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ECONOMIC PLANNING UNIT

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ACADEMIA MODULE

Advocacy, Awareness, Capacity Building and Public Participatory Platforms (AACB)

WATER SECTOR TRANSFORMATION 2040

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CHAPTER 1 INTRODUCTION

1.1 Overview on WST 2040

In preparing the groundwork for the period of the 12th Malaysia Plan (MP) and beyond, the Economic Planning Unit (EPU), Prime Minister's Department, had prepared a Strategy Paper in collaboration with the United Nations Development Programme (UNDP) as a strategic partner and assisted by a Drafting Committee, comprising experts with vast experience in the water sector, from both the Government agencies and non-Government organisations nationwide through extensive stakeholder consultations (ASM 2021a).

In the Strategy Paper, EPU described the Way Forward as a National Agenda for Malaysia's Water Sector Transformation (WST2040), planned to be undertaken in 4 phases over 20 years span, beginning with the 12th MP (2021 - 2025) and ending with the 15th MP (2036 – 2040). In this context, the 12th MP also represents the first half of the nation's Shared Prosperity Vision 2030 which is a stated commitment to ensure Malaysia achieves sustainable growth in tandem with equitable distribution across income groups, ethnicities, regions and supply chains (ASM 2021a).

The WST2040 has two basic objectives as follows (ASM 2021a):

1) WST2040 is to ensure that water security and sustainability nationwide, in line with global and national targets, continues to be fulfilled beyond 2040 where there is water supply for all.
2) WST2040 aims to transform Malaysia's water sector from being one of an economic enabler to a dynamic economic sector as a growth engine that can contribute to the country's Gross Domestic Product (GDP), generate revenue, increase efficiency in water management as well as to provide enhanced employment opportunities in the water sector and drive the country's science, technology and innovation in the water arena.

Considering that WST2040 is a national economic agenda, for the 12th MP, EPU had identified 2 Strategic Shifts as follows (ASM 2021a):

1) Accelerating implementation of IWRM (Integrated Water Resources Management).
2) Transforming the water sector from an Economic Enabler towards becoming a dynamic growth in the national agenda on Water Sector Transformation 2040.

and the 5 Strategies are as follows:

1) Empowering People in Transforming the Water Sector
2) Strengthening Governance at all levels
3) Enhancing Capacity in data-driven decision-making
4) Strengthening financing capacity
5) Developing sustainable infrastructure cost-effective technology

In order to develop a comprehensive roadmap, EPU has engaged Academy of Sciences Malaysia (ASM) to prepare a complete National Agenda Roadmap on the Transformation of the National Water Sector 2040 (Roadmap WST 2040). The EPU-ASM WST 2040 consists of 8 task forces, as stated below (ASM 2021a):

1) Advocacy, Awareness, Capacity Building and Public Participatory Platforms (AACB);
2) Integrated Water Sector Data Centre (IWSDC);
3) IR 4.0 in the Various Water Sub-sectors (IR4.0 WS);
4) Water-Food-Energy Nexus (WFE);
5) Virtual Water and Water Footprint (VW&WF);
6) Climate Change Impact and Adaptation (CCIA);
7) Alternative Water Financing (AWF); and
8) Water as an Economic Sector (WES)

1.2 Background of AACB Task Force

With the current rapid trend of urbanisations, development, industrialisation, and populations growth, it has increased the water demand and supply in Malaysia. Simultaneously, this development has severely impacted the water conditions in terms of water quality and water quantity. Therefore, this situation showed the cruciality of water sector transformations. There is a need for Malaysia to conserve and manage its water resources to ensure adequate and safe water supply. This effort is also required to ensure the water sustainability while protecting and restoring the environment in Malaysia (ASM 2021b).

The past decade has seen the rapid development and tremendous efforts on water sector transformations. Malaysia has launched the National Water Resources Policy in 2012 in the effort to transform the paradigm of water sectors. Moving forward, Malaysia with the initiative to lift up the effort on water sector transformation, adopted the Integrated Water Resources Management (IWRM) which also has been embodied in the National Water Resources Policy. The adoption of IWRM demonstrates a strong move from past fragmented and sectoral management practices (ASM 2021b).

However, the water resource management in Malaysia has been sectoral and fragmented for decades. Although there have been tremendous effort and programmes being carried out, however, due to inadequate understanding and awareness, especially amongst public participatory platforms on water sector transformation being the hindrance of a meaningful implementation of IWRM in Malaysia. This has caused the slow movement on the development of water sector transformation. The ownership of “water is essential in our life” or “water is part of our life” is still cannot be interpreted and embodied by Malaysian. Thus, it is necessary to make progress in rationalising the individual sectorial policies. By doing this, it will help Malaysia to strategise the planning in order to achieve the goals and eventually it can identify any gaps in the implementation and enforcement of IWRM (ASM 2021b).

Therefore, there is an urgent requirement for water sector transformation on **advocacy, awareness raising, and capacity building (AACB)** to be developed and implemented efficiently. This includes the training and education programmes, module and material development, communication, and delivery system, to improve the current water management system and practices in Malaysia (ASM 2021b).

Advocacy is a process of supporting and empowering people to be able to implement Water Sector Transformation, which includes communicating their opinions, ideas, and concerns towards better a recommendation. Advocacy is also a process available for public to access information and services, protecting and promoting their rights and responsibilities, and discovering choices and options toward better implementation of water sector Management (ASM 2021b).

Generating the **awareness** is crucial to provide the knowledge and information which relates to water sector transformation. This is also crucial to change the perceptions and idea on water usage and facts related to water. This all can be done by continuous awareness or campaign through media mass or water related programme, education, and participatory processes, then translating this awareness into more sustainable and meaningful development outcomes. The awareness should be able to change the public perspective and familiar with the water management concept and their roles and responsibilities to support this effort (ASM 2021b).

In order to ensure the sufficiency and developing the capacity of various stakeholders, **capacity building** is very crucial. This is to ensure a certain level of improvement and enhancement of knowledge, experience, and expertise in specific fields is achieved. At many levels in the process, even at the governmental level, it can be found that stakeholders lack the necessary knowledge and skills for a full and effective participation. Capacity building categories include education and awareness raising about community needs, information resources for policy making, regulations and compliance, basic infrastructure, and market stability, as well as technical capacities including practical knowledge and action in specific science and social aspects (ASM 2021b).

Therefore, the AACB Task Force was established under EPU-ASM WST2040 with the objectives as stated below:

1) Recommendation of management plan to government for better enforcement of IWRM policies.
2) Educate industry on their water impact and solution.
3) Community water awareness to translate their water aspirations into a policy.
4) Incorporate academic knowledge to support a sustainable water resource management.

Based on the objectives mentioned above, AACB has established 4 clusters, namely Government Cluster, Business Cluster, Community Cluster, and Academia Cluster.

1.3 Importance of the People: Academia

The word 'Academia' has a broad meaning where it is not only focus on the academics at the universities, but it encompasses the environment or community that is concerned on teaching, learning, research, etc. The core elements under Academia are the knowledge and education. Oxford Learner's Dictionaries (online) defines 'knowledge' as the state of knowing about a particular fact or situation; or the information, understanding and skills that someone gain through education or experience; whereas 'education' is a process of teaching, training and learning in schools, colleges or universities, to improve one's knowledge and develop skills.

As far as AACB is concerned, the AACB Team has identified the scope under the Academia Cluster, as the following:

(i) Preschool,
(ii) Primary School,
(iii) Secondary School,
(iv) Tertiary Education,

Whereby, the Academia Cluster has also referred to the National Education Philosophy when preparing the roadmap under WST 2040:

> *"Education in Malaysia is an ongoing effort towards further developing the potential of individuals in a holistic and integrated manner, so as to produce individuals who are intellectually, spiritually, emotionally, and physically balanced and harmonious, based on a firm belief in and devotion to God. Such an effort is designed to produce Malaysian citizens who are knowledgeable and competent, who possess high moral standards, and who are responsible and capable of achieving high levels of personal well-being as well as being able to contribute to the harmony and betterment of the family, the society, and the nation at large"*

(The National Education Philosophy for Malaysia, written in 1988 and revised in 1996. This Philosophy is also being referred by the Malaysia Education Blueprint 2013-2025)

The Ministry of Education Malaysia (KPM) is responsible to develop and sustain a quality education system that capable to develop individual's potential to achieve aspirations of the nation. In general, KPM is obliged to cover preschools, primary schools, and secondary schools, where KPM standardises syllabus, ensures quality and adequate teachers, provides sufficient infrastructures, and allocate adequate funding for school management and maintenance. All the efforts by KPM are to produce individuals that are intellectually, spiritually, emotionally, and physically balanced and harmonious, which is in accordance with the National Education Philosophy. In the Malaysia Education Blueprint 2013-2025, it also emphasises that every student should have 6 key attributes to be globally competitive, namely

knowledge, thinking skills, leadership skills, bilingual proficiency, ethics and spiritual, and national identity. The descriptions of the 6 key attributes are shown in Table 1.1.

