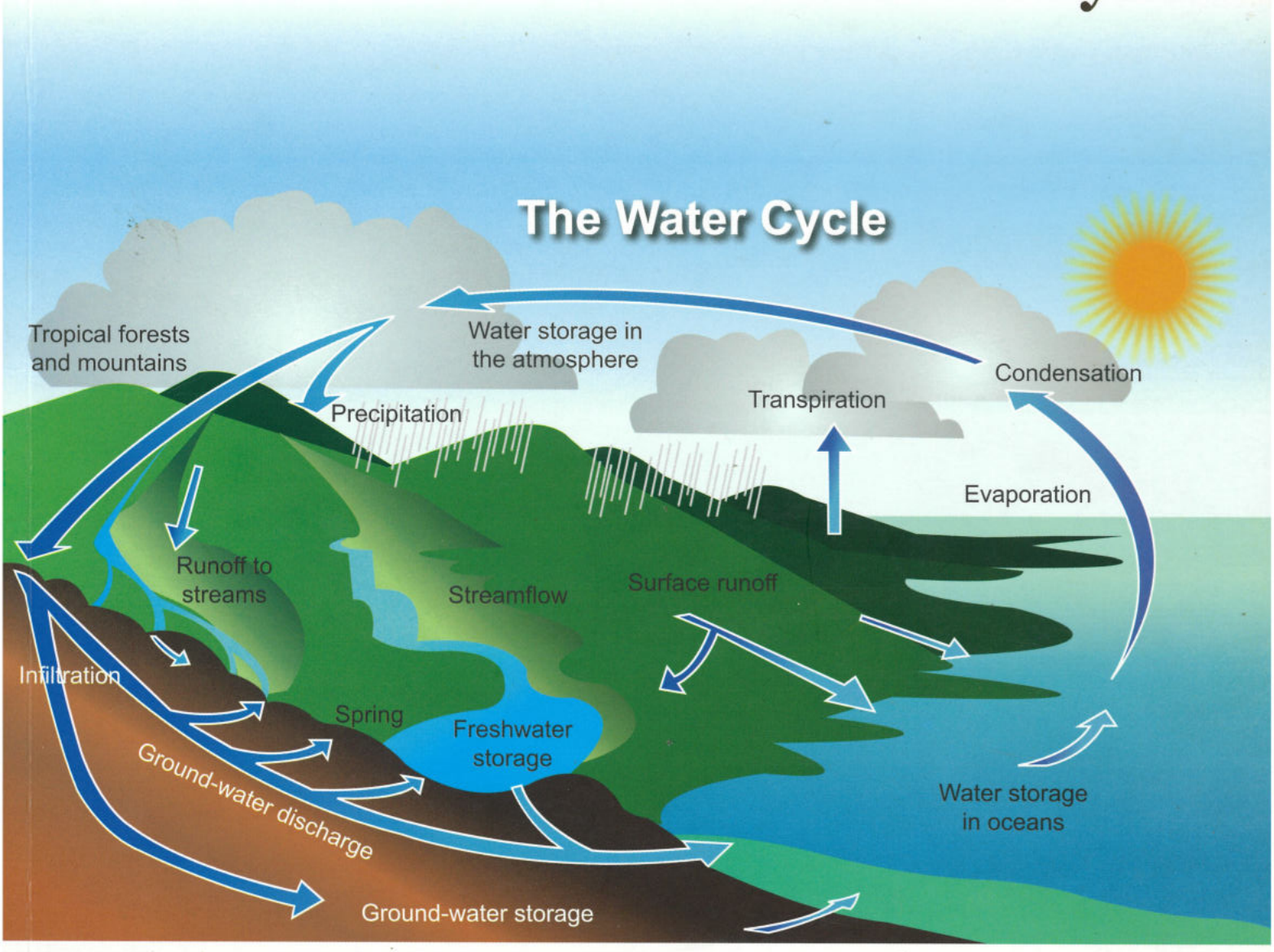
ASM Advisory Report 1/2011

# Strategies for the Sustainable Development and Management of Ground Water Resources in Malaysia




AKADEMI SAINS MALAYSIA

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## Foreword

I would like to convey my congratulations to the ASM Task Force on Ground Water for producing the Groundwater Workshop Proceedings, yet another deliverable of the ASM Water Committee. The Proceedings are the output of a series of five Workshops held to highlight all ground water-related issues and to discuss the various techniques of remedial measures towards resolving these issues and were organised in a consultative manner. These Workshops also looked into the Federal-State governance issues while fostering a closer working relationship among scientists, engineers, managers and the private sector who are involved in the investigation, management and utilisation of ground water resources. In this regard, I would like to extend my appreciation, on behalf of ASM, to our co-organisers, such as the Minerals and Geoscience Department (JMG), the National Hydraulic Research Institute of Malaysia (NAHRIM) and the Ministry of Energy, Green Technology and Water (KeTTHA), as well as the support given by the Ministry of Science, Technology and Innovation (MOSTI) and the Ministry of Natural Resources and Environment (NRE).

These Proceedings include all the papers, presentations and Logical Framework Analysis undertaken at each of the five Workshops setting the status on governance, R&D, data and information accessibility, protection, development and supply, sustainable ground water management as well as identifying the issues facing ground water management in this country.

These Proceedings are yet another important deliverable of the Academy of Sciences Malaysia and we are confident that the findings contained therein would lead to taking concrete steps to developing and agreeing on a strategy plan in line with Integrated Ground Water Resources Management (IGRM) and a plan of action for implementation over the long term within the 10th Malaysia Plan period and beyond.

**Tan Sri Dr Ahmad Tajuddin Ali, FASc.**
*President*
*Academy of Sciences Malaysia*

# Preface

Many studies have been undertaken on the world water scenario. The Leadership Group on Water Security in Asia published that "securing the region's water future is Asia's next challenge". With climate change, the water scenario is expected to be even under greater stress. It is expected that ground water will become more relevant as a supplementary source of supply of water for domestic, agricultural and industrial uses.

The *Colloquium on Groundwater Management* in Malaysia, initiated by the Academy of Sciences Malaysia (ASM), was held from 25–26 March 2009. It was jointly organised by the ASM and the Minerals and Geoscience Department Malaysia (JMGM), with support from the Ministry of Science, Technology and Innovation (MOSTI) and the Ministry of Natural Resources and Environment (NRE). The Colloquium was formally officiated by Y.B. Datuk Douglas Uggah Embas, Minister of Natural Resources and Environment. The Proceedings of the Colloquium have since been published.

Six keynote papers and eight technical papers, representing various government agencies and the private sector, were presented and this was followed by a Panel Discussion to deliberate on *Groundwater Management—The Way Forward*, on five specific sub-topics relevant to the overall theme of the Colloquium. The sub-topics were related to matters of governance, ground water research and development, ground water quality, remote sensing technique in ground water investigation and ground water development and information management.

At the Panel Discussion, the following issues were identified:

(i) Role of ground water in the management and governance of water resources (inclusive of legislation and institutional management),
(ii) Making data and information on ground water available—constraints and solutions,
(iii) Research and development needs and capacity building,
(iv) Ground water development and supply for domestic, agricultural and industrial uses—a conjunctive use to surface supply; and
(v) Promotion and advocacy of sustainable development and management of ground water resources.

In addressing these issues, the ASM Task Force on Ground Water Management decided that a series of five Workshops will be held to highlight all ground water-related issues and to discuss the various techniques of remedial measures towards resolving these issues. These Workshops, organised in a consultative manner, also looked into the Federal-State governance issues while fostering a closer working relationship among scientists, engineers, managers and the private sector involved in the investigation, management and utilisation of ground water resources.

These Proceedings contain all the papers, presentations, and Logical Framework Analysis undertaken at each of the five Workshops. They cover the status on governance, R&D, data and information accessibility, protection, development and supply. In addition, aspects on sustainable management as well as identifying the issues facing ground water management in this country are given.

The findings in these Proceedings will go towards developing a Ground Water Management Strategy Plan document by ASM for managing the resource through Integrated Ground water Resource Management (IGRM) principles. The document will be presented to the Government for its due consideration and implementation.

**Datuk Fateh Chand, FASc.**
*Chairman,*
*ASM Task Force on Ground Water Management*

## Contents

# Strategies for the Sustainable Development and Management of Ground Water Resources in Malaysia

EXECUTIVE SUMMARY

## Background

The Academy of Sciences Malaysia (ASM) teamed up with the Mineral and Geosciences Department of Malaysia (JMG) in March 2009 to convene a two-day Ground water Colloquium carrying the theme 'Groundwater Management in Malaysia — Status and Challenges'. Based on the outcome of this national colloquium, ASM and JMG, with the support of the Ministry of Science, Technology and Innovation (MOSTI), the Ministry of Natural Resources and Environment (NRE), the Ministry of Energy, Green Technology and Water (KeTTHA), and the National Hydraulics Research Institute of Malaysia (NAHRIM) jointly organised five multi-stakeholder consultative workshops in 2009 with the ultimate aim of developing a Strategic Advisory Report on Groundwater Resource Management. The Workshops were structured and organised to address key aspects of Ground water Resource Management. The topics for these workshops were as follows:

- Workshop 1: Ground Water in the context of Integrated Water Resource Management — Its Management and Governance.
- Workshop 2: Research and Development and Capacity Building Needs in Ground Water Development and Management.
- Workshop 3: Making Data and Information on Ground Water Available — Constraints and Solutions.
- Workshop 4: Ground Water Development and Supply for Domestic, Agricultural and Industrial Uses — A Conjunctive Use to Surface Supply; and
- Workshop 5: Promotion and Advocacy of Sustainable Development and Management of Ground Water Resources.

Individual workshops for each of the components were held with the participants selected from various stakeholder groups, such as relevant government agencies, research institutes, the private sector and non-government organisations, whose linkage to ground water related closely to the various issues being discussed. Specialists from academia and agencies were also invited to present position papers on each of these component topics. The position papers, the outputs of the various workshop groups and their collective opinions were then collated and published as the *ASM Groundwater Workshop Proceedings* which formed the basis of a draft Strategic Advisory Report that was then presented to an open forum comprising a larger multi-stakeholder audience to obtain further feedback and inputs.

This document represents the finalised Strategic Advisory Report on *Ground water Resource Development and Management* in Malaysia submitted for the consideration and endorsement of the Government.

## OVERVIEW OF MALAYSIA'S GROUND WATER POTENTIAL AND CURRENT USE

In Malaysia, the development of water resources has seen a shift away from ground water use. Surface waters, specifically from rivers, have been the main source of water supply, whether for agriculture or for piped water (except in a number of districts in Kelantan).

However, surface water resources are not always readily available. Water demand for domestic, industry and agriculture, currently estimated at 12 billion cubic meters, is expected to expand into the future as the population and economy grows. Many rivers are already being tapped intensively for their water and there are limits to how far more that utilisation can continue. It is crucial that basal flows are maintained to ensure the fundamental nature of the river basin ecology and the environmental services they provide are not compromised. Here, it is pertinent to point out that basal flow is fed by ground water.

Compounding the situation are anthropogenic influences that deleteriously affect the ability of rivers to sustain supply. Changes to upper catchments, for instance, have led to seasonal low flows in rivers, seriously disrupting supply. Drought events are expected to increase in future with further disruption of the hydrological cycle through land clearing and climate change.

Pollution of surface waters is yet another factor negating against an over-reliance on surface water resources. Many of our rivers face increasing pollution challenges and, though concerted efforts are currently being made to install and upgrade sewerage systems throughout the country, wastewater and leachate discharges from industrial estates and non-sanitary landfill sites into rivers are still a major problem.

Given this scenario, it is clear that there is an urgent need to diversify the country's water resource base. Ground water development offers such an alternative. Ground water is a resource that does not occur in isolation. It is an integral feature of the water cycle. Water occurs as rain water, surface water in rivers and lakes, ground water, waste water and storm water. All are part of the same resource base. Ground water is recharged from precipitation, and eventually flows to the surface naturally; natural discharge often occurs as springs and seeps, and can form wetlands. These, in turn, combine to flow as surface runoff. Thus, precipitation, ground water and surface waters are intimately linked. In short, ground water is an integral part of a river basin and must be managed as such. An understanding of this linkage is crucial in ensuring sustainable ground water development and management.

Ground water resource management is also a subset of the Integrated Water Resource Management (IWRM) regime, together with associated management instruments such as Integrated River Basin Management and Integrated Lake Basin Management. This synthesis with overall catchment health is embedded in what is referred to as Integrated Aquifer System Management (IASM).

Ground water resources in Malaysia, that is the volume of water stored in the aquifers, has been estimated at 5000 billion cubic metres or 5 trillion cubic metres of water. This is 160 times the volume of water held by our 90 lakes and reservoirs (of 31 billion cubic metres) and 9 times the volume of water that flow annually in our rivers (of 566 billion cubic metres).

To put things into perspective, this volume of the freshwater is sufficient:

- To meet the annual consumption of water for agriculture, industrial and domestic purposes in Peninsular Malaysia (estimated at 12 billion cubic metres in 2010) for several hundred years (assuming, of

course, that there is no increase in water demand and there is no pollution of the resource from anthropogenic activities).

