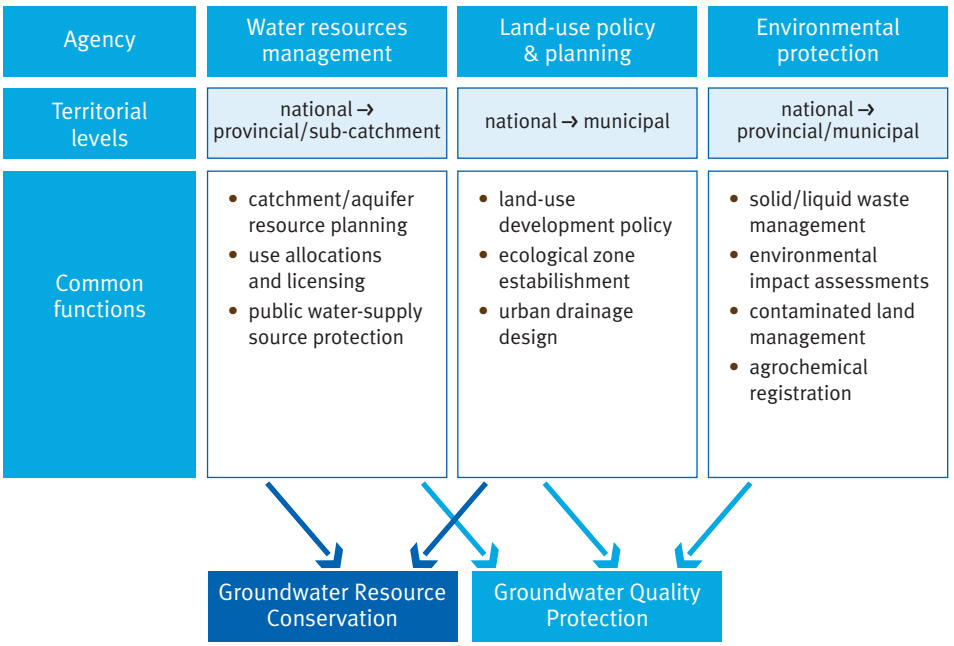
Integration of the responsibility for groundwater resource conservation and quality protection under the same roof is most desirable. Where ‘resource management’ and ‘environmental

protection' functions are split, this results in significant complications when it comes to dealing with groundwater, and the relationship of both to land-use policy and planning is critical. If these functions are separate (Figure 4.2), a mechanism for collaboration between the responsible agencies will be needed.

Figure 4.2

Examples of typical groundwater functions of government agencies

There is a need for water resource management and environmental protection functions to work together, ideally hand in hand with land-use policy and planning



4.3 Making Stakeholder Engagement a Permanent Feature

Sustainable, equitable and efficient groundwater management requires partnership between public agencies and private stakeholders

Effective groundwater management and protection without stakeholder participation is hard to achieve — but equally stakeholders alone are unlikely to be able to manage an aquifer without some form of government support. Thus, permanent **participation of private stakeholders is essential for groundwater management** (see Section 3.6), both for the 'common good' and for stakeholders' own self-interest. Partnerships of various kinds have developed around the world, particularly in the most water-stressed areas. The challenge is the continuity of stakeholder engagement: 'whilst it is pleasant to conceive a child, it is harder to raise it.'

Stakeholder involvement needs to be recognized in law, which may give legal status to formally constituted groundwater associations

For groundwater stakeholders in general, and water well users in particular, to play an effective role in groundwater governance, their role and organizations need to be set up and recognized as part of the overall governance system and not just as targets of regulation. Neither should their engagement be one-off — instead it should be a permanent feature of groundwater governance. This may require the development of legally-constituted associations, which function in accordance with the law and have access to financial provision. National groundwater legislation may thus provide parameters for the formation of 'groundwater management associations' and spell out which functions they have and are expected to fulfil. Stakeholder engagement is best when federated around specific groundwater bodies or sub-catchments or aquifer units, as they can plan for and manage a discrete hydrological unit and water resource.

Law should also mandate consultations with stakeholders on decisions and investments affecting the groundwater resource

Provisions in groundwater or environmental legislation requiring stakeholder consultation for groundwater development projects and for projects potentially impacting groundwater (like oil and gas drilling, mining operations, waste disposal facilities and major urban construction) further empower stakeholders and add to the robustness of the institutional architecture for groundwater governance.

Groundwater management associations or other institutional set-ups should be inclusive of all stakeholders, and should benefit from public support for capacity building and activities

In addition to the legal framework, and as a complement to the delegation of governmental functions, it is desirable also to mobilise some public support for formalized **groundwater management associations** (as distinct from groundwater irrigation users associations) to allow them to set-up premises, hire specialists for advice on key issues or potential disputes, access capacity building etc. Broad-based representation in such associations is essential — including water well owners/operators, indirect groundwater users, environmental/ecological groups, potential polluters, commercial associations, groundwater agencies, and local academics. Other kinds of user-level arrangements are also possible, particularly where groundwater management is embedded in the local institutional landscape.

These stakeholder organizations can participate in planning, management and regulation, and this should increase effectiveness and raise the level of adherence and compliance, so contributing to the achievement of goals

Groundwater management associations should participate in planning and regulation, and may take on certain public interest functions at the local scale (e.g. monitoring water well extractions, policing of water well construction or use, encouraging voluntary compliance with regulations, etc.). So organized, groundwater users can be a useful and effective complement to government agencies in achieving groundwater management goals, especially as groundwater is quintessentially a local resource requiring action closest to individual users and potential polluters.

Transparency of information amongst all stakeholders is an essential component of these participatory and partnership approaches

A key requirement for stakeholder engagement is complete transparency in the provision of information on legitimate water well users/use, wastewater discharge permits, groundwater resource and quality status, etc. The obligation to share information is for all, both government and all other stakeholders. It is preferable for this information to be on-line, with appropriate training for stakeholders on access (and possible provision of a 'help desk' facility).

4.4 Putting Cross-Sector Coordination into Practice

Because of the impact of other sectors on groundwater, institutional mechanisms are needed to coordinate policy and programs

There is a series of vital linkages external to groundwater resources which often exert a major influence on their recharge, use or quality (see also Chapter 5). Therefore, governance of the groundwater resource needs mechanisms, supported if necessary by legal provisions, to coordinate policies and actions with other sectors that directly or indirectly influence groundwater.

Coordination is particularly indicated in the use of sub-surface space, in land use management generally, and in agricultural land use practices in particular

Chapter 5 (Section 5.6) elaborates on the challenge of mobilizing the necessary institutional coordination with land use. The chapter also discusses some institutional coordination mechanisms — for example, for sub-surface space and sub-surface resources (see Section 5.7). There are, however, several other areas where practical coordination could be promoted, including 'landscape programs' and the use of agricultural chemicals (polluting fertilizers and pest management practices).

There is scope for improving cooperation between land use planning and water resources management, particularly in land stewardship for environmental services

In many countries, programmes dealing with land and water management, agriculture, forestry and the environment offer an opportunity for enhanced integration between land use and water resources. Earlier landscape programmes focused primarily on controlling soil erosion and paid little attention to water harvesting. Where this has changed, spectacular transformations have sometimes occurred and groundwater tables have stabilized and increased. The intense development of groundwater recharge measures at landscape level has set the basis for socio-economic development in areas that were considered among the most marginal globally. In integrating land-use management and groundwater management it is also important to control activities such as sand and gravel mining from rivers — as these deplete the flood buffering capacity of rivers and their ability to recharge aquifer systems. Similarly the development of infrastructure such as roads, parking lots and pavements has a huge impact on groundwater recharge and should be managed with full awareness of the disruptive potential.

Land use plans and development should be required to consider groundwater impacts including through Environmental Impact Assessments (EIAs)

Where formal land use planning is operational, the law and financing conditions may mandate consultations, so that land use planning decisions take groundwater implications into account. Ideally, the law would direct that decisions by the land-use planning administration(s) be bound by the advice of the groundwater administration. In many countries, this may already be a requirement in Environmental Impact Assessments (EIAs), and EIAs could be further developed as the prime mechanism for ensuring that linkages between land use planning and groundwater are recognized and acted upon.

Regulation and agricultural advisory services should promote the reduction of nutrient and pesticide losses

Protection of groundwater quality in rural areas requires guidance and regulation on the use of manure, fertilizers and pesticides in agriculture. Many non-polluting techniques are well known in integrated fertility and pest management approaches, and the systematic adoption of these should form part of collaborative agreements between the agricultural authorities and groundwater managers.

Institutional mechanisms are needed to ensure harmonized interactions between groundwater and water-related sectors

As discussed in more detail in Chapter 5, there are strong linkages between groundwater interests and other fields: agriculture, energy distribution, environmental health, urban construction, import/ export regulations, hydrocarbon exploitation and mining activities. These 'external' linkages can have a very large influence on groundwater use and protection, and vice versa. Examples are: energy pricing policy and its effects on incentives to groundwater use; urban and industrial development policy and its effect on water demand; and agricultural trade policy and its effect on demand for water in agriculture.

High level platforms for this kind of inter-sectoral coordination include national planning and budgeting processes — but prioritization may be needed

Institutional platforms for policy engagement with water-related sectors are required. Many of the issues raise high level inter-sectoral policy considerations that may be dealt with through national planning procedures, investment programming, annual government budget processes etc. The importance of the contribution of groundwater to the national economy —

and the inevitable inter-sectoral implications and risks — suggest that groundwater should have a voice when, for example, five year plans are formulated. As inter-sectoral coordination is always challenging, prioritization is essential. In practice, decisions on negotiations with other sectors will have be guided by their importance for groundwater resource management. Pragmatism may be required, aiming for the low-hanging fruit first.

4.5 Dealing with Transboundary Aquifers

Aquifers that cross the boundaries of countries — or of states or provinces in federal countries — are a special case, as they require cooperation among the jurisdictions involved, and supporting legal and institutional arrangements

Transboundary aquifer systems have received relatively little attention up to now. Recent work at the global level has proposed some rules that could be adopted, including UN draft articles for a Law on Transboundary Aquifers; the GEF IW strategies; and the UNECE Water Convention.

Best practice, modelled on cooperation on river basins, suggests starting with professional cooperation, exchange of information and development of a knowledge base, which can then lead into joint programs and, ultimately, to formal agreements

In several parts of the world, cooperation among the jurisdictions has started and this suggests some emerging best practice, modelled on approaches used in transboundary river basin management. For critical transboundary aquifers, a beginning should be made by **developing linkages amongst professionals** from the different countries as a prelude to politically sanctioned cooperation. As a first step, **exchanging data and information** and **engaging in joint understanding** of the transboundary aquifer systems should start. In such systems the link with land management is of significance too — and this should be programmed into the joint activities. From this basis of trust and cooperation, **joint programs and agreements** can be developed, and implemented with the help also of domestic legislation.

