ASM Advisory Report 2/2014

Setting A National Agenda For Integrated Water Research

VOLUME 1

ASM Advisory Report 2/2014

Setting A National Agenda For Integrated Water Research

VOLUME 1

2014

Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

Setting A National Agenda For Integrated Water Research. VOLUME 1
(ASM Study Report 2/2014)
ISBN 978-983-2915-15-7
1. Water resources development --Research--Malaysia.
I. Water quality management--Research--Malaysia. II. Series.
333.91009595

Contents

Foreword

Congratulations to members of the ASM Task Force on Water R&D for producing this Advisory Report on 'Setting a National Agenda for Integrated Water Research'. This Advisory Report is the outcome of an ASM-commissioned Study on the Current Status and Needs Assessment for Water Resources Research in Malaysia. The Study was commissioned in June 2012 and was completed in May 2014. Subsequently, a set of summary conclusions and recommendations based on feedback received from stakeholders during Strategic Consultative Laboratories (SCL) on Water R&D was presented.

Malaysia has embarked on a National Transformation Program, including the adoption of Green Technology on its road towards the achievement of Vision 2020. The Water Sector is an integral part of this mission and needs also to move in tandem. The Water Sector Transformation Road Map comprises of a wide array of strategic action plans anchored by a central Integrated Water Resources Management (IWRM) Implementation Road Map. The main goal of this Integrated Water Research Framework is to seek and provide ***sustainable solutions*** in support of Malaysia's water resources development and management plans pursued along essentially two discrete objectives, namely 'water as a resource and related wealth creation', and 'water for livelihood & wealth creation'. Therefore, a sustained **multi-disciplinary** water R&D program is a pivotal and essential prerequisite **to ensure that the best of science, engineering, technology and innovation** is harnessed for national good and advantage.

This Advisory Report is yet another important deliverable of the Academy of Sciences Malaysia as part of its mandate to provide strategic advice to Government. We are confident that the findings, recommendations and strategies contained therein would assist the Government in the implementation of a robust and continuing water R&D programme to ensure increased resilience and provide timely solutions to the many issues and challenges facing the country's water sector. It would also be in line for the achievement of the country's post-2015 Sustainable Development Goals (SDGs) for the water sector; an outcome from the recent Rio + 20 Earth Summit held in June 2012 that carried the theme 'The Future We Want'.

TAN SRI DATUK DR. AHMAD TAJUDDIN ALI F.A.Sc.
President
Academy of Sciences Malaysia

Preface

The Academy of Sciences Malaysia (ASM), an independent think-tank providing strategic advice to Government on Science, Technology and Innovation (STI) matters, has since 2008, been undertaking studies pertaining to the water sector, considered strategic for the country's economic development. The studies have been overseen by a dedicated ASM Water Committee. Adopting IWRM as the central thrust and noting that IWRM *per se* is a rather abstract concept, the Committee has for practical application in the Malaysian context, broken down IWRM into discrete subsets or subthemes. Each of these subsets or sub-themes is then subjected to in-depth studies culminating in the preparation of an advisory report, for consideration and adoption by the relevant authority or agency which is responsible for their implementation. The studies have also undergone a process of strategic consultations with relevant institutional, community and private sector stakeholders. One of the key studies undertaken by the Academy, overseen by the ASM Task Force on Water R&D, is this Advisory Report entitled 'Setting a National Agenda for Integrated Water Research'.

In leading up to this Advisory Report, ASM had earlier commissioned a position paper entitled '**A Study on the Current Status and Needs Assessment for Water Resources Research in Malaysia**'. This two-year Study that was completed in May 2014 found that past and current research on water in Malaysia had been largely ad-hoc, fragmented, and very often undertaken with a limited and narrow focus to meet academic interests. Furthermore, there was no clear direction in place to ensure the harnessing of STI to address the country's water management issues and challenges through an integrated and coordinated multi-disciplinary research that was underpinned by an overall R&D framework based on national needs and priorities.

ASM considers that a major revamp of the current institutional arrangements for managing integrated water research is urgently required. In moving forward, ASM has developed, and thus is recommending an appropriate integrated water research framework comprising strategic research themes and need-based research topics which are designed to support the IWRM implementation road map towards sustainable development and management of the country's water resources. ASM also recommends a major revamp to the current water research governance structure, the deployment and provision of adequate human and financial resources that includes a launching grant to kick-start the proposed integrated water research programme.

Indeed, the successful completion of the both the Advisory Report (Volume 1) and the Water R&D Status Report (Volume 2) by the Task Force would not have been possible without the guidance of Academician Tan Sri Shahrizaila Abdullah, the first Chair of the ASM Water Committee, as well as the members of the ASM

Water Committee itself. The completion of the work of the Task force would also not have been possible without the full cooperation, support and commitment of the Task Force members, the Water R&D Study Team and the ASM Secretariat. We commend them for their invaluable contribution. Above all, we would like to place on record our deep appreciation for the strong support and cooperation of the many water-related institutional and community stakeholders from the public, private and NGO sectors who had participated and provided feedback at the Strategic Consultative Laboratories (SCL) held on Water R&D.

Prof Dr Ahmad Fauzi Ismail F.A.Sc.
Chairman
ASM Task Force on Water R&D

Academician Datuk Fateh Chand F.A.Sc.
Chairman
ASM Water Committee

Executive Summary

The Academy of Sciences Malaysia (ASM), an independent think-tank providing strategic advice to Government on Science, Technology and Innovation matters, has since 2008, been undertaking studies pertaining to the water sector, considered strategic for the country's economic development. One of the key studies undertaken by the Academy is this study entitled 'Setting a National Agenda for Integrated Water Research'.

Growing population (including the fairly large migrant population) and urbanisation in Malaysia coupled with the fast pace of economic development has led to increased water use in all subsectors with resultant pollution of this finite and renewable yet vulnerable resource. Fragmented management, a legacy from the past, still prevails leading to competition and conflicts in water use in some river basins. The National Water Resources Study 2011 highlighted some 'water-stressed' growth regions and states such as Perlis, Kedah, Pulau Pinang, Selangor and Melaka were listed as water deficit states. Temporal and spatial variability of rainfall, coupled with high population densities and/or extensive agricultural activities in these regions have led to water demands exceeding the carrying capacity of respective river basins. Other water-related issues reported are increased flooding, deteriorating water quality of water sources (rivers, lakes and reservoirs, and groundwater), growing conflicts among sectors, and emerging climate change impacts.

Malaysia has embarked on a National Transformation Program including the adoption of Green Technology on its road towards the achievement of Vision 2020. The Water Sector is an integral part of this mission and needs to move in tandem. The Water Sector Transformation Road Map comprises a wide array of strategic action plans anchored by a central Integrated Water Resources Management (IWRM) Implementation Road Map. A sustained water R&D program is a pivotal and essential prerequisite to ensure that the best of science, engineering, technology and innovation is harnessed for national good and advantage.

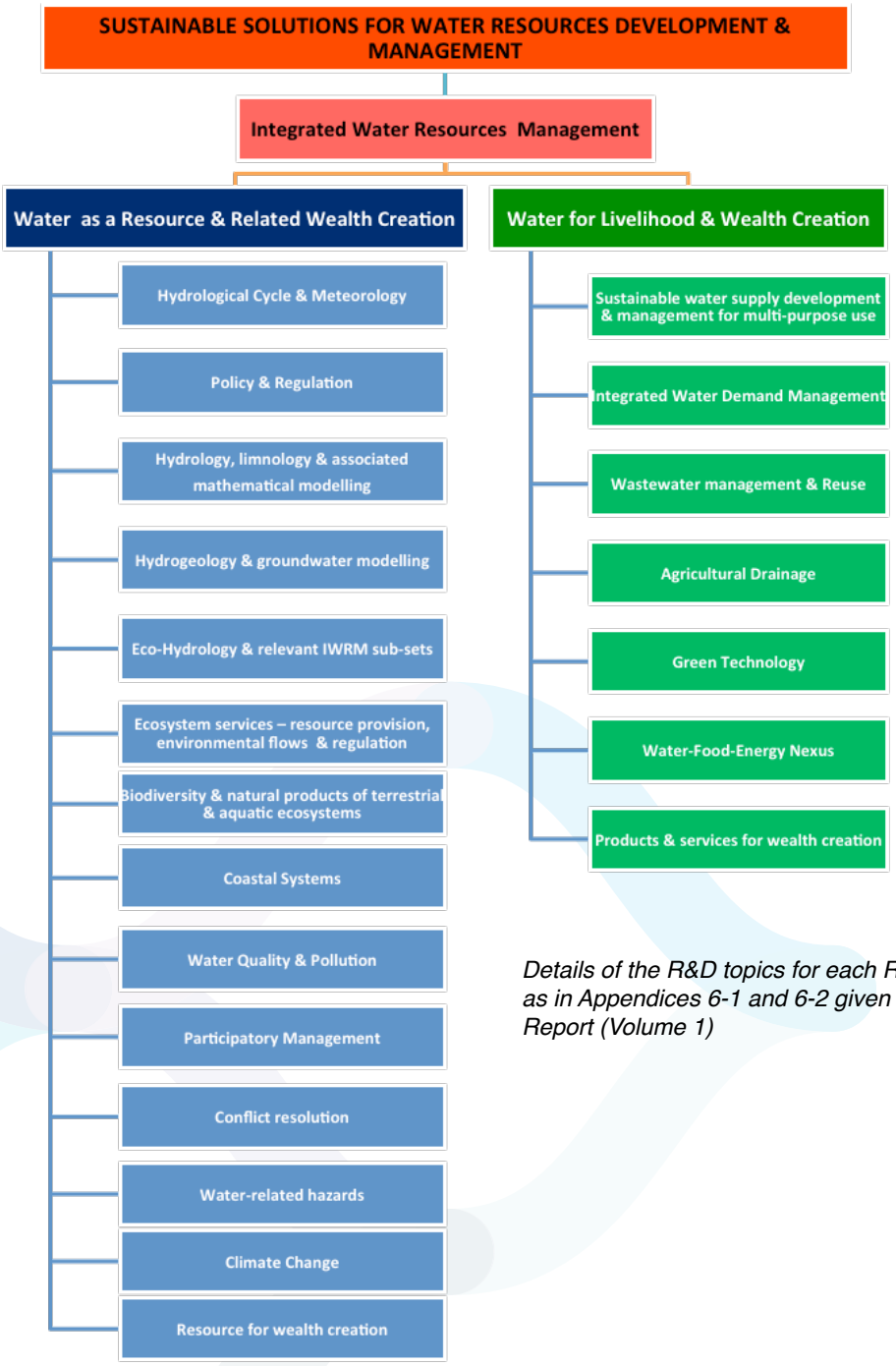
ASM recently commissioned and completed a study on the **Current Status of Malaysia's Water R&D and Research Needs Assessment (RNA)**. The study report provides a good account of where Malaysia stands with regard to water-related R&D and the inherent shortcomings especially concerning the absence of a national agenda for multi-disciplinary and integrated research, inadequacies in resource allocation and ineffective water research governance. The accompanying RNA document representative of wide water-related stakeholder consultations and containing their research needs until the year 2020 marks an important milestone to facilitate the charting of need based integrated water research.

