Ensuring a Better Water Future for Malaysia

A Monograph by
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Chapter One
INTRODUCTION

Human overuse of water resources and diffuse contamination of freshwater are stressing the water resources in the terrestrial water cycle. As a consequence, the ecological functions of water bodies, soils and groundwater in the water cycle are hampered and being further exacerbated by threats from impending climate change. The water crisis today is a crisis of managing water. A holistic, systemic approach relying on Integrated Water Resources Management (IWRM) must replace the current fragmented approach.

Over the last 2 decades, the UN-led Earth Summits have brought nations together to commit themselves to the Sustainable Development Agenda 21. One of the main outcomes of the United Nations Conference on Sustainable Development (Rio+20), held in Rio de Janeiro in June 2012 and carrying the theme "**The Future We Want**", was the agreement by Member States to launch an inclusive process to develop a set of Sustainable Development Goals (SDGs) that would address in a balanced way all three dimensions of sustainable development – economic, social and environment - and be coherent with and integrated into the UN development agenda beyond 2015.

Meanwhile, the World Water Council (WWC) led World Water Forum held triennially beginning 1997, has gathered the global water-related stakeholders and communities to chart the course for the integrated management of water resources (IWRM) for a water secure world, an essential prerequisite to achieve the Sustainable Development Agenda. The recent 7th World Water Forum held in Korea in April 2015 has accordingly carried the theme "**Water for the Future**" focusing on 3 primary objectives, namely, (a) Moving from Solutions to Implementation, (b) Bridging the Platform of Science & Technology to Water Issues, and (c) Contributing to the Sustainable Development Goals (SDGs).

Malaysia has since the early 1990s set its Vision to become a fully developed country by the year 2020. It is currently pursuing a Transformation Programme to progress from a middle-income nation to become a high-income nation by 2020. The transformation of the water sector must also evolve in tandem to meet sustainable development goals befitting a developed nation status by 2020. As a signatory to most of the international agreements and conventions pertaining to water and the environment, Malaysia has formally adopted IWRM as the way forward for the sustainable management of the country's water resources.

Against the above back-drop, this paper entitled "**Ensuring a Better Water Future for Malaysia**" will review the various water-related issues and challenges and proposing the implementation of the IWRM Road Map including the measures to be undertaken to effect the transformation of the water sector in pursuit of Vision 2020 and to achieve the post-2015 SDGs.

Chapter Two
GLOBAL WATER TODAY

2.0 Global Water Today

The UN World Water Development Report 2015 entitled "Water for a Sustainable World" released in March 2015 on the occasion of World Water Day reported the following facts and figures on the current world water situation and its outlook for the future:

- The world's population is growing by about 80 million people per year (USCB, 2012) and is predicted to reach 9.1 billion by 2050.

- Population growth, urbanization, industrialization, and increases in production and consumption have all generated ever-increasing demands for freshwater resources.

- By 2030, the world is projected to face a 40% global water deficit under the business-as-usual climate scenario (2030 WRG, 2009).

- Water availability faces pressures from pollution. Eutrophication of surface water and coastal zones is expected to increase almost everywhere until 2030 (UNDESA, 2012). Globally, the number of lakes with harmful algal blooms will increase by at least 20% until 2050 (Figure 1).

- Regionally, the global limit of ecological sustainability of water available for abstraction is reported to have been exceeded for about one-third of the human population and it will rise to about half by 2030 (WWAP, 2012).

- Groundwater provides drinking water to at least 50% of the global population and accounts for 43% of all of the water used for irrigation (FAO, 2010).

  Worldwide, 2.5 billion people depend solely on groundwater resources to satisfy their basic daily water needs (UNESCO, 2012). An estimated 20% of the world's aquifers is being over-exploited (Gleeson et al., 2012), leading to serious consequences such as land subsidence and saltwater intrusion (USGS, 2013) (Figure 2).

- Economic losses due to water-related hazards have risen greatly in the past decade. Since 1992, floods, droughts and storms have affected 4.2 billion people (95% of all people affected by all disasters) and caused US$1.3 trillion of damage (63% of all damage) (UNISDR, 2012).

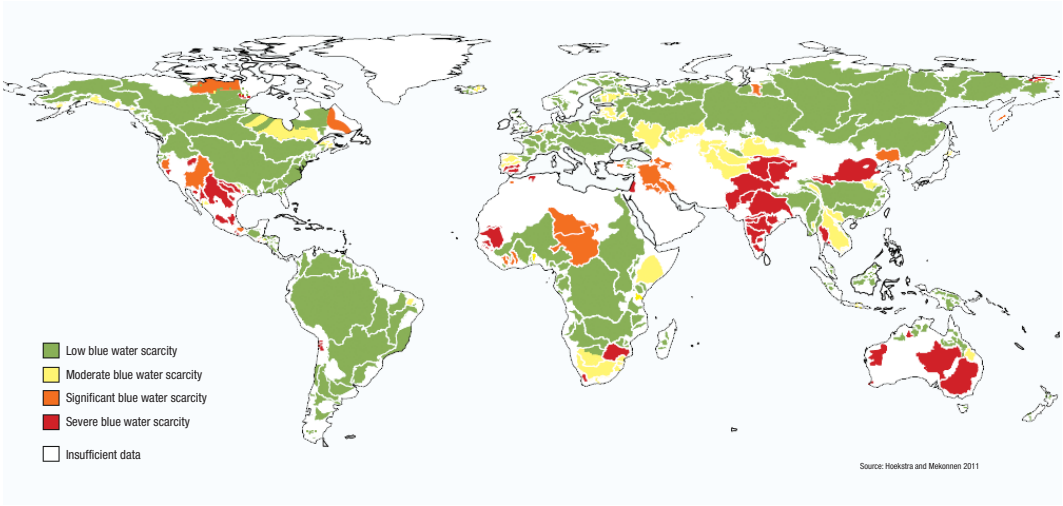

Figure 1: Annual Average Scarcity in Major River Basins

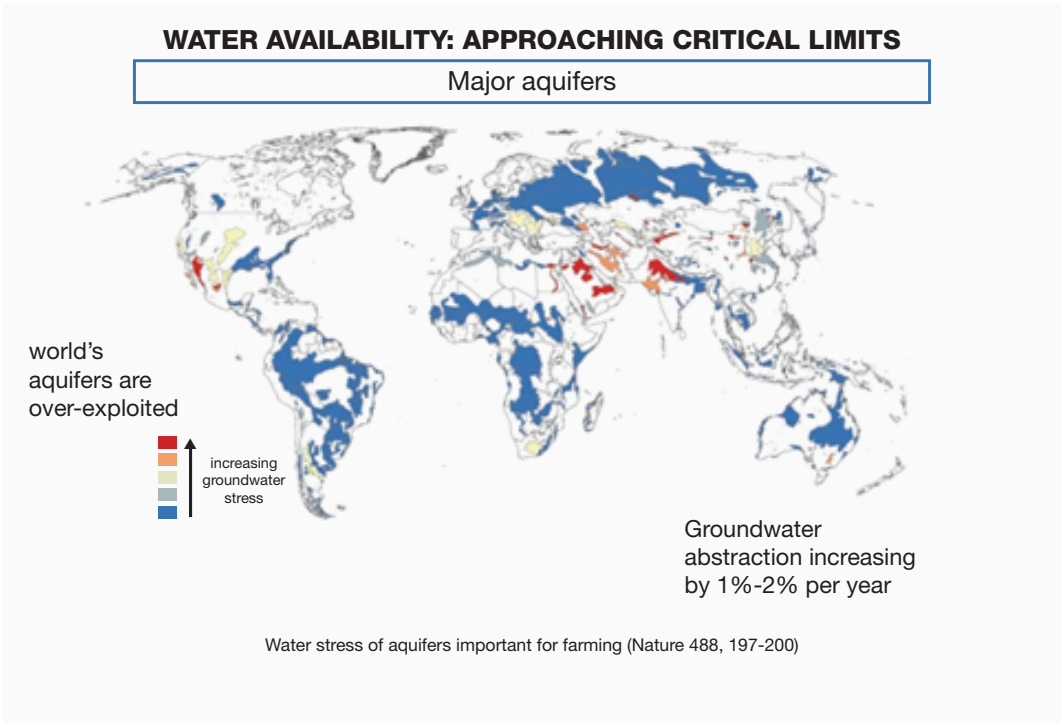

Figure 2: Aquifer Water Stress

- In most countries, funding for water infrastructure comes from government allocations, although many developing countries still depend on external assistance to fund water resources management and utilities. Over 50% of countries low on the Human Development Index have reported that financing for water resources development and management from government budgets and official development assistance has been increasing over the past 20 years (UN-Water, 2012).
- Challenges such as economic shocks, food shortages and climate change threaten to undercut economic and social progress made in recent years.