5. Making essential linkages

Main recommended action points:

- **Identifying the interdependencies.** This activity identifies the interdependencies between groundwater and other components of the real world that are intensive enough to be taken into account in groundwater management and governance. [Section 5.2]
- **Defining area-specific groundwater management issues and groundwater governance goals and priorities.** This activity results in the specification of content, focus and ambitions in each particular area, to enable effective and efficient groundwater resources management. [Section 5.3]
- **Adopting an integrated water resources management approach (IWRM).** As all water resources components and their use in any particular area are interrelated, this activity specifies how they are linked through integrated water management and governance approaches. [Section 5.4]
- **Linking groundwater management to sanitation and to waste and wastewater management.** Like IWRM, this is a logical consequence of adopting a holistic view on the water system in an area, in this case with the focus on pollution control. [Section 5.5]
- **Linking groundwater management to land use and land use practices.** This is in many areas around the world the most relevant and essential key to groundwater pollution control. [Section 5.6]
- **Linking groundwater management to the use of subsurface space and subsurface resources.** This subsurface counterpart of the previous action is particularly relevant in urbanized areas and areas of intensive mining and hydrocarbon exploitation. [Section 5.7]
- **Linking water and energy** in groundwater management and governance. [Section 5.8]
- **Mainstreaming groundwater in other policies.** This activity identifies how potential interactions with groundwater are to be factored into the policies and programs of other sectors. [Section 5.9]

5.1 Linkages relevant to groundwater governance

Identifying linkages between groundwater and other water resources and other sectors is essential for groundwater governance

As is well documented in the Regional Diagnostics and the Global Diagnostic (see 1.2 above), groundwater is not an isolated component but is interconnected with other physical components and subject to a wide range of human activities. In terms of challenges, groundwater may be stressing these activities or be stressed by them, but it should also not be overlooked that groundwater contributes fundamentally to achieving benefits in many interlinked sectors. Good groundwater governance implies that these interconnections and stresses are recognized and that the corresponding interdependencies are taken into account in groundwater management. Hence, exploring and identifying these interdependencies is a fundamental step to be carried out in any particular area where groundwater governance is to be improved.

Linkages include those within the water cycle and those with other water-related sectors

There are two broad categories of linkages: those inside the 'water box' (internal linkages) and those that cross the borders of the water box (external linkages).

The internal linkages are addressed by the following actions:

- Defining area-specific groundwater management issues and groundwater governance goals and priorities (discussed in Section 5.3 below)
- Adopting an integrated water resources management approach, which includes conjunctive management of groundwater and surface water) (discussed in Section 5.4 below)
- Linking groundwater management to sanitation and to waste and wastewater management (discussed in Section 5.5 below)

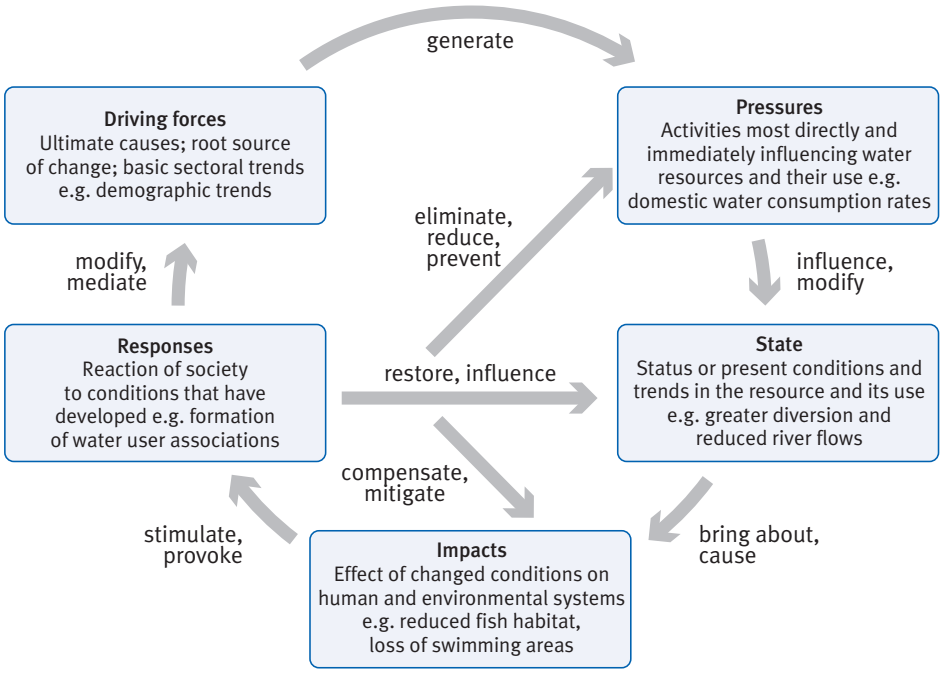
For the external linkages, the most relevant steps are:

- Linking groundwater management to land use and land use practices (discussed in Section 5.6 below)
- Linking groundwater management to the use of subsurface space and subsurface resources (discussed in Section 5.7 below)Linking water and energy in groundwater management (discussed in Section 5.8 below)
- Mainstreaming groundwater in other relevant policies, and vice versa (discussed in Section 5.9 below)

A short characterisation of each of these linkages follows below. The scope of groundwater management and governance widens and the complexity increases by adding the mentioned linkages. Therefore, decisions on incorporating these in governance set-ups should be based on their local relevance and on pragmatic considerations, such as the capacity and financial resources to address the issues raised.

Figure 5.1

The DPSIR framework applied to water resources systems



5.2 Identifying the interdependencies

Structured methodologies may be helpful in identifying relevant interdependencies and the driving forces behind them

Approaches to the systematic identification of relevant interdependencies include *causal-chain analysis* and similar frameworks of analysis. An example is the widely used DPSIR framework, that shows how driving forces, pressures, groundwater state, impacts and human responses are interrelated in a cyclic setting and together explain the dynamics of a groundwater system and its functions (see Figure 5.1).

Table 5.1

Typical causal-chain interdependencies regarding groundwater

Theme	Typical issues
Drivers of change	• Population growth • Urbanization • Growth of secondary and tertiary economic sectors • Increasing demand for municipal water
Anticipated pressures	• Increased pumping for municipal uses • Competition between urban and rural users • Reduced recharge due to and use changes, climate change etc. • Increased use of agricultural chemicals and salinization from agricultural water returns
Change in state	• Declining groundwater levels/resource depletion • Groundwater quality degradation
Impacts on water and water use	• Water shortages in urban and rural areas • Water sources in use polluted/ water treatment needs

Identifying the interdependencies and assessing how important they are for groundwater management is a first step towards making them part of the agenda. Although this process can never be an exact science, it should identify the main drivers of change, the likely consequent changes in the resource and its uses, and the possible impacts.

From this kind of analysis, the priority linkages can be determined, for example, as indicated in Table 5.2.

Table 5.2

Typical priority linkages related to groundwater

Where a key issue is:	Then groundwater management needs to be linked to:
Groundwater is a major economic resource for the local area (or national socio-economy)	• Local and national economic goals (Section 5.3)
Demand for water is rising rapidly and competition is growing between town and country and amongst sectors	• Integrated water resources management (IWRM) (Section 5.4)
Rapid growth of towns	• Urban water supply, wastewater management and pollution control (Section 5.5)
Changes in rural land use, deforestation, and increased water abstractions	• Agriculture, forestry and environment sector policies and programs (Section 5.6)
Competing use of sub-surface space and resources	• Mining policy, energy exploitation policy, subsurface storage policy (Section 5.7)

5.3 Defining area-specific groundwater management issues, goals and priorities

The initial groundwater governance diagnostic is the starting point for defining specific management issues, goals and priorities for an aquifer

The initial groundwater governance diagnostic (Section 3.2) will have characterized a groundwater system in terms of its governance (actors, legal framework, policies and plans, and state of knowledge and awareness) and in terms of its local context (hydrogeology, socio-economy, political and macroeconomic setting) and perceived challenges. By connecting the findings of the diagnostic, with both national goals (on socio-economic development, on food security, on poverty alleviation, on environmental conservation) and local development objectives, area-specific issues, goals and priorities for groundwater management can be defined. These issues, goals and priorities can then help define the most appropriate governance arrangements and formulate specific investment and management plans.
For example, if the priority is enhanced rural incomes, governance arrangements should provide for equitable and sustainable development of the resource for agricultural production, typically with a high degree of stakeholder involvement. By contrast, if the priority is transfer of

groundwater to urban areas, water rights might be reserved to the state and legal and regulatory measures might be set up to promote the quantity and quality of the resource to be transferred.

These issues, goals and priorities can help define the most appropriate governance arrangements and formulate specific investment and management plans.

5.4 Governing groundwater in an integrated water resources context

Groundwater forms part of a continuous water cycle, in which water transits from one component into another, and should therefore be managed conjunctively with other water resources

Water moves continuously through different components of the water cycle: rain water is transformed into surface water, soil water or groundwater, or immediately evaporates and returns to the atmosphere; surface water recharges groundwater systems at certain locations, while elsewhere it is fed by groundwater discharge in the form of spring flows or base flows. The different natural freshwater components — atmospheric water, surface water, soil water and groundwater — are one single resource. As the Vision advocates, this calls for groundwater to be managed conjunctively and to take care of the interactions of groundwater with all other water sources. At present there are still too many 'either/ or' approaches, but groundwater needs to be managed as part of a total approach to water.

Demand also needs to be managed conjunctively

From the point of view of water use, alternative sources may exist to satisfy a certain water demand (e.g. either groundwater or surface water), and all water demands (of the different water use sectors) add up to a combined pressure on the water resource, competing with each other where the resource is limited. Hence not only **supply** requires conjunctive management, the **demand** for water also needs to be managed conjunctively.

This requirement to manage both supply and demand conjunctively indicates the need for integrated water resources management (IWRM)

Groundwater is thus an inseparable component of the total water system and interacts with other components of the water cycle, both in terms of flows between these components and by being to some extent substitutable in meeting water demands. This is the reason

for adopting an integrated water resources management approach (IWRM), which takes the interdependencies in water availability and water abstraction and use into account. This prevents errors of short-sightedness, such as double-counting of exploitable resources or unrealistically 'static' boundary conditions, that sometimes occur in approaches that are resource-wise or sector-wise more limited in scope.