ASM has pursued further to develop an integrated water research framework comprising strategic research themes that are designed to support the IWRM implementation road map aimed towards sustainable development and management of the country's water resources. The 97 research topics identified by the RNA have been realigned to conform to this integrated research framework. The resultant consolidated document, given below and in the main Advisory Report (**Appendix 6**), referred to as the **National Agenda for Integrated Water Research in Malaysia** is recommended for adoption by the relevant authorities, namely the NRE Ministry and NAHRIM. Upon adoption, it is recommended that it be widely disseminated and used as the central document that shall form the basis for all parties who wish to undertake water-related research and for disbursements of financial allocations by funding agencies.

Taking note of the shortcomings in the current water research governance structure, ASM recommends its immediate review by the NRE Ministry. ASM has offered two options for consideration, namely the preferred longer term establishment of a national **Water Research and Development Centre (WRDC)** proposed as a statutory body to act as a clearing house and one-stop centre to deal with all aspects of water R&D in the country. As an interim solution towards improved water research governance, it is recommended that a **Water Research Consortium (WRC)** be formed among the existing water-related public and private sector ROs, as well as research centres at the local universities; led by NAHRIM to facilitate coordinated water-related research to meet the multifaceted needs of the water sector in Malaysia.

In addressing the serious under-provision to-date by way of resource allocation (both human and financial) to undertake water-related research, and considering that implementation of the proposed national integrated water research represents a major undertaking, 'business as usual' is no longer an option. ASM recommends that the NRE Ministry together with NAHRIM in spear-heading the implementation of the national integrated water research agenda work closely with other related ministries and the central agencies to ensure **commensurate human and financial resources to include a launching grant of RM100 million** be allocated to the chosen overseeing research organisation to kick-start the Water Research Agenda.

NATIONAL AGENDA FOR INTEGRATED WATER RESEARCH IN MALAYSIA Appendix 6



Details of the R&D topics for each R&D theme are as in Appendices 6-1 and 6-2 given in this Advisory Report (Volume 1)

Acronyms

ASM	Academy of Sciences Malaysia
BCM	Billion Cubic Metres
FRGS	Fundamental Research Grant Scheme
FRI	Fisheries Research Institute
FRIM	Forestry Research Institute Malaysia
HTC KL	Humid Tropics Centre, Kuala Lumpur
ICWE	International Conference on Water and Environment
IUWRM	Integrated Urban Water Resources Management
IWK	Indah Water Consortium
IWRM	Integrated Water Resources Management
JBA	Water Supply Department
JPS	Drainage and Irrigation Department
KETTHA	Ministry of Energy, Green Technology and Water
KPKT	Ministry of Wellbeing, Housing and Local Government
LRGS	Long Term Grants Scheme
MASTIC	Malaysian Science and Technology Information Centre
MOA	Ministry of Agriculture & Agro-based Industry
MOE	Ministry of Education
MOH	Ministry of Health
MOSTI	Ministry of Science, Technology and Innovation
MOT	Ministry of Transportation
NAHRIM	National Hydraulics Research Institute, Malaysia

NGO	Non-Government Organisation
NRE Ministry	Ministry of Natural Resources and Environment
NWRC	National Water Resources Council
NWRP	National Water Resources Policy
NWRS	National Water Resources Study
PRGS	Prototype Research Grant Scheme
RNA	Research Needs Assessment
RO	Research Organisation
RU	Research University
SAJ	Syarikat Air Johor
SET	Science, Engineering and Technology
STI	Science, Technology and Innovation
SWRC	State Water Resources Council
SYABAS	Syarikat Bekalan Air Selangor
TRGS	Trans Disciplinary Research Grant Scheme (TRGS)
UKM	Universiti Kebangsaan Malaysia
UM	Universiti Malaya
UMS	Universiti Malaysia Sarawak
UMT	Universiti Malaysia Terengganu
UNIMAS	Universiti Malaysia Sabah
UNISZA	Universiti Sultan Zainal Abidin
UNITEN	Universiti Tenaga Nasional
UPM	Universiti Putra Malaysia
USM	Universiti Sains Malaysia
UTAR	Universiti Tunku Abdul Rahman
UTM	Universiti Teknologi Malaysia
UTP	Universiti Petronas Malaysia
WDM	Water Demand Management
WoS	Web of Science
WRC	Water Research Consortium
WRDC	Water Research and Development Centre

1. INTRODUCTION

Since the late 1990s, Malaysia is committed to implementing **Integrated Water Resources Management (IWRM)** for the sustainable management of the country's water resources. The National Water Resources Policy formally launched in March 2012 further reaffirms the adoption of IWRM which calls for the balanced development and management of "water as a resource" and "water for livelihood". Implementation of the IWRM agenda involves the integration of both natural and human systems set within an overall framework that provides the enabling environment with effective institutional arrangements and supported by necessary management instruments. Implementation of IWRM across all sub-sectors and levels of hierarchy are guided by the internationally endorsed 1992 ICWE Dublin Principles.

The Academy of Sciences Malaysia (ASM), an independent think-tank providing strategic advice to Government on Science, Technology and Innovation (STI) matters, has since 2008, been undertaking studies pertaining to the water sector, considered strategic for the country's economic development. The studies have been overseen by a dedicated ASM Water Committee. Adopting IWRM as the central thrust and noting that IWRM *per se* is a rather abstract concept, the Committee has for practical application in the Malaysian context, broken down IWRM into discrete subsets or sub themes. Each of these subsets or sub themes is then subjected to in-depth studies culminating in the preparation of a strategy plan or advisory report for consideration and adoption by the relevant authority or agency responsible for their implementation. The studies also undergo a process of strategic consultations with relevant institutional, community and private sector stakeholders.

One of the key studies undertaken by the Academy is this study entitled 'Setting a National Agenda for Integrated Water Research'.

2. MALAYSIAN WATER SCENARIO: AN OVERVIEW OF ISSUES & CHALLENGES

With the setting of a growing population (including the fairly large migrant population) and urbanisation in Malaysia, coupled with fast-paced economic development, has brought on increased water use in all subsectors with resultant pollution of this finite and renewable yet vulnerable resource. Inherently, the prevailing practice of fragmented management - a legacy from the past, has led to competition and conflicts in water use in certain river basins.

The **National Water Resources Study (NWRS)** commissioned by the Ministry of Natural Resources and Environment and completed in 2011 reported that Malaysia's annual rainfall is around 973 billion cubic metres (BCM), of which 414 BCM is lost to the atmosphere as evapotranspiration, surface runoff amounts to 496 BCM and some 63 BCM contributes towards groundwater recharge. Consumptive demand was assessed to be 14.8 BCM in 2010 and predicted to rise to 17.2 BCM in 2020 and to 18.2 BCM in 2050. With total effective rainfall estimated at around 74 BCM sets the available resource some 4 times above the projected need!

The NWRS highlighted some 'water-stressed' growth regions and states such as Perlis, Kedah, Pulau Pinang, Selangor and Melaka are reported to be as water deficit states. The temporal and spatial variability of rainfall, coupled with high population densities and/or extensive agricultural activities in these regions have led to water demands exceeding the carrying capacity of the respective river basins. The situation has been further exacerbated by resultant pollution affecting the ecology and the functional capacity of the aquatic ecosystems.

The NWRS also highlighted other water-related issues, namely increased flooding, deteriorating water quality of water sources (rivers, lakes and reservoirs, and groundwater), emerging Climate Change impacts, fragmented management and growing conflicts among sectors.

For a country that is on the road towards Vision 2020 it requires the support of a vibrant water sector, with a host of expectations, as listed below, and of which a strong and sustained water R&D programme is a vital component (see highlighted item in bold hereunder):

- The pivotal role of water in economic development and as an integral part of the water-food-energy nexus;
- Implementation of IWRM across all sub-sectors and levels of hierarchy;
- A well-structured and regulated water and sanitation industry providing quality, including efficient services and rationalised tariff settings with provisions for targeted subsidies;
- Green growth with low water footprint and care for the environment;
- Optimum use of the full range of water resources development options used singly or conjunctively including wise waste-water reuse, treated or otherwise;
- Improved agricultural water management to ensure 'more crop per drop';
- More Water Demand Management (WDM) than Supply Management in both potable and agricultural water usage;
- Integrated Urban Water Resources Management (IUWRM) to counter urbanization impacts and the 'twin dilemma of cities' (provision of safe, clean water and adequate sanitation);
- Disaster ready;
- Climate change prepared;
- **Application of state-of-the-art Science, Engineering, Technology and Innovations developed through continuing multi-disciplinary R&D programs;**
- Achievement of Sustainable Development Goals and Solutions post-2015; and
- Concerted Government support for a vibrant water sector, wealth creation and export of services.

3. CURRENT STATUS OF MALAYSIA'S WATER R&D AND NEEDS ASSESSMENT

Before attempting to chart a strategic direction for water R&D in Malaysia over the medium term to year 2020, ASM undertook a **Study on the Current Status and Needs Assessment for Water Resources Research in Malaysia**. The Study also took into consideration the longer term needs as contained in the earlier commissioned ASM Mega Science Framework Report on Water taken to the year 2050 which was completed in the year 2009. This Study on Water R&D commissioned in June 2012 was completed in May 2014. The objectives of the Study were three-fold, namely:

(i) to compile a complete inventory of past and on-going research on water and water-related topics, duly classified under distinct categories for ease of reference;
(ii) to assess water R&D research needs until the year 2020 of different ministries, departments, agencies, companies and public and private NGO sectors; and
(iii) to review the overall governance of R&D on water for greater effectiveness and efficiency including the need for the creation of centres of excellence in existing institutions or forming new ones to undertake specialized and integrated research on specific thematic areas.