The fact is there is enough water to meet the world's growing needs, but not without dramatically changing the way water is used, managed and shared. The global water crisis is one of governance, much more than of resource availability.

Chapter Three
THE MALAYSIAN WATER SCENARIO

3.0 The Malaysian Water Scenario

The National Water Resources Study (NWRS 2011) commissioned by the Ministry of Natural Resources and Environment (NRE) and completed in the year 2011 provides a comprehensive assessment of the current water situation in Malaysia both at the national level and also broken down according to the various States. The Study has also undertaken projections of the state of the country's waters until the year 2050 addressing issues related to supply and demand as well as measures required to ensure the sustainable management of water resources and the protection of the environment.

In brief the Study reports 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. Hence, the adequate provision of quality water to meet the country's short, medium and long term needs is not one of water resources availability but more of sound management and good governance.

Relevant supporting tables and figures from the Study report related to population projections (Table 1), projected GDP (Table 2), annual rainfall data by States (Table 3), water demand projections (Figure 3) and comparison against surface water availability (Table 4) are reproduced below:

Table 1: Malaysia - Population Projections

State	Population ('000)				
	2010	2020	2030	2040	2050
Perlis	246	291	319	343	361
Kedah	2,043	2,440	2,695	2,906	3,065
Pulau Pinang	1,609	1,841	1,958	2,064	2,133
Perak	2,441	2,810	3,004	3,177	3,294
Selangor and FT Kuala Lumpur	6,970	7,951	8,443	8,896	9,195
Negeri Sembilan	1,032	1,190	1,274	1,348	1,399
Melaka	785	925	1,008	1,078	1,129
Johor	3,458	4,117	4,533	4,879	5,140
Pahang	1,573	1,867	2,050	2,203	2,317
Terengganu	1,149	1,445	1,672	1,854	2,006
Kelantan	1,677	2,104	2,427	2,686	2,901
Peninsular Malaysia	**22,983**	**26,981**	**29,383**	**31,434**	**32,940**
Sarawak	2,660	3,127	3,505	3,839	4,117
Sabah	3,267	3,874	4,400	4,719	4,958
FT Labuan	88	101	110	115	118
East Malaysia	**6,015**	**7,102**	**8,015**	**8,673**	**9,193**
Malaysia	**28,998**	**34,083**	**37,398**	**40,107**	**42,133**

Table 2: Projected GDP

Year	Value in RM million								AAGR (%) 2010-2050	AAGR (%) 2020-2050
	2010	2020	2025	2030	2035	2040	2045	2050		
Agriculture	40	53	70	93	118	120	146	176	3.8	4.1
Mining	42	47	41	54	69	75	91	110	2.4	2.9
Manufacturing	139	245	308	410	521	662	802	971	5	4.7
Construction	17	24	34	45	57	66	80	97	4.5	4.8
Services	317	682	948	1,263	1,604	2,085	2,525	3,058	5.9	5.1
GDP Total	**555**	**1,051**	**1,400**	**1,865**	**2,369**	**3,009**	**3,644**	**4,412**	**5.3**	**4.9**

Table 3: Annual Rainfall Data by States

State	Area	Unit in Billion Cu M per year				
	(km^2)	Rainfall	Actual Evaporation	Groundwater Recharge	Surface Runoff	Effective Rainfall
Perlis	821	1.54	1.06	0.10	0.38	0.06
Kedah	9,500	21.95	13.59	1.24	7.12	1.07
P Pinang	1,048	2.46	1.50	0.13	0.83	0.13
Perak	21,035	52.17	27.77	3.58	20.82	3.14
Selangor	8,396	18.39	10.75	1.26	6.38	0.96
Negeri Sembilan	6,686	12.24	8.09	0.87	3.28	0.64
Melaka	1,664	3.13	2.01	0.17	0.95	0.14
Johor	19,210	47.45	21.71	3.84	21.90	3.29
Pahang	36,137	89.26	45.17	4.34	39.75	6.46
Terengganu	13,035	43.15	19.16	1.96	22.03	3.31
Kelantan	15,099	39.26	19.48	2.11	17.67	2.65
Pen Malaysia	**132,631**	**330.98**	**170.28**	**19.56**	**141.11**	**21.17**
Sabah	73,631	188.50	87.62	13.99	86.89	16.21
Sarawak	124,450	453.00	155.56	29.87	267.57	27.44
FT Labuan	91	0.28	0.13	0.01	0.14	0.03
East Malaysia	**198,172**	**641.78**	**243.31**	**43.87**	**354.60**	**53.19**
Malaysia	**330,803**	**972.78**	**413.60**	**63.45**	**495.71**	**74.35**

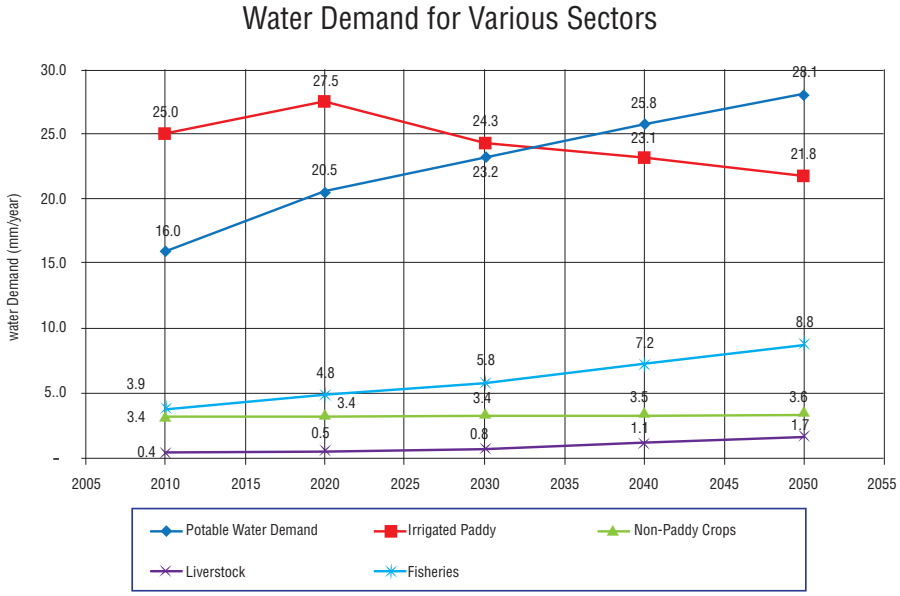

Figure 3: Consumptive Water Demand Projections (BCM/Year)

Table 4: Total consumptive Water Demand Against Total Surface Water Availability for All Sectors

