Jurnal Teknologi

Full paper

# Applications and Sustainability in Groundwater Abstraction in Malaysia

Intan Sazrina Saimy[a], Fauziah Raji[b*]

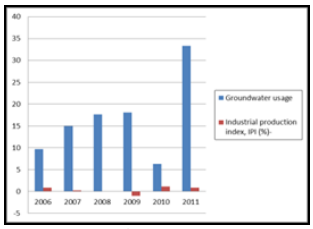
[a]*Perdana School of Science, Technology and Innovation Policy, Universiti Teknologi Malaysia, Jalan Semarak, 54100 Kuala Lumpur, Malaysia*
[b]*Faculty of Geoinformation and Real Estate, Dept. of Real Estate, Univeristi Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia*

*Corresponding author: fauziahraji.kl@utm.my

**Article history**

Received :6 February 2014
Received in revised form :
21 December 2014
Accepted :26 February 2015

**Graphical abstract**




Percentages of Water Abstraction Amount with IPI

**Abstract**

Most major cities in Malaysia face problems of clean and safe water supply. The blame is on the population boom, industrialisation, pollution plus climate change. It becomes more complicated with uncontrolled usage, public's ignorance and ineffective water management. These problems have led to higher dependencies towards alternative usage of groundwater to serve the needs of public, agricultural sector and the industries. Groundwater usage must be abstracted sustainably to avoid short and long term effects. This exploratory qualitative study analyses several aspects: (a) existing documents on Malaysian water management (b) documents on Malaysian groundwater governance; (c) applications and enforcements of groundwater governance in states. The analyses are essential in recognising and providing appropriate and effective groundwater governance towards higher consumption in the country especially in industrial sector. Early finding reveals the current groundwater governance lack good management and there are legal vacuums. This paper promotes appropriate groundwater governance and management of policies and strategies at both federal and state level, relevant agencies, stakeholders and local communities in ensuring sustainable groundwater resources usage in Malaysia.

*Keywords*: Abstraction; governance; groundwater; sustainable

**Abstrak**

Kebanyakan bandar besar di Malaysia mengalami masalah air bersih dan air minum yang selamat. Antara puncanya adalah peningkatan populasi yang mendadak, pencemaran dan perubahan cuaca. Keadaaan ini bertambah komplikasi dengan penggunaan sumber tanpa kawalan, ketidak prihatinan orang awam dan pengurusan air yang tidak efektif. Kesemua masalah ini telah mengakibatkan kebergantungan kepada sumber alternatif iaitu air bawah tanah bagi menampung keperluan awam, pertanian dan industri. Abstraksi air bawah tanah perlu digunakan secara mapan bagi mengelakkan kesan jangka masa pendek atau panjang. Kajian eksporasi kualitatif ini menganalisis beberapa aspek (a) dokumen sedia ada pengurusan air di Malaysia (b) dokumen berkaitan air bawah tanah di Malaysia dan (c) aplikasi dan penguatkuasaan air bawah tanah di negeri-negeri. Analisis ini penting bagi mengenal pasti dan menyediakan pentadbiran air bawah tanah yang sesuai dan efektif terutamanya bagi penggunaan industri yang semakin meningkat. Dapatan awal menunjukkan pentadbiran terkini air bawah tanah kekurangan pengurusan yang baik dan lompong. Kertas kajian ini mempromosi polisi dan strategi urus tadbir dan pengurusan air bawah tanah yang sesuai di peringkat pusat dan negeri, pihak yang berkepentingan, agensi terlibat dan masyarakat tempatan dalam memastikan penggunaan sumber air bawah tanah yang mapan di Malaysia.

*Kata kunci*: Abstraksi; urus tadbir; air bawah tanah; mapan



## 1.0 INTRODUCTION

Continuity of water supply is taken for granted in most developed countries. The demand for clean water supply in major cities is huge in light of both burgeoning human needs and increasing climate variability and change. Clean water supply is already a major issue in certain places in Malaysia particularly in Selangor, Kuala Lumpur, Johor Bahru, and Pulau Pinang. Over usage, negative anthropogenic processes, population boom and climate change contribute to the problem. These situations have created many sorts of problems and water stress.[1-3] Most countries including Malaysia, rely on surface water supply and when it is depleted, the natural response is to search for alternatives from other sources mainly groundwater.