A copy of the water R&D status report appears as **Volume 2**. The main findings and recommendations of the Study are summarised hereunder:'

3.1 Past and Current Water R&D

Analysis of the publications and grants related to water research showed the dominance of Research Universities (RUs), hence suggesting a bias towards established universities with significant critical mass of researchers. However, the total grant value awarded was abysmal, comprising, for example, only some 3% of the total grants awarded under the 8th Malaysia Plan. The research grant award trend showed that 83% are for fundamental research and 66% for Science and Engineering. Whereas, analysis of 3216 publications spanning1963 to 2012 identified 5277 unique authors from 814 institutions with publication themes mostly with a narrow and limited focus

centred on pollution and river related research. The research level is mostly fundamental and the interest of universities is reflected in their repeated themes in grant applications.

Based on funding information provided by Malaysian Science and Technology Information Centre (MASTIC) and Ministry of Education (MOE), the awarded grants mainly focused on the research theme categories (biodiversity, climate change, drainage, energy, pollution, water management and others), geomorphological classification of the water (coast, island, lake, rain, river, waste and undefined) and the type of research (science, technology and social). Analysis of the MOSTI grants data exhibited that Research Universities (RUs) received 56% of the research projects awarded in the last decade (from 2001 to 2011), with a total of 139 research projects.

Notably, the highest number of research grants related to water research were awarded in the 9th Malaysia Plan (2006-2010) by MOHE (now MOE) (159 projects) and MOSTI (88 projects). Moreover, the strength of any higher education institute could possibly be judged from the number of publications, which are being published by its researchers. In this study, a bibliometric analysis on past water research in Malaysia was conducted using data mined from Web of Science (WOS) and SCOPUS. The bibliometric analysis was performed via basic statistical approach such as citations distribution; publications growth, authors' and institutions' networks. The results were summarised in graphical visualisations to portray the complex bibliographic relationships, trends and patterns. In short, a total of 2516 publications were identified, with 489 from WOS and 2027 from SCOPUS. The publications period is from year 1964 to 2012. The report also presented the number of publications per institution and analysis of popular authors in different specific water R&D fields.

In addition, the Research Universities (RUs) showed good inter-institution and intra-institution collaboration when publishing their research. However, the results suggested weak inter-institutional collaborations among top authors in Malaysia. There is an unhealthy trend of excessive 'networking' that publishes medium to low impact papers, worsened with too many authors within an institution sharing the same publications. Apart from that, the water research community in Malaysia seems to be fragmented along institutional lines and dominant personality, as well as having research themes that lack multidisciplinary collaboration. The Study also concluded that the extremely limited allocation of research funds for water-themed research has intensified competition which has further exacerbated the situation within the existing research ecosystem.

Hence, the Study finds that past and current research on water in Malaysia has been largely ad-hoc, fragmented, and very often undertaken with a limited and narrow focus to meet academic interests. There is no clear direction in place to ensure the harnessing of science, technology and innovation (STI) to address the country's water management issues and challenges through integrated and coordinated multidisciplinary research underpinned by an overall R&D framework based on national needs and priorities.

3.2 R&D Needs from the Stakeholders' Perspective

The Study also undertook a Research Needs Assessment (RNA) for Water R&D until the year 2020; covering a broad spectrum of water resources research areas which span across topics on management, environment, policy, planning, supply, demand, storage, stakeholder engagement, hydrology, ecology, irrigation and drainage, water footprint, etc. Accordingly, the RNA undertaken through a process of stakeholder consultations which involved all water-related ministries, departments, agencies, private companies, and NGOs, was completed in over two phases, namely:

(i) Holding a strategic consultation workshop**(Appendix 1);** and
(ii) Conducting interviews with water experts. **(Appendix 2)**

Subsequently, through the above-mentioned 2-phase consultation processes, the Study team identified 97 R&D topics, and classified those under five categories as follows (**Appendix 3**):

1) Water Resources and Watershed Management;
2) Water Supply and Demand;
3) Irrigation and Drainage;
4) Sanitation, Wastewater Treatment & Environmental Issues; and

5) Water and Climate Change.

These topics have been proposed to enable the development of a national water research agenda based on needs over the medium term time horizon until the year 2020. The appropriation of adequate resources (both human and financial) has also been recommended to ensure the timely realisation of benefits to the country's water sector.

3.3 Current Water Research Funding

The Study also observed that administration of R&D funds is largely managed by the Ministry of Science, Technology and Innovation (MOSTI) and Ministry of Education (MOE).

The R&D funds related to MOSTI cluster focuses on research areas, namely Biotechnology, ICT, Industry, Sea to Space and S&T Core provided under 4 types of funds: (i) ScienceFund; (ii) TechnoFund; (iii) InnoFund; (iv) Flagship Program. However, Water R&D *per se* is not listed as a research priority area under these funds.

MOE also provides R&D funds under (i) Fundamental Research Grant Scheme (FRGS); (ii) Long Term Grants Scheme (LRGS); (iii) Prototype Research Grant Scheme (PRGS) and (iv) Trans Discipline Research Grant Scheme (TRGS). Nonetheless, Water R&D is not highlighted as significantly important by MOE for research projects provided under MOE grant schemes.

As the above-mentioned funds are disbursed by the government to academic institutions and various industrial players, the Study recommended that Water R&D be listed as one of the national research priority areas.

3.4 Current Water Research Governance

The Study, in reviewing the first and second national Science and Technology (S&T) Policies introduced respectively in 1986 and 2003, observed that water R&D is not highlighted as one of the specific focus area under these policies. The Study recommended that for the third S&T Policy, recently endorsed by the Cabinet, efforts be taken to ensure that Water R&D be accorded the high priority it deserved.

In reviewing the current institutional framework for the management of water-related research, the Study reported that there are three research organisations (RO) in the public sector and 4 private sector organisations that undertaken particular water-related research, albeit on a limited scale. In addition, there are some 20 research centres in local universities located across the country who also undertake water-related research, but largely to satisfy respective academic interests and needs. It was observed that each of these institutions work independently of each other. **Appendices 4 and 5** (adapted from Tables 7.2 and 7.3 of the status study report) provide a listing of these institutions and centres together with their respective focus areas.

It must be noted that the National Hydraulic Research Institute of Malaysia (NAHRIM) placed under the NRE Ministry is the only public sector RO dedicated to water research. Information on NAHRIM pertaining to its vision, mission, objectives and mandated functions as appearing the institute's web page is reproduced hereunder (see BOX in the following page). The functions stated are fairly extensive purportedly to cover most, if not all, water-related research. Unfortunately, NAHRIM has not been able to fully execute its mandated functions largely due to very limited human and financial resources. Although there have been certain need-based research and studies have been undertaken by NAHRIM in line with its role as an agency under NRE, but it is yet a far cry from what is required to deal with the issues and challenges pertaining to sustainable water management and development at the national scale.

A major revamp of the current institutional arrangements for managing integrated water research is urgently required and the Study recommended two probable options as follows:

a) Establishment of a national Water R&D Centre (WRDC) as a long term solution to act as a clearing house and one-stop centre to deal with all aspects of water R&D in the country. The proposed WRDC would be responsible for overseeing the implementation of the national water research agenda and providing timely responses to research requests and needs from all water-related stakeholders from both the public and private sector.

b) An interim solution for improved water research governance among existing water-related public and private sector ROs and the many water research centres based at local universities through the formation of a Water Research Consortium (WRC).The consortium would facilitate the coordination of water-related research to meet the multifaceted needs of the water sector in Malaysia. Therefore, the WRC will serve as a collaborative platform for the water research nexus with NAHRIM acting as its nucleus.

Information on NAHRIM

VISION
To be the premier hydraulic research centre for water and its environment in the world by 2030.

MISSION
To provide excellent services as an expert centre on water and its environment management to ensure sustainable growth in order to improve the quality of life and well-being.

OBJECTIVES:
- To be an excellent and main referral centre for water and it's environment;
- To be the national focal point to co-ordinate research activities in water and its environment; and
- To be the expert of consultancy service centre in development projects related to water and its environment.

FUNCTIONS:
NAHRIM started its operation in September 1995 to be the centre of excellence in hydraulic engineering research and supporting service, in meeting the demands from both public and private sector in the water related development. In line with its establishment objectives as indicated above and NAHRIM's functions, also written in the Ministerial Function Act 1969 (Ministers of the Federal Government (No.2) Order 2008), are as follows:

1. Conduct basic and applied research in hydraulic engineering, coastal engineering , water resources and water quality for public and private sector;
2. Experts/specialised consultancy services to public and private sectors;
3. Co-operate with local universities and institute in hydraulic engineering research;
4. Function as Government advisor on matters relating to hydraulics; and
5. To act as the National centre in hydraulic engineering research and become the coordinator of all research in the country.

Source : www.nahrim.gov.my

4. SETTING A NATIONAL AGENDA FOR INTEGRATED WATER RESEARCH

Malaysia has embarked on a National Transformation Program including the adoption of Green Technology on its road towards the achievement of Vision 2020. The Water Sector is an integral part of this mission and needs also to move in tandem. The Water Sector Transformation Road Map comprises a wide array of strategic action plans anchored by a central IWRM Implementation Road Map. A sustained water R&D program is a pivotal and essential prerequisite to ensure that the best of science, engineering, technology and innovation is harnessed for national good and advantage.

The recently-concluded ASM status report on water research and RNA **(Volume 2)** reviewed and discussed in the previous section 3 of this advisory report marks an important milestone in facilitating the development of a national agenda for integrated water research in the country:

- The current research status study component has clearly exposed serious weaknesses in the existing water research governance structure, gross inadequacies in resource allocation, but more importantly the lack of clear direction in undertaking integrated and multi-disciplinary research on a need basis to support the sustainable development and management of the water sector.
- The RNA conducted through a wide water stakeholder consultation process provides a sound basis to initiate a need based national water research program to be implemented.

4.1 Framework for Integrated Water Research

(i) Guiding Principles: Currently, there is no formal or informal framework/mechanism for identifying the nation's water R&D programs and projects from the standpoint of their relevance and priority setting against the larger goals and objectives of the country's sustainable water development and management agenda. The development of this water R&D framework must take into consideration the following aspects:

- Recognition of the attributes of the water resource: vital for living systems; renewable (hydrological cycle); vulnerable (solvency and pollution); pervasive flow characteristics (transboundary issues and impacts);
- R&D activities must aim at supporting the NWRP 2012. The policy statement spells out that "the security and sustainability of water resources to be made a national priority to ensure adequate and safe water for all, through sustainable use, conservation and effective management of water resources enabled by a mechanism of shared partnership involving all stakeholders";
- The water research effort should be aligned towards sustaining the water resource and towards wealth creation as envisaged in the ASM Mega Science Study on Water undertaken in the year 2009;
- Specific policy for water R&D to ensure the application of state-of-the-art technologies and tools;
- Integrated Water Resources Management (IWRM) is the central thrust for the sustainable management of the country's water resources. IWRM calls for the balanced management and development between "water as a resource' and "water for livelihood"
- The national water resources research effort should be coordinated to reduce duplication and to ensure that gaps in water research do not occur; and
- Research efforts should be multidisciplinary and interdisciplinary.