States	Land Area sq km	Total Consumptive Water Demand (MCM)					Effective Rain (MCM/ Year)	Excess/Deficit (MCM) - Unregulated Flows				
		2010	2020	2030	2040	2050		2010	2020	2030	2040	2050
Perlis	821	306	299	286	284	281	60	(246)	(239)	(226)	(224)	(221)
Kedah	9500	2922	2916	2842	2873	2876	1070	(1852)	(1906)	(1772)	(1803)	(1806)
Pulau Pinang	1048	765	829	835	874	894	180	(635)	(699)	(705)	(744)	(764)
Kelantan	15099	1632	1619	1586	1600	1604	2650	1018	1031	1064	1050	1046
Terengganu	18085	884	975	970	999	1026	3310	2426	2335	2340	2311	2284
Perak	21035	1949	1923	1798	1801	1811	3140	1191	1217	1342	1339	1329
Selangor	8396	2238	2491	2570	2760	2922	960	(1278)	(1531)	(1670)	(1800)	(1962)
Pahang	86187	726	946	897	911	959	6460	5739	5514	5563	5549	5501
Negeri Sembilan	6686	840	861	858	866	874	640	300	279	282	274	266
Melaka	1664	323	366	376	409	439	140	(183)	(226)	(336)	(269)	(299)
Johor	19210	715	881	1033	1164	1801	8290	2575	2409	2257	2126	1989
Pen Malaysia	182681	12800	13664	13551	14040	14488	21170	8370	7506	7619	7130	6682
Sabah	73631	912	1356	1392	1442	1469	16210	15298	14854	14818	14768	14741
Sarawak	124450	1054	2162	2125	2175	2247	27440	26386	25278	25375	25265	15193
WP Labuan	91	18	24	26	28	29	30	12	6	4	2	1
East Malaysia	198172	1985	3541	3542	3645	3745	53190	51205	49649	49648	49545	49445
Total Malaysia	330803	14785	17205	17093	17683	18233	74350	59565	57145	57257	56665	56117

Some of the major water related issues and challenges that need to be addressed nation-wide, most of which have also been highlighted by the NWRS 2011, are as follows:

a) **Regional Water Stress**: Based on the current and projected consumptive water demand against total surface water availability shown in the Table 4 above, the NWRS 2011 highlighted some 'water-stressed' growth regions and states such as Perlis, Kedah, Pulau Pinang, Selangor and Melaka were reported as water deficit states (computed values shown in red in the Table 4 above). This has been borne out by recurring crises of potable water shortages that occurred recently in 2014 and 2015 in several states which had led to water rationing. The affected states were Selangor, Negeri Sembilan, Johor, Perak and Wilayah Persekutuan (Kuala Lumpur and Putrajaya).

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. Measures taken in the past to augment supplies have largely been through shared river basins and inter-basin water transfers. The sharing of the Klang, Langat and Selangor rivers and supplemented further with waters transferred from Pahang (Langat 2) to service the densely populated greater Klang Valley is a case in point. Similarly, the high water demand to support the granary areas of MADA and Seberang Perai is serviced by regulated waters drawn from the Muda River catchment (falling largely in the state of Kedah) and shared among the states of Perlis, Kedah and Pulau Pinang.

b) **Flooding**: Located in the humid tropics, Malaysia is subject to seasonal torrential rains brought by the south-west and north-east monsoons with the year-end north-east monsoon normally being the more severe one. There are 189 river systems in Malaysia of which 85 are prone to frequent flooding. Despite the many flood mitigation measures undertaken over past years, recent trends indicate that the magnitude of flooding is on the rise and hence has become a major national issue.

Following the rapid pace of Malaysia's economic growth coupled with pressures from an increasing population, development has inevitably encroached into catchment areas, river corridors and flood plains which have led to greater incidences of floods and ensuing damages. An estimated 29,720 km2 or 9% of Malaysia is flood prone and the annual flood damages in Malaysia is approaching closer to RM2 to 3 billion in recent years.

The recent floods in December 2014 and January 2015 in Kelantan, Terengganu, Perak, Pahang, Johor, Sabah and Sarawak resulted in devastating damages forcing about 400,000 people to be evacuated. DID rainfall records showed that for the upper reaches of Sg. Kelantan, Sg. Pahang and Sg. Perak the rainfall exceeded the 100-year return period. A special Parliamentary Session was convened on 20th January 2015 to approve a special budget allocation of RM893 million for flood mitigation works, RM800 million as initial allocation to repair and reconstruct basic infrastructure like schools, hospitals, roads and bridges, RM500 million rehabilitation works and welfare programmes and RM500 million for flood relief loan Guarantee Scheme. The other contributing factors were reported to be extensive land-clearing in the highlands and encroachment into the flood corridors.

Severe land-slides and mud flows in Kampung Raja, Pekan Ringlet and Bertam Valley in the resort area of Cameron Highlands in November 2014 killed 5 people and affected 100 victims from 28 families. A similar event occurred in 2013. The main causes for these recurring flood events have been attributed to the use of rain shelters made out of plastic roofing materials for extensive vegetable farming in the highlands resulting in increased surface water runoff being directly discharged into rivers triggering flash floods. The flash floods have been further aggravated over the years by the uncontrolled opening of forest lands for illegal vegetable farming and also due to the lack of enforcement by the local authorities.

c) **Pollution of Water Sources**: Pollution of water bodies, be they lentic or lotic systems, has evidently been on the rise nation-wide. A 2004 report entitled *A Study on the Status of Eutrophication of Lakes in Malaysia*, confirmed that out of the 90 lakes that were studied, 56 (62%) were in a poor condition (eutrophic), while the balance were in a mediocre to reasonably good state (mesothrophic). The study went on to conclude that eutrophication of lakes has reached levels for serious concern and restoration efforts were urgently needed for many lakes.

The Department of Environment (DOE) under the NRE Ministry is responsible for enforcing the Environmental Quality Act (EQA, 1974). The Act was enacted for the abatement and control of pollution and enhancement of the environment, which includes river water quality. According to the DOE, Malaysian rivers are degraded by both point and non-point sources of pollution. The major point sources of pollution in rivers are from sewage treatment plants, agro-based industries, manufacturing industries, sullage or grey-water from commercial

and residential premises, and pig farms. Nonpoint source (or diffuse) pollution is largely due to storm runoff after a downpour. Earthworks and land clearing activities contribute to siltation of rivers and can be both point and non-point sources of pollution. The many recent shut-down of the WTP in the Sg. Langat area were reported to be attributed to pollution caused by factories upstream.

d) **Environmental Degradation**: Decades of economic development comprising large-scale land development, urbanization, and industrialization coupled with efforts to meet the needs and provide opportunities for a rising population, has significantly changed both the urban and rural landscape. Such change has inevitably had its toll in the continuing degradation of both the terrestrial and aquatic ecosystems. Ecosystem services are the benefits people obtain from ecosystems (Figure 4, Millennium Ecosystem Assessment (2005)). These include provisioning, regulating, and cultural services that directly affect people and supporting services needed to maintain the other services.