- Generate total revenues of RM7.5 trillion if sold at a commercial water rate of RM1.50/cubic metre—a potential major contributor to the National Gross Income. Commercial water rates vary from RM1.20–RM2.20 in different states.

The development of ground water resources carries with it numerous advantages, many of which are not recognised. Among these include reliability even during periods of prolonged drought, quality, lower storage costs and lower transfer costs.

Ground water is also ecologically important, sustaining rivers, wetlands and lakes. Ground water feeds soil moisture through percolation, and many types of terrestrial vegetation depend directly on either ground water or the percolated soil moisture above the aquifer for at least part of each year.

Current management strategies for ground water are fragmented, pursued by different management agencies, each having different, and often competing, sectoral agendas as elaborated below.

## Public Water Supply

Current usage of ground water is limited, estimated to contribute about 0.2 million cubic meters per day or only 1.4% of total water supply annually. The biggest and oldest investment in ground water development in Malaysia has been in Kelantan, which has tapped shallow and deep aquifers to supply much of its drinking water since the 1930s. Currently, ground water supplies 146 million litres of water a day to the residents of Kelantan, accounting for 41% of their requirements, with 100% of the water in Tumpat, Kota Baru and Backok districts being supplied by ground water.

The use of ground water in public water supply is also significant in Sabah. Ground water is important in the resort islands off Sabah and other small and isolated communities, and also supplements supply to a few major towns such as Sandakan. Small quantities are used in Pahang, Perlis and Labuan. Ground water has also been used in islands and coastal areas in the east coast of Peninsular Malaysia.

In Sarawak, ground water was first exploited in 1954 in Sarikei, followed by Bintangor and Sri Aman. However, these towns are currently fed by surface water. Ground water is presently the main source of water supply in several coastal villages in the State.

## Industry

The largest ground water based industry is the bottled mineral water industry. There are currently 63 wholesalers of bottled mineral water in the country, while 45 licensees have been allowed to abstract mineral water from 17 aquifers.

Large-scale ground water abstraction amounting to 32 million cubic metres annually is also undertaken by Lion Bhd's Megasteel plant in Olak Lampit, Selangor.

## Agriculture

The use of ground water in agriculture is widespread, yet the data available on its utilisation is even scantier than of other users. Though ground water is clearly not practicable for large-scale water intensive agriculture, such as rice farming, agriculture activities with a smaller water footprint can, and do, depend on ground water.

## ISSUES AND SUGGESTED ACTIONS

Ground water development and management in Malaysia face many serious problems that relate back to the absence of an adaptive and comprehensive management regime. Among the major issues that must be grappled with in ground water management are as follows:

- **Fragmented Policy, Legal and Governance Framework**
  The absence of a comprehensive regulatory and governance framework is probably the most pervasive problem facing ground water utilisation in the country. While there are numerous Federal and State laws related to the management of river basins in Malaysia, however, the number of regulatory instruments covering ground water is limited. Notwithstanding this, in recent years, some State governments have enacted specific laws in relation to water resource management. These include the Sabah Water Resources Enactment 1998, the Selangor LUAS Enactment 1999, the Pahang Water Resources Enactment 2007 and the Kedah LUAK Enactment 2007. Of these state agencies, Lembaga Urus Air Selangor (LUAS) has been the most proactive where ground water resource management is concerned.

  Local governments do not have rights over water resources *per se*. However, they are mandated to oversee development within their respective jurisdictions. Local Governments are bound to follow zoning provisions in Local Plans, where the protection of recharge areas and sensitive wetlands are embedded. Local governments also oversee (together with the Solid Waste Department) the establishment and construction of landfill sites, which are major sources of contamination for ground water resources.

  Although the Ministry of Natural Resources and Environment has a strategy plan for ground water management and development, it is yet to be implemented. While the strategy plan is laudable, and does address some of the more pressing issues facing ground water development, it has to be further strengthened. The overlap within and between Federal and State jurisdictions highlights the call under the Integrated Aquifer System Management regime to pursue ground water resource management beyond administrative, jurisdictional and political boundaries.

  **The creation of an overarching policy and strategy environment on a national basis pertaining to ground water would provide a framework which all institutional stakeholders would be able to subscribe to.**

- **Pollution**
  Pollution and habitat degradation is another important factor leading to the loss of functional value in ground water. Traditionally, management of water resources has focused on surface water or ground water as if they were separate entities. Nearly all surface-water features (streams, lakes, reservoirs,

wetlands, and estuaries) interact with ground water. Pollution of surface water can cause degradation of ground water quality and conversely pollution of ground water can degrade surface water.

**Ground water is an integral part of a river basin and must be managed as such**. An understanding of this linkage is crucial in ensuring sustainable ground water development and management.

- **Lack of Sustained Research and Development**
  NAHRIM is currently the only government research institute undertaking R&D into ground water. However, lack of funding and the necessary man-power as well as the sporadic studies it had carried have neither been comprehensive nor undertaken over a long-term basis.

  **Investments in R&D on ground water aquifers, systems, modelling and characterisation (in terms of quality and quantity) as well as R&D into ground water assessment and development technologies are crucial in providing the knowledge base towards sound ground water development and management. Furthermore, it will open up opportunities in spin-off industries both locally and globally.**

- **Manpower and Human Resources Issues**
  There is a **fundamental need to strengthen manpower capacity at various governing and technical levels** before improvements in management regimes are going to yield the requisite results. Requirements for sustainable management would include adequate knowledge of hydrogeology and functional linkages that tie the physical, chemical and biological environment to ground water resources. This would involve knowledge of how ground water relates to the greater hydrological cycle of which it is a part.

  The provision of training and exposure would allow the enablers at State and Local Government levels to be better aware of the implications of their actions and how it impinges on ground water. This would go a long way in the protection and management of ground water resources.

- **Resource Data Collection, Management and Dissemination**
  A key shortcoming of ground water development in Malaysia is the limited data on the resource itself. Though the Minerals and Geoscience Department have come up with hydrogeological maps, these provide only a broad brush assessment of the resource. Hard data on locations of aquifers, the quality of water they hold, recharge areas, ground water protection zones, sustainable rates of abstraction and potential economic value are seriously bereft.

  The Department of Minerals and Geoscience (JMG) has established HYDRODAT, an integrated database on ground water data, to enable it to more effectively assess and plan its development. However, the database operates in an institutional vacuum. The Department does not have the legal mandate to compel the numerous players in the government and the industry to populate the database. The database is also limited to Departmental staff, defeating the very purpose it was set up for i.e to promote the ground water industry by making resource data easily and widely available.

  **There is an urgent need for a detailed resource assessment of ground water in Malaysia on an aquifer-by-aquifer and basin-by-basin approach. Efforts are also required to identify:**
  - **Riverine alluvium aquifers within a river basin**
  - **Coastal alluvium aquifers within and across river basins, and**
  - **Hard-rock aquifers within and across river basins.**

There is potential Federal-State, inter-State as well as international boundary implications that may arise in times of water crisis with those aquifers that transcend state and national borders.
**A networked database that link managers, administrators and researchers, would enable a free exchange of information that can empower stakeholders, including the general public, in the management process.**

- **Public Awareness and Stakeholder Participation.**

Public perceptions towards ground water development have ranged from wary to downright hostile. The main objections to ground water used have arisen from experiences from countries which pursued a free-for-all approach to ground water utilisation.

The main perceptions towards ground water utilisation it that it is:
- Is a limited resource
- Is unreliable
- Is polluted
- Is expensive to develop and difficult to maintain
- Negatively impacts on the environment.

While such problems have faced countries that have not been able to put in place a sustainable development regime, it is worth noting that the country has had a 70-year ground water scheme in Kelantan that can be regarded as a model of sustainable resource use.

The general advantages of ground water as a resource (i.e. reliability, cost and quality) are known but in the case of Malaysia, a major driver of ground water development would be water security. This issue has several facets.

- Malaysia now is almost totally reliant (97%) on one source i.e. surface waters for its raw water supply, an untenable situation where water security is concerned.
- Against this overwhelming reliance is the fact that surface water resources can no longer be considered reliable. Among others:
  - Surface sources are subject to the vagaries of climatic variations and shifts. These would include natural climatic cycles such as El Ñino and La Ñina as well as long term shifts such climate change.
  - Surface water sources are also subject to pollution and degradation. Though efforts are being made to control degradation of riverine waters, the rapid growth of the economy suggests that the situation will get worse before it starts getting better.
- Demand for water is expected to increase substantially in the future. Overall water demand in the country is growing at the rate of 4% annually, and projected to be about 20 billion $m^3$ by 2020. The annual domestic and industrial water demand is expected to grow to 5.8 billion $m^3$ and irrigation water demand to about 13.2 billion $m^3$ in 2020.

**In short, the combination of growing demand and the uncertainties surrounding the surface water resources seriously undermines the security of the country's water supplies and the confidence in ensuring its sustainability.**

**The issue then is not if we should pursue development of ground water resources but whether we can afford not to.**

It is not prudent that ground water totally substitute all surface water supplies. **Ground water should be developed to become a conjunctive source of raw water, supplementing and complementing current raw surface water use.**

## THE WAY FORWARD

The current *ad hoc* approach to ground water development and management will only lead to further deterioration of the resource. There must be sustained action to arrive at a better understanding of the resource and its benefits to the nation.

In this respect, there are four major interventions required to ensure sound ground water resources development and management in the country. They are as follows:

- Development of a National Vision for ground water development and management.
- The development of a Mission Statement for ground water development and management
- The development of a policy framework that, while reflecting the Vision statement, takes the exigencies of ground water development and management into account; and
- The development of a strategy framework for ground water development and management.

The articulation of a National Ground water Vision for Malaysia would be the first step in engendering a unified approach to ground water development and management. In this, the following outlook is proposed:

> **"Ensure the sustainable use of ground water for their social, economic and ecological values, in particular, in conjunction with surface water"**

Since Malaysia has formally adopted Integrated Water Resources Management (IWRM) as the central thrust to water resources management, the obvious IWRM sub-set applicable to ground water would be Integrated Aquifer System Management (IASM). Hence, the mission statement would be:

> **"To pursue sound development and management of ground water aquifer systems through the adoption and application of IWRM principles and practices".**

The absence of an overarching policy framework guiding ground water development and management is a major shortcoming. Though the National Economic Action Council (1998) in the National Economic Recovery Plan had identified ground water as one source that has great potential to be developed, a clear policy towards that end has yet to occur. The Outline Perspective Plan 3 called for the development of a National Water Policy. Given the complexities of such an undertaking, the formulation of the policy is still on-going.

However, pending its full development, it is recommended that a policy statement be included on ground water in the 10th Malaysia Plan to highlight the importance of ground water and the need to manage it sustainably. This statement can take the form of:

**Ground water resources will be assessed, managed, sustained, restored and protected through the adoption of an Integrated Aquifer Systems Management approach.**

Where the development of the National Water Policy itself is concerned, the following statements are recommended:

- That the conjunctive use of ground water is advocated to ensure sustainability and reliability of water supply to the nation;
- That the use of ground water is advocated to ensure the reliability of water supply during periods of long drought due to climate change (water security);
- That the crucial role ground water plays in ecological dynamics of river basins is widely understood and appreciated;
- That ground water has an important and critical role to play in the Food/Water/Energy nexus in the production of high-value crops through the use of sprinkler systems and drip irrigation; and
- That, where feasible, Green Technologies be applied in ground water development, for example, through the use of appropriate wind and solar energy technologies to drive submersibles especially in food production of high-value food crops.

## STRATEGIES

The overarching objectives of a policy would enable ground water resources in the country to be adequately explored, assessed, valued and managed optimally to ensure the health of the resource itself and communities that rely on it.

The absence of a policy means there is no strategic framework for the management of ground water resources. Strategic initiatives must address key issues relating to the management of resource in its entirety. A strategy framework towards this end is as follows:

### STRATEGY I. IDENTIFY AND EMPOWER A LEAD MINISTRY/AGENCY AT FEDERAL LEVEL

Water is a natural resource and hence, the overall responsibility for reaching out and integrating across boundaries would rest largely with the NRE. To effectively manage the national water resource as a unitary entity, it follows that there must initially be intra-Ministry integration where the Ministry's surface water and ground water divisions are integrated into one division.

Similarly, in undertaking water resources management on a holistic basis, NRE would have to nominate a department/agency that best lends itself for this mandate of assessing, developing and managing the national water resource (both surface water and ground water). For the purposes of this paper, the term 'Water Resources Department' (WRD) will be used as the agency that will be ultimately designated this function.

Appropriate manpower and financial resources would have to be provided to NRE and the WRD to take on this burden.

## STRATEGY II. FACILITATE STATES TO PLAY A LEADING ROLE FOR GROUND WATER MANAGEMENT

While Federal agencies have their role, the custodianship of water resources, including ground water, that are wholly located within state boundaries rest with the respective State Administrations. The establishment of state water resource management authorities for the holistic management of the states' water resources, inclusive of ground water, has long been actively encouraged by the Federal Government. Only four states have done so and only Selangor, has gone the length to undertake ground water management. In this respect, the LUAS experience can serve as a template for other states to emulate.