(ii) Research Philosophy and corresponding Research Themes:

The overall water research agenda needs to conform to an over-arching research philosophy that recognizes the complexity of water-related issues and challenges for which sustainable solutions require integrated approaches and inputs involving many SET disciplines. Each of these research philosophy concerns would require corresponding thematic research responses. **Table 1** below is a listing of pertinent research philosophy considerations against which the appropriate thematic research response(s) have also been identified:

TABLE 1. RESEARCH PHILOSOPHY AND RESEARCH THEMES FOR WATER

Research philosophy	Research theme
1. Greater understanding of the basic processes related to: a. Resource renewability b. Resource Vulnerability c. Environmental systems at various basin scales d. Transboundary issues and linkages	1. Hydrological Cycle and Meteorology 2. Water Quality &Pollution 3. Water-related hazards 4. Climate Change 5. Ecosystem services – resource provision, environmental flows and regulation 6. Coastal Systems 7. Water-Food-Energy Nexus
2. The development and use of state-of-the-art technologies and analytical models for surface water (lentic and lotic systems) and groundwater resource assessment and monitoring	8. Hydrology, limnology and associated mathematical modelling 9. Hydrogeology and groundwater modelling
3. Measurement of structural and functional attributes of aquatic and related ecosystems and their biodiversity	10. Biodiversity and natural products of terrestrial and aquatic ecosystems
4. Demand driven research for evidenced-based policies and solutions	11. Policy & Regulation 12. Conflict resolution
5. Sustainable water resource management at different basin scales including the adoption of eco-system approaches and solutions	13. Eco-Hydrology and relevant IWRM subsets 14. Participatory Management
6. Sustainable water resource utilisation, conservation, rehabilitation and reuse	15. Sustainable water supply development and management for multi-purpose use 16. Integrated Water Demand Management 17. Wastewater management and Reuse 18. Agricultural Drainage 19. Green Technology
7. Wealth Creation	20. Product and Services for wealth creation 21. Resource for wealth creation

(iii) Malaysia's Sustainable Water Resources Development and Management Agenda:

Since the turn of the 21st century, Malaysia has adopted **Integrated Water Resources Management** (IWRM) as the way forward towards sustainable development and management of the country's water resources. Indeed, this is a clear breakaway from fragmented and sectoral practices of the past. The NWRP 2012 had also formally endorsed IWRM. The underlying principles and philosophy behind the migration away from the sectoral or use approach to the more contemporary IWRM approach is best illustrated by **Figure 1 and Figure 2**, as shown below:

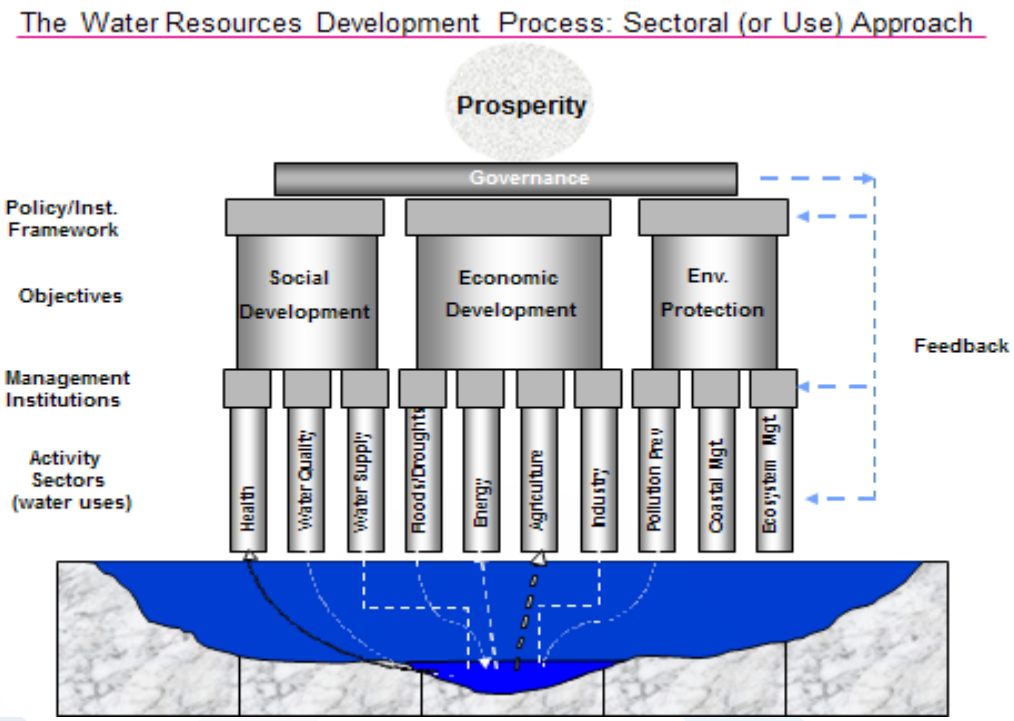


Figure 1: Sectoral Approach of Water Resources Development.

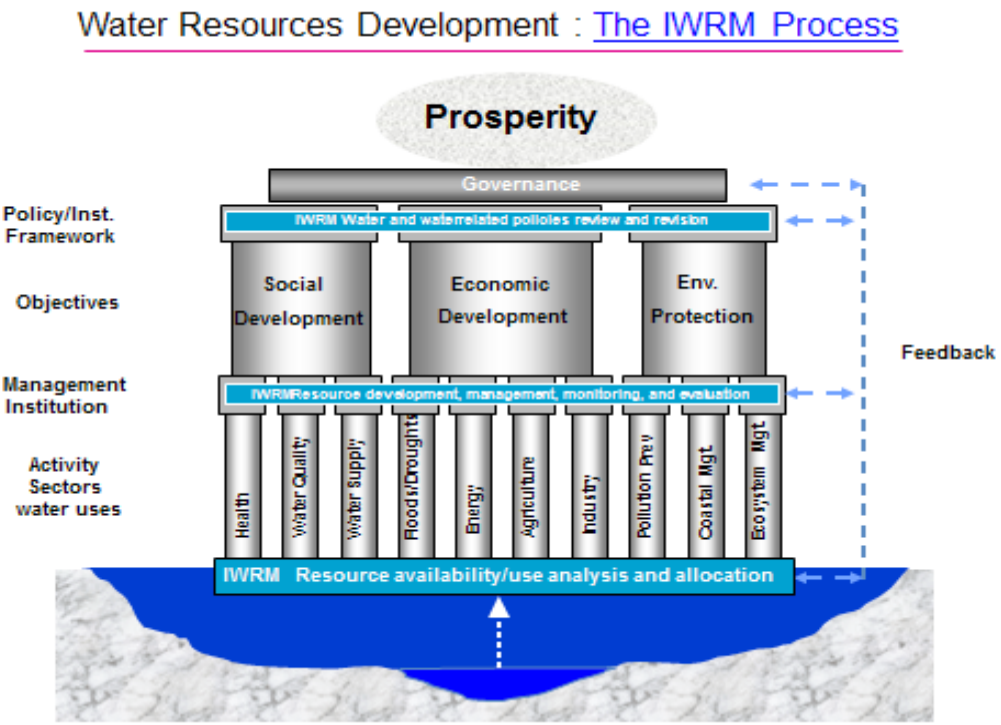


Figure 2. Integrated Water Resources Management Process.

The IWRM implementation model essentially calls for balanced development between 'water as a resource' and 'water for livelihood'. In the Malaysian case, this is again depicted in **Figure 3** below showing the institutional framework where water resource management organisations at the Federal and State levels are placed on one side of the 'IWRM Balance', whilst water users and utility provider agencies are placed on the other, clearly emphasising the need for separation of powers and to ensure no conflict of interest.

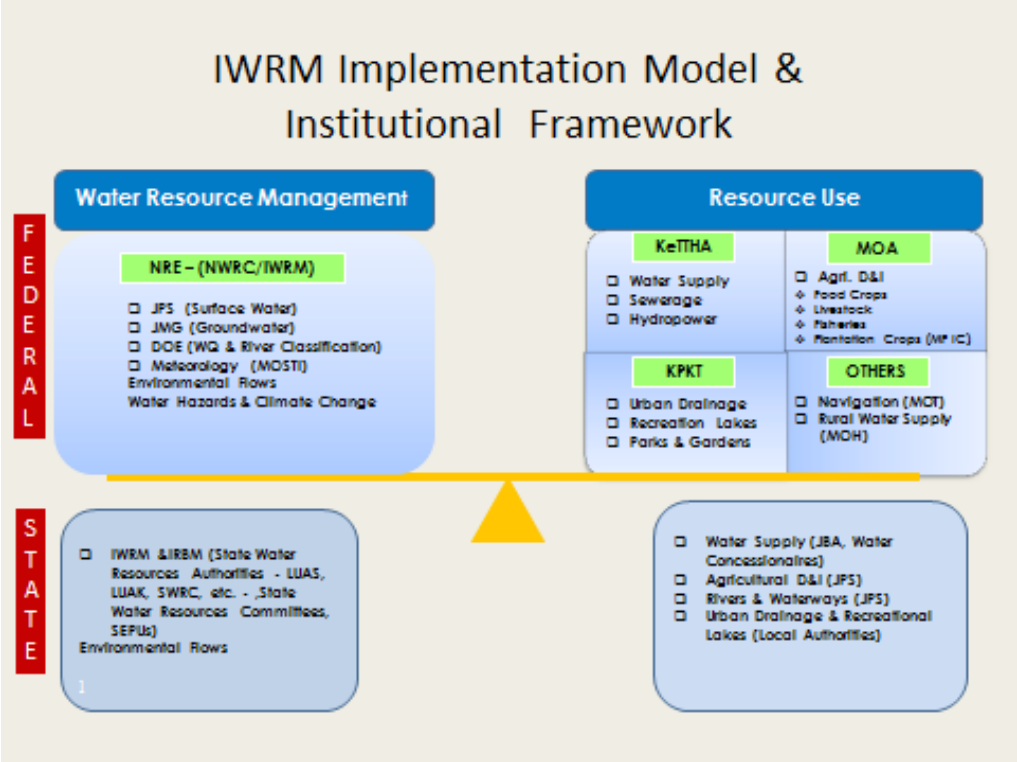


Figure 3: IWRM Model for a Balanced Development between 'Water as a Resource and Water for Livelihood'.