Table 1.1 Descriptions of 6 key attributes needed by every student to be globally competitive

Key attributes	Description
Knowledge	At the most basic level, every child will be fully literate and numerate. Beyond this, it is important that students master core subjects such as Mathematics and Science and are informed with a rounded general knowledge of Malaysia, Asia, and the world. This would include their histories, people, and geography. Students will also be encouraged to develop their knowledge and skills in other areas such as the arts, music, and sports.
Thinking skills	Every child will learn how to continue acquiring knowledge throughout their lives (instiling a love for inquiry and lifelong learning), to be able to connect different pieces of knowledge, and to create new knowledge. Every child will master a range of important cognitive skills, including critical thinking, reasoning, creative thinking, and innovation. This is an area where the system has historically fallen short, with students being less able than they should be in applying knowledge and thinking critically outside familiar academic contexts.
Leadership skills	In our increasingly inter-connected world, being able to lead and work effectively with others is critical. The education system will help every student reach his or her full potential by creating formal and informal opportunities for students to work in teams, and to take on leadership roles. In the context of the education system, leadership encompasses four dimensions: entrepreneurship, resilience, emotional intelligence, and strong communication skills.
Bilingual proficiency	Every child will be, at minimum, operationally proficient in Bahasa Malaysia as the national language and language of unity, and in English as the international language of communication. This means that upon leaving school, the student should be able to work in both Bahasa Malaysia and English language environment. The KPM will also encourage all students to learn an additional language.
Ethics and spiritual	The education system will inculcate strong ethics and spirituality in every child to prepare them to rise to the challenges they will inevitably face in adult life, to resolve conflicts peacefully, to employ sound judgement and principles during critical moments, and to have the courage to do what is right. The education system also seeks to nurture caring individuals who gainfully contribute to the betterment of the community.
National identity	An unshakeable sense of national identity, tied to the principles of the *Rukun Negara*, is necessary for Malaysia's success and future. Every child will proudly identify as Malaysian, irrespective of ethnicity, religion or socio-economic status. Achieving this patriotism requires that every child understands the country's history, and shares common aspirations for the future. Establishing a true national identity also requires a strong sense of inclusiveness. This can be achieved through not only learning to understand and accept diversity, but to embrace it.

Source: Ministry of Education Malaysia, 2013

A quality education system is vital to nurture young generation, and the education system must be supported by adequate resources, including both human and financial resources. As of 31 March 2021, there are about 5 million students (including students from preschools, primary schools and secondary schools) throughout Malaysia (Table 1.2). In order to have sufficient resources to teach these students, Malaysia have trained 423,140 teachers, and have established 16,440 schools that consists of 194,091 classes (Ministry of Education Malaysia, 2021). The details for different types of schools are shown in Table 1.2.

Table 1.2 Details for different types of schools in Malaysia

Types of schools	Number of Students	Number of Teachers	Number of Schools	Number of Classes
Preschools	206,678	9,315	6,215	9,676
Primary Schools	2,765,456	236,348	7,780	106,476
Secondary schools	2,034,358	177,477	2,445	77,939
TOTAL	**5,006,492**	**423,140**	**16,440**	**194,091**

Updated 31 March 2021
Source: Ministry of Education Malaysia, 2021

Besides the preschools, primary and secondary schools, the tertiary education is also important in moulding a generation that is knowledgeable, ethic, creative, innovative and responsible. There are 20 public universities in Malaysia, namely Universiti Malaya (UM), Universiti Sains Malaysia (USM), Universiti Kebangsaan Malaysia (UKM), Universiti Putra Malaysia (UPM), Universiti Teknologi Malaysia (UTM), Universiti Utara Malaysia (UUM), Universiti Islam Antarabangsa Malaysia (UIAM), Universiti Malaysia Sarawak (UniMAS), Universiti Malaysia Sabah (UMS), Universiti Pendidikan Sultan Idris (UPSI), Universiti Teknologi MARA (UiTM), Universiti Sultan Zainal Abidin (UniSZA), Universiti Malaysia Terengganu (UMT), Universiti Sains Islam Malaysia (USIM), Universiti Tun Hussein Onn Malaysia (UTHM), Universiti Teknikal Malaysia Melaka (UTeM), Universiti Malaysia Pahang (UMP), Universiti Malaysia Perlis (UniMAP), Universiti Malaysia Kelantan (UMK) and Universiti Pertahanan Nasional Malaysia (UPNM) (Ministry of Higher Education, 2020). Besides public universities, there are also numerous private higher education institutions (HEIs) in Malaysia, as shown in Table 1.3. Both public universities and private HEIs play an important role in providing tertiary education. Table 1.4 shows different types of student enrolment of universities and private HEIs in 2019, whereas Table 1.5 shows number of lecturers in universities and private HEIs in 2019.

Table 1.3 Numbers of private higher education institutions in Malaysia

Private higher education institutions (HEIs)	Quantity
Private HEIs with university status	51
Private HEIs with university status (branch campus of foreign university)	10
Private HEIs with university college status	39
Private HEIs with college status	335
TOTAL	**435**

Updated 31 March 2021
Source: Jabatan Pendidikan Malaysia, 2021

Table 1.4 Student enrolment in public universities and private HEIs in 2019

	Total Enrolment*	PhD's enrolment	Master's enrolment	Bachelor Degree's enrolment
Public universities	567,625	36,329	56,989	350,102
Private HEIs	633,344	8,165	33,114	313,214
TOTAL	**1,200,969**	**44,494**	**90,103**	**663,316**

**Total enrolment including enrolment of PhD, Master, Bachelor Degree, Postgraduate Diploma, Diploma and other relevant programme offered by the* public universities and private HEIs.
Source: Ministry of Higher Education, 2020

Table 1.5 Number of lecturers in universities and private HEIs in 2019

	Professors	Associate Professors	Lecturers
Public universities	1,945	4,753	22,502
Private HEIs	601	1,006	19,278
TOTAL	**2,546**	**5,759**	**41,780**

Source: Ministry of Higher Education, 2020

The preschools, primary schools, secondary schools and tertiary education are considered as formal education. According to Coombs et al. (1973), in general there are 3 different types of education:

> **Formal education**: the hierarchically structured, chronologically graded 'education system', running from primary school through the university and including, in addition to general academic studies, a variety of specialised programmes and institutions for full-time technical and professional training.

> **Informal education**: the truly lifelong process whereby every individual acquires attitudes, values, skills and knowledge from daily experience and the educative influences and resources in his or her environment – from family and neighbours, from work and play, from the marketplace, the library and the mass media.
>
> **Non-formal education**: any organised educational activity outside the established formal system – whether operating separately or as an important feature of some broader activity – that is intended to serve identifiable learning clienteles learning objectives.

As far as water resource management is concerned, the topics related to water have been incorporated into school curriculum. This means that the topics related to water are already in the formal education. In preschools, students learned on the topic 'Saya dan Alam Sekitar', where students have to find water related information from media, prepare scrapbook related to the cycle of rainwater, discuss about daily water use and how to save water, as well as issues related to water, such as drought, flood, water shortage, water pollution and water treatment. In primary school, the syllabus of Science in Standard 2 has incorporated the topic of 'Bumi dan Air', where students need to identify natural water resources such as rainwater, river, lake and sea, as well as to understand the water cycle. In secondary school, the syllabus of Science in Form 1 has incorporated the topic of 'Sistem dan Struktur Bumi', students will learn about water distribution on earth, including surface water and ground water and their risks. In Form 4 and Form 5, the secondary school students will learn about environmental sustainability, wastewater management, product lifecycle and environmental pollution. In addition, students will also learn water contaminated by domestic wastes.