The world's groundwater usage was predicted to increase by the year 2050 (Figure 1). As laid out below, the highest user of global water usage is for agricultural irrigation purposes such as Thailand 80% and China 78%.[4,5] Countries like Denmark have been using 100% of groundwater as their main water supply.

Groundwater is used in a large scale in regions with limited rainfall.[2,6]

Groundwater has proven to be a life saver during previous dry spells in Malaysia especially to those in Melaka, Selangor and Sarawak.[7] Many users in these states are rapidly searching for alternatives from the usual surface water supply. Groundwater is the answer as it is able to ensure sufficient supply where there is deteriorating quality of surface water and available in remote areas where water supply is hard to reach.[8-10]

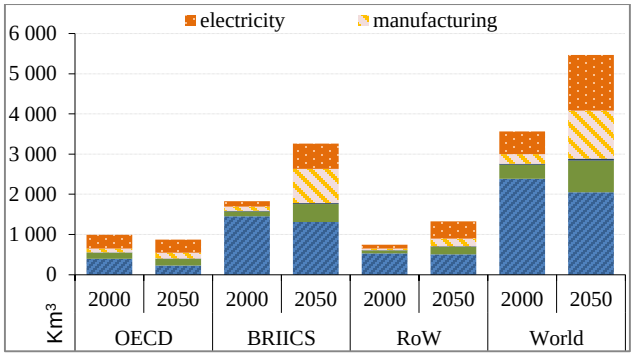



**Figure 1** Global water demand (Baseline Scenario 2000 and 2050) Note: BRIICS: Brazil, Russia, India, Indonesia, China, And South Africa. RoW: Rest of the world. *Source:* OECD (2012)

Water management is a comprehensive and complicated task [27] in addition with mismanagement in many countries. It is a concern if Malaysia would face the negative consequences if they are unable to manage groundwater resource efficiently. The negative impacts would be towards the water ecosystem, the environment and indirect impacts to human health because of human itself, the lack of awareness and mismanagement of water.[28] The inadequacy of GW management could also lead to serious water shortages in the future.[38]

With groundwater set to be exploited in bigger scale in Malaysia to meet the increasing demands for various uses, this important resource must be managed wisely and effectively. Yunus and Mohammed Hatta emphasised that Malaysian groundwater quality and quantity should be monitored systematically for good distribution and reliability.[14] Managing water in a country is complicated with socio-economic, institutional, ecological and technical aspects of the resource.[13] Therefore, to manage groundwater along with the short and long-term period risks, it is important to understand the social and economic dimensions of its uses.[5] Understanding the effects of land and water management is prior to its managing the activities to retain and achieve the acceptable status of the resource. More studies and effective sustainable groundwater management should be done on the resource to ensure sufficient capacity in the future where India and China have now focused in combating groundwater depletion and degradation especially for irrigation purposes.[15]

## 2.0 LITERATURE REVIEW

There are many reasons on the tremendous increase in groundwater usage in many countries in the past decade; (1) groundwater utilisation helps solve water shortages in areas with limited surface water supply and supplement the water supply, (2) it is inexpensive especially for the poor countries as groundwater is widespread and in good quality.[10,16] Groundwater's capital costs are much lower than surface water.[10] With lower capital industries are able to use it while keeping their operation costs low. Industries that produce bottled drinking water find it cheaper because it has lower turbidity than surface water and contains good nutrients for good health.[17] (3) Groundwater is stored underground which makes it reliable during drought season for countries hot climate. The water is under the ground and in between the soil where more can be retained as it prevents loss through evaporation by the heat.[8-10]

Groundwater irrigation is said to promote greater inter-gender, interpersonal, interclass and spatial equity. The positive aspect is focused to individual farmers and small groups compared to large irrigation projects as seen from countries in Asia.[10] Africa, Asia and Latin America have shown where poor farmers improved their livelihoods through small-scale farming based on shallow groundwater.