The ASM Mega Science Study on Water, completed in 2009, had recommended that over the longer term that 'water as a resource', as well as in the form of products and services, to also be considered for purpose of 'wealth creation'.

Merging the IWRM balanced development objectives and the longer term wealth creation goals, what arises are essentially two (2) discrete objectives, namely,

(i) Water as a resource and related wealth creation; and
(ii) Water for livelihood & wealth creation.

Consequently, any associated water R&D program or research framework would need to be aligned to support the above stated objectives.

(iv) Integrated Water Research Framework

The main goal of the Integrated Water Research Framework is to provide ***sustainable solutions*** in support of Malaysia's water resources development and management plans pursued along essentially two discrete objectives, namely, 'water as a resource and related wealth creation', and 'water for livelihood & wealth creation'. Research undertaken shall be ***interdisciplinary,*** with the ***application of the best science, engineering, technology and innovation.*** Integrated research shall follow ***21 research themes*** as identified under section 4.1.ii above, and reclassified against two (2) development objectives, as shown hereunder:

TABLE 2: RESEARCH THEMES UNDER WATER AS A RESOURCE AND WATER FOR LIVELIHOOD OBJECTIVES

Research theme	
Water as a Resource &related Wealth Creation	**Water for Livelihood & Wealth Creation**
1. Hydrological Cycle and Meteorology 2. Policy & Regulation 3. Hydrology, limnology and associated mathematical modelling 4. Hydrogeology and groundwater modelling 5. Eco-Hydrology and relevant IWRM subsets 6. Ecosystem services – resource provision, environmental flows and regulation 7. Biodiversity and natural products of terrestrial and aquatic ecosystems 8. Coastal Systems 9. Water Quality & Pollution 10. Participatory Management 11. Conflict resolution 12. Water-related hazards 13. Climate Change 14. Resource for wealth creation	15. Sustainable water supply development and management for multi-purpose use 16. Integrated Water Demand Management 17. Wastewater management and Reuse 18. Agricultural Drainage 19. Green Technology 20. Water-Food-Energy Nexus 21. Products and services for wealth creation

Earlier on, under section 3.b) of this advisory report, reference was made to the recently-completed ASM-commissioned study which included a Research Needs Assessment (RNA) for Water R&D until the year 2020, which was undertaken through wide stakeholder consultations and interviews with water experts. The RNA had listed 97 research topics (**Appendix 3**), that were classified under five categories as follows:

1. Water Resources and Watershed Management;
2. Water Supply and Demand;
3. Irrigation and Drainage;
4. Sanitation, Wastewater Treatment & Environmental Issues; and
5. Water and Climate Change.

With the formulation now of an integrated water research framework, the 97 research topics (now 96 topics as the 2 identical research topics entitled "Policy and Legislative Instruments" appearing under Appendix 3's Section 1 and Section 4 respectively have been combined and listed under the "Research Theme" entitled "Policy and Regulations") identified by the RNA has now been reorganised and slotted against the 21 research themes based on their relevance. As a result, what has emerged is a consolidated list (**Appendices 6, 6-1 and 6-2**) and need-based water research agenda nested within a strategically structured integrated water research framework to support the country's sustainable water resources development and management plans over the medium and long term. Needless to say, both the research themes and research topics are subject to periodic review.

5. PROPOSED WATER RESEARCH GOVERNANCE

Based on the earlier ASM Status Study report (**Volume 2**), Section 3.d) herein, it had highlighted serious weaknesses present in the existing water research governance structure (currently vested with NRE and NAHRIM), thereby recommending a revamp to ensure greater efficiency and effectiveness for timely delivery of water research solutions. Pertinently, the need is all the more urgent now with the formulation of an integrated national water research agenda and consolidated list of research themes and topics (**Appendices 6, 6-1 and 6-2**) presented in section 4 above.

5.1 Proposed Water R&D Centre (WRDC):

Over the long term, it is recommended that a national Water R&D Centre (WRDC) be established to act as a clearing house and one-stop centre to deal with all aspects of water R&D in the country. The proposed WRDC would be responsible for overseeing the implementation of the national water research agenda and provide timely responses to research requests and needs from all water-related stakeholders from both the public and private sector.

By dealing with many water-related ministries and the private sector, the WRDC then should be able to maintain a high degree of autonomy. And hence, is best created as a statutory body with supporting legislation on similar lines as other existing commodity-related ROs such as RRI and PORIM. The overseeing Board would comprise representatives from key stakeholders from the public and private sectors as well as from academic institutions — people who best understand water problems in varying focus areas. The proposed WRDC would ensure that there is an adequate balance among disciplinary, multidisciplinary, and interdisciplinary water research. The WRDC would maintain a centralised system for setting water research priorities. A multifaceted, demand-based, and appropriately prioritised research program would facilitate and provide the necessary assurances and accountability for securing much-needed human and financial resources. Current water research funding is fragmented coming from many sources to the extent that the earlier Study was unable to assess the precise cumulative total annual funding and instead could furnish only estimates in the status report. One of the first tasks of the WRDC would be to take stock of current level of funding, consolidate them, and seek additional funds as needed for the overall water R&D program.

A suggested mandate for the proposed WRDC is as follows:

- Promoting coordination, cooperation and communication in the area of water research and development;
- Establishing water research needs and priorities;
- Providing sustainable solutions to water research requests & needs;
- Stimulating and funding water research according to priority;

- Promoting effective transfer of information and technology; and
- Enhancing knowledge and capacity-building within the water sector.

Indeed, the proposed WRDC should aim to provide a world-class integrated applied research platform for innovative and sustainable solutions to the water fraternity within Malaysia and internationally, bringing together multiple disciplines within the same cluster, which includes Research Organisations & the Academia, as well as the Government, Industry and Civil Society. Networking and collaboration should be pursued with premier global water research centres with a view of seeking holistic solutions that would accelerate knowledge transfer across different domains: from research to industry and from global centres to Malaysia.

5.2 Interim Solution – Water Research Consortium (WRC)

It is noted that the National Hydraulic Research Institute of Malaysia (NAHRIM), placed under the NRE Ministry, is the only public sector research organisations (RO) dedicated to water research with its vision, mission, objectives and mandated functions being fairly extensive to cover most, if not all, water-related research. Unfortunately, NAHRIM has not been able to fully execute its mandated functions largely due to limited human and financial resources. Certain need-based research and studies that have been undertaken by NAHRIM in line with its role as an agency under NRE are yet a far cry from what is required in dealing with the issues and challenges pertaining to sustainable water management and development at the national scale.

Apart from NAHRIM, the Study reported that there are two other ROs in the public sector and 4 private sector organisations that undertake some water-related research, albeit on a limited scale. There are also some 20 research centres in local universities located across the country who also undertake water-related research largely to satisfy respective academic interests and needs. **Appendices 4 and 5** (adapted from Tables 7.2 and 7.3 of the status study report) provide a listing of these institutions and centres together with their respective focus areas.

Pending the establishment of the WRDC recommended under section 5.1 above, and as an interim solution towards improved water research governance, it is recommended that a **Water Research Consortium (WRC)** be formed among the many existing water-related public and private sector ROs and research centres at the local universities to facilitate the coordination of water-related research to meet the multifaceted needs of the water sector in Malaysia.

Moreover, the formation of the Water Research Consortium will serve as a collaborative platform for the water research nexus with NAHRIM, acting as its nucleus. NAHRIM would have the main responsibility to be the clearing house and to oversee the management and coordination of all need based water research conducted jointly among the various academic institutions and research organisations. The proposed WRC to be headed by NAHRIM as recommended by the ASM Study is shown in the Figure 4 below:

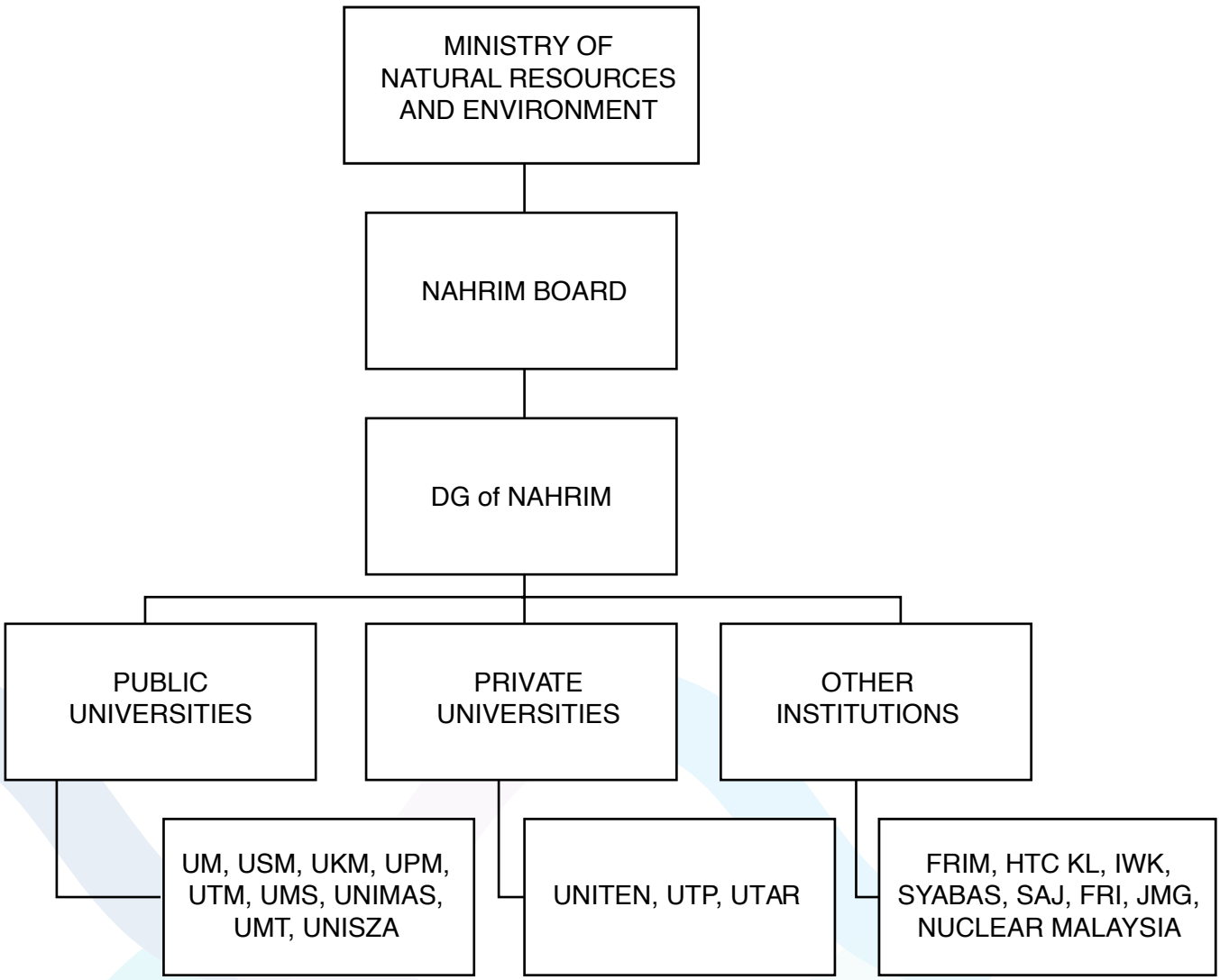


Figure 4. Proposed water research consortium.