Although the school curriculum has incorporated topics related to water are already in the formal education, relevant activities outside the formal education is still very limited, and most of the time these activities are non-structured and ad-hoc. These activities are crucial to bring students on the ground and explore the knowledge that could not found in the textbook. These activities served as a non-formal education and one of the methods under the non-formal education is by carrying out Project-Based Learning (PBL) activities. In general, PBL activities is a teaching method where students learn by hands-on and actively engage in project that dealing with the issues in the real world. The PBL activities that related with water are limited, and there is no proper platform to capture and document these activities for teaching and learning purpose.

Besides PBL, topics related to water can also be incorporated into co-curriculum activities in school. This includes co-curriculum activities related to sports, associations, clubs and uniform bodies, where these platforms allow students to apply the knowledge, skills and values that are related to water and the environment.

Through these co-curriculum activities, students can gain knowledge and skills via hands-on or practical experiences. Some of the co-curriculum entities in schools are:

a) Kelab Alam Sekitar / Kelab Pencinta Alam Sekitar
b) Kelab Lestari Alam
c) Kelab Renjer Sungai
d) Persatuan Geografi / Sejarah
e) Persatuan Pendidikan Sivik / Moral
f) Pengakap
g) Pandu Puteri
h) Kadet Remaja Sekolah
i) Kadet Polis

The topics that are related to sustainable water resource management can also be incorporated during the weekly school assembly at primary and secondary schools. Selected topics can be shared amongst the students and teachers, where examples of these topics include water resources, water management, environmental conservation and protection. Besides, the schools should also establish a strategic collaboration with stakeholders, such as the ministry, private sectors, media, community and PIBG (Persatuan Ibu, Bapa and Guru). Various activities can be conducted, these include Hari Bumi, Hari Air Sedunia, Hari Alam Sekitar, and Hari Kitar Semula.

Based on the discussion above, the framework for Academia is shown in Figure 1.1, where the emphasis is place on formal and non-formal education across preschools, primary school, secondary school and tertiary education.

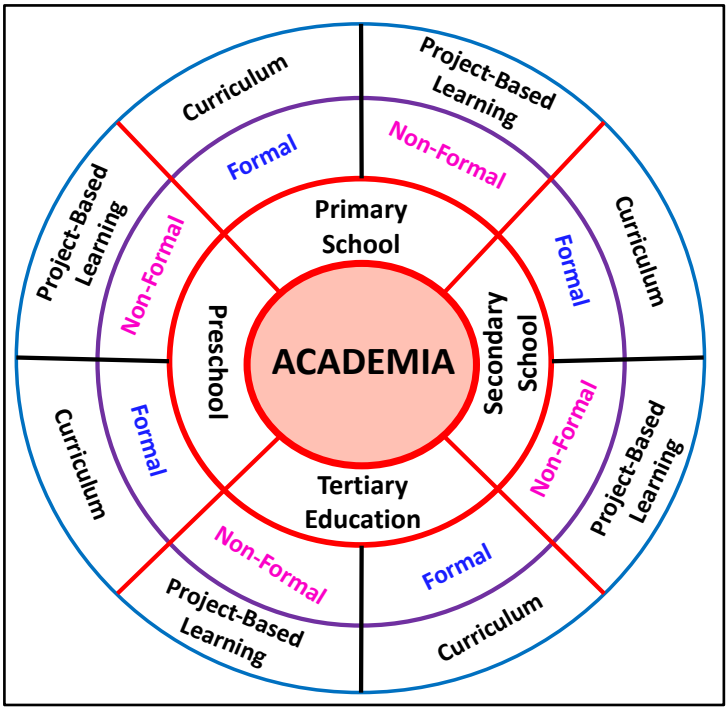

Figure 1.1 Framework for Academia

1.4 The Roadmap for Academia

By taking into account the current situation in Malaysia, as well as inputs from the stakeholders, the AACB would like to propose 3 strategies under the academia cluster, as stated below:

(1) Reiterate importance of rivers as water resources for human and the environment
(2) Inculcation of local values in promoting sustainable water resources management
(3) Enhance the roles of researchers from higher education institutions (HEIs) in promoting sustainable water resources management

Strategy 1: Reiterate importance of rivers as water resources for human and the environment

The topics related to water have been incorporated into school curriculum, this includes the syllabus of preschools, primary and secondary schools. This means that the topics related to water have already being part of the formal education. However, it is possible that students might have forgotten or still not aware that water is actually comes from the rivers. Water from the tap is actually obtained from the river and it was treated before deliver into our house (Figure 1.2). Therefore, when teaching topics that are related to water in schools, teachers should reiterate the importance of rivers as water resources for human and the environment. In this regard, teachers should be trained and retrained, where they should learn more case studies related to river management, thus they can share these case studies with students when teaching water related topics in the syllabus.

Figure 1.2 Water from the tap is actually obtained from the river and it was treated before deliver into our house

On the other hand, there is a need to prepare a guidebook on water sustainability that could be used by students from primary and secondary schools in Malaysia. The proposed guidebook on water sustainability will place emphasis on water resources, water related hazards/disaster, water management, water pollution, and other topics. This guidebook is based on thematic area of water that cross-cut different fields or disciplines, such as geology, hydrology, science and technology, and socio-economics. In order to prepare the guidebook on water sustainability, reference can be made to a guidebook published by the Ministry of Education in 2016, entitled 'Buku Panduan Kelestarian Global'. This guidebook is used by teachers in teaching and promoting global sustainability.

In school, it is proposed to establish an information corner in school's library that is related to water. In this dedicated information corner that focussing on water, the librarian with the assistance from students and teachers can prepare information sheets that could enhance awareness amongst the students on the importance of sustainable water resource management. The information sheets can include, for example, what will happen if the rivers are contaminated; status of river quality in Malaysia; the operation of water treatment plant. Besides, with the advancement of the technology, nowadays information can easily made available via internet. Subsequently, it is proposed that online education tools (such as application and/or gamification) that are related to water should be established. These online education tools served as an interactive and attractive platform to engage and educate students on topics that are related to water.

By referring to the 12th Malaysia Plan, it is stated that a strong TVET (Technical and Vocational Education and Training) ecosystem is one of the key catalysts in Malaysia socio-economic development. A strong TVET ecosystem will be a game changer that will create future-ready talent in meeting industry's demand. In this regard, there is a need to incorporate elements of sustainable water resources management into relevant teaching programmes in public TVET institutions and private providers.

As far as financial resource is concerned, all the activities proposed aforementioned required financial support from the government. Table 1.6 shows the roadmap and the proposed budget for the strategy - Reiterate importance of rivers as water resources for human and the environment.

Table 1.6 Roadmap and the proposed budget for the strategy - Reiterate importance of rivers as water resources for human and the environment

Strategy 1: Reiterate importance of rivers as water resources for human and the environment					
Focus Area	**Programmes**	**Lead Authority**	**Targets**	**Proposed Budget**	**Remarks**
People	Train and retrain teachers on activities that are related to water resource	KASA	211,570 teachers	Teacher's Training RM 10,578,500	The WST 2040 should cover 50% of the total

	management. Bahagian Pendidikan Guru (BPG) - Planning and conducting structured teacher's professional development for in-service teachers based on the guidebook or teacher's professional development module on water sustainability by ASM. Institut Pendidikan Guru Malaysia (IPGM) - The training will be implemented in various approaches of training such as face to face, online, and hybrid. i) Training of Trainers ii) Teachers' Training (8is – Interaction, Intellectual Capital)		**12MP:** 21,157 teachers **13MP:** 42,314 teachers **14MP:** 63,471 teachers **15MP:** 84,628 teachers	(0.5 day training/RM 50 for half day) **12MP:** RM 1,057,850 **13MP:** RM 2,115,700 **14MP:** RM 3,173,550 **15MP:** RM 4,231,400	teachers (423,140) in Malaysia
			140 trainers	Training of Trainers RM 40,000 **12MP:** RM 10,000 **13MP:** RM 10,000 **14MP:** RM 10,000 **15MP:** RM 10,000	Train 140 trainers
	Professional development programme to familiarise teachers with climate science, active pedagogy and project design. BPG - Planning and conducting structured teacher's professional	**Lead Authority** KASA **Collaborating Partners** MOE, ISTIC and Office for Climate Education, UNESCO	23,360 teachers **12MP:** 5,840 teachers **13MP:** 5,840 teachers **14MP:** 5,840 teachers **15MP:**	Teacher Training RM 1,401,600 (12 hours training) **12MP:** RM 350,400 **13MP:** RM 350,400 **14MP:** RM 350,400 **15MP:**	Train 23,360 teachers