## STRATEGY III. ESTABLISH A NATIONAL GROUND WATER RESEARCH CENTRE UNDER NRE

The National Ground water Research Centre would be a one-stop agency which would act as:

- A centre of excellence for research into ground water resource and management, bringing together experts from various research institutions and universities to focus on priority areas for research and study; and
- A reference centre and database for all information and research on ground water in Malaysia.

## STRATEGY IV. ESTABLISH A STANDING COMMITTEE ON GROUND WATER WITHIN THE PURVIEW OF THE NATIONAL WATER RESOURCES COUNCIL (NWRC)

Ground water comprises one of three vital sources of water (the other two being rivers and lakes) that are closely linked and impacted upon by land development within their catchments while, at the same time, involving a wide spectrum of stakeholders.

A standing committee set up under the NWRC to oversee the integrated management of ground water and to engage in continuous inter-ministry dialogue would ensure that policies that have an administrative trans-boundary dimension are implemented. NRE would be best positioned to lead this standing committee having been mandated to deal with the integrated management of all natural resources in the country. Among the first tasks for this national level Committee would be to develop a common set of guidelines for integrated ground water management for use at all levels.

## STRATEGY V. ESTABLISH GROUND WATER MANAGEMENT COMMITTEES AT STATE LEVEL

These committees would be at the political level of Government, allowing coordination among the various agencies that are involved in the development and management of ground water. The model for this would be State Agriculture Committees or State Industrial Committees that are headed by State Executive Councillors or State Ministers. Among the first tasks for this state level committee would be to ensure that all identified aquifer recharge areas are duly gazetted as environmentally sensitive areas. Development in and around these gazetted recharge areas would require prior clearance from this Committee.

## STRATEGY VI. PASS APPROPRIATE LEGISLATION TO STRENGTHEN EXISTING LEGAL FRAMEWORK

Both at National and State level, appropriate legislation must be passed to enable management of ground water as a resource. It is clear that the Waters Act, 1920 is archaic and not consistent with current economic and social conditions. States should enact specific laws and rules for the implementation of ground water management. The Selangor Waters Management Authority Enactment of 1999 provides a good template for holistic management of water resources, inclusive of ground water.

## STRATEGY VII. CHANGE PUBLIC PERCEPTIONS TOWARDS GROUND WATER

There is a crucial need for ground water development to have a buy-in by the public as well as senior administrators and politicians. This can only occur if the disinformation that is associated with it is challenged by a concerted effort to address the biases against ground water that is so prevalent. The lead agency, the WRD, would need to promote ground water as a sustainable source of water, to be used conjunctively with surface waters to meet the needs of the nation, without detriment to the environment among the general public. The WRD would need to approach ground water as a potentially vital reserve in times of water crisis and for security reasons.

At the same time, communities using ground water should be adequately trained so as to ensure that the ground water resource is managed sustainably through the adoption of appropriate Best Management Practices.

## STRATEGY VIII. DEVELOPMENT OF DETAILED ACTION PLANS

Following the recommendations under *Strategies I* and *II* above, the responsibility of preparing the detailed action plans must fall on the collective efforts of NRE, the WRD and related agencies working in concert with other stakeholders and government agencies at Federal and State levels.

Of utmost priority is a more detailed assessment nationwide of the ground water resource, following River Basin Management boundaries to begin with, to determine the current status of the ground water resources in the country, including their various values, issues and problems related to the various aquifers, and the technical and/or management solutions and remedies that should be put in place to resolve them in the short, medium and long term.

Action plans should also be framed to ensure that clear targets for ground water use are set for all water users. It is recommended that ground water use be expanded to 20% of the overall public (domestic/ industrial) water supply by 2030. These action plans should also consider private sector involvement in ground water development (through the appointment of Independent Ground water Producers, with the provision of possible incentives to promote their involvement.

# INTRODUCTION AND BACKGROUND

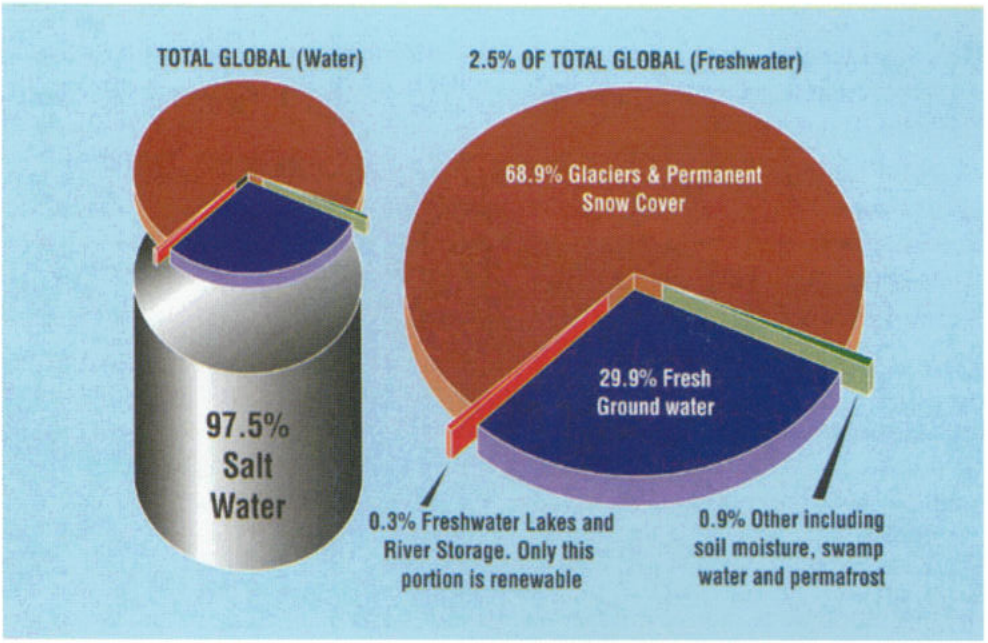
## Ground water — An Underappreciated Resource

Water is an inescapable necessity for all life on Earth. Two thirds of the Earth's surface is covered by water, amounting to approximately 1.4 billion cubic kilometres (Garrison, Tom S. *Oceanography: An Invitation to Marine Science*. Thompson Brooks/Cole, 2005:4). If we consider human needs, however, this picture is deceiving. The reality is that 97.5% of the Earth's water is in its oceans, unavailable for consumption, food production or industry.

Of the remaining 2.5%, about 70% percent is locked in polar icecaps or glaciers and beyond easy human reach. Of the remaining balance, some 30% is ground water, while rivers and lakes account for less than 1% (*Figure 1*).

However, despite its limited availability, fresh water is an absolute prerequisite for economic development of nations and regions. Adequate supplies of clean, safe fresh water are fundamental for establishment of communities and to support their economic well-being. That water represents a vital and strategic economic and social resource is underscored by the fact that most human civilizations of the world emerged in or near river valleys.

However, the use of wells, artesian springs and other manifestations of ground water resources have had an equally ancient history. The use of wells to tap ground water has had precedents since early Egyptian times while the Well of Zamzam, located within the Masjid al-Haram in Mecca, Saudi Arabia, goes back to 2000 BCE. Wells have been traditionally used for domestic and agricultural water supply throughout human history, and up to present times.




(Source: USGS and others)

*Figure 1. Distribution of water on earth.*

The development of water resources has been central in the continuing growth of human civilisation. The supply of treated water by *public utilities*, commercial organisations, community endeavours or by individuals, through a system of pumps and pipes have become an entrenched standard of human comfort to which all countries in the world aspire to. At the same time, the development of large scale irrigation has been a major advance over rain-fed or *dry-land farming*, enabling food production on a massive scale.

Malaysia has not lagged behind in this development. Piped water now reaches 98% of the urban population through reticulated systems from water treatment plants. Some 3650 sq km of irrigated land ensure that its peoples are adequately fed. All this has been possible only through extensive investments in water supply and distribution infrastructure.

This development of water resources, while laudable in itself, has seen a shift away from ground water use. Surface waters, specifically rivers, have become the mainstay of water supply, whether for agriculture or for piped water (except in a number of districts in Kelantan). Wells have fallen into disuse with the convenience of supplied water at everyone's doorstep.

However, surface water resources are not always readily available. Water demand for domestic, industry and agriculture, currently estimated at 12 billion cubic metres, is expected to expand into the future as the population and economy grows. Many rivers are already being tapped intensively for their water and there are limits to how far more that utilisation can continue. It is crucial that basal flows are maintained to ensure the fundamental nature of the riverine ecology and the environmental services they provide are not compromised. **Here, it is pertinent to point out that basal flow is fed by ground water.**

Compounding the situation are anthropogenic influences that deleteriously affect the ability of rivers to sustain supply. Changes to upper catchments, for instance, have led to seasonal low flows in rivers, seriously disrupting supply. Drought events are expected to increase in future with further disruption of the hydrological cycle through land clearing and climate change.

Pollution of surface waters is yet another factor negating against an over-reliance on surface water resources. Many of our rivers face increasing pollution challenges and though concerted efforts are currently being made to install and upgrade sewerage systems throughout the country, wastewater discharge into our rivers are still a major problem. One litre of wastewater pollutes about 8 litres of freshwater [1], a fact that underscores the finding by the Department of Environment in 2009, that out its 1063 river monitoring stations, 46% recorded polluted or slightly polluted conditions.

Given this scenario, it is clear that there is an urgent need to diversify our water resource base. Ground water development offers such an alternative.

## The Challenge in Managing Ground Water Resources

In any discussion of ground water, it is important to understand its peculiarities as a resource and the manner in which its characteristics impinge on its management.

Ground water is a resource that does not occur in isolation. It is an integral feature of the water cycle, as important and crucial as a component as the rain and its expression as rivers and streams (*Figure 2*). Unlike the more visible manifestations of the water cycle, ground water refers to water located beneath the

[1] <http://www.wwf.org.my/media_and_information/learning_sharing/freshwater_main/>.

ground surface in soil and rock pore spaces, and in the fractures of rock formations. A unit of rock or an unconsolidated deposit is called an aquifer when it can yield a usable quantity of water. The depth at which soil- and rock-pore spaces, fractures and voids in rock become completely saturated with water is called the water table.

Ground water is recharged from precipitation, and eventually flows to the surface naturally; natural discharge often occurs at springs and seeps, and can form wetlands. These, in turn, combine to flow as surface runoff. Thus, precipitation, ground water and surface waters are intimately linked. In short, ground water is an integral part of a river basin and must be managed as such. An understanding of this linkage is crucial in ensuring sustainable ground water development and management. **It is further emphasised that ground water needs to be managed as part of the water continuum. In this context, water, though finite and renewable, is essentially a unitary resource manifesting itself in various forms as part of the water continuum, otherwise referred to as the hydrological cycle. Water is also pervasive and, being a natural solvent, is vulnerable to quality degradation. (Rain, surface water in rivers and lakes, ground water, and polluted water are all part of the same resource base).**

Traditionally, management of water resources has focused on surface water or ground water as if they were separate entities. Nearly all surface-water features (streams, lakes, reservoirs, wetlands, and estuaries) interact with ground water. Excessive withdrawal of water from streams can deplete ground water. Conversely, excessive ground water extraction can deplete water in streams, lakes, or wetlands. Pollution of surface water can cause degradation of ground-water quality and conversely pollution of ground water can degrade surface water.

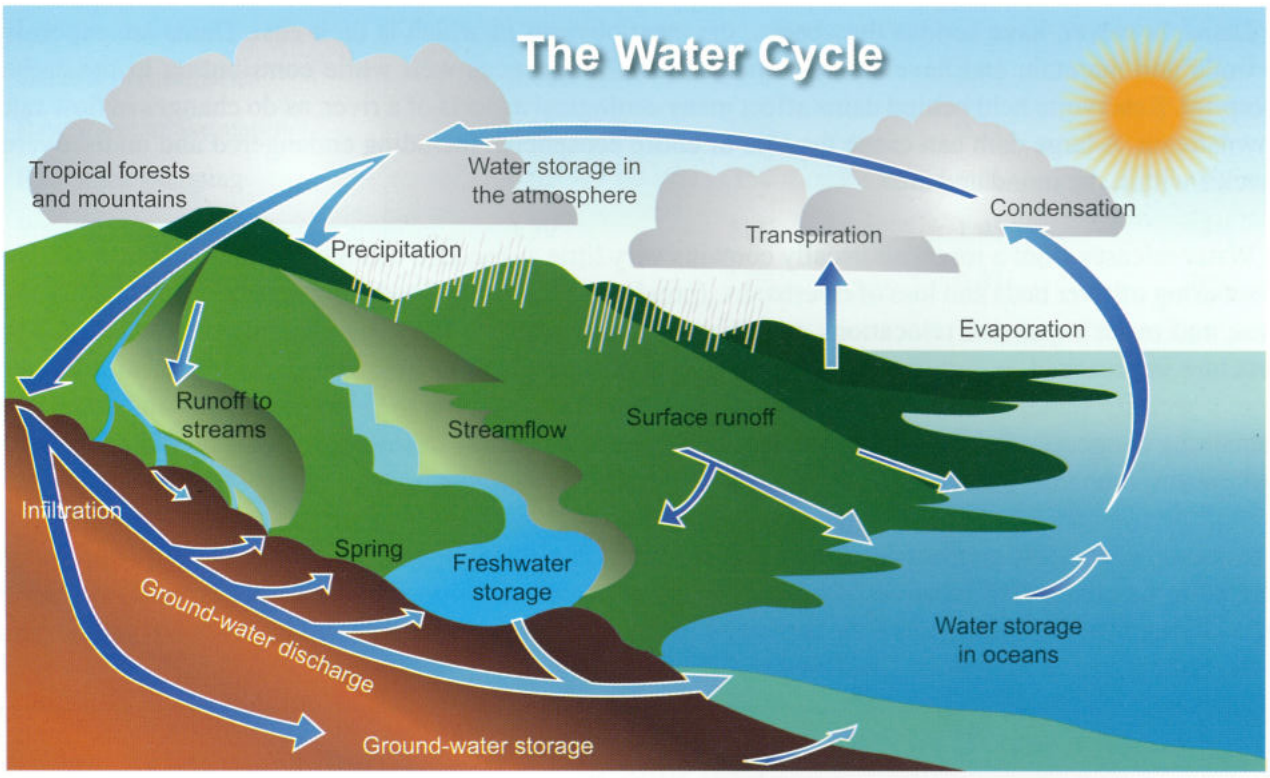



*Figure 2. Ground water — an integral part of the water cycle.*

The development of ground water resources carries with it numerous advantages, many of which are ill-recognised. Among these include the following.