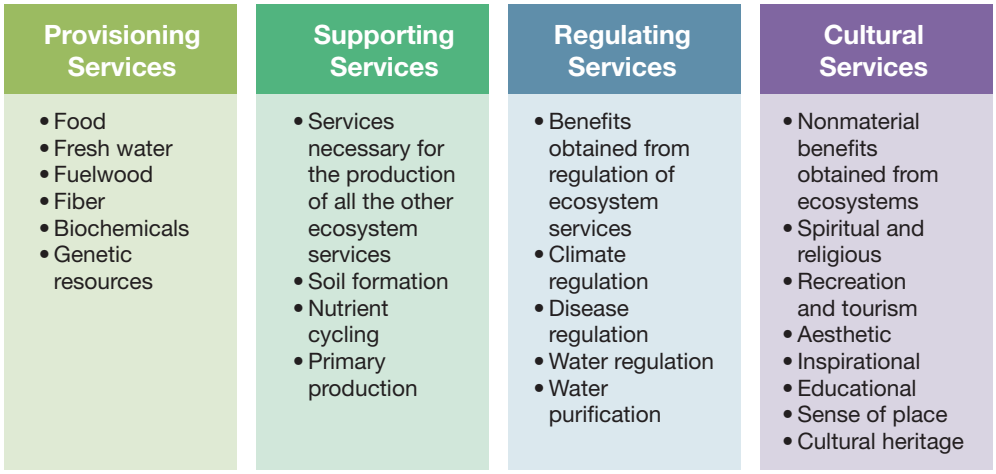

Figure 4: Ecosystem Services (Millennium Ecosystem Assessment (2005))

Based on the country's track record to-date and as reported in NWRS (2011), one can reasonably conclude that in exploiting the ecosystem provisioning service functions for multiple purpose use and development, the ecosystem regulating service function has largely been impaired resulting in depleted and degraded stream flows threatening loss of biodiversity in both the terrestrial and aquatic environment and particularly so in the more developed river basins.

e) **Fragmented Management and Conflicts among Sectors**: Under the Constitution, matters pertaining to natural resources such as land, minerals, forests

and water fall under the jurisdiction of the states. Water becomes a federal matter only if a dispute arises as in the case of a shared river basin between two or more states. Otherwise, State Governments are responsible for water management including the gazettement of water catchments. Currently only five states have the equivalent of a state water resources council backed by appropriate legislation to oversee water resources governance in their respective states. They are Selangor (Selangor Water Management Authority); Kedah (Kedah Water Management Board); Pahang (State Water Regulatory Body); Sabah (Sabah Water Resources Council) and Sarawak (Sarawak Water Resources Council).

At the Federal level, the governance and administration of water resources involve several ministries, departments and agencies. Water resources development is sectorally-based, a legacy from the past. Since the year 2004, however, the creation the NRE Ministry saw the clear separation of powers between "water as a resource" and "water for utilities". Management of water as a resource is vested with the NRE Ministry which also includes the management of water-related hazards such as floods and droughts. Water for agriculture comes under the purview of the Ministry of Agriculture, potable water supply, sewerage services, and hydropower generation falls under the Ministry of Energy, Green Technology and Water (KeTTHA). The Ministry of Health deals with water supply and sanitation in areas not covered by KeTTHA. Urban drainage and storm water retention in urban areas is under the Ministry of Housing and Local Government. Water legislations are contained within the laws that are enforced by the various water-related government agencies and are focused on specific aspects of water resources that are under the jurisdiction of the respective agencies.

There are gaps and overlaps. Conflicts in water resources management such as allocation of water rights, flood management, pollution control and environmental protection are resolved through inter-agency coordination and consultation. In order to resolve persistent disagreements, the Federal Government established a National Water Resources Council (NWRC) in June 1998 with the foremost intention to pursue a more effective and cohesive water management by various States that includes the initiation of inter-state water transfers. The NWRC as the apex advisory and coordinating body for water resources governance was entrusted to formulate, among others, a national water policy as well as establish guidelines to ensure long-term sustainable development and management of the country's water

resources. The National Water Resources Policy has since been formulated and officially launched in March 2012.

f) **Climate Change Impacts**: Exposure of people and assets to hydro-meteorological hazards in Asia Pacific, including Malaysia, has been growing over the past few decades. Malaysia has seen rapid urbanization, economic growth, and changes in local environmental conditions whereby more assets and people are located in hazardous areas such as flood plains and coastal low-land areas. The country has of late experienced extended droughts and widespread flooding and expected to continue to be more exposed and vulnerable to such natural hazards. Climate change is anticipated to create extreme events, with some projections including an increase in the frequency of years with above normal monsoon rainfall or extremely rainfall deficient.

An increase in rainfall extremes of landfall cyclones in South and East Asia have been recently projected in the IPCC's AR5 (Fifth Assessment Report), along with enhanced monsoon precipitation and increased drought in some areas over the long term. Consequential impacts from two likely scenarios are listed in Table 5:

Table 5: Climate Change and its Impact on Water Resources

Scenario 1: Increases in temperature and increase in rainfall	Scenario 2: Increases in temperature and reduced rainfall
Increased inflow to water storages	Reduced inflows to water storages (dams and reservoirs)
Increased pressure on water storage infrastructure	Reduced stream flows
Increased availability of water for rain-fed agriculture	Reduced water availability for rain-fed agriculture
Increase risk of flood damage	Reduced recharge of groundwater
Possible changes to ecosystems	Threatened water supplies to cities and towns, agricultural, industrial and environmental needs
	Severe droughts

The impacts of climate change on the water resources characteristics cannot be avoided as it is a global phenomenon. Nevertheless, its negative impacts could be mitigated with the following general measures (NWRS 2011):-

(i) Construction of more storage dams to capture the higher flows. As the run of the river flows will be lower, larger release from existing dams would be necessary to enable water supply to meet demands and to maintain system reliability. For states already experiencing water stresses, inter-basin and interstate water transfer would be necessary.

(ii) Efficient water supply and demand management in the areas of:

- Increasing irrigation efficiency as irrigation is currently still the largest water user and the irrigation efficiency is relatively low;
- Irrigated paddy where water savings measure in the form of farm practices and the introduction of paddy strains with lesser water demand;
- Reduce non-revenue water and other wastages; and
- Potable water demand where savings in the form of lowering per capita domestic consumption and the widespread practice of water recycling and the use of alternative water resources.

(iii) Prudent land-use planning for new developments in anticipation of sea level rise and raising of coastal bunds to protect existing development areas.

Chapter Four
ENSURING A BETTER WATER FUTURE FOR MALAYSIA

4.0 Ensuring a Better Water Future for Malaysia

a) **Malaysia's Vision 2020 and the National Transformation Programme**: Since the early 1990s Malaysia had embarked on Vision 2020 to attain developed nation status by the year 2020. In renewed efforts for timely achievement of this goal and to help fast-track the process, the country has, since the year 2010, launched the National Transformation Program comprising of both a Government Transformation Program (GTP) and an Economic Transformation Program (ETP) which was followed by the Political Transformation Programme (PTP), the Community Transformation Programme (CTP), Social Transformation Programme (STP), and the Fiscal Transformation Programme (FTP).

The GTP is a broad-based programme of change to fundamentally transform the Government into an efficient and people-centred institution. It focuses on seven pressure points, designated as National Key Results Areas (NKRAs) to improve the socio-economic growth of the country.

The ETP was launched in September 2010 with its goal is to elevate the country to a developed-nation status by 2020, targeting a gross national income (GNI) per capita of US$15,000. To achieve this, US$444 billion in investments is targeted, which will create 3.3 million new jobs.

The ETP's targets for 2020 will be achieved through the implementation of 12 National Key Economic Areas (NKEAs) representing economic sectors which account for significant contributions to GNI and job creation. The ETP is also centred on raising Malaysia's competitiveness through the implementation of six Strategic Reform Initiatives (SRIs), comprising policies which aim to strengthen the country's commercial environment to ensure Malaysian companies are globally competitive.

The 12 NKEAs are as follows (Table 6). Each NKEA has Entry Point Projects (EPPs), which explore new growth areas, and business opportunities (BOs), to enable the sector to move further up the value chain.

Table 6: National Key Economic Areas (NKEAs)

1. Oil, Gas and Energy.	7. Wholesale and Retail.
2. Palm Oil and Rubber.	8. Education.
3. Financial Services.	9. Healthcare.
4. Tourism.	10. Communications Content and Infrastructure.
5. Business Services.	11. Agriculture.
6. Electronics and Electrical.	12. Greater Kuala Lumpur/ Klang Valley.

b) **The Malaysian Water Vision and Framework for Action**: The **Malaysian Water Vision** formulated in the year 2000 is as reproduced below:

"In support of Vision 2020 (towards achieving developed nation status), Malaysia will conserve and manage its water resources to ensure adequate and safe water for all (including the environment)".