	development for in-service teachers based on the teaching module on climate education. IPGM - The training will be implemented in various approaches of training such as face to face, online, and hybrid: i) Training of Trainers ii) Teachers' Training (8is – Interaction, Intellectual Capital)		5,840 teachers	RM 350,400	
			80 trainers	Training of Trainers RM 40,000 **12MP:** RM 10,000 **13MP:** RM 10,000 **14MP:** RM 10,000 **15MP:** RM 10,000	Train 80 trainers
Governance	Develop teacher's professional development workshop module and pedagogical activities (for formal and non-formal settings) on water sustainability and climate change adaptation. (8is – Integrity, Institution)	**Lead Authority** KASA **Collaborating Partners** MOE, Humid Tropics Centre (HTC - KL)	The content for the module and pedagogical activities are developed during **12 MP.**	RM 20,000	
	Develop inquiry-based climate change pedagogical resources for formal and non-formal settings, including resources for teacher's professional development. (8is – Integrity, Institution)	**Lead Authority** KASA **Collaborating Partners** MOE, MGTC, ISTIC and Office for Climate Education, UNESCO	The pedagogical resources are developed during **12 MP.**	RM 20,000	

	Offering courses related to water sustainability and climate change education in Program Ijazah Sarjana Muda Pendidikan (PISMP) (8is – Integrity, Institution)	**Lead Authority** KASA **Implement Authority** MOE & MOHE	The courses are developed and offered in **12 MP.**	RM 20,000	
	Incorporate elements of sustainable water resources management into relevant teaching programmes in public TVET institutions and private providers (8is – Integrity, Institution)	**Lead Authority** KASA **Implement Authority** MOE & MOHE	Relevant TVET programmes have been revised in **12 MP.**	RM 1,000,000	
Information and RDCI	Develop a water and climate literacies assessment instrument (8is – Infostructure)	**Lead Authority** KASA **Collaborating Partners** MOE, MOHE	The instrument is developed during **12 MP**.	RM 20,000	
	Establish a whole-school approach to promote water and climate literacies through formal and non-formal settings and quadruple helix model (8is – Infostructure)	**Lead Authority** KASA **Collaborating Partners** MOHE, MOE	8,220 schools **12MP:** 822 schools **13MP:** 1,644 schools **14MP:** 2,466 schools **15MP:** 3,288 schools	RM 822,000 (RM 100 per school) **12MP:** RM 82,200 **13MP:** RM 164,400 **14MP:** RM 246,600 **15MP:** RM 328,800	The WST 2040 should cover 50% of the total schools (16,440) in Malaysia

Infrastructure and Technology	Expand digital platforms/tools for teaching and learning Develop simulation-based games, mobile platforms, virtual environments, and augmented reality tools to heighten curiosity and increase learner's engagement. (8is – Infrastructure)	**Lead Authority** KASA **Collaborating Partners** MOE, MOHE	The online education platforms/ tools are developed during **12 MP.**	RM 1,000,000	
	Educate present and future generations about climate change by providing tools to help students learn science and geography more fun and effectively. (8is – Infrastructure)	**Lead Authority** KASA	2,445 secondary schools	RM 104,108,100 **12MP – 15MP:** Green House: RM92,910,000 Water Distillation Equipment: RM5,085,600 Meteorological Station: RM6,112,500	Involving 2,445 secondary schools
	Establish one-stop educational resources and activities on water and climate change in Digital Educational Learning Initiatives Malaysia (DELIMa) platform. (8is – Infrastructure)	**Lead Authority** KASA	The one-stop platform is developed during **12 MP**.	RM 1,000,000	All schools can access the educational resources and activities in DELIMa.
Finance	The financial support is needed for the programmes proposed above. Please refer to respective programme for the detailed budget.				

Strategy 2: Inculcation of local values in promoting sustainable water resources management

Although topics related to water have been incorporated into school curriculum, there is a need to link the knowledge that they learnt from the book with the real world. Students should appreciate their surrounding environment (Figure 1.3). In this regard, teachers can carry out water related activities together with students, such as via project-based learning (PBL) activities, as part of the initiatives under non-formal education. Therefore, teachers should be trained and retrained on potential activities that are related to water resource management. These activities will place emphasis on the local setting, such as information on the rivers that are near to their school, local initiatives in river protection and cleaning, local entities that are responsible to manage the rivers. In addition, the Ministry should also compile local and international case studies on the best practises of river/water management, and then share these case studies throughout Malaysia.

When conducting PBLs, teachers and students are expected to collect local data. This data includes the nearest river to the school, water quality data of the river, information on the flora and fauna near the river, land use, meteorological data and other relevant data. Once this data is made available, the schools can set up a dedicated resource centre for the river nearest to their school. Besides, teachers can consider establishing a website to showcase the PBL activities that were conducted. The website can be incorporated into the schools' website to reduce cost and to ease maintenance.

As stated in the 12th Malaysia Plan, TVET in Malaysia will be enhanced in order to prepare TVET graduates that are capable in meeting industry's demands. In this regard, the collaboration and cooperation between TVET and industry should be strengthened. This include having more sessions or platforms for industry to share their experiences and expectations with the TVET students.

As far as financial resource is concerned, all the activities proposed aforementioned, required financial support from the government. Table 1.7 shows the roadmap and the proposed budget for the strategy – Inculcation of local values in promoting sustainable water resources management.

Figure 1.3 Students should appreciate their surrounding environment

Table 1.7 Roadmap and the proposed budget for the strategy - Inculcation of local values in promoting sustainable water resources management

Strategy 2: Inculcation of local values in promoting sustainable water resources management					
Focus Area	**Programmes**	**Lead Authority**	**Targets**	**Proposed Budget**	**Remarks**
People	Train and retrain teachers on activities that are related to water resource management. BPG - Planning and conducting structured teacher's professional development for in-service teachers based on the guidebook or teaching module by ASM. IPGM - The training will be implemented in various approaches	**Lead Authority** KASA **Implement Authority** Ministry of Education (MOE)	211,570 teachers **12MP:** 21,157 teachers **13MP:** 42,314 teachers **14MP:** 63,471 teachers **15MP:** 84,628 teachers	Teacher's Training RM 10,578,500 (0.5 day training/RM 50 for half day) **12MP:** RM 1,057,850 **13MP:** RM 2,115,700 **14MP:** RM 3,173,550 **15MP:** RM 4,231,400	The WST 2040 should cover 50% of the total teachers (423,140) in Malaysia

	of training such as face to face, online, and hybrid. i) Training of Trainers ii) Teachers' Training (8is – Interaction, Intellectual Capital)				
Governance	Compile local and international case studies on the best practices of river/water management and climate change adaptation. (8is – Integrity, Institution)	**Lead Authority** KASA **Collaborating Partners** MOE, Humid Tropics Center (HTC - KL)	The case studies on the best practices of river/water management are compiled during **12 MP.**	RM 20,000	Establish a committee to compile local and international case studies on the best practices of river/water management
	Strengthen collaboration and cooperation between TVET and industry, where more sessions or platforms for industry to share their experiences and expectations with the TVET students will be established (8is – Integrity, Institution)	**Lead Authority** KASA	Sessions or platforms for industry to share their experiences and expectations with the TVET students have been established in **12 MP.**	RM 1,000,000	
Information and RDCI	Federal and state/local agencies arrange education programmes that involve learners use open government data related to water and climate change in data-driven decision making.	**Lead Authority** KASA **Collaborating Partners** MOE	8,220 schools **12MP:** 822 schools **13MP:** 1,644 schools **14MP:** 2,466 schools **15MP:**	RM 822,000 (RM 100 per school) **12MP:** RM 82,200 **13MP:** RM 164,400 **14MP:** RM 246,600 **15MP:**	The WST 2040 should cover 50% of the total schools (16,440) in Malaysia

	(8is – Infostructure)		3,288 schools	RM 328,800	
Infrastructure and Technology	Establish a single, searchable, user-friendly online resource for finding water- and climate-related education programmes and resources and funding opportunities as well as to showcase the project-based learning (PBL) activities that were conducted by schools (using a new or enhanced platform). (8is – Infrastructure)	**Lead Authority** KASA **Collaborating Partners** MOE, MOHE, MOSTI	The online platform is developed/ enhanced during **12 MP.**	RM 1,000,000	
Finance	The financial support is needed for the programmes proposed above. Please refer to respective programme for the detailed budget.				