IWRM provides for integrated, inter-sectoral management of all water resources in pursuit of agreed water management objectives

IWRM approaches (under the 'ecological principle' agreed at the 1991 UN Dublin Conference) provide for integrated, inter-sectoral management of all water resources, with the water basin as the unit of management. IWRM can thus guide many aspects of groundwater management. The guiding rule may be, for example, to allocate groundwater in a particular region to a certain use and dedicate surface water to other uses. In other cases the decision may be to manage both surface and groundwater conjunctively. In the mega-irrigation systems that are common in South Asia, the challenge for instance is to dovetail surface water supplies with groundwater recharge and usage. As these surface irrigation systems overlay alluvial aquifer systems, surface water and groundwater need to be conjunctively managed.
Irrigation deliveries from the main canal systems have a major impact on groundwater levels. If these deliveries are too high, water logging is the result — causing loss of production, higher incidence of diseases and higher flood risks. When surface supplies are limited on the other hand, there will be too large a demand on groundwater and depletion or saline up-coning can be the result. The challenge is to have a balance whereby surface irrigation supplies and groundwater use complement each other and are balanced. In general this integrated use demands an appropriate institutional arrangement. There is thus often a strong case to ensure that groundwater management is part of the operations of basin organizations, provided these have sufficient capacity.

Increasing climatic variability will lead to growing variability in water resource availability. Groundwater can act as a buffer and this needs to be factored in to IWRM planning

A special dimension that needs to be highlighted is groundwater vis-a-vis **climate variability and climate change**. Groundwater's capabilities to buffer seasonal and multi-annual climatic variations are traditionally made use of everywhere around the world, especially in climatically dry areas. However, with growing and convincing evidence that the world's climate is changing rapidly, both in terms of mean values and extremes, predictions of groundwater availability and unit groundwater demands in future decades can no longer be derived reliably from statistics

related to observations in the past. Changing climates will produce a chain reaction of change in water resources conditions, interacting with human responses and other interferences. Within this chain, groundwater resources stand out as being the key water resource to buffer the larger variability that comes with climate change. Groundwater governance should ensure that this aspect is properly incorporated in groundwater management planning.
Special attention should be paid to areas where the groundwater buffer may form part of the solution to coping with climate change in the future, and also to groundwater systems particularly vulnerable to climate change. The coordination with climate change can also go a step further and address climate mitigation too, by systematically taking into account how much water is involved in carbon capture.

5.5 Developing the linkage with sanitation, waste and wastewater management

Groundwater quality is vulnerable to pollution from wastewater and waste

Unless properly managed, wastewater and solid waste pose serious threats to groundwater quality, especially at shallow depths. Sewage pollutes groundwater in particular by faecal bacteria and viruses, nitrogen compounds, heavy metals and various organic substances, resulting in considerable health risks if this water is used for drinking purposes. Leachate seeping downwards from waste dumps, variable in terms of polluting compounds, has similar harmful impacts on groundwater quality.

Groundwater forms an important input to water supply, sanitation and hygiene and thus both the pollution risk and the development opportunity indicate scope for joint planning and investment

Groundwater is a key source for water supply and consequently plays an important role in improving sanitation and hygiene. Therefore, linking up groundwater management with sanitation and with the management of wastewater and solid waste is a logical step. Components of waste and wastewater management include — among others — basic sanitation provisions for households, the development of sewerage systems, treatment of sewage water and of industrial wastewater, planned disposal of treated waste water, re-use of treated waste-water, and the development of properly designed and controlled waste dumps and landfills. Considerable synergy may be achieved by coordinating groundwater management with local, national and international projects, programmes and initiatives related to sanitation (e.g. WASH and MDG-7C) and to wastewater or solid waste management.

5.6 Developing the linkage with land use practices and land use control

Land use in an area interacts intensely with groundwater and thus needs to be factored into groundwater management

On the one hand, groundwater facilitates land use activities by providing a source of water. On the other hand, these activities have an impact on the groundwater system, either by influencing groundwater recharge, discharge, groundwater levels and waterlogging, or by modifying groundwater quality (with impacts that are usually negative). Land use activities create **point sources** of groundwater pollution as well as **diffuse groundwater pollution** that may result from agricultural cropping practices and urban wastewater and storm water disposal. Land use planning can influence or even control the pattern of land use in an area. Given a certain type of land use, land use practices may still vary considerably, but to a certain extent these can be controlled by laws and regulations.

The linkages between groundwater and land-use are strong — but quite different for urban and rural areas — in urban areas, the main issues are pollution and reduced recharge

Urban areas are characterized by a relatively large percentage of paved surface and by drainage provisions, both of which may change the original groundwater regime considerably. They also form zones of concentrated production of domestic and industrial waste and waste water; to what extent these threaten groundwater quality depends on the availability and adequacy of sewerage systems and wastewater treatment provisions, and on the prevailing waste and wastewater disposal practices. Environmental hazards of *industrial zones* can be reduced drastically by implementing regulations on use, re-use, treatment and disposal of specific chemical substances.

In rural areas, the main issues are over-abstraction (accompanied by groundwater level declines), rise in the water table, reduced recharge, salination and pollution

In rural areas, land use interactions with ground¬water are especially strong on irrigated lands and intensively cultivated agricultural lands. The former either may have triggered intensive groundwater abstraction leading to groundwater level declines (groundwater-irrigated lands) or they may show steadily rising groundwater levels (surface water irrigation). In many countries, deforestation of slope lands is contributing to increased run-off and reduced

infiltration, with consequent reduction in upstream groundwater recharge. Downward seepage of excess irrigation water also leads to increased groundwater salinity levels at shallow depths. Artificial recharge and drainage, respectively, may reduce the negative impacts on the groundwater regime. Intensive cultivation of agricultural land tends to be accompanied by the use of large amounts of fertilizers and pesticides, of which significant quantities commonly move downward and pollute shallow groundwater. Laws and regulations on handling manure, fertilizers and pesticides (defining which ones are allowed and under what conditions they may be applied) may help protect groundwater quality.

Sand and gravel extraction and dredging can also affect groundwater

Open-pit mining (extraction of gravel, sand, lignite, etc.) and **dredging** in river beds tend to produce a significant disturbance of the local groundwater regime and form also groundwater quality hazards. These activities thus need to be coordinated with groundwater management.

Coordination between groundwater management and land use is thus very important — but often hard to achieve

Overall, groundwater management requires mechanisms for concerting with planning, investment and management in both urban and rural areas. Institutionally, this represents a challenge as many different agencies and processes are typically involved. Urban and industrial development and service provision are usually spread amongst a range of public and private agencies and central and local bodies. In rural areas, a limited number of agencies may be responsible for infrastructure and irrigation but most land use decisions are taken by innumerable private farmers with varying degrees of knowledge of — and respect for — plans and regulations.

A mitigation measure frequently applied is to declare a "groundwater protection zone"

Where groundwater has a highly strategic function — for example well fields for domestic water supply or zones particularly vulnerable to groundwater pollution — a common practice is to declare a 'groundwater protection zone', which allows the managing agency to exert much tighter regulatory control, including restrictions on land use and land use practices.

5.7 Developing the linkage with the subsurface space and use of subsurface resources

With increased sub-surface economic activity and emerging impacts on groundwater, the need to coordinate management of sub-surface activities is pressing

The **use of the subsurface** and the **exploitation of subsurface resources** in both urban and rural settings have grown apace, with strong interactions with groundwater. Almost everywhere the subsurface space is unmanaged or at best subject to fragmented regulation, which can pose a threat to the long-term sustainability of aquifer systems and groundwater reserves. Mechanisms to factor in the groundwater interface into decision-making on the use of subsurface space and subsurface resources are therefore important for effective groundwater governance.

Use of the underground space for transport and temporal storage can affect groundwater levels and quality

At shallow depths (upper tens of metres) use of the underground space is primarily for transport and temporal storage, in the form of pipelines, sewerage systems, cables, tunnels, underground railways, underground car parks and other underground constructions (offices, stores, etc.) and for seasonal heat storage. Many of these uses have an impact on groundwater levels (for example, if drainage is needed to create dry conditions) and some of them (in particular sewerage systems) may present a significant risk to groundwater quality.

Extraction of minerals and other solid matter impacts on aquifer structures and on groundwater quality and quantity

Mining can have a serious impact on groundwater quantity and quality, and it is therefore important to ensure an understanding of the connection and to provide for concerted planning and management. However, this may be challenging in many countries because of the 'elder brother' attitude of the mining industry. Extraction of minerals and other solid matter occurs at variable depths, depending on the geological formation where these resources are located. Usually these geological formations have to be drained, which sometimes requires large quantities of groundwater to be pumped. In addition to modifying the groundwater regime, drainage and mineral extraction together may produce land subsidence, the collapse of the overburden or the perching of geological layers. Mining may also affect groundwater quality by the injection of acids and lixiviants (solution mining), or by mining residues. Although, as discussed above, there is often limited coordination between mining and groundwater

management, recently there are voices emerging within the mining industry advocating a long-term view of mining as a 'life-cycle activity' rather than to use a hit-and-run approach. This could mean preparing mine shafts to serve as man-made aquifers, after the mining activities come to an end.

Storage of hydrocarbons and hazardous waste creates risks for groundwater

Also at variable depth (but usually deep) are the uses of subsurface space for the **storage of hydrocarbons**, for **hydrocarbon capture and sequestration** and for the **injection of residual geothermal fluids**. Uses of the subsurface space at great depth include the **disposal and storage of hazardous waste** (e.g. radio-active waste). By its very nature, this type of use of the subsurface space can be very risky, unless utmost care is taken in site selection, technical design and operations.

Hydrocarbon development (oil and gas) and geothermal energy development are significant users of groundwater, and can bring pollution risks

Hydrocarbon development (oil and gas) and **geothermal energy development** also are typically related to the deeper subsurface domains. In the case of oil withdrawal, water is needed to bring the energy resource to the surface. In the case of geothermal energy development, groundwater is the energy carrier. Energy development operations have an impact on hydrostatic pressures in the subsurface. They also bring pollution risks, for example if chemicals are injected to increase permeability of geological formations, such as occurs in 'fracking' for shale gas development.

Regulation and joint planning can help coordinate and, in the longer term, integrate governance of the sub-surface and its resources

All these subsurface activities need to be taken into account in groundwater governance and management, and steps need to be taken towards joint planning and management. Dedicated legislation and corresponding regulations, as well as coordinated planning of activities across sector boundaries, are required. A further dimension concerns groundwater alone: groundwater development not only affects the quantity and quality of the groundwater stored and system inflows and outflows, but also has an impact on the solid aquifer matrix and the adjoining geological formations. Thus both other sub-surface activities and groundwater exploitation itself impact on the sub-surface structure, as well as interacting with each other. This argues in favour of talking about 'the governance of the sub surface space' in addition to 'groundwater governance'. In the longer term, if local conditions, the stage of development and the institutional setting would allow, it seems desirable to bring the planning and coordination

of all subsurface activities and use under a single roof: that of governance of the subsurface and its resources.