*Reliability*. Ground water is usually reliable even in times of drought, when surface waters often cannot be depended on. Ground water is used conjunctively to supplement river water supplies in many countries, including in developed nations like Denmark (where ground water accounts for 100% of supplied water) and Switzerland (83%). Though reliance on ground water is not as high in other developed countries, it continues to be an important source. In the United Kingdom, 30% of the water is drawn from aquifers, while in the United States it is 20%.

*Quality*. Ground water can be very clean since water percolating down to the aquifers is filtered by intervening soil and rocks. Even where it becomes necessary, ground water can easily be treated through aeration at minimal cost. Ground water is the basis of a huge global industry catering for potable mineral water. In Malaysia, there are over 63 companies listed in the Ali Baba business website engaged in abstracting, bottling and marketing mineral water for public consumption[2].

*Lower storage and transfer costs*. There is a general misperception that abstraction of ground water is more expensive than tapping surface water supplies. However, the converse is actually true. Indeed, one of the most compelling advantages of ground water abstraction is the reduced need for water storage and transfer infrastructure.

To enable a consistent supply, surface waters need to be stored and supplied on a regulated basis to the consuming public. Towards this end, rivers are often dammed, creating large impoundments, where the necessary volumes of water can be accumulated and suitably managed.

Dams, however, have serious drawbacks, the most obvious of which is their cost. Dams are expensive to build and maintain and have serious environmental impacts as well while contributing to the carbon footprint. Reservoirs held behind dams affect many ecological aspects of a river, as do changes in flow rates downstream. A large dam can cause the loss of entire ecospheres including endangered and undiscovered species within the inundated area.

Water releases from a reservoir usually contains very little suspended sediment, and this in turn can lead to scouring of river beds and loss of riverbanks. Inundated areas often flood human settlements and heritage sites, and make expensive relocations exercises necessary. Dam failures are generally catastrophic if the structure is breached or significantly damaged. It is also pertinent to note that dams represent a liability from a security standpoint as well. During an armed conflict, a dam is to be considered as an 'installation containing dangerous forces' due to the massive impact of a possible destruction on the civilian population and the environment.

Another major cost element in surface water supply is transmission. Most surface water supplies are located in upstream riverine areas, far from the point of consumption. Suitable (and expensive) transfer infrastructure (pipes and canals) have then to be installed to bring the water from its upstream source point to the consuming communities downstream.



[2]<http://www.alibaba.com/countrysearch/MY/drinking-water.html>.

With respect to both storage and transmission requirements ground water abstraction, for most part, involves a much lower capital outlay. There is no requirement for a dam, the aquifer itself serving as a holding facility. Transmission costs are lower, since aquifers can be tapped in the vicinity of major consuming regions.

This reduced need for storage and transfer infrastructure translates into lower production costs for the water. In a comparative assessment of surface and ground water abstraction costs undertaken by Air Kelantan Sdn Bhd. (Malaysia's oldest ground water public utility), capital costs for the latter were 3% and operational costs, 25%, lower than for the former (*Table 1*). What is even more convincing is that this lower cost comes in the face of the high manganese and iron content of Kelantan's ground water, both of which demand a significant degree of treatment to strip out.

Where such treatment is not required, the cost differentials are even more significant. Data from Dutch water operators indicate that the cost of abstracting and distributing ground water can be up to 60% cheaper than using surface water. The advantages of ground water have been so compelling that in Denmark, all supply for domestic and drinking water is based on ground water abstraction. Despite challenges arising from pesticide use and other contamination, the country has been able to maintain a high quality of water, which does not need special treatment or purification before drinking or other use[3].

TABLE 1. COMPARATIVE INFRASTRUCTURE AND OPERATIONAL COST FOR SURFACE WATER AND GROUND WATER ABSTRACTION IN KELANTAN[a].

| Cost item | Surface water | | Ground water | |
|---|---|---|---|---|
| | RM/ $m^3$ | % | RM/ $m^3$ | % |
| *Capital costs* | | | | |
| General preliminaries | 0.14 | 5% | 0.13 | 5% |
| Raw water intake station | 0.27 | 10% | 0.21 | 8% |
| Raw water pumping | 0.02 | 1% | 0.01 | 0% |
| Water treatment works | 1.39 | 51% | 1.95 | 74% |
| Treated water piping | 0.58 | 21% | 0.01 | 0% |
| Others 0.33 | 12% | 0.34 | 13% | |
| | **2.73** | | **2.65** | |
| *Operating costs* | | | | |
| Electricity | 0.1447 | 49% | 0.1322 | 61% |
| Chemicals | 0.0564 | 19% | 0.0216 | 10% |
| Maintenance | 0.0187 | 6% | 0.0100 | 5% |
| Management | 0.0735 | 25% | 0.0546 | 25% |
| | **0.2933** | | **0.2184** | |

[a] Source: Air Kelantan Sdn Bhd

[3] < http://www.unep.org/gc/gcss-viii/denmark.iwrm.pdf>

TABLE 2. DUTCH WATER SECTOR (2000)—YEARLY COSTS FOR AN AVERAGE FAMILY (WATER CONSUMPTION OF 130 $M^3$/YR)[a].

| Type of company | Name of operator/supply area | Yearly cost (€) |
|---|---|---|
| Surface water companies | | |
| Most expensive supply area | PWN — Region Haarlem | 248 |
| Cheapest supply area | Water supply company Amsterdam | 166 |
| Ground water companies | | |
| Most expensive supply area | Vitens — Friesland<br>Groningen — Province | 166 |
| Cheapest supply area | (Excluded city) | 101 |

[a] Source: *Drinking Water: Principles and Practices*, P.J. de Moel, J.Q.J.C. Verbert and J.C. van Dijk, World Scientific Publishing Co. Pte. Ltd. 2007.

In the development of ground water resources, whether on a conjunctive basis or otherwise it is important to point out that there are many exclusive challenges that managers must cope with. Two major vulnerabilities separate ground water from rivers and other types of water resources.

*Limited flushing capability*. Waters in aquifers are stagnant compared to the relatively rapid changes that the gush of river water brings with it. Thus, any contamination tends to be confined within the aquifer and is difficult to treat. Pollutants released to the ground can work their way down into ground water and can create a contaminant plume within an aquifer. Movement of water and dispersion within the aquifer spreads the pollutant over a wider area. Its advancing boundary, called a plume edge, can then intersect with surface water through seeps and springs, making even surface water supplies unsafe for humans and wildlife. Once degraded, aquifers are very difficult to rehabilitate over the short term.

*Dynamic linkages with river basins*. As emphasized above, ground water is dynamically intertwined with the river basin(s) with which they are associated. Ground water is naturally replenished by precipitation when this recharge reaches the water table. Thus, sustainable management of the river basins is key to ensuring the quality and perpetuity of ground water resources. Interventions in the river basin that do not take this into account can have deleterious effects on ground water resources.

For instance, flood mitigation schemes, intended to protect infrastructure built on floodplains downstream, can have the unintended consequence of reducing aquifer recharge associated with natural flooding in upstream areas.

These two vulnerabilities collectively mediate the kind of management that needs to brought to bear where sustainability of ground water resources are concerned. Any development approach that does not consider the complexities of ground water and its specialised demands would not only fail to yield the desired results, it can also cause major problems to human users and to the environment.

The most evident problem (as far as human ground water use is concerned) is a lowering of the water table beyond the reach of existing wells through over-abstraction. A lowered water table may, in turn, cause other problems such as ground water-related subsidence.

Subsidence may occur in some situations when ground water is abstracted over long periods of time exceeding the safe yield. This occurs because in its natural equilibrium state, the hydraulic pressure of ground water in the pore spaces of the aquifer supports some of the weight of the overlying sediments. The same loss of hydraulic pressure can allow the intrusion of salt water, particularly in coastal areas, leading to salination of the ground water, making it unfit for consumption.

Ground water is also ecologically important, sustaining rivers, wetlands and lakes. Ground water feeds soil moisture through percolation, and many types terrestrial vegetation depend directly on either ground water or the percolated soil moisture above the aquifer for at least part of each year.

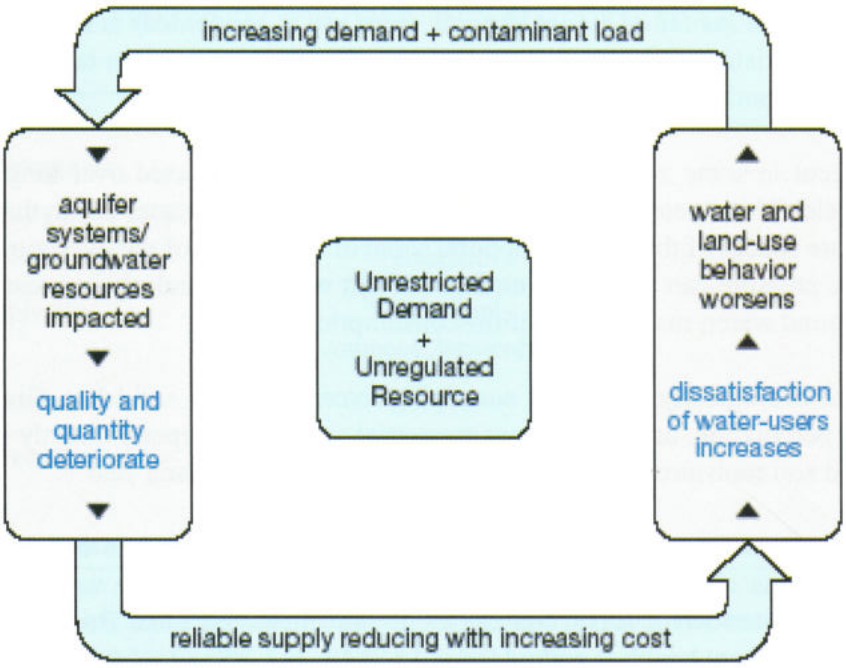
Thus, ground water resource management cannot, and should not, be seen in isolation of the natural systems that sustain it. It is clearly a subset of IWRM regime, together with associated management instruments such as Integrated River Basin Management and Integrated Lake Basin Management. This synthesis with overall catchment health is embedded in IASM.

The primary goals of IASM are to balance recharge to the basin's ground water storage against discharge for economic, environmental and human benefits; provide protection from pollution; and prevent uncontrolled pumping leading to declining well yields/quality. It calls for an integrated approach to ground water management by linking it with the greater hydrological cycle of which it is a part. The IASM concept is exemplified in *Figure 3*.

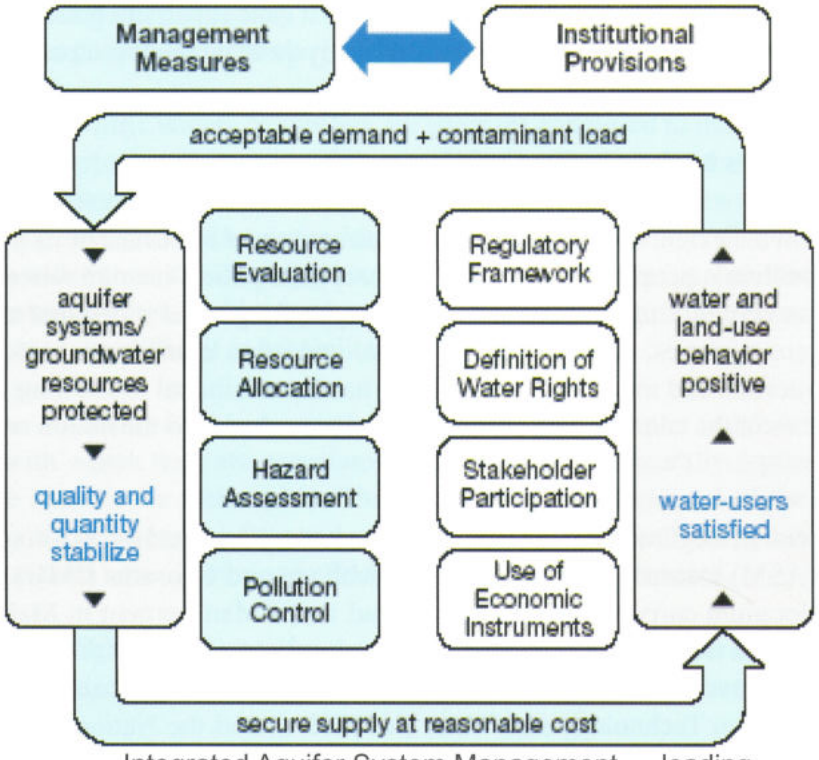
## The Academy of Sciences Malaysia Ground Water Initiative

The limited awareness on the extent of our ground water resources, and importantly, its potentially strategic value in sustaining the nation's people and economy has created a policy vacuum where the management of these resources are concerned. Current management strategies for ground water are fragmented, pursued by different management agencies, each having different, and often competing, sectoral agendas. This mosaic of competing interests and management emphasis has been inimical to the long term development of ground water resources in the country, besides shrouding its true value to the nation and its development goals.