The key objectives of the Malaysian Water Vision are:

(i) **Water for people** – all communities will have access to safe, adequate and affordable water supply, hygiene and sanitation;
(ii) **Water for food, agriculture and rural development** – provisions of sufficient water to ensure national food security and promote rural development;
(iii) **Water for economic development** – provisions for sufficient water to spur and sustain economic growth within the context of a knowledge-based economy and e-commerce;
(iv) **Water for the environment** – protection of the water environment to preserve water resources (both surface and groundwater resources) and the natural flow regimes, biodiversity and cultural heritage as well as the mitigation of water related hazards; and
(v) **Water for Energy** – this has been added in to reflect the current trends on the water-energy-food nexus, looking at it in terms of both policy and process, as water is inextricably linked to agriculture, food production and where there is an urgent need for continuous improvements in water and energy efficiencies to ensure sustainable economic growth.

To complement the Vision statement, a **National Framework for Action** was also developed structured to achieve the key objectives of the Vision, entailing:

(i) Managing water and water resources efficiently and effectively (addressing both quantity and quality aspects) as water demands increase in tandem with population growth and industrialisation;
(ii) Moving forward towards IRBM and ILBM taking full cognizance of river and lake basins as geographical units with well-defined boundaries containing the sum of all hydrological processes operating within them, and transcending political and administrative constraints, making them ideal water management units to address water problems;
(iii) Translating awareness to political will and capacities to create an enabling environment for the much needed

institutional reforms to deal with deterioration of water quality, decrease in water availability and conflicts among users (irrigation, hydropower, industry and domestic users). There is also a need to instil awareness of the economic, social and environmental values of water among politicians, decision makers and all stakeholders; and

(iv) Moving towards adequate (safe) and affordable water services (befitting a developed nation status by 2020) through the provisions of adequate infrastructure for water delivery to all sectors of the economy.

c) **National Water Resources Policy (NWRP 2012)**: This contemporary policy was formally launched in March 2012. The Policy is based on the 3 essential principles of water resources security, water resources sustainability and collaborative governance, as elaborated briefly below:

(i) **Water Resource Security**: Water security, similar to food and energy securities in the country, is to ensure that water is readily available to meet all demands of society and the environment. It has an intrinsic as well as a financial cost value that could be much higher than those of other economic sectors.

(ii) **Water Resource Sustainability**: Water is a catalyst for national development and for societal and environmental well-being. It should be sustained for present and future uses. This opens up vast opportunities to develop the water industry and to explore the use of alternative water sources through science, technology and investments.

(iii) **Collaborative Governance**: Inclusiveness and collaboration are essential elements towards ensuring the security and sustainability of water resources as well as achieving the common goals of addressing multiple resource use, governance and priorities.

d) **Integrated Water Resources Management (IWRM)**: As highlighted in section 3 above, Malaysia is blessed with fairly abundant rainfall. The adequate provision of quality water to meet the country's short, medium and long term needs is not one of water resources availability but more of sound management and good governance. The NWRP 2012 reaffirms Malaysia's commitment since the turn of this century to adopt internationally endorsed IWRM for the sustainable management of the country's water resources.

This is a clear break away from past fragmented management

practices. IWRM 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 (Figure 5).

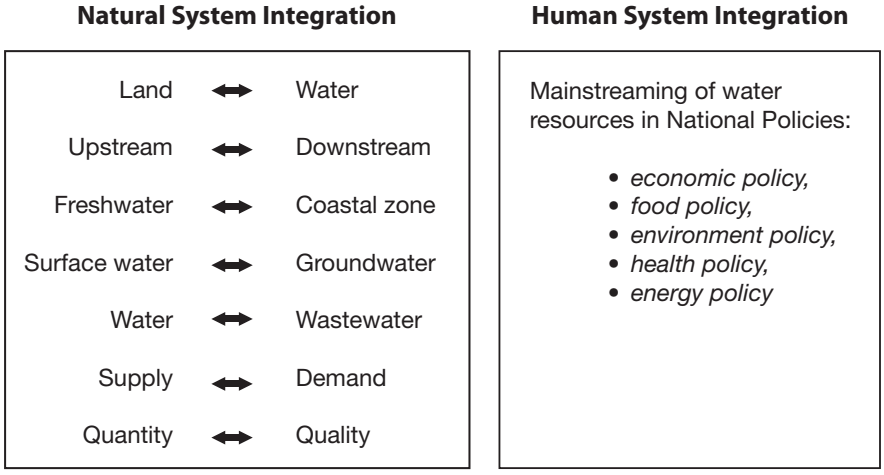

Figure 5: The IWRM Agenda Involves the Integration of both Natural and Human Systems

The general framework for the implementation of IWRM is based on four practical elements:

1. an enabling environment comprising policies, laws and plans;
2. an institutional framework;
3. use of management and technical instruments; and
4. investments in water infrastructure.

e) **Academy of Sciences Malaysia (ASM) and the National IWRM agenda**: The Academy of Sciences Malaysia (ASM), an independent think-tank providing strategic advice to Government on STI matters, had taken the initiative since 2008 to focus on the water sector recognizing it as being one of the strategic sectors vital for the country's economic development. Adopting IWRM as the central thrust and noting the absence of a nation-wide IWRM Work Plan, the ASM through its dedicated Water Committee set about developing a National IWRM Strategy Plan for consideration and adoption by Government for implementation nation-wide.

Noting also that IWRM concept per se is rather abstract; there is a need to break it down into discrete sub-sets or sub-themes. Each sub-set or sub-theme is subject to in-depth multidisciplinary studies that include a review of the current status followed by a process of stakeholder consultations involving the public, private, and NGO sectors to formulate recommendations and strategies to chart the way forward for improved and sustainable management of the country's

water resources through the infusion of IWRM principles and practices. The studies undertaken and their current status are as follows:

(i) Integrated Lake Basin Management (completed)
(ii) Integrated Aquifer Systems Management (completed)
(iii) Water Demand Management (completed)
(iv) Water Supply and Wastewater Management (completed)
(v) National Agenda for Integrated Water Research (completed)
(vi) Climate Change and Water (completed)
(vii) NKPA on Water (completed)
(viii) Integrated River Basin Management (completed)
(ix) Water and Agriculture (in progress)
(x) Integrated Urban Water Management (in progress)
(xi) WFE Nexus (in progress)

In addition, ASM under the first phase of the Mega Science Study aimed at a longer term horizon until the year 2050 also addressed the Water Sector. The Study, completed in the year 2009, recommended the inclusion of "water for wealth creation" in addition to sustaining the resource. The water sector must also be regarded as a source for growth of the national economy by way of exploitation of the full potential of income generating value added products and services that can be derived from the sector.

f) **Transformation of the Water Sector for a Better Future**:
The country is on the road towards Vision 2020 anchored by a National Transformation Programme. A vibrant water sector is an integral part of this mission and needs to move in tandem with a host of expectations as highlighted below:

- To ensure 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 and efficient services and rationalized 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;
- Harnessing of Science, Engineering, Technology and Innovations developed through 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.

Hence, "business as usual" is no longer an option. The way forward would require concerted efforts for a parallel Transformation of the Water Sector through a wide array of component action plans anchored by a central IWRM Strategies Implementation Road Map. Component plans and programs would be implemented concurrently nation-wide and led by the key ministries with entrusted responsibilities be it under water resource management or water utility provision and working closely with the state governments. The three (3) principles of water resource security, water resource sustainability, and collaborative governance laid down by the NWRP 2012 will be the core rationale behind the transformation process.