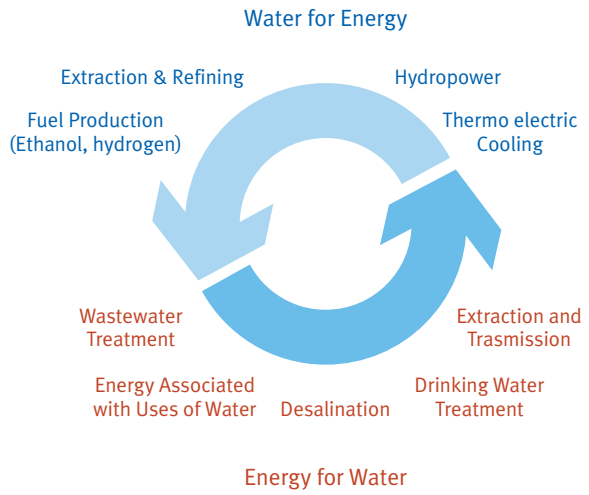
5.8 Developing the linkage with energy

There is a strong 'water-energy nexus'

Water and energy are both vital for life and they are inextricably linked: water is used to produce energy and energy is used to provide water, as is illustrated in Figure 5.2 and documented in the WWDR-2014 ("Water and Energy").

Figure 5.2

Water for energy, energy for water (After Paul Reiter, IWA, modified)



Making groundwater available for use requires considerable energy, and energy prices are an important part of irrigating farmers' costs — and incentives

Lifting groundwater to the surface requires on a global basis substantial energy, and the same applies to groundwater treatment and to the conveyance of groundwater from the withdrawal

site to where it is used. As an example, in several states in northern and central Mexico energy consumption for groundwater abstraction comprises up to 30% of the total energy demand. Pumping costs are an important cost factor in groundwater operations, and energy prices can in principle significantly influence the behavior of those who abstract large quantities of groundwater (e.g. irrigating farmers).

Governments have used energy prices to set the incentive structure for farmer behavior, often with negative impacts in the form of groundwater overdraft

As governments usually determine energy prices by their control of the tax regime, they can thus vary the incentive structure for groundwater use. Higher prices can reduce incentives to over-pump and can encourage more efficient use. In practice, governments world-wide have used lower energy prices to encourage agricultural production and boost rural incomes, with consequently increased incentives to deplete groundwater resources.

Energy pricing is thus an important tool for sustainable groundwater management

Energy pricing needs to be aligned with the objectives set for groundwater management. In general, this would entail setting energy prices within an incentive framework that promotes recharge and efficient use rather than unsustainable extraction. In addition to these sustainability and efficient use considerations, the fiscal impact would also be a factor: the provision of subsidized energy for pumping, the use of flat rates or the non-payment of electricity charges by agricultural and institutional users often put a large claim on public expenditures, and can even undermine the financial viability of energy providers.

Collaboration with energy providers — and even specific energy systems for groundwater — provide a useful lever for groundwater regulation

As part of effective groundwater governance, energy providers may be taken on as partners in groundwater governance. They can, for example, connect or disconnect consumers depending on whether the consumer has a license to extract groundwater or not. Electricity companies can also influence groundwater abstraction by providing energy for a rationed number of hours at different times of the year. Dedicated electricity feeder lines can also be a regulatory mechanism in areas with a very large number of agricultural consumers. These dedicated lines can provide a predictable but rationed supply of energy to farmers — thus reducing abstractions whilst also improving reliability. The separation of agricultural supply from village power supply allows the latter service to be provided on a continuous basis, with consequent impact on the quality of life and on the local economy and services.

The water demands of the energy sector are considerable and need to be factored in to groundwater policies and planning

On the other side of the water-energy nexus, water is required to withdraw crude oil from reservoirs, for oil refining and gas processing, for the production of geothermal energy, for biomass production, for coal mining, for nuclear power generation and for uranium mining and milling. The water demand can be met either by surface water or groundwater, except in the case of geothermal energy that is exclusively linked to groundwater. So far, geothermal energy remains an underdeveloped energy resource, but if this changes in the future, then care is required to address possible pollution risks.

5.9 Mainstreaming groundwater in other policies

Just as linkages with other sectors need to be taken into account in groundwater governance, so the actual and potential impacts on groundwater need to be 'mainstreamed' into the policies of those sectors

The inter-connection of groundwater with other sectors needs to be reflected not only in groundwater governance but also in the policies of those sectors, notably in: urban and industrial development; water supply and wastewater services; rural spatial planning and infrastructure development; agriculture, forestry and the environment; mining and hydrocarbon extraction; energy provision; and trade (in view of 'virtual water'). Solutions for groundwater problems often have to come from decisions taken and measures implemented in these sectors. Some countries have successfully 'mainstreamed' groundwater considerations e.g. by banning the use of certain hazardous persistent chemicals; by introducing groundwater protection zones; by prohibiting certain exploration techniques; by regulating groundwater abstraction by energy restrictions; and by trade policies (e.g. importing fodder to save water in water-scarce countries).

6. Redirecting finance

Main recommended action points

- **All public finances** as they relate to groundwater use need to be re-assessed and **brought in line with the priorities** for sustainable groundwater management within overall national policy frameworks.
- Imagination is required to develop new financial systems to **encourage private investment in sustainable groundwater management**, such as payment for recharge services or for real water savings.
- **New billing systems** making use current information technology such as swipe cards and mobile money may be introduced to improve the efficiency of service delivery and to regulate the use of groundwater.
- Given the value that groundwater brings to the economy and society, more and regular **financing for the basic functions of groundwater governance** should be secured, including for monitoring, regulation, innovation and capacity building. An assessment in each country of the institutions in place, the services they need to provide and the resources allocated to them can provide the basis for a structured increase in budgets.
- Governments and international financing institutions should develop **investment portfolios in sustainable and productive groundwater management** — be it large recharge programs, water use efficiency measures, remediation of polluted sites, smart billing systems, participatory planning and management or others. Investment in other fields should be coordinated or combined with sustainable groundwater management.
- The important financial **nexus between energy provision and groundwater** should be systematically developed both in the way energy for groundwater use is charged and the way it is delivered (see also chapter 5).

Introduction

Despite its growing importance for water security and economic growth, incentive policies and public expenditure often do little to promote good groundwater management — and may even lead to harm

Given the importance of groundwater and aquifer systems for long term socio-economic security and prosperity, it is surprising that in general very limited resources are dedicated to these national and global assets — compared for instance to the financial outlays for military securitization or internet surveillance. Where financial resources are allocated to groundwater, they are often misaligned — funding activities that lead to depletion or pollution rather than promoting efficient, sustainable and equitable management. There is a need to understand the total financial system — subsidies, taxes, penalties — and redesign the financial arrangements that effect groundwater use and protection.

To counter rising threats and to improve management, incentive structures should be realigned to promote conservation and efficiency, and governments should invest in groundwater governance and management

Because of its availability in places where there is no alternative source of water and its many vital functions, groundwater resources and the related aquifer systems are a valuable part of the natural capital of a country. This should be clearly reflected in the way public finances for groundwater development and management are organized. First, financial instruments should regulate and influence the behavior of people, so as to serve the sustainable use of groundwater and protection of the aquifer systems rather than aggravate the threats and challenges. Secondly, there should be ample and secure finances for groundwater governance provisions and implementing groundwater management programs.

The incentive system can be realigned to promote national policies — often at no fiscal cost or even to produce savings

This chapter discusses the incentive systems first (Section 6.1) and the financing for governance and groundwater management subsequently (Section 6.2 and 6.3). The financial systems are part of a larger system of national financial priorities that take into account a broad range of policy objectives. However, in many countries there is insufficient consideration on how public finance impacts on groundwater management. There is, therefore, a pressing need to reassess the effect of public finances on groundwater use and to align public finances with the requirements of sustainable groundwater exploitation

within overall national policy frameworks. In many instances, this realignment will not necessarily increase the need for public financing, and in some cases it can free up public money that can be reallocated.

Policy on incentives and investment has to match the local context — but generally, better outcomes are possible at no extra fiscal cost, and improved governance can actually increase fiscal receipts

As with other governance arrangements, the financial mechanisms implemented depend on the nature of the groundwater resources and the groundwater challenges at hand, as well as the overall socio-economic situation and ability to govern in a country. There is no magic formula, but in many cases there is considerable scope to do better within existing limitations and to have a better understanding of how public finance affects groundwater and vice versa. There is also a case that, as regulation and monitoring improves, new cost recovery or water charging systems can be introduced.

6.1 Aligning incentive systems

Public finances have often encouraged excessive groundwater abstraction and could be realigned to promote sustainable use

In many countries subsidies make up a large proportion of public expenditure. Farm subsidies are common in many countries and often contribute 50% or more of farm income. The same can be true of energy subsidies. However, they are often implemented without considerations for sustainable groundwater use or impacts on those who are most dependent on continued access. There are still many examples where incentives do the opposite and encourage excessive groundwater abstraction, reducing the availability of water for domestic use, impacting public health and impairing the livelihoods of those with limited access to groundwater. These public financial incentive systems could be re-oriented to address the challenges in groundwater depletion, pollution, water logging, salinization or threats to ecosystems or to the subsurface space.

The lack of a charge for using high volumes of groundwater is a powerful incentive to over-use

It is rare to find any explicit charge or tax for the direct use of groundwater by individual users. The costs of drilling, pumping and pump maintenance may be the only direct cost for a

groundwater user, Arguably without a resource 'price' the incentives to conserve and protect groundwater do not exist.

... and the effect may be exacerbated by subsidies and other price distortions which then drive resource depletion with eventual costs to both the public purse and the agricultural economy.

In many instances not only is groundwater not paid for by those using it, but public funds are used to encourage the abstraction of groundwater, even where the source is under stress. Such perverse incentives come in several shapes: fuel and electricity subsidies for groundwater use, support to agricultural solar systems that greatly reduce the cost of pumping, and farm subsidies and support mechanisms for agricultural commodities with high water demands. Public systems may, for example, assure minimum prices for basic food crops, particularly cereals — yet these crops are the ones that are least profitable per unit of water ('income per drop') and have high crop water requirements. There may be strong political reasons for these subsidies and other support measures, although often their rationale and impact have not been fully assessed. Generally, however, they drive over-exploitation of aquifers, encouraging use of groundwater that is not economically efficient (high quality groundwater may have a very high opportunity cost in urban supply), reduce agricultural value added (and even household incomes with consequent impoverishment), and impact public finances — money that could be better used elsewhere. Ideally as part of effective water governance, the incentive system faced by groundwater users should be aligned with sustainable groundwater management. A careful move away from traditional subsidy systems towards supporting 'payment for environment services' (PES) is one possible route, and this can be set up so that the most vulnerable are protected.