Strategy 3: Enhance the roles of researchers from higher education institutions (HEIs) in promoting sustainable water resources management

Unlike preschools, primary and secondary schools, the higher education institutions (HEIs), either public or private, will determine and develop relevant curriculum for their undergraduate and postgraduate programmes. If the programmes are being recognised and accredited by professional bodies, such as engineering and medical programmes, then the HEIs must comply with all the requirements set by the professional bodies. On the other hand, for those programmes that are not being monitored by professional bodies, then the HEIs will take their own initiatives to develop the programmes. These programmes will then submitted to be approved by Ministry of Higher Education and accredited by Malaysian Qualification Agencies (MQAs).

The HEIs offer programmes in various fields and disciplines, these include the STEM (Science, Technology, Engineering and Mathematics), economics, social sciences, laws, arts and humanities. The topics related to water resources management might be one of the topics in the programmes offered by HEIs, however, it is challenging to find out which programmes that have incorporated topics related to water resources management as there is no central body that compile and consolidate the courses taught under these programmes. Furthermore, according to the requirement of

Ministry of Higher Education and MQAs, these programmes have to be revised after a certain timeframe to ensure the programmes are up-to-date and relevant to current development. In this regard, there is a need to train lecturers on topics and activities that are related to water resource management. The topics here include Integrated Water Resources Management (IWRM), Integrated Lake Basin Management (ILBM), Integrated River Basin Management (IRBM), and other relevant topics. The topics can also relate to the water issues that are encountered in Malaysia (Figure 1.4). In addition, lecturers can also compile success stories related to water resources management in HEIs (public and private) and share it throughout Malaysia.

In HEIs, we believe there are numerous water resources experts. However, there is no platform to compile the contacts of these experts, and their relevant expertise. Therefore, there is a need to establish a database of resource persons in the field of water resource management. Besides, an interactive tool can also be established where this tool can create a platform for interactive communication between HEIs (public and private) and the public.

In order to strengthen the local knowledge, there is a need to strengthen RDCI (Research, Development, Commercialisation and Innovation) that are related to water resource management in Malaysia. The Government should mainstream water resource management as one of the priority research areas in RDCI, and then to provide and sustain adequate research funding to researchers in Malaysia. The research can encompass both fundamental research (e.g. establish theoretical framework that support IWRM) and application research (e.g. establish rainwater harvesting system).

Researchers at HEIs have vast experience in research, training and consultation, hence they should share their expertise with stakeholders, namely the government, industry and community. For the government, researchers can provide technical inputs as subject matter experts (SMEs) to government officers, as well as to represent Malaysia or assist government officials in international and regional negotiations. Besides, researchers can also become the memory keeper for the relevant ministry/agency to ensure a sustainable knowledge transfer. For industry, researchers can work closely with professional bodies to provide professional training courses or become consultants/technical advisors to selected industries. As far as community is concerned, researchers can take the leadership and proactive measures to outreach to the communities. Besides, researchers can also promote the concept of citizen science to enhance the community's engagement in sustainable water resources management.

As far as financial resource is concerned, all the activities proposed aforementioned, required financial support from the government. Table 1.8 shows the roadmap and the proposed budget for the strategy – Enhance the roles of researchers from higher education institutions (HEIs) in promoting sustainable water resources management.

Figure 1.4 Water issues that are encountered in Malaysia

Table 1.8 The roadmap and the proposed budget for the strategy – Enhance the roles of researchers from higher education institutions (HEIs) in promoting sustainable water resources management

Strategy 3: Enhance the roles of researchers from higher education institutions (HEIs) in promoting sustainable water resources management					
Focus Area	**Programmes**	**Lead Authority**	**Targets**	**Proposed Budget**	**Remarks**
People	To train lecturers on topics and activities that are related to water resource management. (8is – Interaction, Intellectual Capital)	KASA	25,043 lecturers **12MP:** 2,504 lecturers **13MP:** 5,008 lecturers **14MP:** 7,513 lecturers **15MP:** 10,018 lecturers	RM 2,504,300 (1- day training/RM 100 for 1 day) **12MP:** RM 250,400 **13MP:** RM 500,800 **14MP:** RM 751,300 **15MP:** RM 1,001,800	The WST 2040 should cover 50% of the total lecturers (50,085 that includes professor, associate professor and lecturers) in Malaysia
Governance	To compile success stories related to water resources management in	KASA	The success stories are compiled during **12 MP.**	RM 20,000	Establish a committee to compile success stories related to water

	HEIs (public and private) (8is – Integrity, Institution)				resources management in HEIs (public and private)
Information and RDCI	To establish a database of resource persons (from public and private HEIs) in the field of water resource management (8is – Infostructure)	KASA	The database is established during **12 MP.**	RM 50,000	The database is made available online.
	To mainstream water resource management as one of the priority research areas in RDCI. (8is – Infostructure)	KASA	10 projects for **each Malaysia Plan (MP)**	RM 20 million for **each Malaysia Plan (MP)**	The funding will be provided by Government
	Researchers' outreach to government agencies. (8is – Infostructure)	KASA	Government will provide **yearly operation fund** to researchers.	RM 5 million for **each Malaysia Plan (MP)**	The funding will be provided by Government
	Researchers' outreach to industry. (8is – Infostructure)	KASA	Government will provide **yearly operation fund** to researchers.	RM 5 million for **each Malaysia Plan (MP)**	The funding will be provided by Government
	Researchers' outreach to community. (8is – Infostructure)	KASA	Government will provide **yearly operation fund** to researchers.	RM 5 million for **each Malaysia Plan (MP)**	The funding will be provided by Government
Infrastructure and Technology	To establish an interactive tool that encourage interactive	KASA	The interactive tool is established	RM 200,000	The interactive tool can be used in different

	communication between HEIs (public and private) and the public (8is – Infrastructure)		during **12 MP.**		platforms, such as Windows, Mac, Android, iOS, etc.
Finance	The financial support is needed for the programmes proposed above. Please refer to respective programme for the detailed budget.				

As far as the database of resource persons is concerned, the AACB has taken the proactive initiative to compile a preliminary list of potential resource persons from 20 public universities and 5 private universities. Emails have been sent to the Dean/Directors of 93 entities, which include faculty of engineering, faculty of science and technology, faculty of earth science and environment, faculty of law, and other relevant faculties from 25 universities. Based on the email, the Dean/Directors have nominated potential resource persons in the field of water management, and they have also provided the short and full CVs of the potential resource persons. The status of the **preliminary list** of resource persons is shown in Table 1.9. The summary of resource persons' expertise can be found in Appendix A, whereas the compilation of short CV of the potential resource persons can be found in Appendix B. With this preliminary list, EPU and ASM can now evaluate and then identify the resource persons for WST 2040.