Under the on-going Economic Transformation Programme (ETP), water underlies all of the 12 NKEAs to varying degrees and scale. Some of the areas like agriculture and energy rely heavily on the availability and harnessing of water for growth and yet water was not explicitly recognized as an NKEA. It is vital that water be placed high on the national agenda and recognized as a National Key Priority Area (NKPA) with a slew of Entry Point Projects (EPPs) implemented to ensure timely transformation of the water sector. While it may now be longer be practicable to aim for a year 2020 transformation target, a more realistic target over three (3) Malaysia Plans by the year 2030 is considered feasible thereby coinciding with the target year set by UN to achieve the currently being finalized global Sustainable Development Goals (SDGs).

g) **National IWRM Strategies Implementation Road Map**: The ASM studies and component (sub-theme) plans referred to in section (e) above provide a sound basis for the development and implementation of a holistic and inclusive National IWRM Strategy Plan both for the short, medium and long term. Their relevance within the context of the IWRM agenda is as depicted in Table 7:

Table 7: ASM Studies and the IWRM Agenda

No.	Component Plan	Relevance to IWRM
1.	Integrated Lake Basin Management	Water as a resource
2.	Integrated Aquifer Systems Management	Water as a resource
3.	Water Demand Management	Water as a resource and for livelihood
4.	Water Supply and Wastewater Management	Water for Livelihood
5.	National Agenda for Integrated Water Research	Water as a Resource and for Livelihood (harnessing STI)
6.	Climate Change and Water	Preparing for impending threats
7.	Integrated River Basin Management	Water as a resource
8.	Water and Agriculture	Water for Livelihood
9.	Integrated Urban Water Management	Water as a resource
10.	NKPA on Water	Investing in water infrastructure
11.	WFE Nexus	Dealing with trans-boundary issues

The component plans have been structured and formatted conforming to a common IWRM general framework (Figure 6) that includes an implementation road map where relevant. The NKPA study undertaken with the complementary objectives of (i) ensuring water security in the country and (ii) for the creation of economic opportunities, has recommended some 15 major programmes (10 under “water as a resource” and 5 under “water for livelihood”) that include a total of 72 EPPs that have been identified for implementation. These component plans and programmes make up the National IWRM Strategies Implementation Road Map that would together drive the transformation of the water sector nation-wide for a better future befitting a nation vying for developed status.

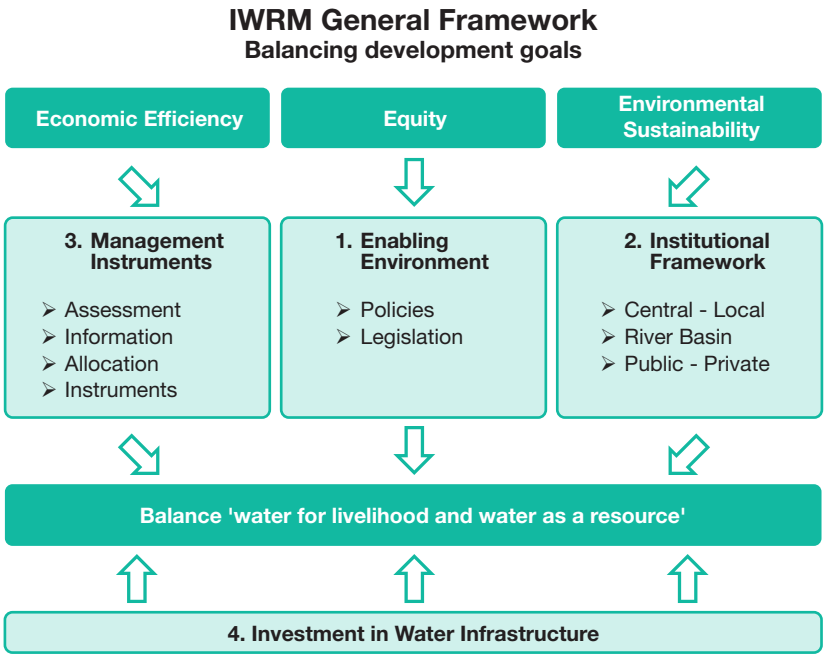

Figure 6: IWRM General Framework

A broad summary and synthesis of the proposed National IWRM Strategies Implementation Road Map spread over a time frame until 2030 and spanning 3 Malaysia Plans, categorized under the following 4 main headers, are attached as appendices:

1. Enabling environment (Appendix 1);
2. Institutional framework (Appendix 2);
3. Management instruments (Appendix 3); and
4. Investments in water infrastructure (Appendix 4).

4.1 Concluding Remarks

In his message to the 7th World Water Forum held in Korea in April 2015, Mr Benedito Braga, the President of the World Water Council said:

"The year 2015 is an opportunity the world cannot afford to miss: we must invent our water future together. Today, we gather in Korea at the 7th World Water Forum; in September, the United Nations General Assembly will adopt Sustainable Development Goals; and we will end the year debating a global climate agreement in Paris, in which water is to be recognized as a major factor to reach consensus. Our ability to build a water-secure future will depend upon our capacity to turn future challenges into opportunities. To succeed, we need the political decision-makers and the international community to come together to implement changes. There is no time to waste".

Drawing from this message, Malaysia, which is currently in the midst of implementing the National Transformation Programme on its road towards achieving Vision 2020, is well placed to meet the challenges faced by the water sector. The water sector must be accorded the high priority that it deserves on the national agenda and be included as an NKPA, if not an NKEA, together with 12 other NKEAs listed under the Economic Transformation Programme (ETP) so as to ensure that the transformation of this sector progresses in tandem. The proposed National IWRM Strategies Implementation Road Map provides the central basis and thrust that would help mobilise all water-related stakeholders to work concertedly on a common agenda to spur and accelerate the transformation process. Needless to say, it requires strong political commitment both at the Federal and State levels with timely appropriation of the necessary human and financial to ensure success.

4.2 Acknowledgements

The author would like to express his gratitude to IEM for inviting him and granting him the honour to deliver this 25th Prof Chin Fung Kee Memorial Lecture. He wishes also to acknowledge and record his appreciation to ASM for granting permission to use relevant information from its publications. Thanks are due to Datuk Hanapi Mohd Noor, Director, Water Resources Management and Hydrology Division, DID, Malaysia, for his support and assistance in providing relevant slides on current water related issues. A special word of appreciation must also go to Mr P. Loganathan from the ASM Secretariat for his kind assistance and inputs in editorial work pertaining to this paper.

TSSA/01092015

APPENDICES

APPENDICES 1

1. Enabling Environment					
Attribute	**Instrument/ Program/ Activity**	**Hierarchical Level**	**Lead Authority/ Implementing Agency**	**Current Status**	**Target Completion**
Policy	1. NWRP 2. Component Water Service and Management Policies	National inclusive of all states	MSAN/NRE KeTTHA/MOA/ NRE	Launched Mar. 2012 None	11th MP
Legislation	1. NWR Act	Model law; Wilayah Persekutuan	NRE	Draft ready	11th MP
	2.SWR Enactment	13 States	State Govts.	Enacted in Sabah, Selangor and Kedah In force since 2006 with varying progress In force since 2003.	11th MP
	3. WSIA 2006 and SPAN 2006	Peninsular Malaysia and Labuan	KeTTHA, SPAN, State Govts	In force since 1994. Migration completed in some states	11th MP
	4. Sabah Water Supply Enactment 2003	Sabah	Sabah State Water Authority	Need for water regulating body	11th MP
	5. Sarawak Water Ordinance 1994	Sarawak	Sarawak State Water Authority	In force since 1994	11th MP
	6. Irrigation Areas Act 1953 and Drainage Works Act 1954	National		In force including amendment up to 2006 with varying progress. Needs review in view of NWRP 2012	11th MP
Regulations	Rules specific to sub-sets and sub-themes	All States	SWRCs	LUAS, LUAK and Sabah WRC	11th MP
Finance	1. Federal funding support for Capacity Building, R&D and Development programmes	National inclusive of all states	NRE, KeTTHA, MOA. KPKT and State Govts.	Ad-hoc	11th MP and beyond