In 2009, the Food and Agriculture Organisation (FAO) identified both the agriculture and industry as the main exploiters of groundwater worldwide.[25] Globally, agriculture is the highest user at 62% followed by industries at 21%. This was supported by the Organisation for Economic Co-operation and Development (OECD) and Shah *et al*., when they predicted Indonesia and China who uses groundwater mainly for irrigation purposes will increase their usage by 2050.[18,10] However, the main exploiters of groundwater abstraction in Indonesia are the big industries which have relocated their factories to Asia because of cheap labour.[19]

The groundwater boom for agriculture is driven by several supply-push factors such as government subsidies, inexpensive pumps and drilling technologies. In developing countries where the economics depend totally on agriculture, the governments give incentives to farmers to have enough water for irrigation of the crops to provide food for urban settlers and make sure the agricultural industry does not fall out.

Technology moreover has made groundwater drilling easier thus enabling people to use deep aquifer storage.[17] Technologies have made GW drilling easier thus enabling people to use deep aquifer storage that are sometimes difficult to monitor. Thus, GW will face the same consequences as surface water. Without good management and strict regulation, the depletion and deterioration will continue. Hefny has forewarned that climate change gives direct impact to water resources but mismanagement causes more harm to the natural resource.[3]

Groundwater abstraction often exceeds the recharge rate especially in developing countries[11] and the water management in these countries are declared unsustainable by the United Nations Economic and Social Council in Geneva in 1997.[12] Groundwater depletion, land subsidence, infrastructure imbalance, saline water intrusion and water quality deterioration are among the biggest threat to unsustainable water supply management in these regions.

Malaysia's water resources are rapidly depleting if the existing water supply is not managed properly nor used sustainably.[1,20] One of the main factor is most of the water laws available focuses only towards surface water where groundwater is hardly managed.[14] The Minister of Natural Resources and Environment in 2009 was quoted saying that groundwater development in Malaysia is lagging compared to other countries in Asia as it fails to recognise the vast potential of the resources.[4] Groundwater and soil pollution were not identified as key environmental issues in Malaysia since it had not been widely used. There were even misconceptions from the community who think groundwater exploitation is unsustainable.

Suratman stressed that Malaysian groundwater has the potential to supplement and supply water for the country.[16] Thus lays the urgent need to better manage our natural resource. It is also urgent to develop institutions with the necessary powers and resources for the creation, coordination and implementation of a

comprehensive water resource strategy and policy whereby a 'one roof management' would be handy.

The geological type of aquifer mostly found in Malaysia is alluvium followed by limestone, fractured sandstone and fractured igneous (hard) rocks.[14] These types of aquifers are difficult to explore and manage due to fractures where water is stored. Groundwater from alluvial aquifer is the most suitable source for drinking water and industrial use.[7] This type of aquifer is mostly found in the coastal plains and valleys of major rivers. Even though the limestone aquifer is the most productive aquifer, not many wells are built in them being within developed areas which may develop sinkholes. Recognizing the importance of aquifers, Mohamed *et al.* recommended Malaysia to have proper guidelines and mitigations measures that may include formulations of regulations on groundwater recharge to be adopted.[7]

According to Mohammed Hatta, this country needs to explore the potential of groundwater with basinal approach, the actual reserve and safe yield of the basin.[23] Study of water balance is a prerequisite to study the region/ basin thoroughly. Yunus and Mohammed Hatta presented that groundwater abstraction should respond to changes in groundwater level to an acceptable level and quality.[14] Sustainable groundwater uses is bound to natural recharge rate. Thereby, natural recharge is mandatory in groundwater management.[12,14] This is to avoid jeopardizing the environment, since the water table will drop whilst groundwater is extracted. Pumping groundwater will cause a dimple in the water table known as the cone of depression. When the pumping stops, the original shape will return. However, the recharge estimation was not much emphasised in previous studies in the country.

Aros suggested that water use should be planned to be sustainable in every aspect thus sufficient for present or future usage.[12] Achieving good water governance requires the impact of the water usage in the long run at every turn of action. Water resources should be managed in a holistic manner. In order to be sustainable, water management should be able to serve various users while protecting the ecology, minimizing the damage of human activities[21] and physical processes.[22] Many other countries have similar water problems but they are united and very objective in solving and rectifying the problems.