Table 1.9 Status of the **preliminary list** of resource person from 25 universities in Malaysia

No.	HEIs	Number of resource persons
1.	Universiti Kebangsaan Malaysia (UKM)	7
2.	Universiti Putra Malaysia (UPM)	9
3.	Universiti Malaya (UM)	7
4.	Universiti Sains Malaysia (USM)	14
5.	Universiti Malaysia Perlis (UniMAP)	3
6.	Universiti Teknologi Malaysia (UTM)	1
7.	Universiti Islam Antarabangsa Malaysia (UIAM)	2
8.	Universiti Utara Malaysia (UUM)	4
9.	Universiti Malaysia Sarawak (UNIMAS)	6
10.	Universiti Malaysia Sabah (UMS)	13
11.	Universiti Pendidikan Sultan Idris (UPSI)	2
12.	Universiti Sains Islam Malaysia (USIM)	1
13.	Universiti Teknologi MARA (UiTM)	13
14.	Universiti Malaysia Terengganu (UMT)	12
15.	Universiti Tun Hussein Onn Malaysia (UTHM)	21
16.	Universiti Teknikal Malaysia Melaka (UTeM)	3
17.	Universiti Malaysia Pahang (UMP)	1

18.	Universiti Sultan Zainal Abidin (UniSZA)	1
19.	Universiti Malaysia Kelantan (UMK)	3
20.	Universiti Pertahanan Nasional Malaysia (UPNM)	3
21.	Sunway University	3
22.	Monash University Malaysia	7
23.	Curtin University	6
24.	University of Nottingham Malaysia	4
25.	Universiti Teknologi Petronas	8
	TOTAL	**154**

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CHAPTER 2 APPROACH

2.1 Overview

Water is essential for human and the environment. We need to consume adequate water in order to stay healthy, and water is also needed by animals and plants for their living and growing. Therefore, it is crucial to ensure good water quality and sufficient water quantity to achieve a sustainable livelihood. We must acknowledge and appreciate the importance of water, and then to protect and conserve water. In this regard, educating young generation in promoting sustainable water resources is crucial, where this can be accomplished by incorporating water related knowledge via formal and non-formal educations.

2.2 The Training Module for Academia

Under AACB, we attempted to develop a training module that could train the young generation in promoting sustainable water resources. Nonetheless, to ensure training sustainability, although the ultimate purpose is to train the young generation, this module was designed to train the teachers (from preschool, primary and secondary schools) and lecturers (from higher education institutions (HEIs)) rather than students. The teachers and lecturers are the 'trainers' for the young generation, and they will spend more time in schools and HEIs compare to students. Hence, in other words, this training module is designed for Training of Trainers (TOTs). The objectives, scopes, expected output and outcomes for the training modules are as stated below:

A. Objectives

- To train teachers and lecturers in the aspect of sustainable water resource management.

B. Scopes

- Teachers (preschool, primary and secondary schools)
- Lecturers (higher education institutions)

C. Expected Output

- Teachers and lecturers have been trained on sustainable water resource management.

D. Expected Outcome

- Teachers and lecturers have incorporated elements of sustainable water resource management into their classes and lectures.

Under the AACB roadmap for academia, there are 3 proposed strategies, namely:
(1) Reiterate importance of rivers as water resources for human and the environment
(2) Inculcation of local values in promoting sustainable water resources management
(3) Enhance the roles of researchers from HEIs in promoting sustainable water resources management

The proposed strategies are mainly based on the requirement of formal and non-formal educations in relation to sustainable water resource management. Therefore, in this training module, for the formal education, we will be placing emphasis on the topics that are related to water resource management; whereas for non-formal education, activities related to water resource management will be highlighted. The correlation between the proposed strategies, topics (formal education) and activities (non-formal education) for teachers and lecturers is shown in Figure 2.1.

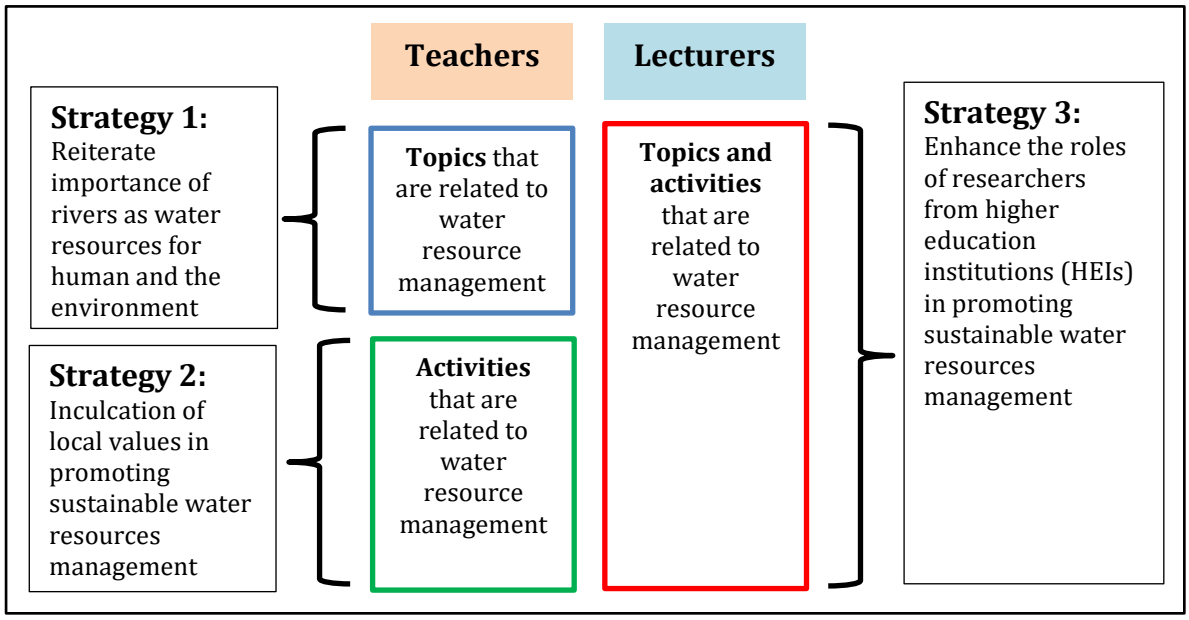


Figure 2.1 Correlation between the proposed strategies, topics (formal education) and activities (non-formal education) for teachers and lecturers

2.3 The Toolbox for Academia Module

There are many existing and available information that are related to sustainable water resource management. However, this information is scattered and might not be suitable to be used directly by educators in Malaysia. Therefore, in the AACB training module for academia, we have adopted the toolbox concept, where educators can select appropriate tools (i.e. topics and activities) from the toolbox (i.e. the training module) (Figure 2.2). Inside the toolbox, there are designated **topics** that suitable to be used as formal education, such as water and livelihood, water hazards, integrated water resources management (IWRM), integrated lake basin management (ILBM). Besides, there are also list of project-based learning (PBL) **activities** that can be used at preschool, primary and secondary schools, and HEIs. In order to assist users of the toolkit, we use the word 'educators' that represent teachers and/or lecturers; and the word 'students' representing preschool student, primary school student, secondary school student and/or HEIs' student.

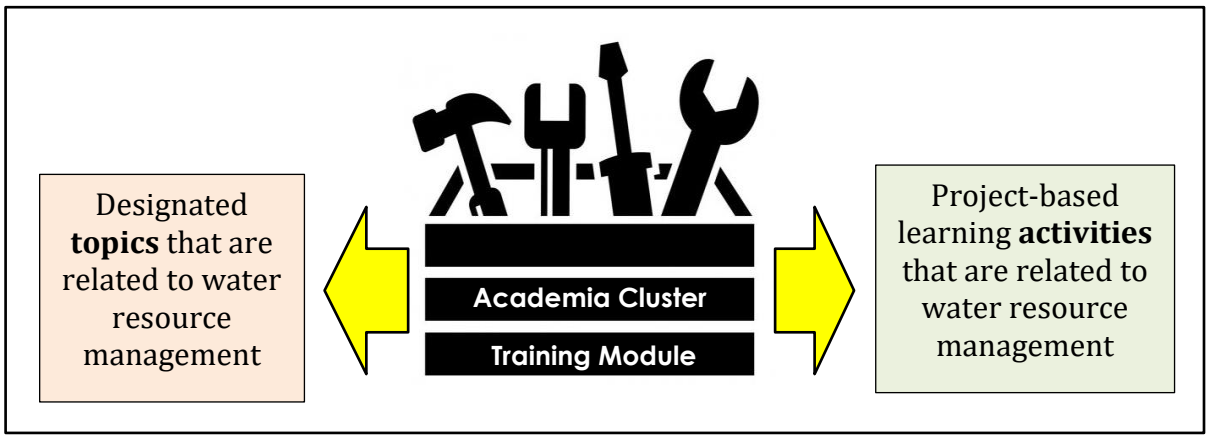


Figure 2.2 The toolbox for AACB academia training module

As far as the topics that are related to water resource management are concerned, the training module has identified 3 different levels that can accommodate the needs of selected target audiences, namely basic, intermediate and advance levels. Table 2.1 shows the description of each level in this training module.