Incentives can be channelled into promoting aquifer stabilization by encouraging water conservation and higher crop water productivity

Subsidies can be directed to promoting reduced abstractions and higher crop water productivity (see box 6.1) where aquifers are threatened.

Overall, changes in the incentive structure could promote conservation, increase farm incomes — and even reduce public expenditure

In summary, there is an urgent need — as part of groundwater governance — to assess the incentive structure faced by groundwater users and to adjust accordingly: revising counterproductive and even harmful incentives and subsidies; where institutionally feasible

having a price paid for the use of water; and using financial resources thus generated for the protection or regeneration of groundwater.

Box 6.1

Promoting water conservation and higher farmer incomes

Demand-side measures that can reduce the amount of groundwater pumped for irrigated agriculture in a given area are important because irrigated agriculture is by far the largest abstractor and consumer of groundwater in most countries.

The replacement of flood irrigation with precision drip or sprinklers can reduce the volume of groundwater needed to cultivate specific crops and therefore also reduce the energy used for groundwater pumping. In addition, well managed precision irrigation can deliver fertiliser (fertigation) directly to the root zone and reduce pests and disease incidence. As a result, input costs can be reduced and yields increased.

However, groundwater can fall victim to this conversion in several ways. First vertical recharge to underlying aquifers can be reduced and remove an effective store of accessible groundwater. Second the reduced leaching may impact the soil salt balances to the extent that high value crops are rejected or that soil salinization becomes an immediate threat. Thirdly, the presence of drip and sprinkler systems can also encourage an expansion of the farm area, undoing any water saving that was achieved.

A balance need to be achieved. The challenge, particularly in arid areas, is therefore not to simply to go for 'efficient use' by promoting drip or sprinkler systems but to keep overall abstraction and recharge levels within limits that stabilize aquifer storage. Water accounting including the application of evapotranspiration quotas, and the use of soil management to retain moisture and adjust salt balances are agronomic measures that have an impact on local groundwater dynamic. Governance arrangements that allow the application of subsidies to be married with groundwater resource regulation are likely to have positive outcomes if they can boost crop water productivity (net revenue/m^3 evaporated) within any established abstraction and cropping limits.

It may be possible to set up incentives to encourage recharge

In some other fields of resource management, the concept of payment for environmental services (PES) has gained ground. In the management of surface water, promising example

have been developed in the last years. This concept could be extended to groundwater and the subsurface space as well — by rewarding those that recharge groundwater and protect the recharge zones for instance. Box 6.2 discusses this possibility.

Box 6.2

Rewarding recharge

There is an opportunity now to develop innovative arrangements for funding sustainable groundwater management. An approach is suggested by the example of alternative energy 'reverse metering', where local producers of wind or solar energy feed the grid system and are paid accordingly. Such an arrangement could in the future be applied to groundwater recharge as well. Land owners who invest in groundwater replenishment could be compensated just as others are charged for using the water. In addition, as is common practice in many countries already, associations can be supported in developing recharge structures such as surface and sub-surface dams, bunds and terraces. On a broader scale, watershed management programs have been widely used to protect recharge zones and promote infiltration.

Where groundwater has been formally developed — by governments, by projects, by user associations — and water is metered at hydrants, water charging is commonly practiced and technology is improving adoption.

Where water is metered at hydrants, breakthroughs in information and communication technology make charging for water more feasible and more efficient. Mobile money — held on smartphones — for instance can be used to pay for water use and ensure full payment of charges. Electronic cards systems that activate well systems make it easy to record water use and set a price for groundwater consumption. User quota may be built into the swipe card systems, whereby farmers using more than their quota have to pay a penalty and others can trade in their unused water. Where such swipe card systems have been introduced, as in parts of China, fully controlled water systems are created.

6.2 Investing in governance

Groundwater governance is generally under-resourced, compromising management

The Global Diagnostic established that shortage of funding is a constraint to groundwater governance in a large number of countries. This includes many countries where groundwater forms a large part of the resource base — for domestic water, irrigation, industries or mining. Funds in some countries are so limited that the performance of the groundwater institutions falls below a critical minimum. This threatens the sustainability of water supply and environmental services provided by the groundwater resource. In other cases funding is highly unpredictable, leading to stops and starts, and discontinuity in general. Sometimes in the same countries, where basic functions of groundwater management — monitoring and communication, regulation and planning (see chapter 4) — are under-resourced, there are substantial expenditures on extensive one-off hydrogeological investigations. In general it makes better sense to invest in a constant level of governance support. It is also important to agree on performance criteria and make these part of institutional financing.

Groundwater management functions need to be properly resourced — and efficiency savings could help free up some of the needed finance

The basic groundwater management functions should not be compromised: there needs to be investment in the actors, institutions, policies and knowledge. It is useful to do an assessment in each country of the basic institutions in place and the resources allocated to them. This can also serve to identify and eliminate possible wasteful overlaps — for instance in some countries groundwater monitoring is done by several organizations that do not coordinate or share data. It will also help to see where the important gaps are. The Regional Diagnostics undertaken as part of the Groundwater Governance Project almost uniformly observe that the development of legal instruments and regulatory provisions is not matched by the means required for their implementation. Where there is a legal and regulatory framework, there should be adequate funding for staff, legal awareness activities and resources to investigate, plan and supervise implementation. The same applies to all other key functions of groundwater governance. These are moreover virtuous jobs — serving an important public good and setting the basis for investment in a sustainable future.

6.3 Investing in management

Compared to other sectors — and to surface water — there has been little investment in groundwater management

There is a need to manage groundwater resources better, and this requires significant investment. However, to date, investment by national governments and international financial institutions in groundwater management has been limited — in contrast to expenditures in other sectors. In some countries there is limited capacity to develop plans and investment programmes. There is a need for governments and international financial institutions to develop portfolios that support the productive use and sustainable management of groundwater. Depending on the local context, examples of investment programs are:

- Investing in **knowledge and its dissemination**, including hydrogeological investigations, subsurface exploration, multi-purpose monitoring networks, detailed mapping of aquifer systems and providing access to information
- Creating **stakeholder platforms and promoting user participation** in the management of groundwater systems, through introducing local monitoring and groundwater use planning — combined with introducing measures for better water use and recharge
- Investment in **landscape improvement** and **watershed and wetland restoration** with emphasis on buffering local water resources for productive and consumptive use and on improved drought and climate change resilience, especially in areas facing scarcity and depletion of shallow aquifers
- Urban or industrial water supply projects that make use of **artificial groundwater recharge**
- Developing **dedicated electricity lines** for groundwater well users, to ensure supplies and regulate consumption in areas that are under threat of depletion
- Developing **well regulation systems with electronic cards** to enable regulation against groundwater quotas
- **Groundwater substitution projects**, investing in surface water storage to replace groundwater in over-exploited areas
- **Agricultural groundwater use efficiency projects**, that achieve 'more income for less drop' (see box 6.1) in areas under stress of depletion
- **Industrial and mining water productivity and water recycling programs** to reduce pressure on scarce groundwater resources

- **Protection and improvement of recharge zones** — to prevent depletion and protect groundwater quality — including relocation of hazardous industries and other polluters
- Programs that reorient the use agro-chemicals and hence reduce non-point pollution — such as introduction of **integrated pest management** and **integrated nutrient management**
- **Urban drainage, waste and waste water management programmes** and **sewerage rehabilitation** to reduce pollution from urban and industrial sources
- **Groundwater remediation projects** in high value localities with polluted aquifer systems, including sanitation of underground storage of hazardous material
- **Prevention of seepage through canal and river lining** in areas with saline groundwater

To reduce the burden on public expenditure, co-investment from beneficiaries should be sought, and investments should be designed to create revenue streams

Alternative approaches are necessary to leverage parallel investments by groundwater users and by the beneficiaries of other functions of aquifer systems. Many investment programs that serve the sustainable use of groundwater are likely to contribute to other livelihood and ecosystem functions, and this multi-functionality should make the programmes more attractive to investors. For example measures that promote more precise use of groundwater in crop production are likely to result in higher yields and improved farmer income. Equally, the development of recharge projects and the protection of recharge zones can be combined with controlled recreational functions, which provide scope for investments in tourism facilities.

In addition, investments in other sectors (such as roads, aquaculture, leisure) can be tailored to promote recharge

Similarly, there is scope to invest in groundwater as part of other programmes. An example concerns rural roads programs that are being rolled out in many countries. Roads by their very nature affect run-off and are main elements of the landscape. Rather than this road run-off flowing uncontrolled and creating damage, this can be turned around. The run-off from low traffic rural roads can be used for local storage and for groundwater recharge. There is much strength in understanding and optimizing multi-functionality. Other inspiring examples are the combination of recharge areas with leisure functions or the control of salinity by pumping saline water for brackish water aquaculture.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7. Establishing a process of planning & management

Main Recommended Action Points

Elaborating and implementing groundwater management plans for priority aquifers is the ultimate test of adequacy of governance provisions, and involves the following stepwise sequence of actions in each adaptive management cycle:

- identification and characterisation of groundwater management units
- assessment of resource status, opportunities and risks
- reaching consensus on required aquifer services and plan objectives
- drawing up the management strategy (including specific measures, monitoring needs and associated finance)
- planning implementation over a specified period, with systematic monitoring, review of effectiveness, and adjustment of the next cycle

The final element in groundwater governance is the establishment of a planning process

This Framework document has so far discussed four necessary components of governance:

- A conducive **legal framework** (Section 4.1)
- Accurate and widely-shared **knowledge** of groundwater systems to promote **awareness** (Sections 3.4 and 3.5)
- An **institutional framework** characterized by leadership (Section 3.3), sound institutions and capacity (Section 4.2), stakeholder engagement and participation (Sections 3.6, 4.3), and working mechanisms to coordinate between groundwater and other sectors (Sections 5.1-5.9)
- An **incentive structure and financial system** aligned with policy goals (Sections 6.1 - 6.3)

To translate this governance framework into action in pursuit of policy goals for groundwater systems, a planning process is required that will result in a structured programme of action for priority aquifer systems.