## 3.0 METHODOLOGY

This study assessed how the Malaysian water governance optimises groundwater abstraction for the benefits of agricultural productivity and groundwater sustainability. Effective governance of groundwater means improving management system that requires changes in infrastructure, capacity building, efficient organisation, better information and communication. This is to ensure the i) groundwater resource will not decline or affected with negative consequences; ii) sustainable aquifer management depends on better management and planning of groundwater use.

By using qualitative research method, assessing and analysing national and international legislations on groundwater is used first. Second, interviews and group discussions with stakeholders namely the legislators from state and federal water authorities were conducted. The data collected were analysed and put into respective constructs.

## 4.0 RESULTS AND DISCUSSIONS

Malaysian natural water resources was estimated in 2002 to be around 25 178 cubic metres available for each person.[24] Surface water is the main source of water in the country with 566 km2 while groundwater estimated at 64 $km^2$.[25] Approximately about 47% of the groundwater withdrawals intended are for agriculture. In addition, majority of the people in Sabah and Sarawak depend on groundwater to cater for their daily needs, as it is arduous to supply them with pipe water because of their natural terrain and geographic location.[14] Malaysian usage is comparatively small compared to the United States (US), which uses about 77 billion gallons per day and Australia which uses groundwater mainly for mining.

Malaysia relies too much on dams and treatment plants constructed along rivers for reservoirs according to Water Watch Penang (WWP).[37] The National Water Resources Study (2000–2050) even recommended 47 new dams and 3 new inter-state water projects be implemented to meet future demands.[26] Dams and other infrastructure have caused 60% fragmentation to large rivers in the world with Asia being the highest number by 59%.[36] Dams require water be kept for power, therefore less water flow downstream especially for agriculture users.[27]

Malaysia has reached limited space while the population, industries and agriculture kept increasing. Malaysia is at present water-stressed and recent severe droughts in the last few years have caused these dams' water levels to drop drastically. Many crops and economy of farmers were affected by the water hold up. This causes the country especially farmers dilemma when the water level is low.

Groundwater is sought after during drought season[8-10] especially in Melaka, Selangor and Sarawak.[23] Many have realised the resource as an alternative water resource[7,28] with high potential to be developed in the National Economic Action Council (NEAC) of the National Economic Recovery Plan (NERP) in 1998.[29,16,14] It is significantly utilised in Kelantan and Perlis by small communities and isolated industries while other states as a supplementary resource.[17,30] The abstraction wells are used primarily for commercial purposes under commercial sector. However the availability and the quality vary because of the dissimilar geological environment.[12]

Research shows that the amount of groundwater abstraction parallels with the number of registered industries between the year 2006 to 2010 (Figure 2). The amount of groundwater abstraction is from the industries registered with the state water authority of Selangor while compared with percentage of Industrial Pollution Index (IPI) from Malaysian national statistics department. The bigger the factories, the bigger amount of groundwater abstraction will be and higher amount of bottled water supplied. The longer years of operation therefore, the higher number of groundwater abstracted.