The suggested objectives for the WRC are as follows:

1. To strengthen the existing structure of water research institutes and organisations;
2. To manage and coordinate multi-disciplinary water-related research among academic institutions, public and private sector ROs and NGOs;
3. To source, consolidate, allocate and manage research funding for water-related research and studies according to listed priorities;
4. To conduct periodically research needs assessment among water-related stakeholders;
5. To develop a Decision-Support-System as well as new tools through undertaking innovative modelling research; and
6. To act as a Repository and central database of all WRC-funded water research reports.

The task of implementing the need-based integrated water research agenda, developed under section 4 above, will fall on the Water Research Consortium.

The interim WRC option for improved water research governance can be implemented with immediate effect simply through an administrative order or instruction to enable the proposed integrated water research agenda to get a head start while awaiting the migration to the more effective and preferred WRDC option which may require some time to obtain the necessary clearances prior to being instituted as a statutory body.

6. RESOURCE ALLOCATION

As reported earlier, in section 3. c), research funding for water R&D has been very limited and scattered, which comprises:

a) Funds allocated to NAHRIM, the foremost public sector RO, are entirely devoted to water research under the NRE Ministry.
b) MOSTI R&D allocation under 4 types of funds: (i) Science Fund; (ii) Techno Fund; (iii) InnoFund; (iv) Flagship Program and confined to prescribed research priority areas (RPA). Water R&D *per se* is not listed as an RPA.
c) MOE R&D funds under (i) Fundamental Research Grant Scheme (FRGS); (ii) Long Term Grants Scheme (LRGS); (iii) Prototype Research Grant Scheme (PRGS) and (iv) Trans Disciplinary Research Grant Scheme (TRGS). Water R&D is not highlighted as being significantly important under these MOE grant schemes.

Against the mandate for holistic water research that has been entrusted to NAHRIM, the agency has hitherto not been able to perform to expectations mainly due to under-provision of its human resource capacity clearly reflected in the agency's rather lean organisational structure and limited specialised expertise. In addition, annual budgetary allocations have also largely been restricted over the past, and the agency in adapting to these constraints had confined its need-based research activities to only a few selected areas in the attempt to obtain the best return for the ringgit disbursed.
Conversely, the Study also observed that R&D funds disbursed by MOSTI and MOE for water-related research to research centres and individual researchers from the academia, which have been mainly on low impact serving academic interests rather than on meeting the national water-related stakeholders' needs and priorities.

7. RECOMMENDATIONS – MOVING FORWARD

In the absence of demand-driven research programme, ineffective research governance and the serious under-provision of resource allocation (both human and financial) to undertake water-related research, ASM recommends that the following actions be considered for implementation by the Government:

7.1 Adoption and Dissemination of the National Integrated Water Research (NIWR) Agenda

The 96 research topics identified by the earlier RNA have been realigned and listed to conform to a strategically designed integrated water research framework. The consolidated document (**Appendices 6, 6-1 and 6-2**) referred to as the **National Agenda for Integrated Water Research in Malaysia** is recommended for adoption by the authority concerned, namely the NRE Ministry and NAHRIM.

Upon its adoption, it is recommended that the national integrated water research agenda (that is, **Appendices 6, 6-1 and 6-2**) based on research needs until the year 2020 be widely disseminated and to be used as the central document that shall form the basis now for all parties who wish to undertake water-related research and for finance allocation by funding agencies.

7.2 Water Research Governance Options

Considering the shortcomings in the current water research governance, its immediate review is recommended to be undertaken by the NRE Ministry. Two options are offered for consideration, namely, the preferred longer term establishment of a national **Water Research and Development Centre (WRDC)** proposed as a statutory body to act as a clearing house and one-stop centre to deal with all aspects of water R&D in the country. As an interim solution towards improved water research governance, it is recommended that a **Water Research Consortium (WRC)** be formed among the existing water-related public and private sector ROs and research centres at the local universities, and led by NAHRIM to facilitate coordinated water-related research to meet the multifaceted needs of the water sector in Malaysia.

7.3 Provision of adequate Human and Financial Resource (Launching Grant)

The implementation of the proposed research agenda is a major undertaking involving concerted and parallel multi-disciplinary thematic research efforts along many fronts. Indeed, 'Business as usual' is no longer an option. Most importantly, it requires the strengthening of implementation capacity through deployment of adequate human resources in specialised areas and the appropriation of adequate funding to implement the multifaceted research programs and initiatives. It is therefore recommended that the NRE Ministry together with NAHRIM, in spearheading the implementation of the national integrated water research agenda, work closely with other related ministries and the central agencies to ensure **commensurate human and financial resources, including a launching grant of RM100 million** be allocated to the chosen overseeing research organisation (WRDC or WRC) to kick-start the Water Research Agenda. The breakdown of the grant according to the 21 research themes is as provided in **Appendix 7**.

7.4 Implementation of the NIWR Agenda

Going by the Ministerial Functions Schedule reinforced further by the launching of the NWRP in 2012, the NRE Ministry must be acknowledged as the custodian ministry for the country's water resources. Hence, it would be incumbent for the NRE Ministry, together with NAHRIM, to spearhead the implementation of the national integrated water research agenda, and work closely with other related ministries and the central agencies to ensure adequate human resources and funding are made available.

8. CONCLUSION

The ASM-led status study report (**Volume 2**) on the current status of Malaysia's water R&D and Research Needs Assessment (RNA) is a good reference document to understand where the country stands with regard to water-related research and the inherent weaknesses not only with regard to setting an agenda for multi-disciplinary research but also regarding related resource allocation and governance matters. Remarkably, the accompanying RNA document involving wide stakeholder consultations and containing their research needs until the year 2020 marks an important milestone for the charting of a need-based national integrated water research agenda.

In reviewing the Study Report, ASM, through this Advisory Report, has ventured further to develop and recommend an appropriate integrated water research framework comprising strategic research themes and need-based research topics that are designed to support the IWRM implementation road map towards sustainable development and management of the country's water resources. Apart from that, it is also recommended that a major revamp be initiated on the current water research governance structure, the deployment and provision of adequate human as well as financial resources, which includes a launching grant to kick-start the proposed integrated water research programme.

Appendix 1

List of Attendees at Strategic Consultation 1 on Water Research and Development NAHRIM – 26th March 2014

No.	Name	Institution
1.	Mr. Affan Nasaruddin	Research Assistant University of Malaya
2.	Tn Hj Akashah Hj Majizat	Perbadanan Putrajaya
3.	Mr Alizan	ISIS Malaysia
4.	Mr. Anthony Tan	Executive Director Centre for Environment, Technology & Development, Malaysia (CETDEM)
5.	Tn Hj Ayob Abd Hamid	Deputy Director Mechanization & Automation Research Centre, Institut Penyelidikan dan Kemajuan Pertanian Malaysia
6.	Dr Chan Chee Sheng	Principle Research Officer Mechanization & Automation Research Centre, Institut Penyelidikan dan Kemajuan Pertanian Malaysia
7.	Mr Gopinath Nagarajah	-
8.	Ir. Hor Tek Lip	Lembaga Kemajuan Pertanian Muda (MADA)
9.	Assoc. Prof. Dr. Ir. Marlinda Bt. Abdul Malek	Head of Climate Change (Adaptation), Universiti Tenaga Nasional
10.	Dr Mohamed Hasnain Isa	Universiti Teknologi PETRONAS
11.	Dato Ir Dr Mohd Akbar Johari	-
12.	Prof Dr Nik Meriam Nik Sulaiman	Chemical Engineering Dept. Dean, Research Cluster on Sustainability Science University of Malaya
13.	Nurliyana Abdul Rahaman	Perbadanan Putrajaya
14.	Pn. Soraya Mohd Yusoff	Jabatan Laut Malaysia
15.	Ms Wan Portia Hamzah	Senior Fellow ISIS Malaysia
16.	Mr Wong Chee Ching	Ketua Penolong Setiausaha (D), Ministry of Natural Resources and Environment
17.	Ir Zakaria Mohd Yasin	IWK
18.	Mr Lim Pek Boon	IWK

19.	Alijah Mohd Aris	IWK
20.	Prof Dr Zulkifli bin Yusop	UTM
21.	PM Dr. Mohd Shahir Shamsir	UTM
22.	PM Dr. Azmi Aris	UTM
23.	Dr Noorul Hassan Zardari	UTM
24.	Dr Yong Ee Ling	UTM
25.	PM Dr. Zainura Zainon Noor	UTM
26.	Nurfarhain Mohamed Rusli	UTM
27.	Hj Jabir Kardi	JPS Hidrologi Ampang
28.	Ahmad Shahrir bin Md. Naziri	Bah. Sumber Air, Saliran & Hidrologi, Kementerian Sumber Asli & Alam Sekitar
29.	Mohd Akbar Johari	MWA
30.	Prof Dr Mohd Razman bin Salim	UTM
31.	Lloyd Ling	UTM
32.	Dr Pan Khang Aun	WWE – Malaysia
33.	Ismail Tawnie	NAHRIM
34.	Ir. Wan Mohd Zamri	Air Kelantan
35.	Nurul Huda Md Adnan	NAHRIM
36.	Siti Nurshima Mohd Soffee	SPAN
37.	Ranjeni A/P Krishnen	UTM
38.	Nor Ai'han Mujar	UTM
39.	Nor 'Asikin Roslan	UTM
40.	Syakila Mohd Alif	UTM
41.	Mohd. Rodzi	NAHRIM
42.	Dr Zati Sharip	NAHRIM
43.	Rasyikah Khalid	UKM
44.	Ang Shin Ying	NAHRIM
45.	Zubaidi Johar	NAHRIM
46.	Hazlinda Balkesh Annuar	Kem. Perusahaan Perladangan dan Komoditi (MPIC)
47.	Meera Munusamy	NAHRIM