Cognizant of this crucial strategic and financial value of the country's ground water resources, the Academy of Sciences Malaysia (ASM) teamed up with the Jabatan Mineral and Geosains (JMG) to convene a two-day Ground water Colloquium carrying the theme 'Ground water Management in Malaysia—Status and Challenges' held in Putrajaya from 25–26 March 2009. Based on the outcome of this National Colloquium, ASM and JMG, with the involvement of the Ministry of Natural Resources and Environment (NRE), the Ministry of Energy, Green Technology and Water (KeTTHA), and the National Hydraulics Research Institute of Malaysia (NAHRIM), jointly organised a series of multi-stakeholder consultative workshops to specifically address the following aspects of ground water resource management:




Supply-driven Groundwater Development — leading to a virtuous circle.




Integrated Aquifer System Management — leading to a virtuous circle.

(Source: Modified by Saim Suratman (NAHRIM)

*Figure 3. Approaches in Integrated Aquifer System Management.*

- Workshop 1: Ground water in the context of Integrated Water Resource Management — its management and governance.
- Workshop 2: Research and development and capacity building needs in ground water development and management.
- Workshop 3: Making data and information on ground water available — constraints and solutions.
- Workshop 4: Ground water Development and Supply for Domestic, Agricultural and Industrial Uses — A Conjunctive Use to Surface Supply; and
- Workshop 5: Promotion and advocacy of sustainable development and management of ground water resources.

Participants for each of these component workshops were selected from various stakeholder groups, such as relevant government agencies, research institutes, the private sector and non-government organisations, whose linkage to ground water related closely to the specific issues being discussed. Specialists from academia and agencies were invited to present position papers on each of these component topics and the issues raised were discussed extensively by workshop participants. The various position papers, the outputs of the various workshop groups and their collective opinions were then collated and published as the ASM Ground water Workshop Proceedings which forms the basis of a draft Strategic Advisory Report that was presented to an open forum comprising a larger multi-stakeholder audience to obtain further feedback and inputs. This document represents the finalised Strategic Advisory Report on Ground water Resources Development and Management in Malaysia submitted for the consideration and endorsement of the Government.

# MALAYSIA'S GROUND WATER —A VALUABLE RESOURCE

## Resource Profile

In discussing ground water and its value as a resource, it is important to clearly define what is at stake. In this respect, the data on the country's ground water resources is seriously wanting. There has been no comprehensive inventory of ground water resources in Malaysia. The data available at hand is based on sporadic exploration data garnered from numerous private and public agencies.

With an average annual rainfall of 3000 mm, Malaysia is rich in water resources. The average annual rainfall over the Malaysian land mass amounts to 990 billion cubic metres, of which 566 billion cubic metres becomes surface runoff, 64 billion cubic metres recharges the aquifers and 360 billion cubic metres returns to the atmosphere through the process of evapotranspiration. **The ground water resources in Malaysia, that is the volume of water stored in the aquifers, has been estimated at 5000 billion cubic meters or 5 trillion cubic metres of water. This is 160 times the volume of water held by our 90 lakes and reservoirs (of 31 billion cubic metres)** and 9 times the volume of water that annually flows in our rivers (of 566 billion cubic metres) (GOM/JICA National Water Resources Study, 1982).

To put things into perspective, this volume of the freshwater is sufficient:

- To submerge the entire land area of Malaysia (329 750 square kilometres) to a depth close to 15 metres.
- To meet the annual consumption of water for agriculture, industrial and domestic purposes in Peninsular Malaysia (estimated at 12 billion cubic metres in 2010) for several hundred years (assuming, of course, that there is no increase in water demand and there is no pollution of the resource from anthropogenic activities).
- Generate total revenues of RM7.5 trillion if sold at a commercial water rate of RM1.50/cubic metre —a potential major contributor to the National Gross Income (GNI). Commercial water rates vary from RM1.20–RM2.20 in different states.

It is unclear to what extent this resource is being tapped. Data on the utilisation of ground water by various users in the country is incomplete. Whatever reliable data that is available relates only to public water supply, and not on industrial or agricultural abstraction.

Data from the Malaysian Water Association (*Table 3*; *Figure 4*) on public water supply indicates that current usage of ground water is limited, estimated to contribute about 0.2 million cubic metres per day or only 1.4% of total water supply annually. The use of ground water in public supply is only significant in Kelantan and Sabah, with small quantities used in Pahang and Perlis. There is an overwhelming reliance on river (87%) and storage dams (11%) to supply raw water for public water supply. This figure, however, excludes ground water resource developed by the private sector and other government agencies, data for which is not available.

More pertinent, the data at hand also indicates that there appears to be no imperative to develop ground water for public water supply except in Kelantan and Labuan. A comparison of the raw water utilisation over 2008 and 2009 indicated ground water utilization only expanded in Kelantan. The amount of ground water utilised for public water supply in Pahang and Perlis actually declined.

The available data suggests that the country has a huge, largely untapped ground water resource at hand. However, it is too simplistic a view. It is pertinent to point out that there is little data to indicate the locations of the large fresh water aquifers and to what extent the resource can be utilised. Many shallow aquifers close to the coast, for example, are naturally saline and not fit for human consumption. Many aquifers could have been polluted by wastewater discharge and similarly unfit to be developed. An investigation by NAHRIM, for instance, on seven landfills in Selangor indicated that leachate contamination of ground water had occurred in four of them.

A similar study of ground water in Kelantan reported that 34% of monitoring wells indicated nitrate levels above the drinking water standard of 10 ppm. Thus, gross volume estimates provide a misleading picture of the true extent and value of ground water. A more comprehensive appraisal is required so that its current and potential values can be more fully ascertained.

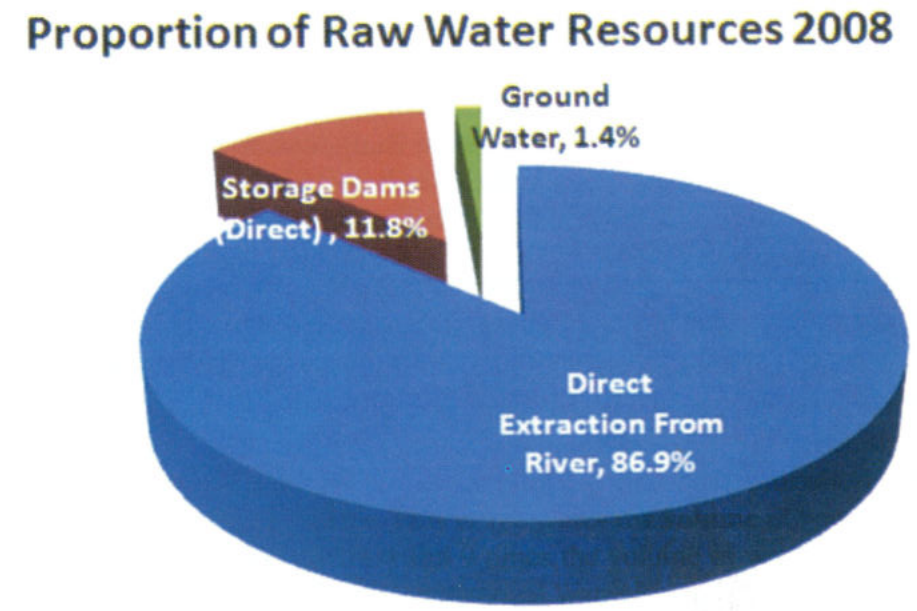
TABLE 3. RAW WATER RESOURCES FOR PUBLIC WATER SUPPLY IN MALAYSIA[a]

| Water Supply Entities | 2008 | | | | 2009 | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct Extraction From River | Storage Dams (Direct) | Ground Water | Total | Direct Extraction From River | Storage Dams (Direct) | Ground Water | Total |
| | MLD | | | | MLD | | | |
| Johor | 1,039 | 398 | - | 1,437 | 1,265 | 334 | - | 1,599 |
| Kedah | 1,226 | 17 | - | 1,243 | 1,246 | 16 | - | 1,262 |
| Kelantan | 207 | - | 135 | 342 | 200 | - | 148 | 348 |
| Labuan | 41 | 10 | - | 51 | 40 | 11 | 0.7 | 51 |
| Melaka | 342 | 145 | - | 487 | 289 | 216 | - | 506 |
| N.Sembilan | 703 | 368 | - | 1,071 | 509 | 420 | - | 929 |
| Pulau Pinang | 860 | 78 | - | 938 | 895 | 96 | - | 991 |
| Pahang | 971 | - | 6 | 977 | 1,090 | - | 4 | 1,094 |
| Perak | 1,134 | 127 | - | 1,261 | 1,021 | 319 | - | 1,340 |
| Perlis | 47 | 53 | 9 | 109 | 50 | 53 | 8 | 112 |
| Sabah | 596 | 241 | 45 | 882 | 599 | 243 | 45 | 887 |
| Sarawak | 858 | 100 | - | 958 | 892 | 100 | - | 993 |
| Kuching | 411 | - | - | 411 | 420 | - | - | 420 |
| LAKU | 130 | 100 | - | 230 | 132 | 100 | - | 232 |
| JKR Sarawak | 210 | - | - | 210 | 238 | - | - | 238* |
| Sibu | 107 | - | - | 107 | 103 | - | - | 103 |
| Selangor | 3,843 | 145 | - | 3,988 | 3,914 | 153 | - | 4,067 |
| Terengganu | 551 | - | 0.2 | 552 | 571 | - | 0.1 | 571 |
| **MALAYSIA** | **12,418** | **1,683** | **195** | **14,295** | **12,583** | **1,961** | **206** | **14,750** |

**Notes:**

1. Increase in volume extracted from dams contributed by:
   a. Melaka —New bunded storage at Bertam Phase II
   b. Perak — Raw water extraction for new plant at Sungai Kinta.
2. Not all intakes are equipped with raw water flow meters, therefore volumes are estimated.
3. Excluding raw water extraction by private operators.

[a] *Malaysian Water Industry Guide 2010*, The Malaysian Water Association.



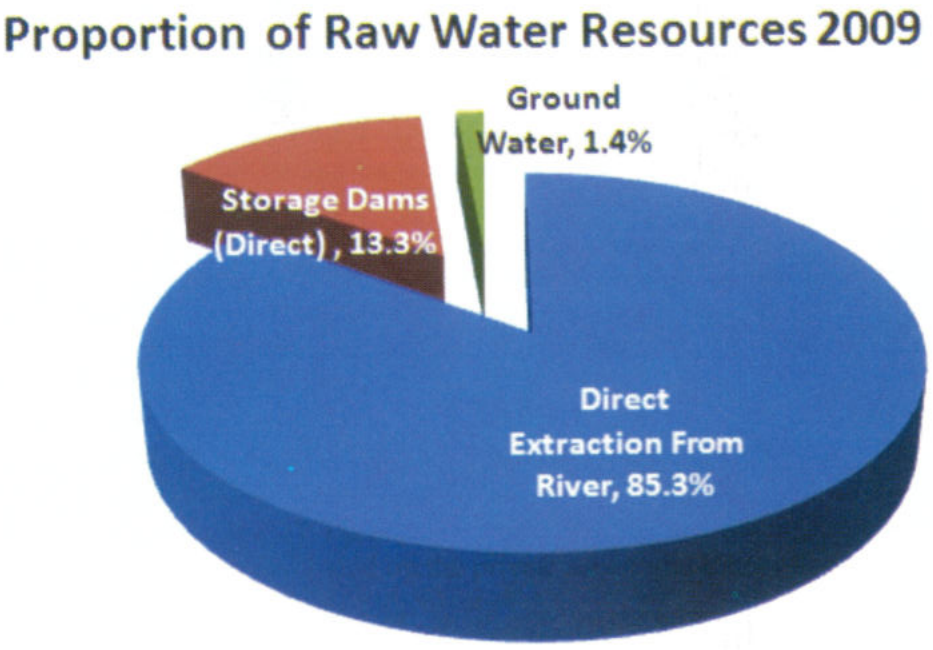




*Figure 4. Proportion of ground water [a] use to total raw water resources for public supply 2008—2009 [b].*

[a]Excludes ground water developed by private sector and other government agencies.
[b](Source: Malaysia Water Industry Guide 2010,The Malaysian Water Association)

## Utilisation

There has been no effort to collate the totality of the economic and social values of ground water to the country. Though ground water is abstracted and utilised for various purposes by a wide spectrum of users, there is no unified data collection.