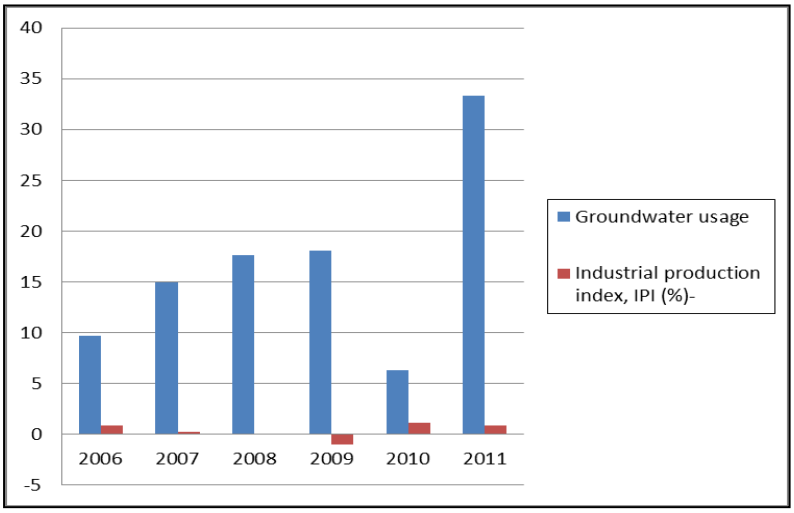



**Figure 2** Percentages of water abstraction amount with IPI

There is no centralised or specific body for the planning and management of water resources and supply in Malaysia.[26,1,31, 32,22]. Groundwater in Malaysia involves all of the listed ministries in Table 1 under the federal government. It can be understood how groundwater is not under the radar. The current water supply management are fragmented between the federal and the state government.[8]

Currently, there are no policies or written legislation specifically on groundwater in Malaysia.[1,20,14,22] Mohamed *et al.* said, even the Environmental Quality Act (EQA) 1974[34] with the intention to prevent, abate, pollution control and enhance the environment[33] has no existing regulation or management approach to groundwater abstraction.[7] Table 2 lists the available acts or guidelines that touch groundwater in its governance and management. These acts and guidelines are under several ministries and used by different states. Some of the legislations have been used for a long time and not amended according to current usage or situation.

Abstraction of a well would involve multiple ministries, state and local municipalities before it is operational. These processes would take a long time and money besides getting some confusion. Even different states opt for different water enactments which is not consistent throughout the country (Table 3). This is why among other factors many individuals or industries opt not to apply for any type of groundwater abstraction licenses especially small-scale farmers.

As water supply or quality is managed by state-by-state basis and involves a multitude of action by multiple authorities and organisations, it is without much coordination or efficiency. It was found there were overlapping responsibilities of water resources which are common scenarios in most developing countries as in Malaysia.[1,2] this is in line with the situation which FOMCA described as the lack of holistic water management that creates inefficiency that will lead to short and long-term problems.[31,32]

**Table 1** Relevant ministries in water governance

| Departments | Tasks / Responsibilities |
|---|---|
| The Department of Irrigation and Drainage (DID) | hydrology, river management, flood mitigation, coastal management and storm water management |
| The Public Works Department (PWD) | Domestic and industrial water supply. |
| Department of Environment (DOE) | Monitor and control water quality of rivers, reservoirs or any water catchment areas |
| The Ministry of Health (MOH) | Quality of raw water supply especially for drinking water purposes |
| The Ministry of Energy, Green Technology and Water (KeTTHA) | Setting water supply and sanitation policies |
| National Hydraulic Research Institute Malaysia (NAHRIM) | Conduct basic and applied research on water resources; river, coastal areas, geo-hydrology and water quality. |

**Table 2** Relevant legislations to groundwater

| |
|---|
| Water Act 1920 |
| Water Supply Enactment 1955 |
| National Land Code 1965 |
| Land Conservation Code, 1965 |
| Environmental Quality Act 1974 |
| Food Act 1983 |
| Water Supply (Federal Territory of Kuala Lumpur) 1998 |
| National Guidelines for Raw Drinking Water Quality |
| Geological Survey Act |
| National Policy on Environment, 2002 |
| Guidelines for Groundwater Drilling, Abstractions and Monitoring 2002 |
| Water Services Industry Act (WSIA), 2006 |
| National Water Resources Policy 2012 (NWRP) |

**Table 3** State water enactments

| |
|---|
| Kedah Water Resources Enactment 2008 |
| Selangor Waters Management Authority Enactment, 1999 |

Overall, Malaysia is slowly commencing common regulations and actions for sustainable groundwater exploitation such as groundwater data and monitoring. There are many national policies planned within the respective sectors regarding the water resources. In addition, in 1998 the National Economic Action Council (NEAC) of the National Economic Recovery Plan (NERP) has identified groundwater as a resource with high potential to be developed.[29,16,14] The Economic Planning Unit (EPU) of the Prime Ministers Department is currently focusing on sustainable water resources since the Eighth Malaysian Plan (2001-2005) to the current Tenth Malaysian Plan (2011-2015).[35] The identification of pollution, setting water quality standard, control of abstraction, establishment of protected areas and enforcement of standards and regulations on groundwater are being looked into. [10] Nevertheless, the newest NWRP does not have any specifications on groundwater. Groundwater is still subjected to as an alternative water supply although many states have now opted groundwater as their main water resource.