The planning process is evidence-based, transparent and contestable — and the resulting plans create a framework of accountability

The planning process and the resulting programmes of action bring several advantages. They create a transparent, evidence-based process that involves stakeholders and is open to contest. Plans are prepared as a cooperative effort between national ministries, local agencies and relevant stakeholders, which leads to co-ownership. The process produces a formal document that can be validated, with time-bound actions and indicators that can be monitored, and outputs and outcomes that can be evaluated. It includes a budget linked to outputs and is subject to review as performance is tracked and conditions change. Planning thus forms the bridge between governance provisions and practical management.[1]

[1] The approach proposed derives from the general philosophy of the EU Water Framework Directive and its Common Implementation Strategy for Groundwater, whilst leaving aside its more specific procedures and regulatory arrangements.

7.1 Identification and prioritization

The first step is identification of aquifer systems, taking account both of the geological and geophysical 'container' — the aquifer — and of the groundwater it contains (see Box 7.1).

The process of identification would include:

- **physical delineation of the system:** mapping the groundwater flow regime from natural recharge to discharge zones (thus connecting the landscape with the subsurface system), whilst taking account of major man-made perturbations
- **socio-economic evaluation of the system:** evaluating the importance of the system to the economy and to human and environmental well-being, and highlighting systems where groundwater plays a critical role in water supply, irrigated agriculture, industrial production or ecosystem sustainability
- **assessment of pressures on the system:** assessing susceptibility and vulnerability to irreversible degradation (through subsidence, salinization and persistent pollution) or tendency to be associated with land water-logging and groundwater flooding, and identifying any opportunity to create new or enhanced underground water reservoirs

Box 7.1

Managing aquifer systems — both container and content

Any plan to manage groundwater has to address aquifer systems as whole. What is important is that the aquifer is managed as well its groundwater resources — in other words both the container (the aquifer and its connected landscape) and its content (the availability, quality and use of groundwater). It is important that aquifer systems are preserved in good shape, so that recharge is optimized, storage is maximized and quality not jeopardized. At the same time the groundwater resource should generally be managed to avoid serious long-term depletion and to minimise the risk of serious pollution.

The prioritization process should rank systems for levels of management according to objective criteria

Priority aquifers are not necessarily the largest aquifers in a country. Prioritization criteria would include socio-economic importance, degree of threat to services or sustainability, and

level of socio-political engagement. Urban aquifer systems may often be amongst the highest priorities because of their strategic importance in water-supply and the major pressures to which they are subjected. An 'integrated approach' (Box 7.2) will be required. Because of the complex connections with other services and sectors, strong leadership will be required, for example from a municipal mayor or water-utility chief engineer, as well as good technical capacity and an assured budget.

Box 7.2

Urban groundwater planning — requiring an integrated approach

Aquifer systems within, and in the immediate hinterland of, major urban conurbations are often priority cases. This is because water services for a large population depend on the quality and quantity of water in the aquifer — but that aquifer is also very vulnerable to both over-pumping and pollution. Any deficiencies can create negative social, economic and political problems. One common challenge for planning is that the surface area overlying the aquifer — or the part of the aquifer affected by urban withdrawals — does not coincide with municipal boundaries. Specific agreements with other authorities may be needed, and a protection zone may be declared. Urban groundwater management plans are needed even where large-scale water-supply transfers are going to be introduced into urban areas that previously used their own local groundwater supplies.

Urban groundwater management plans will need to coordinate with the planning and management of infrastructure and services that can affect the aquifer or be affected by it, notably:

- **urban sanitation:** groundwater source protection will be a high priority, especially in areas of unsewered sanitation and wastewater reuse from sewered areas
- **urban infrastructure stability:** intensive groundwater abstraction and declining piezometric surface in more confined aquifer systems can result in land subsidence, with very costly consequences for urban buildings and built infrastructure
- **subsurface infrastructure damage:** conversely the water table in unconfined aquifers may rise as a result of infiltration from water mains leakage or in-situ sanitation, or from abandonment of water wells. This can cause infrastructure damage due to seepage into (or uplift of) underground structures such as railway or road tunnels or cuttings, building basements, or mains sewerage systems
- **urban drainage:** it will usually be good conservation practice to encourage groundwater recharge via soakaways, but this brings the risk of infiltration of diffuse contaminants or of illegal liquid effluent disposal.

Plans — and management — should generally be set at the lowest level to ensure stakeholder engagement

Priority aquifers systems, which are treated as groundwater management units, should generally be defined at the lowest meaningful spatial scale, in other words closest to actual groundwater abstractors and potential polluters.

... except for transboundary aquifers

An exception to this preference for local management is where an aquifer system extends across international frontiers (or state boundaries in large federal countries). Here transboundary cooperation will be required at the system scale, even if many aspects of routine management could be handled at a local level in groundwater sub-catchments.

Assessment of Status

A second step is assessment of the present resource status for each priority aquifer system selected, and evaluation of the risk of degradation

The assessment would document current groundwater extraction and use, and pollution pressures in recharge areas, as well as directly of the subsurface space. Where adequate monitoring is in place, the assessment can be done directly, using data on groundwater levels, aquifer discharge and groundwater quality. However, information is frequently limited even for important aquifer systems, and the assessment will need to be done indirectly using surveys of ecosystem condition, pollution pressures and evaluations of aquifer degradation susceptibility and pollution vulnerability. It is important that the information base provides a minimum level of confidence. The assessment should also be to identify the critical gaps in information.

Management Characterization of the System

The final preparatory step is to identify the characteristics of the system which will determine how it can best be managed.

Once all the data are in place, the overall state of groundwater development and the hydrogeological characteristics of the aquifer system will need to be taken into account in developing groundwater management plans — clearly there is no one size that fits all needs. Of most importance are:

- the **geographical scale of the aquifer system** and **size of its storage reserve**, which will determine how identifiable it will be for local stakeholders and how amenable it will be to self-regulation
- the **degree of connectivity with surface water**, which will indicate whether conjunctive management of surface and groundwater is essential to achieve the efficient use and improved conservation of both resources
- the **level of contemporary** recharge, since — if the use of non-renewable groundwater resources is likely to be involved — it should be subject to rigorous control given the strategic implications for intergenerational equity
- **aquifer susceptibility to irreversible degradation** and **groundwater vulnerability to pollution**, which together will determine the urgency for action and the degree and nature of regeneration that will be needed

The work should be done and owned by local agencies and stakeholders under the guidance of the national groundwater agency

All this work will normally be undertaken — and in due course owned — by the responsible local agency, working with local specialists and stakeholders, and following protocols provided by the national groundwater agency.

7.2 Drawing Up Management Plans for Priority Aquifer Systems

The Consultation Process

A consultative, participatory process is required to reach consensus on what aquifer services should be prioritized

The fourth essential step will be to promote dialogue to establish consensus on the priority services required from the aquifer system. The priority services could include:

- water-supply security for urban, agricultural or other purposes
- guaranteed access for small private users
- sustaining dependent ecosystems and dry-weather river flows

This has to be a consultative participatory process, but in the end a decision will have to be reached by the public agency mandated to manage groundwater. It is very important that the consultations are well informed about current groundwater resource and quality status, any

related trends, the potential consequences and costs of 'no management action', and the options as regard management measures — essentially the results of the first three steps of the planning process.

The consultative process has to be well-managed. This requires it to be based on permanent stakeholder mechanisms. It also necessary in stakeholder engagement to manage expectations and time requirements and still achieve inclusiveness.

Preparation of the Management Plan

The fifth step will be to elaborate the groundwater management plan itself. Plans will be specific to each priority aquifer system identified and incorporate the elements of institutional soundness, incentives and investment described in Chapters 4-6. The following are typical elements of groundwater management plans:

- a technically and economically sound array of **demand-side and supply-side management measures** to achieve re-balancing of groundwater withdrawals with average recharge, such that the risk of irreversible damage to aquifers and ecosystems is avoided
- **prioritization of water uses** on the basis of social and economic priorities
- additional governance provisions and management strategies where essentially **non-renewable groundwater resources** are to be drawn down (Box 7.3)
- definition of **stakeholder roles and institutions** and specification of how those roles will be factored in to planning and management, and how stakeholder institutions will be supported
- planning for **conjunctive management measures** in situations of groundwater over-abundance and consequent soil water-logging and land drainage problems
- **pollution abatement or control measures in the aquifer recharge zone** such that the risk of groundwater quality deterioration is managed (Box 7.4)
- **regulatory measures, economic incentives and policy changes** to address groundwater management needs within the given legal and institutional framework — here the priority will be to achieve a practical balance between top-down administration and bottom-up stakeholder engagement participation
- working on the essential **linkages to other sectors**, be it land use planning, energy provision, trade or other policies (see chapter 5).

Box 7.3

Governance of non-renewable groundwater resource exploitation

The governance of non-renewable groundwater deserves special care. Because of distorted incentives (see above) or wilful ignorance it is not uncommon for non-renewable 'fossil' groundwater to be used without consideration of the strategic uses that it may serve in the future or even an understanding of the nature of the resource If the utilisation of non-renewable groundwater resources is to be governed effectively, special emphasis must be put on aquifer system characterization to assess:

- groundwater availability over a given time horizon with a given well-field design
- the impact of abstraction on third parties and on any related ecosystem
- possible groundwater quality changes during intensive aquifer exploitation.

Uncertainty is often unavoidable — but confidence will increase greatly when a few years' monitoring data of aquifer response to large-volume abstraction are available from a carefully-designed groundwater monitoring program.

A comprehensive socio-economic assessment of options for the mining of aquifer reserves and its impacts will also be a pre-requisite, including consideration of:

- potential alternative uses (present and future) of aquifer reserves
- the value of the proposed use(s) in relation to the in-situ value of groundwater
- the 'what happens after' (aquifer reserves are depleted) question.

Other features of good governance for non-renewable groundwater resources include:

- referring the decision on large-scale mining of aquifer reserves to a high-level of government (preferably the prime minister's or provincial governor's office)
- making groundwater abstraction and use rights consistent with the hydrogeological reality of continuously-declining groundwater levels, potentially decreasing water well yields and possibly deteriorating groundwater quality — for example, use permits may be time-limited and subject to periodic review
- promoting maximum efficiency and economic productivity of groundwater use, with accurate measurement and realistic charging for abstraction and enforcement of regulations to discourage inefficient uses
- assessing the impacts of intensive groundwater exploitation on all traditional users and ecosystems with some form of compensation provided for predicted or actual impairment of pre-existing rights, and ensuring sufficient reserves of extractable groundwater of acceptable quality left in the aquifer system at the end of the proposed period of intensive exploitation to sustain the pre-existing activity

Box 7.3

(Continued)

- full participation of groundwater users and other stakeholders through establishment of an aquifer management organisation
- public awareness campaigns on the uniqueness and value of non-renewable groundwater to create social conditions conducive to planned aquifer management

Box 7.4

Groundwater pollution control

Groundwater management plans will often need to incorporate groundwater pollution control measures. As this is extremely difficult, trade-offs will be essential. For example:

- Where it is impossible to protect all groundwater recharge, focus could initially be on protection of the capture areas of major public water supply sources
- It may be decided initially to deal with point-source pollution (which is relatively easy once the problem has been identified), whilst recognising that the control of diffuse-source pollution is likely to take much longer and to require a different approach
- Monitoring requirements for groundwater quality assessment are onerous and data are often scarce — but substitution of indirect geologically-based methods to assess pollution vulnerability may be used as a first approximation for planning purposes.