This is because ground water utilisation operates in a regulatory environment that is fragmented, with no one nation-wide agency empowered to regulate and manage the industry. However, the following represent major investments in ground water abstraction in the country.

*Public water supply*. The biggest and oldest investment in ground water development in Malaysia has been in Kelantan, which has tapped shallow and deep aquifers to supply much of its drinking water since the 1930s. Currently (2010), ground water supplies 146 million litres of water a day to the residents of Kelantan, accounting for 41% of their requirements, with 100% of the water in Tumpat, Kota Baru and Backok districts being supplied by ground water. Ground water has also been used in islands and coastal areas in the east coast of Peninsular Malaysia.

A case in point has been the wells in Labuan and Langkawi, which originally supplied much of the water supply on both islands. They were abandoned in favour of surface water supplies over the years, but that came at as cost. In the case of Langkawi, it involved damming and inundating the Sembilan waterfalls, losing a valuable natural heritage. In Labuan, local surface supplies proved incapable of sustaining supply, and the original ground water well had to be rehabilitated.

In Sarawak, ground water was first exploited in 1954 in Sarikei, followed by Bintangor and Sri Aman. However, these towns are currently fed by surface water. Ground water is presently the main source of water supply in several coastal villages in the State. Ground water is also important in the resort islands off Sabah and other small and isolated communities, though it also supplements supply to a few major towns such as Sandakan.

*Industry*. The largest ground water based industry is the bottled mineral water industry. There are currently 63 wholesalers of bottled mineral water in the country, while 45 licensees have been allowed to abstract mineral water from 17 aquifers.

Large-scale ground water abstraction amounting to 32 million cubic meters annually is also undertaken by Lion Bhd's Megasteel plant in Olak Lampit, Selangor. Sime Darby Bhd. had pursued the feasibility of a multi-million ringgit ground water abstraction and treatment plant in Batang Padang, Perak, to supply water to Selangor.

*Agriculture*. The use of ground water in agriculture is widespread, yet the data available on its utilisation is even more scanty that other users. Though ground water is clearly not practicable for large-scale water intensive agriculture, such as rice farming, agriculture activities with a smaller water footprint can, and do, depend on ground water. The Department of Agriculture actively promotes ground water use in agriculture, providing drilling services to agropreneurs who need ground water and also within their Permanent Food Production Parks. The Department, in fact, recommends ground water abstraction at a rate of 6.7 $m^3$/ha/hour for fruits and 18.75 $m^3$/ha/hour for vegetables.

The Department estimates that there are over 1800 tube wells in the country employed for agricultural purposes but maintains no records on how much is abstracted. This figure excludes tube wells used for watering livestock and for fish farming.

Where aquaculture is concerned, the most prominent example of ground water use was the Song Cheng farm in Nenasi, Pahang, which originally produced Japanese eels. The massive abstraction required to meet farming conditions led to land subsidence and flooding. The farm has currently changed hands and produces marine shrimp. Only marine water drawn from the sea is used and its original ground water wells have been abandoned.

## MANAGING GROUND WATER RESOURCES —THE CHALLENGES WE FACE

Ground water resources, because of their inherent nature, are unique and pose peculiar challenges in their management. Aquifers are contiguous bodies of water and thus problems are shared through their holding volume. Ground water aquifers are easily impacted by complex land and water relationships; they receive water, sediments, contaminants, nutrients and biota from rivers, surface runoff and precipitation and, at the same time, discharge them into the river basins of which they are a part.

In this context, it is pertinent to note that ground water resources in Malaysia face many serious problems that relate back to the absence of an adaptive and comprehensive management regime. Among the major issues that must be grappled with in ground water management are as follows:

- Fragmented Policy, Legal and Governance Framework
- Pollution
- Lack of Sustained Research and Development
- Manpower and Human Resources Issues
- Resource Data Collection, Management and Dissemination; and
- Public Awareness and Stakeholder Participation.

These issues are discussed in further detail.

### Fragmented Policy, Legal and Governance Framework

The absence of a comprehensive regulatory and governance framework is probably the most pervasive problem facing ground water utilisation in the country. Ground water is classed as a water resource. In general, under the Federal Constitution, States have greater powers over water, coastal foreshores and rivers. They also have greater jurisdiction over land and local government. The Federal Government has powers over shared rivers, federal projects, hydro electric power and navigation.

Both the State and Federal authorities have concurrent powers over drainage and irrigation, raw water, mining pools, ox-bow lakes and natural lakes.

While there are numerous Federal and State laws related to the management of river basins in Malaysia, however, the number of regulatory instruments covering ground water is limited.

**Federal laws** include the *Geological Survey Act* which enables collection of data and monitoring of exploration and development of ground water, the *Environmental Quality Act* (EQA) which empowers monitoring of water quality and Environmental Impact Assessments for ground water, *Town and Country Planning Act* (TCPA), which encompasses land use and *National Water Services Commission Act* (SPAN Act) and the *Water Services Industry Act* (WSIA), both of which regulate production and distribution of treated water. However, there is currently no specific law on ground water resource development at the Federal level.

There are, however, a number of Federal agencies that are involved directly, or indirectly, in ground water management and development. The *Department of Minerals and Geoscience* has established itself as the expert organisation for matters related to ground water in general. Their mandate, however, is limited to exploration and development work. They are not empowered to issue concession licenses, these being the prerogative of the State in which the aquifer is located.

The *Department of Environment* undertakes monitoring of selected, but not all, ground water wells.

The Water Services Industries Commission licenses all companies involved in the abstraction, treatment and distribution of potable water, including from ground water sources.

They, however, do not cover the bottled mineral water industry, oversight for which is provided by the *Food Safety and Quality Division, Ministry of Health.*

Another unit of the Ministry of Health, the *Rural Water Supply and Environmental Sanitation Programme (BAKAS)*, also undertakes ground water abstraction for water supply and sanitation in rural communities.

Under the *Bekalan Air Luar Bandar (BALB)* under the *Ministry of Rural and Regional Development*, funds are allocated for rural water supply using ground water.

The Department of Agriculture actively promotes the use of ground water in agriculture, providing drilling services to agropreneurs who need ground water and also within their Permanent Food Production Parks.

None of these agencies work in tandem with each other and there is no overall coordinating mechanism to ensure a coherent approach is taken in ground water management.

In fact, though the *Department of Drainage and Irrigation (DID)*, (which is in charge of river basin management) and *Department of Minerals and Geoscience* are both within the Ministry of Natural Resources and Environment, there is no institutional platform on which two agencies can merge their common interests where water resource management is concerned.

**State laws** draw from the National Land Code, *Local Government Act* (LGA), *Street Drainage and Building Act* (SDBA), *Waters Act*, National Land Code (NLC) and State Water Resources Enactments. The Federal Constitution largely empowers State Governments to manage water resources (including ground water) but it appears that ground water management has been a poor cousin to more visible issues, such as land use, which provides the State with its main source of revenue. Water resources at State level were originally handled by the state Drainage and Irrigation and Waterworks Departments, either in relation to flooding, drainage and irrigation, or water supply. Where it needed to be treated as a resource in its own right, the District and Land Offices were mandated. However, the District and Land Offices, being licensing and revenue collection agencies, do not have the technical capacity to do anything more than issue permits and collect fees.

Notwithstanding this, in recent years, some State governments have enacted specific laws in relation to water resource management. These include the Sabah Water Resources Enactment 1998, the Selangor LUAS Enactment 1999, the Pahang Water Resources Enactment 2007 and the Kedah LUAK Enactment 2007. Of these state agencies, Lembaga Urus Air Selangor (LUAS) has been the most proactive where ground water resource management is concerned.

Established under Selangor Water Management Authority Enactment 1999, LUAS is mandated to undertake the management of water resources, river basin and coastal waters in Selangor State in a holistic, integrated and sustainable manner. It has a comprehensive licensing and monitoring regime for ground water, including a requirement for all users of the resource to be licensed and appropriate fees to be imposed. Licensed wells are currently being fitted out with flow meters to gauge abstraction rates. An

oversight committee consisting of the main technical agencies (Departments of Minerals and Geoscience, Environment and Health) and management (District Offices) agencies has been set up under LUAS to monitor ground water abstraction and use. However, LUAS is alone in this effort. To date, none of the other states (even those with water management administrations) have resource management set-ups comparable with that of LUAS.

**Local governments** do not have rights over water resources per se. However, they are mandated to oversee development within their respective jurisdictions. Local Governments are bound to follow zoning provisions in Local Plans, where the protection of recharge areas and sensitive wetlands are embedded. Local governments also oversee (together with the Solid Waste Department) the establishment and construction of landfill sites, which are major sources of contamination for ground water resources.

It is important to emphasise that the key issue here is not legal or institutional fragmentation in itself. Such fragmentation is an inevitable consequence of the Federal system that the country follows. A mosaic of institutions and legal instruments are also seen where the management of other resources are concerned, for instance land, minerals, rivers and forestry.

**The legal and governance framework for managing these resources are in place but is sorely absent where ground water is concerned. The creation of an overarching policy and strategy environment on a national basis would provide a framework which all institutional stakeholders would be able to subscribe to.**

Although the Ministry of Natural Resources and Environment has a strategy plan for ground water management and development (see box below), it is yet to be implemented.

While the strategy plan is laudable, and does address some of the more pressing issues facing ground water development, it has several major shortcomings:

- It appears to be more of an institutional initiative, rather than a national initiative. It uses the language of the hydrogeologist and does not reach to other stakeholders of the same resource.

MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT
STRATEGY PLAN FOR GROUNDWATER DEVELOPMENT

**SP 1: Legal Augmentation and Enforcement**
To reinforce laws related to the management of groundwater including the Geological Survey Act (1974) and to ensure all states create and enforce the groundwater management aspects in the State Water Enactments.

**SP 2: Assessment and Development of Resources**
To encourage the groundwater exploration in the alluvium and hard rock areas in systematic and continuous manner. With the available data collected, database and hydrogeological thematic maps can be developed for use in the development plan for groundwater exploitation in an efficient manner.

**SP 3: Monitoring of Groundwater**
To encourage the groundwater monitoring activities for the purpose of evaluating the quantity, quality, the extent of contaminated groundwater and land subsidence. Groundwater protection zone has to be established to avoid contamination and sterilization of aquifers.

**SP 4: Capacity Building**
To do capacity building for manpower to all agencies through training, purchasing of new equipments and usage of latest technology. This will improve their skill, expertise and knowledge in the development and management of groundwater

**SP 5: Promotion and Awareness**
To increase the pro3otional activities among the authorities to the potential of groundwater as an additional water source. Awareness campaign to all users to focus on the steps to be taken to avoid contamination and excess abstraction of groundwater.

**SP 6: Research and Development**
To increase activities of Research and Development to identify effective methods for the development and management of groundwater. Also to do smart partnership among research institutions and universities in aspects of groundwater development and management.

Source: NRE

- More important, it fails to identify why ground water resources should be developed in the first place i.e. it is not framed within the context of a national policy framework on ground water utilisation. This means that there is no overarching goal that can drive ground water development as a whole.

This absence of an overall policy and strategy environment, coupled with the fractured administrative landscape in which ground water resource development is currently being pursued, has implications that extend down to the safety and well being of both the resources as well as the people who depend on it.

For instance, the Ministry of Health licenses and monitors mineral water producers, with limited inputs from professional hydrogeologists within the Department of Minerals and Geoscience. The Ministry of Health's primary concern, rightfully, is the quality of the product being marketed.

However, in the absence of information on the aquifer from which the mineral water is being abstracted, the Ministry is in no position to determine if over-abstraction is taking place.

More ominous, the Ministry of Health would not be able to ascertain if the production by a particular operator exceeds the capacity of the relevant aquifer to meeting his ostensible production volumes i.e. the mineral water is possibly being mixed with drinking water.

The overlap within and between Federal and State jurisdictions highlights the call under the Integrated Aquifer System Management regime to pursue ground water resource management beyond administrative, jurisdictional and political boundaries. In Malaysia, this can only occur if there is an overarching policy and strategy framework to which all stakeholders can subscribe.

## Pollution

Pollution and habitat degradation is another important factor leading to the loss of functional value in ground water. In 2009, out of the 81 wells sampled by the Department of Environment, most recorded levels of Arsenic, Iron, Manganese and Coliforms exceeding the limits set by the National Guidelines for Raw Drinking Water, established by the Ministry of Health.

While some of these would have arisen from the surrounding sediment, parameters such as Coliforms would have clearly had an anthropogenic origin. The limited protection currently offered to ground water is basically because it is an invisible resource.

Administrators and managers, are often not aware of the extent of their actions, and must be exposed to the potentials that lie beneath their own feet.

They need to be informed that pollution and habitat degradation need be an inevitable impact of development. Careful planning, comprehensive resource management and enforcement of regulations in relation to pollution and soil conservation, would mitigate much of the impacts that befall ground water.

## Lack of Sustained Research and Development

NAHRIM is currently the only government research institute undertaking R&D into ground water. However, lack of funding and the necessary man-power as well as the sporadic studies it had carried have neither been comprehensive nor undertaken over a long-term basis. Centres of Excellence within existing institutions of higher learning dedicated towards research could be an added advantage.