From the available legislations that has more control on groundwater abstraction are emphasised through i) Food Act 1987, ii) Selangor Waters Management Authority Enactment 1999 and iii) Kedah Water Resources Enactment 2008. From the above said legislations, the focus of the legislations is as laid in Table 4; licensing; offences; source protection and monitoring.

Findings show that the states' enactments are charging users a low rate for per cubic meter of usage. The rate is the same for Selangor and Kedah which is categorised in two: commercial and water supply. Only these two states have the power to take any action according to the enactments of any offences towards groundwater abstraction. The Food Act 1987 only applies if there are any contaminations towards the water quality that may harm humans' health.

Findings also show that the state water authorities or any other federal stakeholders are short of staff in the monitoring department. Many groundwater users in the country are agricultural and industrial users, therefore it is usually located at hard to reach areas. There are not enough personnel to look into each industry for any illegal abstraction or well or exceed the limit provided.

**Table 4** Content of available legislations on groundwater abstraction for mineral water

| | | |
|---|---|---|
| A. | Licensing/ permit | |
| B. | Water Charges | |
| C. | Offence or penalties | |
| D. | Protection of Source | |
| 1. | Water Source | a. Location<br>b. Pumping test<br>c. To deepen, enlarge or alter an existing well<br>d. Digging, drilling or building a well.<br>e. Pollution<br>f. Shutting down, stopping or neglecting a well |
| 2. | Zoning critical areas | |
| 3. | Monitoring | a. Water Level<br>b. Water Quality |
| E. | Recharge | |
| F. | Alternative Water Source | |
| G. | Use<br>Efficient use (quantity)<br>Public Awareness | |

As groundwater usage will continue to rise in the developing world,[10] participatory approaches to sustainable groundwater management combined with supply-side measures such as artificial recharge, aquifer recovery, interbasin of transfer needed to be applied. It may also need to be combined with the demand-side measures such as pricing, legal and regulatory control, water rights and withdrawal permits and water saving promotion and technologies. Nevertheless, not all measures are suited for each developing country depending on their socioeconomic and political terms. Supply-side measures are easier to implement compared to demand-side measures even to advanced countries. Key objectives towards a better water future include managing water resources effectively and efficiently in quality and quantity aspects. In order to achieve it, a national water policy and comprehensive water legislation and guidelines should be formulated. The fragmentation of jurisdictions, authorities, powers and lack of clear legislative provisions as well as policies and guidelines must be overcome first.

Stakeholder participation is compulsory in the decision making process. In making sure of the effectiveness of the policies, there should be awareness programmes on the water sector, implementation monitored by many parties and feedback

encouraged. This is to create a more informed and concerned society. The communities, industries and stakeholders should be made aware of the importance of water and take part to protect the natural resources. As an initiative, the federal government of Malaysia should develop a National Water Resources Framework. It should include the framework, action plans and implementation, mitigations and monitoring management. With this framework, it should be adapted into each state and municipalities in the country. The guidelines would be the key instruments to the legislations and enforcements of activities. The framework should be made aware to all stakeholders involved and put in good use as many cases happen where the existence of the policies were unnoticed. The manifestation would also otherwise not be effective if awareness is not instilled among the public.

## ■4.0 CONCLUSION

The strain on water supply and depletion of clean water resources would further shoot the demand for groundwater, as there are many cases of water supply failure in Malaysia. Both the industries and the agricultural sectors need water to maintain their products. Therefore, the groundwater is seen as an alternative. However, there is no control of the abstraction amount at the national level and several states in Malaysia which could create negative effects in the long term and problems are inevitable if no appropriate actions are taken immediately.