Adapting the Plan to the Local Institutions

Plans need to be adapted to the local socio-economy, institutional set-up and capacity

Some governance provisions and management measures will need to be specifically tailored to certain facets of the socioeconomic situation conditioning groundwater use, dependence, management and protection:

- the **number and spread of groundwater abstraction points or potential polluters:** if the number of points is very high, it is extremely hard for the public administration to promote conventional regulation

- **state of institutional development:** since regulatory and charging approaches require a public administration with considerable capacity and experience, and recognition and acceptance of their authority by all stakeholders
- **proportion of population abstracting groundwater directly:** if the proportion is high, there is scope for effective stakeholder involvement in regulation and management, as most households will have a stake in equitable access and efficient and sustainable use
- **economic significance of groundwater resource use:** this will influence the ease with which finance can be raised to invest in governance provisions and instruments.

7.3 Implementing and Reviewing Plans

Implementation

Plan implementation should be done according to annual programmes and budgets, with stakeholder involvement and regular reporting for accountability

The seventh step will be the implementation of the agreed groundwater management plan, which preferably should be undertaken progressively on a structured periodic basis — for example, with annual programmes and budgets and subsequent annual reports. Stakeholder involvement should be continuous, through agreed institutional mechanisms e.g. groundwater associations represented in decision and review meetings. Awareness raising and information sharing should be built in. The plan would include an operational time-frame and management monitoring framework endorsed by the responsible national/local groundwater agencies and all relevant stakeholders. Plan implementation will often require some strengthening of institutional linkages, raising capital investment, improving groundwater use and protection measures and aquifer response monitoring, promoting more effective public information campaigns, and undertaking capacity building. It will also be necessary to pursue inter-ministerial cross-sector coordination to align groundwater planning and agricultural or industrial development plans and to agree on the implementation of demand management measures.

Flexibility is required during implementation as conditions change and as monitoring data against indicators and targets become available

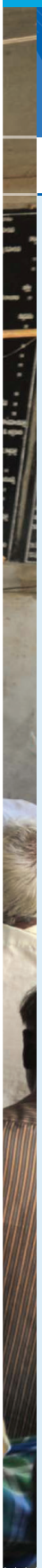
The plan must be dynamic in nature, providing capacity for adaptation to changes in groundwater knowledge and in external drivers (such as climate and land-use). Indicators of groundwater status (for example a predefined groundwater level or quality at a strategic

monitoring site) can act as barometers of aquifer condition and facilitate an adaptive management approach. Whilst some types of aquifer system response to external pressures is relatively rapid, and can be expected to be manifest in a period of say five years, thick aquifers are slower to show signs of improvement, especially when quality is the issue.

Monitoring, Reporting and Evaluation

In all cases, monitoring and regular reporting on changes against indicators and targets are essential

The final step is systematic monitoring and periodic reporting to assess performance and results against plan targets. Feedback from the first cycle of plan implementation can be used to adjust the plan itself and, if necessary, to refine the underlying governance provisions (including the legal provisions and institutional arrangements).



8. Call for action

This Framework has detailed the steps required to realize the Shared Global Vision for Groundwater Governance

The Framework for Action is designed to set out the action steps to achieve the Vision on Groundwater Governance. The Vision envisages a world in 2030 in which countries have taken appropriate and effective action to govern their groundwater resources and aquifer systems in order to reach their goals of social and economic development and to avoid irreversible degradation of the priority aquifer systems.

Vision 2030 targets sound groundwater governance that establishes the public interest, collective responsibility, and inter-sectoral integration…

The ambition in the Vision is that in 2030 there are appropriate and effective governance frameworks for groundwater everywhere that establish public custodianship, collective

responsibility and integration of groundwater with important related policy fields. The Vision also aims that by 2030 all major aquifer systems are well documented, that this knowledge is available and shared, and that it makes use of the on-going information and communication revolution.

... as well as properly resourced and capable management agencies, and financing and incentives in line with policy objectives

Furthermore, the Vision on Groundwater Governance envisages that groundwater management agencies, locally, nationally and internationally, are adequately resourced and capable of executing the key tasks of capacity building, resource and quality monitoring, and promoting demand management and supply-side measures. Also the Vision foresees that by 2030 improved and innovative financing mechanisms for sustainable groundwater development are widespread, and that the subsidies that currently often encourage unsustainable resource exploitation are phased out.

Implementation of the Framework can achieve the Vision — but this will require concerted action from all stakeholders

With adequate governance and management, groundwater resources can be harnessed and protected, their availability can in some cases even be increased, and the enabling environment for economic growth and fulfilling basic social needs can be supported. The Framework for Action calls for **leadership** by national and local governments and for substantive **support by international organizations** in order to achieve the goals of the Vision on Groundwater Governance. It calls for action by a large number of actors both inside and outside the water community to safeguard the many beneficial and essential functions of groundwater for future generations. To achieve this Vision, all stakeholders have their part to play, as discussed in the following paragraphs.

Action by national governments

National governments are responsible for ensuring that the components of groundwater governance are in place

The role of governments in groundwater governance is pivotal. Groundwater is a key national resource and governments have the duty to ensure that it is used equitably, sustainably and efficiently in pursuit of the growth and livelihoods objectives of the nation. Governments are essentially responsible for putting into place all the four essential components of governance:

a conducive **legal framework**; accurate and widely-shared **knowledge** of groundwater systems together with **awareness**; an **institutional framework** characterized by leadership, sound organizations and capacity, stakeholder engagement and participation, and working mechanisms to coordinate between groundwater and other sectors; and **polices, incentive structures and plans** aligned with society's goals.

A stocktaking will indicate areas for strengthening

The Framework for Action calls upon national governments to diagnose existing groundwater governance arrangements and to decide how to strengthen them. The stock-taking would include an assessment of the current institutional arrangements and their adequacy, the effectiveness of stakeholder engagement, the state of shared knowledge, the integration of groundwater with other policy areas and the extent to which investments and incentives are aligned with policy goals. At present in many countries financial systems are not conducive to sustainable groundwater use. One priority should be to ensure that key governance functions and groundwater management programs are adequately financed. In taking stock, a recognized matrix of groundwater governance indicators will be useful — to assess the level of maturity, to see where a country is now, how it compares with others and where it will go to. Such a set of indicators may need to be further developed and agreed and serve as a common index: a proposed set of groundwater governance indicators is included as Annex 1.

Groundwater management plans can then put the governance provisions to work

National governments should also initiate steps in cooperation with groundwater users and local governments to prepare actionable **groundwater management** plans, prioritizing the most important or vulnerable aquifers. Best practice would be for these plans to be systematically monitored and the information shared transparently with stakeholders.

Action by local government and decentralized agencies

Local government and decentralized agencies have a key role in the governance framework, jointly with stakeholders on the ground

The Framework for Action calls upon local government and decentralized agencies to support the management of groundwater and the related aquifers and subsurface systems in their area of jurisdiction. As groundwater is quintessentially a local resource, in many countries much of the effort to apply the governance framework and ensure management in line with policy goals rests with local government bodies and decentralized agencies in close cooperation with local

stakeholders. Local governments and decentralized agencies are called upon to make sure that the engagement of stakeholders is constructive and permanent.

Local governments are also uniquely positioned to foster integration between land management and groundwater management and protection

Local governments and decentralized agencies may support integration of land use planning and groundwater management — to protect recharge zones but also to develop healthy and productive landscapes by managing groundwater recharge at scale. Local governments and decentralized agencies may also ensure other measures that protect or enhance groundwater, such as the protection of streams from uncontrolled sand mining or the better management of surface run-off related to the development of roads.

Action by municipalities

Municipalities need to take responsibility for protection and conservation of aquifers…

This call for action is also specifically addressed to mayors and municipalities. They can play a catalytic role in water management in and around their cities, using their authority and ability to organize and coordinate across sectors. Many of the world's fast growing cities — of all sizes — see immense pressure on their groundwater resources — leading to recharge areas being encroached upon by new settlement and to polluted shallow aquifers, cones of depression and land subsidence.

… especially where cities depend on groundwater for water supply

Not only does this menace the resource, it also threatens municipal water supply. Thus, regulating groundwater use and curbing contamination of groundwater is essential for cities to continue to develop and to remain attractive and healthy places for people to reside and for business to flourish. City governments may work with water management agencies and cooperate with neighbouring jurisdictions to ensure that catchments are protected and the use of shared aquifer systems is regulated.

Increasingly, other uses of sub-surface space risk interfering with aquifers, and municipalities need to monitor and manage this

In several of the key cities in the world, other uses of sub-surface space risk interfering with aquifers, and a start should be made to manage the entire subsurface space beneath the urban area. The management of subsurface space is a new frontier that requires intense engagement of the different parties, starting with an adequate inventory of what is happening below the ground in terms of storage, mining, conveyance and groundwater use.

Actions from private sector players

The private sector in all its variety is a main stakeholder in groundwater

The private sector is a main user, not least the myriad private owners of agricultural wells, and hence has an obligation to behave responsibly.

In particular, agriculture is a major groundwater user and represents a significant part of the groundwater challenge

Almost everywhere, agriculture is the primary user of groundwater, and this is in the hands of both private small farmers and large agricultural corporations.

Small farmers have to be brought into the governance framework through participatory institutional approaches

The case of the small farmer is perhaps the most challenging of all, as these farmers have typically developed wells on their own land quite outside any regulatory or monitoring framework. Few countries have effectively recovered control over groundwater once this type of small farmer development has taken place. As these farmers have a stake in the resource and its sustainability, incentives to good management are possible. Farmers as stakeholders have to work in partnership with government and with each other to develop and operationalize institutional measures for self-regulation and local collective management.