Table 2.1 Different levels for the topics that are related to water resource management

Levels	**Description**
Basic	This level is for **awareness**. Educators can use the information in the teaching modules to teach their students, for example, primary school students. The information for the basic level should be sufficient to enhance the awareness of the target audiences.
Intermediate	This level is for **capacity building.** Educators can use the information in the teaching modules to teach their students, for example, secondary school students and university students. The information in the intermediate level can help students to have a better understanding on selected topics.
Advanced	This level is to train **potential advocators**. However, due to many materials and information have been established by relevant bodies at local and international levels, thus in this training module, we have listed down relevant materials that are available online, where educators can access these materials for further reading. In addition, educators can also contact the resource persons listed in this training module to further understand relevant topics.

Besides, although this training module was designed to train teachers and lecturers, trainers can also use this training modules to train students, as indicated in Figure 2.3. The mode of training includes both physical (face-to-face) training and online training.

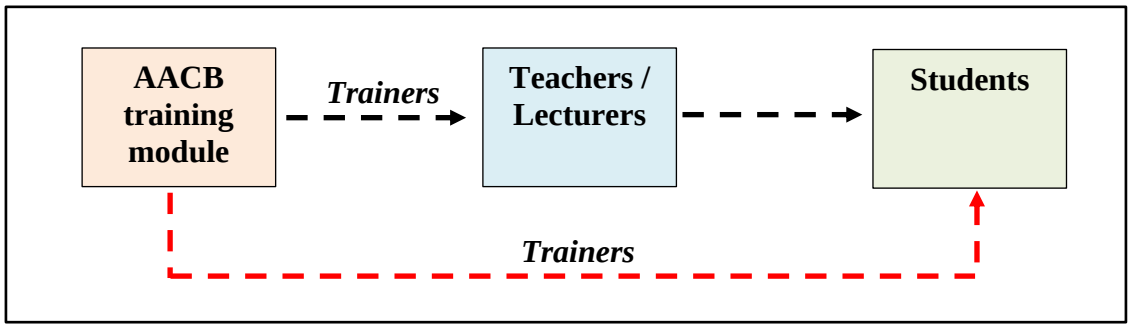


Figure 2.3 Application of AACB academia training module

As a starting point, the science teachers should be the priority group to receive training from AACB, and eventually it should cover teachers from different zones in Malaysia, namely Zon Utara, Zon Tengah, Zon Selatan, Zon Timur, Zon Sarawak, and Zon Sabah and Labuan. If the buy-in from the teachers are encouraging, this module can be used as reference for teachers once it has been evaluated by Bahagian Sumber dan Teknologi Pendidikan (BSTP) and Bahagian Pembangunan Kurikulum (BPK), followed by approval from the management of KPM.

CHAPTER 3 TOPICS

3.1 Overview

As far as water resource management is concerned, the topics related to water have been incorporated into school curriculum. This means that the topics related to water are already in the formal education. In preschools, students learned on the topic 'Saya dan Alam Sekitar', where students have to find water related information from media, prepare scrapbook related to the cycle of rainwater, discuss about daily water use and how to save water, as well as issues related to water, such as drought, flood, water shortage, water pollution and water treatment. In primary school, the syllabus of Science in Standard 2 has incorporated the topic of 'Bumi dan Air', where students need to identify natural water resources such as rainwater, river, lake and sea, as well as to understand the water cycle. In secondary school, the syllabus of Science in Form 1 has incorporated the topic of 'Sistem dan Struktur Bumi', students will learn about water distribution on earth, including surface water and ground water and their risks. In Form 4 and Form 5, the secondary school students will learn about environmental sustainability, wastewater management, product lifecycle and environmental pollution. In addition, students will also learn water contaminated by domestic wastes.

In this chapter, we have gathered and compiled existing relevant topics/information related to water resource management. These topics/information are aimed to complement existing syllabus (if the topics are already in the curriculum), else it will served as new topics if otherwise. Hence, educators can choose and select the information that they need from this training module and then use it when teaching students in the class. In addition, we have also listed the sources of information in each section, where we have retrieved/adopted/adapted information from these sources to prepare this training module.

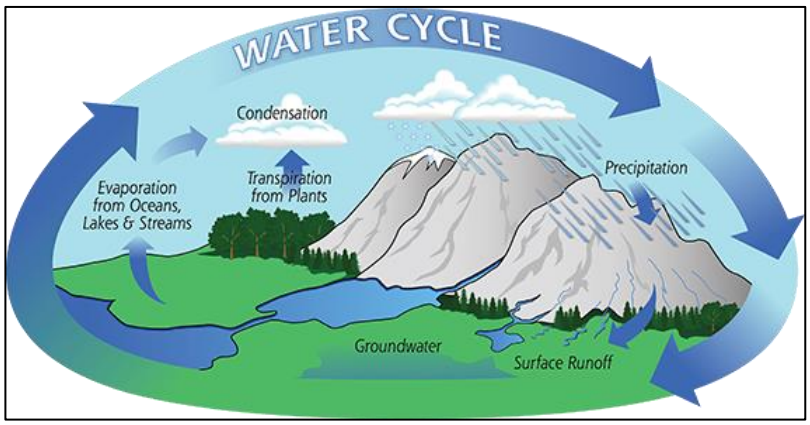
3.2 Water Resources

3.2.1 Why we need water?

The fact sheets [BASIC]

- About three quarters of the Earth's surface is covered by water, however, the freshwater that we depend upon only makes up 1% of this water.
- The same amount of water on Earth as there was when the Earth was formed.
- Water regulates the Earth's temperature, and water also regulates the temperature of human bodies.
- Fresh water is the most precious resource on earth – we use it in almost everything we do!
- 75% of the human brain is water, and 75% of a living tree is water.
- If we reduce 3 minutes a day in our shower time, it is estimated to save 13,140 litres of water a year.

- The amount of water needed to produce the following:
  - Slice of bread = 40 litres
  - An egg = 135 litres
  - Cup of coffee = 140 litres
  - Cotton t-shirt = 2,000 litres
  - Leather shoes = 8,000 litres



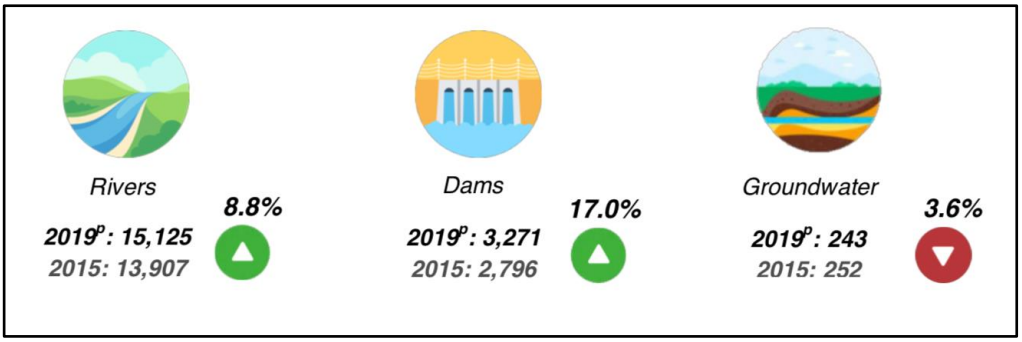
Source: NASA (via UCAR)

What can we do to save water? [BASIC]

- Install rainwater harvesting system or use water tanks to catch rainfall.
- Don't leave the water running while brushing your teeth or washing your hands.
- Ensure the laundry is full load before we start the washing machine.
- Hand washing dishes at once instead of throughout the day.
- Reuse grey water (from washing dishes, laundering clothes or bathing), if possible.
- Clean vegetable and fruits in a container/bowl. Do not wash using running water.
- When using shampoo to clean your hair, turn off the water.