The demand would put a strain on the sustainability of the resource but with proper water management, establishment of good strategies, effective legislation and proper maintenance of water resource it can be sustainable. Therefore, this paper promotes a revamp of the current system. It must be replaced with newer and current as well as appropriate water management policies and strategies to cater to the current demand at both Federal and State levels. Stakeholders must be included into this program where they must be properly and adequately informed. So does the relevant agencies and local communities. It also requires a mind-set change amongst the public.

It is therefore recommended for Malaysia to develop strategic policies and guidelines for groundwater abstraction sustainability in relation to higher usage. A uniform policy and legislation implemented in all states in the country would enable groundwater to be managed effectively to meet water supply growing demand. Successful implementation of communication strategies and programmes at the local level would lead the stakeholders and community actively involved in planning and management of water resources.

## References


[1] U. Norsaliza and I. M. Hasmadi. 2010. Use of Remote Sensing and GIS in Monitoring Water Quality. *J. of Sustainable Development.* 3(3): 228.

[2] A. Palacio. 2007. *Water Ethics. Proceedings of the Marcileno Botin Water Forum.* Spain. Taylor and Francis Group.

[3] M. A. Hefny. 2007. *Water Management Ethics in the Framework of Environmental and General Ethics: The Case of Islamic Water Ethics. Proceedings of the Marcileno Botin Water Forum.* Spain. Taylor and Francis Group. 25.

[4] N.C. Yee. 2009. Malaysian Groundwater Needs to be Exploited. *The Star*. 15.

[5] A. Mukherji and T. Shah. 2005. Groundwater Socio-ecology and Governance; A Review of Institutions and Policies in Selected Countries. *J. of Hydrogeology.* 1: 328.

[6] A. Ross and P. Martinez-Santos. 2010. The Challenges of Groundwater Governance. *J. of Reg. Environ Change*. 10: 299.

[7] A. F. Mohamed, W. Z. W. Yaacob, M. R. Taha and A. R. Samsudin. 2009. Groundwater and Soil Vulnerability in the Langat Basin Malaysia. *European J. of Scientific Research*. 27(No. 4): 628.

[8] A. Mohamed. 2012. How to Ensure Sustainable Supply? *Presented at the Conference Groundwater-What, Why, Where and How?* 8-9 May 2012. Petaling Jaya.

[9] J. Schaeffer. 2012. Business Opportunities in Groundwater. *Presented at the Conference Groundwater-What, Why, Where and How?* 8-9 May 2012. Petaling Jaya.

[10] T. Shah, J. Burke and K. Villholth. 2009. Groundwater: A Water Assessment of Scale and Significance. *Proceedings of the Groundwater Management in Malaysia- Status and Challenges.* 25–26 March. Putrajaya, 15–47.

[11] R. M. Stephan. 2007. Framework Legal Framework of Groundwater Management in the Middle East (Israel, Jordan, Lebanon, Syria and the Palestinian Territories). *Water Resources in the Middle East*. 2: 293.

[12] M. A. Aros. 2009. Groundwater Development in Selangor and Impact to Environment. *Proceedings of the Groundwater Management in Malaysia- Status and Challenges.* 25–26 March. Putrajaya, 63.

[13] K. Knuppe, and C. Pahl-Wostl. 2011. A Framework for the Analysis of Governance Structures Applying to Groundwater Resources and the Requirements for the Sustainable for the Sustainable Management of Associated Ecosystem Services. *Journal of Water Resource Management.* 25: 3387.

[14] A. R. Yunus and A. K. M. Hatta. 2009. Groundwater in the Malaysian Context. *Proceedings of the Groundwater Management in Malaysia-Status and Challenges*. 25–26 March. Putrajaya, 1–14.

[15] B. Bahashim and H. S. L. Sukimin. 2009. Application Procedure for Groundwater Management in Selangor. *Proceedings of the Groundwater Management in Malaysia-Status and Challenges*. 25–26 March. Putrajaya, 135.

[16] S. Suratman. 2012. *Groundwater-What and Why? Presented at the Conference Groundwater-What, Why, Where and How*? 8–9 May 2012. Petaling Jaya.

[17] M. T. Ahmed and G. A. Halim. 2009. Evaluation of Yield and Groundwater Quality for Selected Wells in Malaysia. *Pertanika J. Science and Technology*. 17(1): 33.