48.	Hoo Huey Ching	NAHRIM
49.	Ahmad Rajiun Abu Bakar	KeTTHA
50.	Gordon A. Fernandez	SYABAS

Appendix 2

List of Water Experts Interviewed

1.	DOE Malaysia YM Tengku Bakry Syah B. Tengku Johan Director of Water & Marine Division
2.	SAJ En. Mohd Zin Othman General Manager of SAJ
3.	IWK Ir Mohamed Haniffa Hj Abdul Hamid Chief Operating Officer
4.	UTM Prof Dr Mohd Razman Salim Researcher and Dep Director Institute of Environmental and Water Resource Management
5.	UTM Prof Dr Abdull Rahim bin Mohd Yusoff Director of Institute of Environmental and Water Resource Management
6.	UTM Prof Dr Maketab Mohamed Researcher & Presiden Persatuan Pencinta Alam Malaysia
7.	UPM Prof Dr Mohd Kamil bin Yusof Researcher
8.	JPS Dato' Hanapi bin Mohamad Noor Director Division Water Resources & Hydrology
9.	SPAN Chow Kin Liung Director of Research, Development & Innovations Divisions
10.	SMHB Dato' Ir Syed Muhammad Shahabudin Chairman of SMHB
11.	EPU YBhg Datuk Nor Azmal bin Mohd Nazir Director Infrastructure and Utilities

Appendix 3

List of 97 R&D Topics

Section I: Water Resources & Watershed Management

Surface water hydrology

1. Rural hydrology
2. Urban hydrology
3. Erosion and sedimentation
4. Flood management and mitigation
5. Ecohydrology
6. Groundwater hydrology
7. Environmental water requirements
8. River morphology
9. River rehabilitation
10. Environmental and indigenous people related issues
11. Electromechanical equipment
12. Advanced dam technology
13. Risk assessment
14. Dam modelling construction
15. Hydrometeorology
16. Climate change and hydrologic cycle
17. Climate change and rainfall modelling
18. Terrestrial atmospheric pollution and water quality
19. Water resource assessment and accounting
20. Alternative water resources (ground water, rain water harvesting, etc.)
21. Catchment/river basin management
22. Storm water management
23. Integrated water resource management
24. Conservation and preservation of water resources
25. Impacts of climate change, increased population and changing human demographics on watersheds
26. Public participation in watershed management
27. Social and environmental costs of watershed degradation
28. Sustainable and integrated watershed management
29. Policy and legislative issues
30. Eutrophication
31. Fresh water ecology
32. Impacts of climate variability on wetlands ecosystem
33. Wetland modelling
34. Wetlands and lakes restoration
35. Integrated coastal zone management
36. Coastal erosions
37. Coastal habitat management
38. Coastal ecology
39. Protected conservation areas in marine environment
40. Seawater and sediment chemistry
41. Marine pollution
42. Marine ecology
43. Marine biodiversity, conservation and management

Section 2: Water Supply and Demand

1. Water-use efficiency
2. Water supply and demand for industry
3. Water supply and demand for livestock and agriculture
4. Sustainable water supply management in rural areas
5. Balancing water supply versus demand
6. Water footprint
7. Assessment of freshwater withdrawal
8. Water demand projection and forecasting
9. Consumer and corporate water footprint assessment
10. Assessment of water use and availability
11. Water quality modelling
12. Drinking water quality standards
13. Ground water quality
14. Advanced water treatment process
15. Water quality Information management and modelling
16. Technologies for controlling and monitoring non-point source pollution
17. Drinking water quality versus public health

Section 3: Irrigation and Drainage

1. Improved and innovative irrigation technology (for water use reduction)
2. Quality waters and wastewater reuse for irrigation
3. Impacts of irrigation on environmental and health
4. Micro drainage system for small scale farming
5. Rainwater harvesting for irrigation purpose
6. Drainage, water logging and salinity control
7. Environmental effects of nutrients carried in drainage discharge
8. Development of best drainage design and practices that enable crops to use shallow groundwater efficiently, while reducing the use of agricultural chemicals and reduce flood flow
9. Drainage, and water-logging and salinity control
10. Drainage for ecosystem and conservation

Section 4: Sanitation, Wastewater Treatment and Environmental Issues

1. Water and sanitation hygiene in rural areas
2. Environmental and social impacts
3. Decentralised sanitation system
4. Integrated urban water management
5. Alternative unconventional urban sanitation systems
6. Low carbon and energy efficient treatment system
7. Nutrients removal and management
8. Phytoremediation/Bioremediation technology
9. Zero discharge technology
10. Advanced and innovative technology for industrial wastewater treatment
11. Public awareness and participation in water resources conservation
12. Policy and legislative instruments
13. Salt/sea water intrusion
14. Waterborne pathogens and microbial risks
15. Environmental impacts assessment of effluent discharge to environment
16. Technologies for monitoring, controlling and removing diffuse and point source pollution
17. Newly emerging water pollutants

Section 5: Water and Climate Change

1. Climate change and aquatic invasive species
2. Modelling climate-related water resource stressors
3. Water security challenges and mitigation measures
4. The adaptation of urban water supply to climate change
5. Environmental flow versus climate change issue
6. Policy and legislative instruments
7. Energy and water efficient cities/township
8. Water-energy-food nexus
9. Carbon footprint of water and wastewater treatment system

Appendix 4

Universities' Water R&D Centres/Institutes

No.	Universities	Research Centre	Year Established	Focus Area
1.	**Universiti Malaya**	Water Research Centre	-	• Industrial wastewater treatment technology • River basin management river modelling and hydrology • River and marine water quality • Standards and criteria development, • Social and economic impacts of water pollution.
2.	**Universiti Sains Malaysia**	River Engineering and Urban Drainage Research Centre (REDAC)	2001	• River management • Urban Drainage Management • Environmental Hydraulics Management • Hydro informatics
3	**Universiti Sains Malaysia**	Centre for Marine and Coastal Studies (CEMACS)	1991	• Mangrove ecosystems • Marine pollution and toxicology • Mariculture • Coral reef ecosystem • Integrated coastal zone management • Marine sciences • Biodiversity conservation
4.	**Universiti Kebangsaan Malaysia**	Institute for Environment and Development (LESTARI)	1994	Comprises 4 Research Centres: • Research Centre for Sustainability Science and Governance • Research Centre for Environmental, Economic and Social Sustainability (KASES) • Langkawi Research Centre (PPL) • Research on natural Southeast Asia Disaster Prevention Research Initiative (SEADPRI) Core Groups: • Geological Heritage of Malaysia • Water, forests and natural resources • Liveable cities and landscape ecology • Socio-economic • Chemical management • Ecosystem change and adaptation • National tropical rock engineering research group

5.	**Universiti Kebangsaan Malaysia**	Institute for Climate Change Studies (IKP)	2011	Research Cluster: 1. Tropical Climate Change: • Atmosphere, sea and Climate • Ecosystem response and climate change • Data mining and mathematical modelling of climate change 2. Impact and Adaptation of Climate Change: • Liveability and climate change • Climate change and adaptation
6.	**Universiti Putra Malaysia**	Tropical Forest Ecosystem Science Research Centre	2008	• Plant ecology and conservation • Soil Science • Wildlife ecology and conservation • Economics of biodiversity conservation • Water quality • Social science • Biotechnology and ecosystem • Terrestrial and aquatic flora and fauna
7.	**Universiti Putra Malaysia**	Smart Farming Technology Research Centre	2012	• Precision farming engineering • Agricultural automation & robotics • Irrigation and drainage engineering
8.	**Universiti Teknologi Malaysia**	Coastal and Offshore Engineering Institute (COEI)	1990	• Coastal and offshore engineering • Hydraulic and coastal designs • Offshore and coastal hydraulics • River and urban hydraulics
9.	**Universiti Teknologi Malaysia**	Institutes of Environmental & Water Resource Management (IPASA)	1994	• Environmental chemistry • Eco-hydrology • Water & wastewater treatment • Green technology • Climate change impact • Waste recovery • Impact and restoration of water bodies • Integrated water resources management
10.	**Universiti Malaysia Sarawak**	Centre for Water Research (CWR)	2006	• Engineering hydrology • Wastewater management • Integrated water resource management • Natural aquatic environments

11.	**Universiti Malaysia Sabah**	Borneo Marine Research Institute	1995	• Aquaculture and marine science • Marine biodiversity • Coastal oceanography • Marine aquaculture, • Marine biotechnology
12	**Universiti Malaysia Sabah**	Water Research Unit	2010	• Environmental • Managerial • Economic and social
13.	**Universiti Malaysia Terengganu**	Institute of Oceanography and Environment	2001	• Physical & geological oceanography • Biological oceanography & biodiversity • Geochemistry & marine pollution • Satellite oceanography & marine informatics
14.	**Universiti Malaysia Terengganu**	Institut Akuakultur Tropika (AKUATROP)	1979	• Economics & post-harvest technology • Aquatic animal health • Fish nutrition • Breeding technology • Aquaculture biotechnology • Aquaculture engineering
15.	**Universiti Malaysia Terengganu**	Institut Bioteknologi Marin	2004	• Marine biotechnology • Genomic, agriculture, and Nutraceutical/pharmaceutical • Biotechnology
16.	**Universiti Sultan Zainal Abidin**	East Coast Enviromental Research Institute (ESERI)	2013	• Quality Engineering and Modelling • Forensic science environment • Risk assessment and environmental health • Environment and resources • Smart forensic laboratory
17.	**UNITEN**	Centre for Sustainable Technology and Environment	-	• Sustainable Urban Drainage Systems (SUDS) • Urban water system • Rain water harvesting, • Eco-hydrology • River rehabilitation
18.	**UNITEN**	Centre for Storm Water and Geohazard Management	2008	• Stormwater • Flood hydrology • Geohazard • Water quality • Environment • Hydropower

19.	**Universiti Tunku Abdul Rahman (UTAR)**	Centre for Biodiversity Research	2001	• Aquatic biology
20.	**Universiti Tunku Abdul Rahman (UTAR)**	Centre for Environment and Green Technology	2001	• Water & wastewater treatment