Larger agricultural ventures can be formal partners of government in good practice sustainable management

Where formally constituted partners like agri-business corporations are involved, there is the possibility to make sustainable use of groundwater and control of pollution part of an agreed

long-term business model and to require the business to invest in the protection and efficient and sustainable use of the groundwater collective asset. One possibility would be to include sustainable, non-polluting groundwater use in the current thrust towards certification and labelling of sustainable practices.

... and agro-chemical companies can work to reduce pollution risks

Regulatory approaches — voluntary or compulsory — may also be applied to agro-chemical companies, requiring the phasing out the use of polluting chemicals, and research to develop alternatives, or at a minimum to provide better information on appropriate use to reduce the widespread non-point pollution from fertilizers, pesticide and herbicides.

Industries are major users and can be called on to conserve groundwater and protect quality

Industries are large groundwater users too. There is a trend in some industries to reuse process water and hence save on costs and pollution loads and to contribute to groundwater resource conservation. These practices may be supported, or at least recognized, and so contribute to good corporate reputations. There is an important function of government agencies here to regulate and allocate water to high yielding clean industries.

The mining industry, as a user of the sub-surface space, has a special responsibility to protect aquifers — and also to share data

Mining companies, including the oil and gas sector, compose a special stakeholder group in groundwater governance. As mining companies share the same subsurface space as groundwater users, they are called upon to share data and be responsible users in terms of pollution, safety and geological disturbance and, as far as possible, to take a long-term life-cycle view of their operations, for example by leaving mining sites in as good a condition as they found them.

The private sector is also encouraged to take the current challenges in groundwater governance as a commercial proposition

There are commercial opportunities in developing and providing solutions for better measurement — be it with cumulative flow meters, chemical/isotopic measurements, radio-telemetry or others. Regulation can be supported by commercially developed and marketed pre-paid systems and swipe card system. There is also immense business scope in

treatment and reuse of waste and wastewater. Private business is also encouraged to develop commercial solutions that can rebalance groundwater use and recharge, from better moisture conservation techniques to better surveillance and precision water usage.

Action from utilities

There is usually scope for utilities — water suppliers, irrigation service providers, energy companies — to work within groundwater management plans on conservation and resource protection

Action is also required from **local utilities and water supply companies** to secure their groundwater sources and to control leakage and discharge of untreated waste-water. Equally **irrigation service providers** are called upon to manage groundwater efficiently and within agreed plans and regulatory frameworks. Where relevant, they have the responsibility to introduce systems of effective net water saving and conjunctive management, balancing use of surface water and groundwater. Similarly, **energy utilities** are encouraged to liaise closely with groundwater managers. In some cases, there is a strong joint interest to rationalize energy pricing, which could help achieve the policy goal of conservation, for example. There may also be a clear case to improve services through dedicated feeder lines.

Action by media and civil society

Groundwater receives little attention from the media, civil society and the general public

Attention to groundwater in the media does not generally match its importance for the economy or the challenges and risks. Barring a few exceptions, there is too little attention paid by the press, civil society or the public at large to the important role of groundwater and the major threats to it.

The media could give expanded coverage of the issues and so create awareness and motivation for change by civil society and citizens at large

Media — both traditional and new, global and local — could provide more in-depth coverage, making the case for the need to govern and manage groundwater. This coverage could create broad and factual understanding and highlight current risks and future potential, in order to create broad awareness and better understanding. Barring a few exception, there is too little vigilance by the press, civil society or the public at large and the important role of groundwater

and the major threats to it go unnoticed and un-discussed. Wider public discussion could trigger citizen initiatives, increase political support and strengthen the motivation of those directly involved to act on the issues. The current highly networked world and the ability to report fast and visually provides the opportunity to both 'name and shame' offenders as well 'raise and praise' change-makers and champions.

Civil society too can raise awareness, encourage the emergence of champions and act as watchdog

Civil society is also called upon to contribute to wider awareness of groundwater challenges and opportunities and of the need for more effective governance. Awareness activities should cast the net wide, so that many champions are encouraged. Beyond this, civil society could undertake initiatives to contribute to better groundwater governance — linking stakeholders, promoting new approaches and developing local visions. Civil society can also act as a watchdog on inappropriate policies and report on gross violations of water use, pollution and the destruction of groundwater-dependent ecosystems.

Actions from educational organizations, knowledge institutes and professional associations

Education in the social, economic and political aspects of groundwater governance needs to be provided along with training in the science and engineering aspects: a new kind of professional is required.

There is a need for an entirely new professional, who does not only understand the hydrogeology of the area (or any other facet of groundwater, such as groundwater law or groundwater economics), but also has expertise on the multiple functions, potential and risks of groundwater use and the links with politics and planning. There is a need for experts who are trained to look beyond aquifers systems, and understand the way and means to govern the entire subsurface space and balance various social and economic objectives. At present not much education is offered in groundwater governance and management. Instead of education being holistic, the classical emphasis on single disciplines prevails.

The Framework for Action calls upon to educational organizations and professional associations to intensify the efforts to build capacity in groundwater governance and to come up with new courses and curricula to groom new cohorts of 'broader' professionals.

Research is also needed, both on improved ways to regulate and monitor and to tackle the main groundwater challenges

In addition to building new capacity, research can help to develop better practical ways to regulate and monitor groundwater use and to devise new approaches to the main groundwater challenges: overexploitation, pollution, salinity, water logging, eco-system degradation and the use of the subsurface space, as well as the opportunities of safeguarding groundwater resources.

Professional associations can contribute to education and research, and also help to inform and inspire professionals about the broader challenges of groundwater management

Professional associations have a large role to play in education and applied research, integrating the realities of actual experience into the teaching curriculum. The role of professional associations also goes beyond education — to developing and sharing best practice in groundwater governance and setting minimum standards. Associations can inspire professionals to use new insights and create a community of practice in effective groundwater governance.

Action by international organizations

International organizations are also called upon to build a global network of groundwater leaders, with particular attention to pressing issues common to a number of countries

The global reach and convening power of international organizations makes them well-placed to build a global network of leaders on groundwater governance — young and old, official or informal — to draw from each other's strengths, to give recognition and to provide inspiration. Within global networks, attention can be paid to leadership on particularly critical issues common to a number of countries, for example small island states where groundwater often is the only water source, or transboundary groundwater management.

International organizations are involved in research, study of best practice and the definition of norms and standards, and this can open doors to new policy development and to the development of guidelines for country codes of conduct

The Framework for Action calls upon international organizations to undertake path-breaking norm-setting work on: **water tenure**, especially the relationship with surface water and land management, the regulation of groundwater use in the public domain, innovative ways of defining access to groundwater, the liability for damage, and the use of non-renewable groundwater; on the **governance of the subsurface space**; and on **open data protocols**. One possibility is that international organizations might be asked to initiate a definition of minimum responsible groundwater governance which could be embedded in **guidelines for country codes of conduct and be reflected in indicators of country groundwater governance** (see Annex 1).

International organizations can also promote good groundwater governance through their advisory and financial support to countries

International organizations are also involved in the provision of policy advice and technical support to countries for the purpose of capacity building and field project implementation. In so doing, they are called upon to promote sound groundwater governance and to foster the adoption of relevant provisions of the Framework for Action by stakeholders. International financing agencies, in particular, are called upon to enlarge their portfolios with investments that address groundwater management, setting examples for other financiers.

International organizations are well-placed to support moves towards transboundary groundwater management

Finally, international organizations are also called upon to support transboundary water management, of which there are at present few successful examples. International organizations can support bridging and confidence building between countries and pave the way for processes of cooperation.

Commitment of the partners in the GEF Groundwater Governance Project

The partners in the GEF Groundwater Governance Project commit to joining with all other stakeholders to support the whole range of activities conducive to good groundwater governance, and to monitor and report on progress towards achieving the Shared Groundwater Governance Vision through to 2030

This call for action is addressed to a large number of stakeholders, reflecting the pervasive nature of groundwater challenges globally, and the need to enlist broad support to govern groundwater assets. The **Groundwater Governance Vision 2030** and **Framework for Action** are the intermediate result of a consultation and discussion process, convened by the Global Environmental Fund, the Food and Agriculture Organization of the United Nations, the International Association of Hydrogeologists, the UNESCO-International Hydrology Program and the World Bank. These convening organizations commit themselves to undertake and support the activities required as outlined in this Framework for Action. They also commit to monitoring progress in groundwater governance regularly in the period up to 2030.

Annex 1: Qualitative Indicators for Groundwater Governance

Type of provision	Governance performance indicator	Context for application	National provision #		Local situation #	
			strong	weak	strong	weak
Institutional	Government Agency as 'Groundwater Resource Guardian'	*empowered to lead and act across sectors*				
	Permanent Stakeholder Engagement Mechanism	*for balanced participation and active support*				
	Coordination with Agricultural Development	*to ensure 'real water saving'/pollution control*				
	Coordination with Urban/ Industrial Development	*to ensure consideration of groundwater*				
Legal & Fiscal	Waterwell Drilling Permits & Groundwater Use Rights	*subject to revision for adaptive management*				
	Instrument to Constrain Waterwell Construction/ Use	*in critical resource areas*				
	Sanctions for Illegal Waterwell Operation	*to penalize illegal waterwells/excessive use*				
	Groundwater Abstraction & Use Charging	*resource admin charge for commercial users*				
	Land-Use Controls to Reduce Diffuse Source Pollution	*restriction according to hazard*				
	Constraints on Ground Discharge of Waste (water)s	*as required for aquifer protection*				

(Continued)

Type of provision	Governance performance indicator	Context for application	National provision #		Local situation #	
			strong	weak	strong	weak
Legal& Fiscal	Users of Sub-Surface Space Registered & Regulated	*considering potential system perturbation*				
Technical	Groundwater Body/ Aquifer Delineation	*including characterisation for management*				
	Groundwater Piezometric Monitoring Network	*sufficient to establish resource trend*				
	Availability of Aquifer Numerical 'Management Models'	*for assessment of management measures*				
	Groundwater Pollution Hazard Assessment	*to identify and rank pollution risks*				
	Groundwater Quality Monitoring Network	*to detect incipient pollution/salinization*				
Policy & Planning	Public Investment in Groundwater Management	*to ensure operational effectiveness*				
	Financial Policies Encouraging Groundwater Sustainability	*and not stimulating depletion/degradation*				
	Incentives for Groundwater Ecosystem Services	*for recharge enhancement/quality protection*				
	Existence of Groundwater Management Action Plan	*with consensus on targets and measures*				

Primarily related *_ groundwater abstraction related* *_ groundwater quality related* *_ groundwater abstraction and quality*

 # each performance indicator to be ranked on 'strong to weak scale' as regards 'capacity to influence' and 'present status'