APPENDICES 2

2. Institutional Framework				
Hierarchical Level	**Lead Agency/ Composition**	**Functions**	**Current Status**	**Target Establishment**
National 1. MSAN	Chair: DPM Secretariat: NRE/ KeTTHA Members: Relevant Ministers and State Chief Ministers	Apex Body for WR Management	Established since 1998	
2. Inter-Ministerial Committee on IWRM	Chair: KSU NRE Secretariat: NRE Members: KSUs of water related ministries and State Secretaries	1. Oversee implementation of IWRM programs nation-wide. 2. Develop & set IWRM standards and guidelines 3. IWRM Capacity Building and R&D nation-wide	ILBM only. Need for expansion to address IWRM holistically	11th MP
3. IWRM Technical Committee	Chair: KP JPS/CEO SPAN Secretariat: JPS Members: Heads of Federal water-related departments and agencies, Directors of SWR Boards/Councils/ Committees as relevant		None	11th MP
State 1. SWRCs	SUKs/State water related depts. & agencies	Oversee State Water Res. development & management	SWRC Sabah 1998 LUAS 1999 LUAK 2008	11th MP
2. State IWRM Technical Committee	State JPS/ State heads of water-related departments and agencies	Oversee implementation of state IWRM programs	None	11th MP
River Basin 1. River Basin Committee	SWRC/District heads of water-related departments and agencies	Oversee planning and implementation of basin level programs	Selangor only	11th MP
2. Local community groups	RBC/NGOs	Participatory management	Currently informal	11th MP and beyond

APPENDICES 3

3. Management Instruments				
Focus Area	**Lead Agency/ Collaborating Partners**	**Scope**	**Current Status**	**Target Completion**
1. Information Management	NRE/Water related ministries/ SWRCs	National WR Database & Repository with links to all IWRM sub-sets and stakeholders	Fragmented along sectoral lines	11th MP
2. Planning	NRE/KeTTHA/ MOA/KPKT/MOH/ SWRCs	1. Foresight studies on IWRM and sub-sets 2. Guidelines on IWRM and sub-sets	Limited extent & Ad-hoc	11th MP
3. Economic	NRE/KeTTHA/ SPAN/MOA/ KPKT/MOH/ SWRCs	1. Incentive Schemes (PES,etc) 2. Uniform pricing and tariff structure 3. Targeted Subsidies	Limited success	11th MP
4. Legal	NRE/KeTTHA/ SPAN/MOA/ KPKT/MOH/ SWRCs	Enforcement of all related laws and regulations	Limited success in WSM but practical nil on WDM	11th MP
5. Participatory Management	NRE/KeTTHA/ MOA/SWRCs	Engagement with NGOs and local communities for greater efficiency and taking “ownership” and seeking win-win solutions	Limited and ad-hoc	11th MP and beyond
6. Research & Development	NRE/KeTTHA/ SPAN/MOA/ KPKT/MOH/ SWRCs	Setting a National Agenda for integrated water research	ASM Study report completed. Awaiting adoption and implementation	11th MP and beyond
7. Capacity Building	NRE/KeTTHA/ SPAN/MOA/ KPKT/MOH/ SWRCs	Provide coordinated training modules in IWRM and sub-sets targeting public, private, NGO, and community stakeholders	Limited extent & mostly sectoral	11th MP and beyond
8. International Collaboration	NRE/KeTTHA/ MOA/KPKT	Networking and strategic alliances with international organisations and WRIs relevant to IWRM and sub-sets	Limited extent	11th MP and beyond

APPENDICES 4

4. Investments in Water Infrastructure: Summary of EPPs for a Water NKPA				
Item	**Water Infrastructure Development Programme**	**Lead Implementing Agency/ Collaborating Partners**	**Entry Point Projects**	**Target Completion**
		A. **Water As a Resource**		
1	Flood/ Drought Mitigation	NRE/Relevant States	• Develop and improve flood forecasting centre and technology	• 11th MP
			• Structural and non-structural flood mitigation works	• 11th MP
			• Develop flood sensitive designs/ solutions for commercialisation	• 12th MP
			• Improve flood relief, response and recovery mechanism/ institutions	• 11th MP
			• Develop drought infrastructure and alternative water sources	• 12th MP
			• Develop catastrophe insurance industry	• 11th M
2	Integrated Water Resources Management (IWRM)	NRE/Water-related Ministries/ SWRCs	• Set up IWRM Training Centres	• 11th MP
			• Setup RBOs for all major river basins	• 11th MP
			• Watershed management/ restoration programmes	• 12th MP
			• Develop ILBM and IRBM	• 11th MP
			• Develop trans-boundary water resources management	• 11th MP
3	Water Research and Innovation Cluster	NRE/IHLs/ Water related Ministries/ SWRCs	• Set up a dedicated Water Research Centre	• 11th MP
			• Establish a Water Data Centre	• 11th MP
			• Developed Water Innovation and Industry Clusters	• 11th &12th MP
			• Develop Centres of Water Excellence in Local Academia	• 11th MP

APPENDICES 4

4. Investments in Water Infrastructure: Summary of EPPs for a Water NKPA				
Item	**Water Infrastructure Development Programme**	**Lead Implementing Agency/ Collaborating Partners**	**Entry Point Projects**	**Target Completion**
4	Ecosystem Services	NRE/SWRCs	• PES framework and mechanism for Malaysia	• 11th MP
			• Watershed rehabilitation and management of river basins and resources	• 11th MP
			• Lake briefs and management plans for Malaysian lakes	• 11th MP
			• Wetland restoration and management	• 12th MP
			• Mangrove replanting and coastal protection	• 12th MP
5	Climatic Change Adaptation	NRE/Water related Ministries/ SWRCs	• Establish a Regional Water Hub for Climatic Change Adaptation	• 11th MP
			• Weather and climatic change forecasting and modelling	• 11th MP
			• Climatic change adaptation	• 12th MP
			• Carbon sequestration/ financing	• 12th MP
6	Water Pollution Monitoring and Rehabilitation	NRE/MOH/ SWRCs	• River Basin Pollution Management Programme	• 11th MP
			• Superfund for clean-up of polluted rivers in Malaysia	• 11th MP
			• Modernising water quality monitoring network	• 11th MP
			• Develop water quality modelling tools and infrastructure	• 12th MP
			• Community river management programmes	• 12th MP
			• Pollution control at source	• 12th MP

APPENDICES 4

4. Investments in Water Infrastructure: Summary of EPPs for a Water NKPA				
Item	**Water Infrastructure Development Programme**	**Lead Implementing Agency/ Collaborating Partners**	**Entry Point Projects**	**Target Completion**
7	Integrated Coastal Zone Management (ICZM)	NRE/SWRCs	• ICZM/ ISMP Network for all Malaysian States	• 13th MP
			• Coastal Erosion Monitoring and Rehabilitation Programme	• 12th MP
			• Estuarine and Marine Fishery Management	• 11th MP
			• Offshore Sand Mining, Reclamation and Dredging Industry	• 11th MP
			• Coral Triangle Initiative (STI)	• 13th MP
			• Trans-boundary Pollution Monitoring	• 12th MP
8	Meetings, Incentives, Conference and Exhibition (MICE)	NRE/Water related Ministries/ SWRCs	• Develop Malaysia as Water Hub	• 11th MP
			• Develop Malaysia as MICE for water sector/ industry	• 11th MP
			• Host global/ regional/ national water events	• 12th MP
9	Water-based Recreation and Tourism	KPKT/MOTAC/ LAs	• Water tourism products	• 12th MP
			• Conservation of high-value tourism areas	• 11th MP
			• Hosting of water-related events, competitions and festivals	• 12th MP
10	Waterfront and Water-Sensitive City	KPKT/LAs	• Develop integrated urban water resource management	• 11th MP
			• Improve storm-water management	• 11th MP
			• Rainwater harvesting	• 12th MP
			• Water efficient design/ buildings	• 12th MP
			• River of Life	• 12th MP