A review of research inputs into Malaysian ground water indicate that there are few sustained initiatives that are in a position to provide the kind of long-term data that would support comprehensive resource management initiatives. Almost all studies undertaken on ground water in Malaysia have been sporadic, one-off events, undertaken with little reference to each other and over limited spatial and temporal ranges. From the standpoint of research areas, most of the studies that have thus been undertaken are on water quality and modelling.

This limited available baseline data on ground water and their various values has not allowed for a comprehensive understanding of the hydrological and ecological dynamics of ground water resources and the manner they have changed over time.

This has had the effect of preventing the development of sustainable management regimes based on long-term trends and requirements. More important, the paucity of data has prevented the values of our ground water resources to be adequately quantified, as a consequence of which planners and administrators have little understanding of the full value of the country's ground water assets.

This situation again relates back to the absence of an overall planning and management framework for ground water that would set the basis for such long term studies to be carried out.

## Manpower and Human Resource Issues

Having a strategy framework would only be a preliminary step in enabling a more comprehensive management of the country's ground water resources. Actualizing strategy statements and giving it a tangible dimension would still fall in the hands of managers and administrators at local, state and national levels.

There is thus a fundamental need to strengthen capacity at various governing levels before improvements in management regimes are going to yield the requisite results.

Requirements for sustainable management would include adequate knowledge of hydrogeology and functional linkages that tie the physical, chemical and biological environment to ground water resources. This would involve knowledge of how ground water relates to the greater hydrological cycle of which it is a part.

At present, there are only a handful of hydrogeologists in the country. Universiti Kebangsaan Malaysia does run a programme on the subject and this bodes well for the future. However, there must a corresponding effort to restructure present efforts in developing ground water resources so that university's graduates can contribute meaningfully to the development effort.

Over and above that, there is also a need to provide a basic understanding on the dynamics of ground water resource management to administrators and managers. Such programmes do not, at the present time, exist to any significant extent. The provision of such training and exposure would enable the enablers at State and Local Government levels to be better aware of the implications of their actions and how it impinges on ground water. This would go a long way in the protection and management of ground water resources.

## Resource Data Collection, Management and Dissemination

A key shortcoming of ground water development in Malaysia is the limited data on the resource itself. Though the Minerals and Geoscience Department have come up with hydrogeological maps, these provide only a broad brush assessment of the resource. Hard data on locations of aquifers, the quality of water they hold, recharge areas, sustainable rates of abstraction and potential economic value are seriously bereft.

**There is an urgent need for a detailed resource assessment of ground water in Malaysia on a basin-by-basin approach that covers these various aspects.**

As important as data gathering would be its dissemination. Effective management of ground water would demand access to the kind of data that can support intelligent and informed decision making. The need for such data to be made available to managers and researchers cannot be underestimated. **A networked database that link managers, administrators and researchers, would enable a free exchange of information that can empower stakeholders, including the general public, in the management process**.

When communicated to an end-user, real-time information can provide accurate and timely answers to questions of how much, where, when, and by whom about ground water resource management.

This capability can form the foundation of a more comprehensive, proactive management and planning capacity where, ultimately information acquired from drillers, prospectors, water users and researchers can be used to optimise the management process itself.

It is significant that the first steps towards this end have already been initiated. The Department of Minerals and Geoscience has established HYDRODAT, an integrated database on ground water data, to enable it to more effectively assess and plan its development. However, the database operates in an institutional vacuum. The Department does not have the legal mandate to compel the numerous players in the industry to populate the database. The database is also limited to Departmental staff, defeating the very purpose it was set up for i.e to promote the ground water industry by making resource data widely available.

Other ground water players do not also have an adequate database and much valuable information is not being captured.

## Public Awareness

Public perceptions towards ground water development have ranged from wary to downright hostile. The main objections to ground water use have arisen from experiences from countries which pursued a free-for-all approach to ground water utilisation.

The main perceptions towards ground water utilisation it that it is:

- Is a limited resource
- Is unreliable
- Is polluted
- Is expensive to develop and difficult to maintain; and
- Negatively impacts on the environment.

However, while such problems have faced countries that have not been able to put in place a sustainable development regime, it is important to note that we have a 70-year ground water scheme in Kelantan that has proved itself to be a model of sustainable resource use (see box).

**Air Kelantan Sdn. Bhd.—The Poster Boy of Sustainable Ground Water Development**

Air Kelantan Sdn. Bhd. (AKSB) had its beginning as the Waterworks Department of Kelantan in the early 1900s. Mandated even then to manage the supply of treated water to the people of the state, the then Department opted to use ground water to meet its needs. Ground water at the state of Kelantan is fully developed for potable use since 1935. The demand on ground water for potable use has risen steadily over the last 30 years. Ground water production in 1981 was 36.37 Ml/d in 1981, increasing to 45 Ml/d in 1984 and 66 Ml/d in 1989. Under the Bekalan Air Kelantan Utara (BAKU) project implemented in 1993, 72 tube wells were constructed which had a total abstraction of 115.6 Ml/d. These new tube wells, together with the 51 existing tube wells in operation, provided a total production capacity of 184.35 Ml/d by 2003. With the construction of new treatment plants during the 8th Malaysia Plan, the output of treated ground water that in the same year was 114 Ml/d.

At present, fresh ground water supply is obtained from 94 production wells located at 14 wellfields and being treated in 7 ground water treatment plants. Ground water from these wellfields is drawn from shallow aquifers except in Tanjung Mas and new wells at Pintu Geng and Kg. Puteh. Current (2010) ground water consumption is 146 Ml/d, constituting about 41% of the total potable water produced in the state. The districts of Kota Bharu, Tumpat and Bachok are being supplied 100% with treated ground water of its potable water demand.

To ensure sustainability of ground water supply, a Ground water Monitoring System (GMS, will be implemented under the 10th Malaysia Plan to monitor and control the abstraction of ground water and prevent over abstraction of ground water resulting in lowering of water table, exposing ground water resources to surface water pollution and saline water intrusion.

Water supply to Kota Bharu and adjoining districts (currently managed by Air Kelantan Sdn. Bhd.) has relied on ground water since 1935 for its water requirements. Ground water resource development is also being expanded to meet growing needs into the future. Fresh ground water supply is obtained from 94 production wells located at 14 wellfields and being treated in 7 ground water treatment plants. Ground water from these wellfields is drawn from shallow aquifers except in Tanjung Mas and new wells at Pintu Geng and Kg. Puteh (*Table 4*). Current (2010) ground water consumption is 146 Ml/d, constituting about 41% of the total potable water produced in the state. The districts of Kota Bharu, Tumpat and Bachok are being supplied 100% with treated ground water.

At present, the aquifers that supply the State have shown no signs of diminution, meaning that abstraction has been in balance with recharge. As long as such a balanced approach is taken, there is no reason to believe that ground water development cannot be undertaken sustainably.

However, public awareness of the success of Kelantan's water supply system is poor. The general public is still fed on media reports of subsidence in Bangkok, Mexico City and Taiwan due to over abstraction. There is an important need for the model we have at hand to be showcased as an exemplar of sustainable ground water development.

TABLE 4. GROUND WATER ABSTRACTION AND SUPPLY IN KELANTAN

| Groundwater treatment plant | Wellfield | No. of production wells | Treatment plant capacity | Groundwater abstraction (Ml/d) |
|---|---|---|---|---|
| Chica | | | 80.0 | 62.461 |
| | Zone 1 | (19) | | 34.605 |
| | Pasir Hor | 7 | | |
| | Penyedap | 5 | | |
| | Seribong | 5 | | |
| | Pasir Tumbuh | 2 | | |
| | Zone 2 | (10) | | 10.226 |
| | Kubang Kerian | 5 | | |
| | Kenali | 5 | | |
| | Zone 3 | (2) | | 8.911 |
| | Chica A | 2 | | |
| | Zone 4 | (2) | | 8.719 |
| | Chica B | 2 | | |
| Kg. Puteh | | (28) | 40.0 | 48.000 |
| | Kg. Puteh | 20 | | 37.200 |
| | Kota | 8 | | 10.800 |
| Pintu Geng | Pintu Geng | 10 | 8.0 | 9.696 |
| Tanjung Mas | Tanjung Mas | 8 | 10.0 | 9.875 |
| Wakaf Bharu | Wakaf Bharu | 9 | 19.0 | 9.642 |
| Kg. Chap | Kg. Chap | 4 | 4.9 | 3.498 |
| Perol | Perol | 2 | 3.2 | 2.642 |
| Total | | 94 | 168.9 | 145.814 |

## GROUND WATER—THE WAY FORWARD

In pursuing ground water development, it is pertinent to ask — why do it at all? Though it is clear that we have substantial ground water resources, what role can it play where our water supply situation is concerned?

The more general advantages of ground water as a resource (i.e. reliability, cost and quality) were discussed earlier. Specifically in the case of Malaysia, a major driver of ground water development would be water security. This issue has several facets.

- Malaysia now is now almost totally reliant (97%) on one source i.e. surface waters for its raw water supply, an untenable situation where water security is concerned.
- Against this overwhelming reliance is the fact that surface water resources can no longer be considered reliable. Among others:
  - Surface sources are subject to the vagaries of climatic variations and shifts. These would include natural climatic cycles such as El Ñino and La Ñina as well as long term shifts such climate change. A study by NAHRIM on the potential impact of climate change has indicated that the Malaysian water infrastructure very likely cannot sustain the kind of extreme weather events that are likely to occur. More important, minimum monthly flows in rivers in Peninsular Malaysia are likely to be reduced by 31% to 93%[a] This would seriously impinge on the ability of surface water supplies to meet existing water demand, what more future requirements. Ground water development should thus be pursued as an adaptation to climate change and its impacts.
  - Surface water sources are also subject to pollution and degradation. Though efforts are being made to control degradation of riverine waters, the rapid growth of the economy suggests that the situation will get worse before it starts getting better.
- Against this, demand for water is expected to increase substantially in the future. Overall water demand in the country is growing at the rate of 4% annually, and projected to be about 20 billion m3 by 2020. The annual domestic and industrial water demand is expected to grow to 5.8 billion m3 and irrigation water demand to about 13.2 billion m3 in 2020.

  It may be argued that this is less than 2% of the country's annual runoff, but it is a position that is totally unsafe to take. Due to variation of rainfall both in time and space, some regions of high water demand are approaching the limits of readily available water and water stress has become more prevalent over the past few years. This is exemplified by the water crisis that affected some parts of the country in early 1998.

In short, the combination of growing demand and the uncertainties surrounding the surface water resources seriously undermines the security of the country's water supplies and the confidence placed in ensuring its sustainability.

**The issue then is not if we should pursue development of ground water resources but whether we can afford not to.**

It is not prudent that ground water totally substitute all surface water supplies. However, ground water should be developed to become a conjunctive source of raw water, supplementing and complementing current raw water use. This diversification of resources means that the country will not be overly reliant

[a]< http://www.wepa-db.net/pdf/1003forum/25_cc_malaysia_zubaidijohar.pdf>

on surface waters and would have the comfort of knowing that future water demand can be met without hesitation.

However, against this backdrop, it is painful to note that the management of a resource that has the value and strategic importance as ground water is not covered by a coherent management framework that would enable the nation to optimise its benefits.

Nor has it been a matter of pure policy. Ground water was identified by the National Economic Advisory Council as well as within the 10th Malaysia Plan as major thrust areas for development.

However, despite this recognition at the very highest levels of national governance, the development of ground water as a resource remains stymied in terms of human resources, their development, funding for resources assessment and funding for R&D.

Funds for R&D for ground water in 2011, for instance, are non existent while allocations to the Department of Minerals and Geoscience is nowhere close to being able to undertake the kind of ground water resource assessments that would be a necessary precursor to a sustainable development regime. **It needs to be stated that initial investments in R&D on ground water aquifers, systems, modelling and characterisation (in terms of quality and quantity) as well as R&D into ground water assessment and development technologies will open up opportunities in spin-off industries whenever and wherever the occasion/time arises, both locally and globally. An example of a current technology that was utilised in Malaysia was in the undertaking, with immense success, of drilling investigations in deep mega-watershed hard-rock aquifers in the Batang Padang district, Perak, by Sime Darby Bhd.**

This situation occurs because of the fragmented approach to its management and development. The consensus of all the parties that have come together in producing this document concur unequivocally that the root problem facing ground water management in the country is a governance regime that does not have an overarching policy and strategy framework that would engender the various stakeholders to work together in the interest of the resource.

In taking stock of the current situation in the country, it is important that the following issues be addressed:

- The Federal-State dichotomy must be acknowledged and adequately addressed. The Federal Government has the finances and the expertise to undertake and implement ground water management, albeit in relation to their respective administrative mandates. The State Government is vested with the legal jurisdiction on several key matters including land and water resources. Without a partnership in place, ground water management will face almost insurmountable hurdles;
- It is important to view ground water resources as part together with river systems or wetlands;
- There is no institution vested with responsibility for the overall management and development of ground water though functional elements are vested in a spectrum of agencies; and
- There is no national or state policy dedicated to the integrated development and management of ground water. Enforcement, regulation and control may not be possible as there are no appropriate laws.