[18] Organisation for Economic Co-operation and Development, OECD. 2012. *Executive Summary, in Meeting the Water Reform Challenge. OECD Publishing*. Retrieved 23rd June 2013 from http://dx.doi.org/org/10.1787/9789264170001-2-en.

[19] O. Braadbaart and F. Braadbaart. 1997. Policing the Urban Pumping Race: Industrial Groundwater Overexploitation in Indonesia. *World Development.* 25(2): 199.

[20] N. A. Rahman. 2009. Research and Development of Groundwater at Universiti Teknologi Malaysia. *Proceedings of the Groundwater Management in Malaysia–Status and Challenges.* 25–26 March. Putrajaya, 76.

[21] Wolf, S. and Stanley, N. 2011. *Wolf and Stanley on Environmental Law* Fifth ed. London and New York: Routledge, Taylor and Francis Group.

[22] M. D. M. Nor and S. Atikah. 2003. IWRM and Capacity-Building in Malaysia. *Proceedings of the Policies and Strategic Options for Water Management in Islamic Countries.* 15–16 December 2003. Tehran.

[23] A K. M. Hatta. 2011. *Overview of Groundwater Resources in Malaysia*. Dept. of Minerology and Geoscience (JMG). K. Lumpur. Retrieved 20 February 2011 from http://www.jmg.gov.my.

[24] World Resource Institute Retrieved 20 June 2013 http://earthtrends.wri.org.

[25] Food and Agriculture Organisation, FAO. 2005. Malaysia–*FAO's Information System on Water and Agriculture. Encyclopedia of Earth. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment) United Nations*. Retrieved on October 2, 2012 from http://www.eoearth.org.article/MalaysiaFAO's_Information_System_on Water_and_Agriculture.

[26] World Health Organisation, WHO. 2011. *Malaysia.* Retrieved 21 November 2011 from http://www.who.int/ water_malaysia.

[27] M. Azhar, G. 2000. *Managing Malaysian Water Resources Development*. Buletin Kesihatan Masyarakat Isu Khas. 40–57.

[28] Ministry of Science, Technology and the Environment, MOSTE. 2002. National Policy on the Environment. ISBN 983-9119-82-6.

[29] P. Loganathan. 2012. *Groundwater–The Way Forward. Presented at the Conference Groundwater–What, Why, Where and How?* 8–9 May 2012. Petaling Jaya.

[30] N. Sapari, R. A. R. Zainariah and H. Jusoh. 2011. Quantity and Quality of Groundwater in Fractured Metasedimentary Rocks of the West Coast of Peninsular Malaysia. *Sains Malaysiana*. 40(6): 537.

[31] M. A. Melati. 2010. *Malaysia: No Water, No Life*. Bernama, Retrieved on 15 March 2011, from http://www. bernama.com.

[32] FOMCA, WECAM and Malaysian Water Forum. 2009. *No Recharge, No Discharge, Sime Darby Will Be Charge.* Research Report on Groundwater Project in Batang Padang, Perak.

[33] Water Environment Partnership in Asia, WEPA. 2011. *Organizational Arrangement: Malaysia.* Retrieved 20 November 2011 from www.wepa-db.net/.
[34] Malaysia. 2011. Environmental Quality Act (EQA). 1974. Act 127. ISBN: 978-967-89-2135-0.
[35] Economic Planning Unit, EPU. 2010. *Chapter 6: Building an Environment That Enhances Quality of Life.* 10th Malaysian Plan. Prime Ministers Department.
[36] Global Water Partnership, GWP. 2012. *IWRM concepts in National Laws and Policies.* Retrieved on July 27, 2012 from http://www.gwp.org/en/gwp-in-action/Southeast-Asia/.
[37] Anonymous. 2010, May 10. *Government Should Refrain From Tapping Into Underground Water Resources. Bernama*. Retrieved 28 February 2011 from http://proquest.umi.com/pqdweb?did.
[38] S. Foster and H. Garduno. 2013. Groundwater-resource Governance: Are Governments and Stakeholders Responding to the Challenge? *Hydrogeology Journal.* 21: 317.