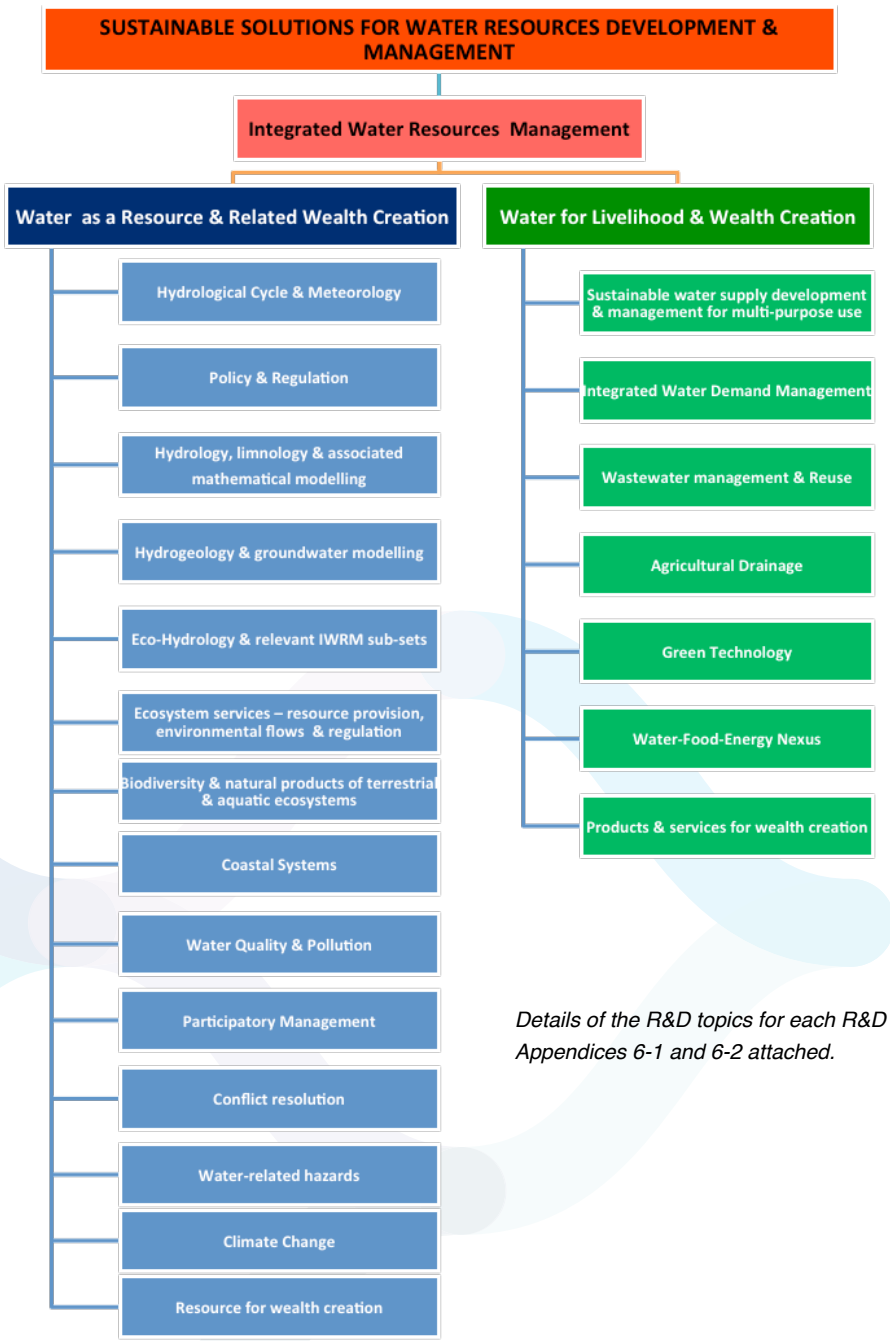
Appendix 5

Government and Private Water R&D Institutions

No.	Research Centre	Year Established	Research Focus Area
1.	National Hydraulic Research Institute Malaysia (NAHRIM)	1990	• Water Resources • River • Coastal • Geohydrology • Water Quality • Water and Environment Management
2.	Forest Research Institute Malaysia (FRIM)	1929	• Water Quality • Forest hydrology
3.	Humid Tropic Centre Kuala Lumpur	1999	• Water Resources Management & Development • Hydrology • New Drainage Manual (MASMA)
4.	Fisheries Research Institute (FRI)	1949	• Sustainable Aquaculture Technology
5.	Nuclear Malaysia	1972	• Water and Natural Resources Management • Marine
6.	Indah Water Konsortium	1994	• Sewerage Management Research and Development • Sewage Treatment Plants Treatment Process Performance
7.	Syarikat Air Johor	1999	• Water Supply Management • Wastewater management
8.	Syarikat Bekalan Air Selangor (SYABAS)	1996	• Water Supply

Appendix 6

National Agenda for Integrated Water research in Malaysia



Details of the R&D topics for each R&D theme are as in Appendices 6-1 and 6-2 attached.

Appendix 6-1

Water as a Resource and Related Wealth Creation (Research Themes 1 to 14)

Research theme	Research topics
1. Hydrological Cycle and Meteorology	1. Hydrometeorology 2. Climate change and hydrologic cycle
2. Policy & Regulation	1. Policy and legislative issues 2. Risk assessment 3. Water security challenges and mitigation measures 4. Impacts of irrigation on environmental and health 5. Policy and legislative instruments 6. Energy and water efficient cities/township
3. Hydrology, limnology and associated mathematical modelling	1. Surface water hydrology 2. Rural hydrology 3. Urban hydrology 4. Water resource assessment and accounting 5. Alternative water resources (ground water, rain water harvesting, etc.) 6. Wetland modelling
4. Hydrogeology and groundwater modelling	1. Groundwater hydrology

5. Eco-Hydrology and relevant IWRM subsets	1. Eco-hydrology 2. River morphology 3. River rehabilitation 4. Catchment/river basin management 5. Integrated water resource management 6. Conservation and preservation of water resources 7. Sustainable and integrated watershed management 8. Eutrophication 9. Fresh water ecology 10. Wetlands and lakes restoration
6. Ecosystem services – resource provision, environmental flows and regulation	1. Environmental water requirements 2. Environmental flow versus climate change issue
7. Biodiversity and natural products of terrestrial and aquatic ecosystems	1. Environmental and indigenous people related issues 2. Marine biodiversity, conservation and management
8. Coastal Systems	1. Integrated coastal zone management 2. Coastal erosion 3. Coastal habitat management 4. Coastal ecology 5. Protected conservation areas in marine environment 6. Seawater and sediment chemistry 7. Marine ecology

9. Water Quality & Pollution	1. Water quality modelling 2. Terrestrial atmospheric pollution and water quality 3. Marine pollution 4. Ground water quality 5. Water quality Information management and modelling 6. Technologies for controlling and monitoring non-point source pollution
10. Participatory Management	1. Public participation in watershed management 2. Public awareness and participation in water resources conservation
11. Conflict resolution	1. Social and environmental costs of watershed degradation
12. Water-related hazards	1. Erosion and sedimentation 2. Flood management and mitigation 3. Storm water management

13. Climate Change	1. Climate change and rainfall modelling 2. Impacts of climate change, increased population and changing human demographics on watersheds 3. Impacts of climate variability on wetlands ecosystem 4. Climate change and aquatic invasive species 5. Modelling climate-related water resource stressors 6. The adaptation of urban water supply to climate change
14. Resource for wealth creation	

Appendix 6-2

Water as a Resource and Related Wealth Creation
(Research Themes 15 to 21)

Research theme	Research topics
15. Sustainable water supply development and management for multi-purpose use	1. Advanced dam technology 2. Dam modelling construction 3. Electromechanical equipment 4. Assessment of water use and availability 5. Water-use efficiency 6. Water supply and demand for industry 7. Water supply and demand for livestock and agriculture 8. Sustainable water supply management in rural areas 9. Balancing water supply versus demand 10. Assessment of freshwater withdrawal 11. Drinking water quality standards 12. Advanced water treatment process 13. Drinking water quality versus public health 14. Improved and innovative irrigation technology (for water use reduction) 15. Micro drainage system for small scale farming 16. Rainwater harvesting for irrigation purpose
16. Integrated Water Demand Management	1. Water demand projection and forecasting

17. Wastewater management and Reuse	1. Quality waters and wastewater reuse for irrigation 2. Water and sanitation hygiene in rural areas 3. Environmental and social impacts 4. Decentralised sanitation system 5. Integrated urban water management 6. Alternative unconventional urban sanitation systems 7. Low carbon and energy efficient treatment system 8. Nutrients removal and management 9. Phytoremediation/Bioremediation technology 10. Zero discharge technology 11. Advanced and innovative technology for industrial wastewater treatment 12. Policy and legislative instruments 13. Salt/sea water intrusion 14. Waterborne pathogens and microbial risks 15. Environmental impacts assessment of effluent discharge to environment 16. Technologies for monitoring, controlling and removing diffuse and point source pollution 17. Newly emerging water pollutants
18. Agricultural Drainage	1. Drainage, water logging and salinity control 2. Environmental effects of nutrients carried in drainage discharge 3. Development of best drainage design and practices that enable crops to use shallow groundwater efficiently, while reducing the use of agricultural chemicals and reduce flood flow 4. Drainage, and waterlogging and salinity control 5. Drainage for ecosystem and conservation
19. Green Technology	
20. Water-Food-Energy Nexus	1. Water footprint 2. Consumer and corporate water footprint assessment 3. Carbon footprint of water and wastewater treatment system
21. Products and services for wealth creation	

Appendix 7

R&D Launching Grant to Kick-start the National Agenda For Integrated Water Research In Malaysia

RESEARCH THEME	ALLOCATIONS (Million)
1. Hydrological Cycle and Meteorology	6.0
2. Water Quality &Pollution	5.0
3. Water-related hazards	6.0
4. Climate Change	8.0
5. Ecosystem services – resource provision, environmental flows and regulation	6.0
6. Coastal Systems	5.0
7. Water-Food-Energy Nexus	5.0
8. Hydrology, limnology and associated mathematical modelling	4.0
9. Hydrogeology and groundwater modelling	8.0
10. Biodiversity and natural products of terrestrial and aquatic ecosystems	5.0
11. Policy & Regulation	2.0
12. Conflict resolution	1.5
13. Eco-Hydrology and relevant IWRM subsets	3.0
14. Participatory Management	3.5
15. Sustainable water supply development and management for multi-purpose use	3.0
16. Integrated Water Demand Management	3.0
17. Wastewater management and Reuse	6.0
18. Agricultural Drainage	6.0
19. Green Technology	7.0
20. Resource for wealth creation	3.5
21. Product and Services for wealth creation	3.5
Total	**100.0**

Academy of Sciences Malaysia
Level 20, West Wings, MATRADE Tower
Jalan Khidmat Usaha, Off Jalan Duta, 50480 Kuala Lumpur
Malaysia

Phone : +6 (03) 6203 0633
Fax : +6 (03) 6203 0634

ISBN 978-983-2915-13-3