There is currently little or limited scientific information and resource data on ground water in the country. Data availability and dissemination is a major constraint in ground water development and management.

The Department of Minerals and Geoscience's HYDRODAT database on ground water data began only recently and would take some time to be fully functional and further populated, particularly from those players outside the Department.

However, these players may not be collecting the relevant data or not doing in compliance to the Department's requirements. In either event, the Department does not have a regulatory power to compel them to do so. Valuable information for planning and implementation is thus being lost.

There is a crucial need to arrive at a better understanding of the issues surrounding governance of ground water resources. The current ad hoc approach to ground water development and management will only lead to further deterioration of the resource. There must be sustained action to arrive at a better understanding of the resource and its benefits to the nation.

In this respect, there are four major interventions whose necessities bare themselves i.e.:

- Development of a National Vision for ground water development and management.
- The development of a Mission Statement for ground water development and management
- The development of a policy framework that, while reflecting the Vision statement, takes the exigencies of ground water development and management into account.
- The development of a strategy framework for ground water development and management.

These interventions are articulated in greater detail below.

## Development of a National Vision for Ground Water Development and Management

The articulation of a National Vision for Malaysia would be the first step in engendering a unified approach to ground water development and management. In this, the following outlook is proposed:

**"Ensure the sustainable use of ground water for their social, economic and ecological values, in particular, in conjunction with surface water".**

The accompanying principles, to serve as guidelines in framing the vision, should be addressed separately.

## Development of a Mission Statement for Malaysian Ground Water Management

The development of a Mission Statement for ground water management would be an important precursor to setting strategic goals. The mission statement would provide a sense of direction and orientate strategies to achieve the outcomes exemplified in the Vision statement.

Since Malaysia has formally adopted IWRM as the central thrust to water resources management, the obvious IWRM sub-set applicable to ground water would be IASM. Hence, the mission statement would be:

**"To pursue sound development and management of ground water aquifer systems through the adoption and application of IWRM principles and practices".**

## Development of a Policy Framework for Ground Water Development and Management

The absence of an overarching policy framework guiding ground water development and management is a major shortcoming. Though the National Economic Action Council (1998) in the National Economic Recovery Plan had identified ground water as one source that has great potential to be developed, a clear policy towards that end has yet to occur.

The Outline Perspective Plan 3 (Chapter 7, Item 70) called for the development of a National Water Policy. Given the complexities of such an undertaking, the formulation of the policy is still on-going.

However, pending its full development, it is recommended that a policy statement be included on ground water at the first available opportunity and latest in the 10th Malaysia Plan Mid-Term Review to highlight the importance of ground water and the need to manage them sustainably. This statement can take the form of:

**Ground water resources will be assessed, managed, sustained, restored and protected through the adoption of an Integrated Aquifer Systems Management (IASM) approach.**

Where the development of the National Water Policy itself is concerned, the following is recommended:

- That the conjunctive use of ground water is advocated to ensure sustainability and reliability of water supply to the nation;
- That the use of ground water is advocated to ensure the reliability of water supply during periods of long drought due to climate change (water security);
- That the crucial role ground water plays in ecological dynamics of river basins is widely understood and appreciated;
- That ground water has an important and critical role to play in the Food/Water/Energy nexus in the production of high-value crops through the use of sprinkler systems and drip irrigation; and
- That, where feasible, Green Technologies be applied in ground water development, for example, through the use of appropriate wind and solar energy technologies to drive submersibles especially in food production of high-value food crops.

If the current terms of reference for the proposed National Water Policy allows for it, the specific requirements of ground water should be incorporated in it.

If there is a variance in the overall objectives of the National Water Policy and ground water management and development, then a specific policy or policy statement must be framed to address it.

The overarching objectives of such a policy would enable ground water resources in the country to be adequately explored, assessed, valued and managed optimally to ensure the health of the resource itself and communities that rely on it.

## Development of a Strategy Framework for Malaysian Ground Water Development and Management

The absence of a policy means there is no strategic framework for the management of ground water resources. Strategic initiatives must address key issues relating to the management of resource in its entirety.

A proposed strategy framework towards this end is as follows:

PROPOSED STRATEGY FRAMEWORK GROUND WATER DEVELOPMENT

| | |
|---|---|
| Strategy I | Identify and Empower a Lead Ministry/Agency at Federal Level for Ground water development and management. |
| Strategy II | Facilitate States to play a leading role for ground water management. |
| Strategy III | Establish a National Ground water Research Centre under NRE. |
| Strategy IV | Establish a Standing Committee on Ground water within the purview of the National Water Resources Council. |
| Strategy V | Establish Ground water Management Committees at State Level. |
| Strategy VI | Pass appropriate legislation to strengthen existing legal framework. |
| Strategy VII | Change public perceptions towards ground water. |
| Strategy VIII | Development of Detailed Action Plans. |

## Strategy I. Identify and Empower a Lead Ministry/Agency at Federal Level

Every policy needs a dedicated ministry and associated implementing agency to champion its cause and garner valuable resources and capacities within government agencies. State actions will also require sustained Federal funding and incentives. However, this paper does not advocate the establishment of a new agency but rather to vest the role of coordination within existing or agencies already advocated to be established by other studies.

Water is a natural resource and hence, the overall responsibility for reaching out and integrating across boundaries would rest largely with the Ministry of Natural Resources and Environment (NRE). To effectively manage the national water resource as a unitary entity, it follows that there must initially be intra-Ministry integration where the Ministry's surface water and ground water divisions are integrated into one division.

Similarly, in undertaking water resources management on a holistic basis, NRE would have to nominate an agency that best lends itself for this mandate of assessing, developing and managing the national water resource (both surface water and ground water). For the purposes of this paper, the term 'Water Resources Department' (WRD) will be used as the agency that will be ultimately designated this function.

The WRD's role pertaining to ground water would be:

- To undertake assessment, characterisation and modelling of all aquifers (riverine alluvium, coastal alluvium and hard-rock) and aquifer systems
- To ensure that the development and utilisation of ground water is undertaken as part of the water continuum in a sustainable manner and consistent with dynamics of the river basin(s) within which an aquifer is located in line with IWRM, IRBM and IASM principles.
- To facilitate, develop and implement IASM-based ground water projects jointly with various agencies and state governments;

- To develop and disseminate common management standards for ground water management and development; and
- To develop the necessary human resources, both within itself as well as in other agencies, with respect to IASM, through training, extension and technical support.

Appropriate manpower and financial resources would have to be provided to NRE and the WRD to take on this burden.

### Strategy II. Facilitate States to Play a Leading Role for Ground Water Management

While Federal agencies have their role, the ultimate custodians of water resources, particularly ground water, are the states. The establishment of water resource bodies at state level has been a good first step, but it is noteworthy to point out that only four states have done so and only one, Selangor, has gone the length to undertake ground water management.

The establishment of state water resource boards is an initiative that is actively encouraged by the Federal Government. However, there is a corresponding need to encourage these boards to consider not just surface waters, but also, ground water, as part of their administrative ambit. In this respect, the LUAS experience can serve as a template on which other states can predicate their management machinery on.

### Strategy III. Establish a National Ground Water Research Centre under NRE

The National Ground water Research Centre (NGRC) would be a one-stop agency which would act as:

- A centre of excellence for research into ground water resource and management, bringing together experts from various research institutions and universities to focus on priority areas for research and study.
- A reference centre and database for all information and research on ground water in Malaysia.

This paper does not advocate the establishment of a new agency but rather to vest this role in NAHRIM. This is because:

- NAHRIM is a research institute and has as its' mission to be "an expert centre on water and its environment management to ensure sustainable growth in order to improve the quality of life and well being".
- NAHRIM already has strong links with local research institutions and universities.
- NAHRIM is located within NRE and this would better enable intra-agency coordination.

When established, the immediate tasks to be undertaken by the NGRC would be to:

- Develop, together with other relevant institutions, an agenda for sustained multi-disciplinary research related to ground water development and management and, identifying in the process, its short-term, medium-term and long-term needs as well as their financial implications;
- Develop, together with other organisations, and the private sector, new technologies for the development of the ground water resource; and
- Work with various agencies to ensure that their databases are populated and updated.

### Strategy IV. Establish a Standing Committee on Ground Water within the Purview of the National Water Resources Council (NWRC)

The NWRC is modelled after the National Land Council, which also brings State and Federal stakeholders together to engender a consensus on land use, forestry, minerals and spatial planning, respectively.

Ground water comprises one of three vital yet vulnerable sources of water (the other two being rivers and lakes) that are closely linked and impacted upon by land development within their catchments while, at the same time, involving a wide spectrum of stakeholders.

It would be appropriate that a standing committee be set up under the NWRC to oversee the integrated management of ground water so as also to enable policies that have an administrative transboundary dimension to be engendered and implemented. Towards this end, the standing committee should be designated as an Inter Ministerial Dialogue to underscore its importance. NRE would be best positioned to lead this standing committee having been mandated to deal with the integrated management of all natural resources in the country. Among the first tasks for this national level Committee would be to develop a common set of guidelines for integrated ground water management for use at all levels.

### Strategy V. Establish Ground Water Management Committees at State Level

These committees would be at the political level of Government, allowing coordination among the various agencies that are involved in the development and management of ground water. The model for this would be State Agriculture Committees or State Industrial Committees that are headed by State Executive Councillors or State Ministers. Among the first tasks for this state level committee would be to ensure that all identified aquifer recharge areas are duly gazetted as environmentally sensitive areas (ESAs).

Development in and around these gazetted recharge areas would require prior clearance from this Committee. Water Catchment areas above reservoirs and water intakes would normally have already been gazetted with appropriate development restrictions and controls. An immediate review and extension of this requirement to cover all ground water recharge should also be undertaken. Where considered relevant and desirable, the need for Special Area Plans or such other equivalent statutory plans may also be prescribed.

### Strategy VI. Pass Appropriate Legislation to Strengthen Existing Legal Framework

Both at National and State level, appropriate legislation must be passed to enable management of ground water as a resource. It is clear that the *Waters Act, 1920* is archaic and not consistent with current economic and social conditions. States should enact specific laws and rules for the implementation of ground water management.

### Strategy VII. Change Public Perceptions towards Ground Water

In the absence of a champion for ground water, the deleterious experiences of other countries in using ground water have gained centre stage. Examples such as Bangkok and Mexico City are often touted as examples why we should not utilise ground water.

The fact that they have occurred in conditions with a very different geology is never discussed. The problem lies in the fact that no one has come to the defence of ground water under these circumstances.

The general public is not aware of the lithographic conditions that underpinned subsidence problems in Bangkok. What is even more striking is the public is not aware of the success stories of ground water, and that the examples of these are not found in some far off country, but within our own borders.

There is a crucial need for ground water development to have a buy-in by the public as well as senior administrators and politicians. This can only occur if the disinformation that is associated with it is challenged by a concerted effort to address the biases against ground water that is so prevalent. The lead agency, the WRD, would need to promote ground water as a sustainable source of water, to be used conjunctively with surface waters to meet the needs of the nation, without detriment to the environment among the general public. The WRD would need to approach ground water as a potentially vital reserve in times of water crisis and for security reasons.

At the same time, communities using ground water should be adequately trained so as to ensure that the ground water resource is managed sustainably through the adoption of appropriate Best Management Practices.

### Strategy VIII. Development of Detailed Action Plans

The establishment of an implementing agency without a corresponding action plan for the immediate term would be counterproductive.

Under this ASM/multi-stakeholders initiative to address ground water management, a set of preliminary activities and action plans have been identified and collated through wide consultations with relevant stakeholders under five thematic areas, namely governance, management, R&D, capacity building and business opportunities and outlook. The thematic outputs from Logical Framework Analysis workshops held over the year 2010 can be found in the published ASM Ground water Workshop Proceedings. Using these findings to start with, the implementing agency would be able to build on it to develop a detailed Plan of Action with necessary priority settings.

As a first step, it is recommended that that a more detailed assessment nationwide, following River Basin Management boundaries to begin with, be undertaken to determine the current status of the ground water resources in the country, including their various values, issues and problems related to the various aquifers, and the technical and/or management solutions and remedies that should be put in place to resolve them in the short, medium and long term. The detailed assessment needs to be undertaken on a systematic basis on the following aquifer systems:

(i) Riverine alluvial aquifers within a river basin (may be within a state)
(ii) Coastal alluvial aquifers within or across river basins (may cut across states and nations); and
(iii) Hard-rock aquifers within and across river basins (may cut across states and nations).

There is potential Federal-State, inter-State, as well as international boundary implications that may arise in times of water crisis with those riverine, coastal and hard-rock aquifers that transcend state and national borders.

The mapping and characterisation of these aquifers need to be urgently undertaken by studying aquifer basins and aquifer systems.

Action plans should also be framed to ensure that that clear targets for ground water use are set for all water users. It is recommended that ground water use be expanded to 20% of the overall public (domestic/ industrial) water supply by 2030. These action plans should also consider private sector involvement in ground water development (through the appointment of Independent Ground water Producers) with the provision of possible incentives to promote their involvement.

Following the recommendations under *Strategies I* and *II* above, the responsibility of preparing the detailed action plans must fall on the collective efforts of NRE, the WRD and related agencies working in concert with other stakeholders and government agencies at Federal and State levels.

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