APPENDICES 4

4. Investments in Water Infrastructure: Summary of EPPs for Water NKPA				
Item	**Water Infrastructure Development Programme**	**Lead Implementing Agency/ Collaborating Partners**	**Entry Point Projects**	**Target Completion**
		B. **Water as a Utility**		
1	Water Supply Sector	KeTTHA/ SPAN/Sabah SWA/ Sarawak SWA/SWRCs	• Privatisation/ corporatisation of water supply sector	• 13th MP
			• Smart water network monitoring systems for non-revenue water reduction	• 12th MP
			• Improve urban and rural water supply infrastructure	• 11th MP
			• Develop water demand management initiatives	• 12th MP
			• Inter-basin water transfer schemes	• 13th MP
			• Commercialisation of technology and expertise	• 13th MP
2	Wastewater and Energy Sector	KeTTHA/SPAN/ TNB/SEB/ SESB/Sabah LAs/ Sarawak LAs/SWRCs	• Expand sewerage infrastructure and regionalisation of sewerage networks	• 13th MP
			• Waste to wealth – bio-effluent, bio-solids and bio-gas industry	• 13th MP
			• Potable and non-potable wastewater recycling	• 13th MP
			• Tertiary treatment for sewage to reduce eutrophication in public waters	• 13th MP
			• Develop industrial wastewater treatment systems	• 13th MP
			• Zero-discharge and zero-energy for wastewater facilities	• 13th MP
			• Hydropower development	• 13th MP
			• Improving efficiency of water use in thermal power plants	• 13th MP

APPENDICES 4

4. Investments in Water Infrastructure: Summary of EPPs for Water NKPA				
Item	**Water Infrastructure Development Programme**	**Lead Implementing Agency/ Collaborating Partners**	**Entry Point Projects**	**Target Completion**
3	Groundwater Development	KeTTHA/ Sabah SWA/ Sarawak SWA/ SWRCs	• Groundwater mapping and abstraction	• 11th MP
			• Groundwater metering and licensing	• 13th MP
			• Groundwater recharge technology	• 13th MP
			• Groundwater infrastructure and service sector development	• 12th MP
	Agricultural Water Management	MOA/SWRCs	• Water metering for irrigation areas	• 12th MP
			• Improve productivity of agriculture water	• 11th MP
			• Reuse of wastewater for irrigation	• 11th MP
			• Recycling systems for aquaculture industry	• 11th MP
			• Livestock waste treatment systems	• 12th MP
			• Urban Farming	• 12th MP
5	Commercial water to Shipping	MOT/SWRCs/ LAs	• Water supply for shipping	• 11th MP
			• Navigational channel and port dredging	• 11th MP
			• Ballast water monitoring, management and treatment systems	• 11th MP
			• Urban water transport	• 11th MP

BIBLIOGRAPHY

Bibliography

Academy of Sciences Malaysia (2009). Strategies for the Sustainable Development and Management of Lakes and Reservoirs in Malaysia (Volume 1: Main Report).

Academy of Sciences Malaysia (2009). Strategies for the Sustainable Development and Management of Lakes and Reservoir in Malaysia (Volume 2: Conceptual Framework, Component Plans, and Position Papers)

Academy of Sciences Malaysia (2009). Strategies for the Sustainable Development and Management of Lakes and Reservoir in Malaysia Volume 3 (Part 1 – A Desk Study on the Status of Eutrophication of Lakes in Malaysia (2005))

Academy of Sciences Malaysia (2009) Volume 3 (Part 2 – Proceedings of the Colloquium on Lakes and Reservoir Management in Malaysia: Status and Issues (2007)).

Academy of Sciences Malaysia (2009). Groundwater Colloquium 2009:"Groundwater Management in Malaysia – Status and Challenges"

Academy of Sciences Malaysia (2010). Managing Lakes and Their Basins for Sustainable Use in Malaysia (Lake Briefs Report Series 1)

Academy of Sciences Malaysia (2010). Groundwater Workshop Proceedings: Groundwater in the Context of IWRM

Academy of Sciences Malaysia (2010). National Colloquium on Water Demand Management Towards More Sustainable Solutions in Water Demand Management.

Academy of Sciences Malaysia (2010). Forum on "Making IWRM Work: A Review of Current Regional and Global Programmes and Initiatives"

Academy of Sciences Malaysia (2010): Study on the Status of Climate Change Impact on Water-Related Issues. ASM Study Report 1/2011.

Academy of Sciences Malaysia (2011). ASM Study Report 1/2011: Study on the Status of Climate on Water-Related Issues.

Academy of Sciences Malaysia (2011). ASM Advisory Report 1/2011: Strategies for the Sustainable Development and Management of Groundwater Resources in Malaysia.

Academy of Sciences Malaysia (2011). Managing Lakes and Their Basins for Sustainable Use in Malaysia: "Lake Briefs Report Series No. 1".
Academy of Sciences Malaysia (2012). ASM Series on Climate Change Malaysia: Climate Change Scenarios.

Academy of Sciences Malaysia (2012). National Conference on the Impact of Climate Change on Water Resources and the Consequences to Major Economic Sectors.

Academy of Sciences Malaysia (2013). Lakes of Malaysia Coffee Table Book

Academy of Sciences Malaysia (2014). ASM Advisory Report 1/2014: Strategic Plan for Addressing the Impacts of Climate Change on Water-Related Issues in Malaysia.

Academy of Sciences Malaysia (2014). ASM Advisory Report 2/2014: Setting a National Agenda for Integrated Water Research (Volume 1).

Academy of Sciences Malaysia (2014). ASM Position Paper 2/2014: A Study on the Current Status and Needs Assessment of Water Resources Research in Malaysia (Volume 2).

Academy of Sciences Malaysia (in print). ASM Advisory Report (../2015): Strategic Plan for the Management of Water Supply and Waste Water

Academy of Sciences Malaysia (in print). ASM Advisory Report (../2015): For "A National Key Priority Area (NKPA) On Water"
Academy of Sciences Malaysia (in print). ASM Advisory Report (../2015): Strategic Plan for Integrated River Basin Management (IRBM)

Academy of Sciences Malaysia (in print). ASM Position Paper .../2015: Water Demand Management (WDM)

Academy of Sciences Malaysia (in print). ASM Position Paper: Adaptive Capacity Report on Water-related Policy and Legislation (WPL)
Government of Malaysia (GOM). (2012). National Water Resources Policy. Ministry of Natural Resources and Environment.

Government of Malaysia (GOM). (2011). National Water Resources Study (NWRS) 2000-2050. Department of Irrigation and Drainage Malaysia.

Government of Malaysia (GOM). (2006). Water Services Industry Act 2006 (Act 655). National Water Services Commission (SPAN).

Government of Malaysia (GOM). (2010). National Physical Plan 2 (NPP 2), Department of Town and Country Planning (JPBD).

Government of Malaysia (GOM). (2006). Irrigation Areas Act 1953. Law of Malaysia Act 386.

Government of Malaysia (GOM). (2006). Drainage Works Act 1954. Law of Malaysia Act 354.

Millennium Ecosystem Assessment (2005). Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. World Resources Institute

WWAP (United Nations World Water Assessment Programme). (2015). The United Nations World Water Development Report 2015. Water for a Sustainable World, Paris, UNESCO.

World Water Council (2015). Integrated Water Resource Management: A New Way Forward - A Discussion Paper of the World Water Council Task Force on IWRM
World Economic Forum (2015). Global Risks 2015, 10th Edition

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