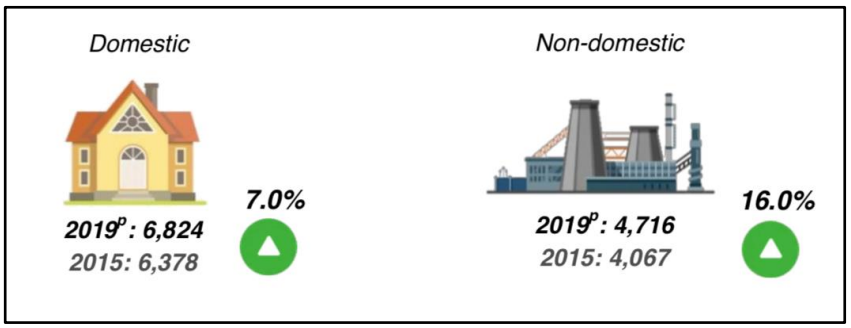
Water resources in Malaysia [BASIC/INTERMEDIATE]

- There are three (3) raw water sources in Malaysia, namely river, dam and groundwater.
- River is the main resources for raw water supply in 2019 with the quantity of 15,125 million litres per day (MLD).
- The supply of abstracted raw water from river and dam increased by 8.8% and 17.0%, respectively in 2019 (compared to 2015). On the other hand, the groundwater resources decreased by 3.6% (compared to 2015).



Source: Department of Statistic Malaysia

- Metred water consumption for domestic and non-domestic categories have increased 7.0% and 16.0%, respectively in 2019 (compared to 2015).



Source: Department of Statistic Malaysia

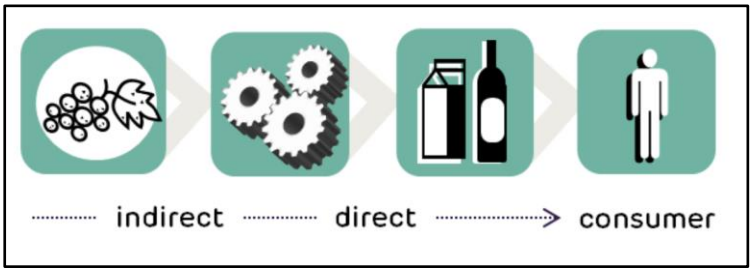
Exercise [BASIC/INTERMEDIATE]

- Title: Water – renewable or non-renewable?
- Instruction:
  - Students are divided into few groups.
  - Each group are given 10-15 minutes to discuss whether water is renewable or non-renewable resources.
  - Representative from each group will share their thoughts.
- Tips for educators:
  - Trigger the discussion by asking the definition of renewable and non-renewable recourses.
  - If a renewable resource is defined as a resource that is renewed or replenished by natural processes, then water on Earth is regarded as a renewable resource.
  - However, if the discussion is on drinking water supplies, students can argue that water is a non-renewable resource.

3.2.2 Water footprint

Water footprint [BASIC/INTERMEDIATE]

- Many of us do not aware that we consume water directly and indirectly.
- Hence, the water footprint was designed to measure the amount of water used to produce each of the goods and services we use.
- The water footprint can measure a single process, such as growing vegetable, or a product, such as manufacturing a car.
- The water footprint measures both direct and indirect water use of a process, product, industry, and includes water consumption and pollution throughout the supply chain, i.e. from production to consumption.



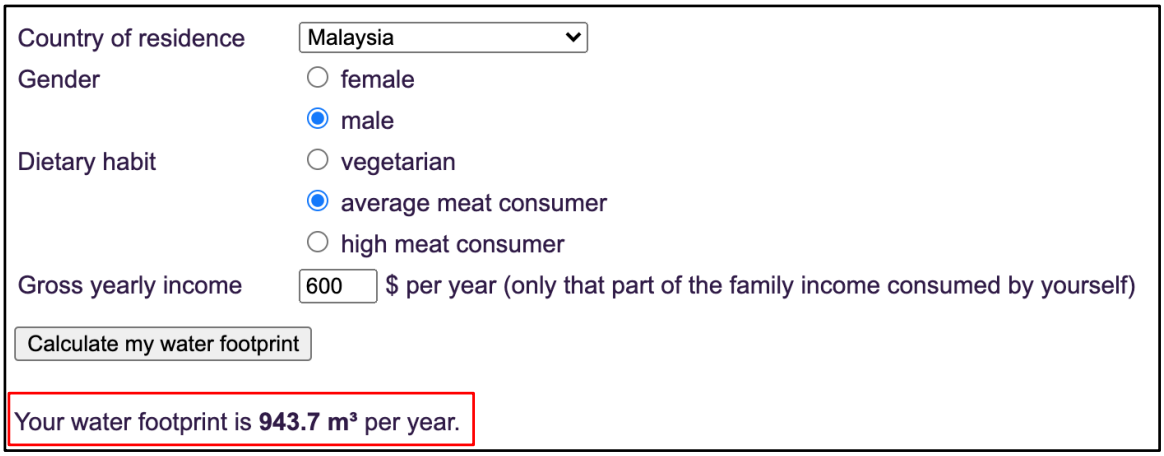
Source: Water Footprint Network

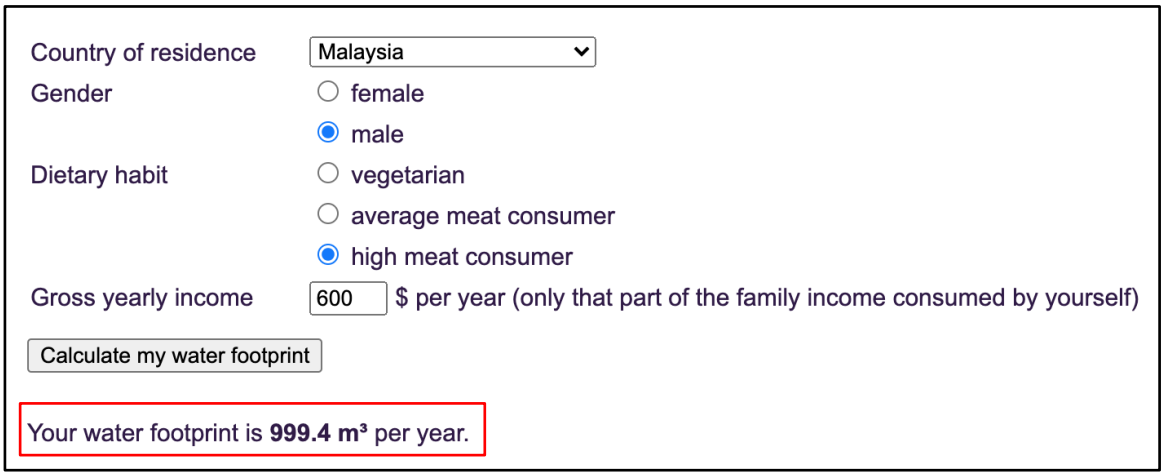
- The water footprint has 3 components: green, blue and grey. All these components can collectively provide a comprehensive picture of water use by describing the source of water consumed, and the volume of fresh water required for environmental remediation.

	**Green water footprint** is water from precipitation that is stored in the root zone of the soil and evaporated, transpired or incorporated by plants. It is particularly relevant for agricultural, horticultural and forestry products.
	**Blue water footprint** is water that has been sources from surface or groundwater resources and is either evaporated, incorporated into a product or taken from one body of water and returned to another, or returned at a different time. Irrigated agriculture, industry and domestic water use can each have a blue water footprint.
	**Grey water footprint** is the amount of fresh water required to assimilate pollutants to meet specific water quality standards. The grey water footprint considers point-source pollution discharged to a freshwater resource directly through a pipe or indirectly through runoff or leaching from the soil, impervious surfaces, or other diffuse sources.

Source: Water Footprint Network

- There are simplified water footprint calculator and extended water footprint calculator.
- Simplified water footprint calculator (https://www.waterfootprint.org/en/resources/interactive-tools/personal-water-footprint-calculator/). Examples (screenshots) as below:





- Extended water footprint calculator (https://www.waterfootprint.org/en/resources/interactive-tools/personal-water-footprint-calculator/personal-calculator-extended/). Examples (screenshots) as below:

Country of residence	Malaysia
Food consumption	
Cereal products (wheat, rice, maize, etc.)	kg per week
Meat products	kg per week
Dairy products	kg per week
Eggs	number per week
How do you prefer to take your food?	Fat content
How is your sugar and sweets consumption?	Sugar consumption
Vegetables	kg per week
Fruits	kg per week
Starchy roots (potatoes, cassava)	kg per week
How many cups of coffee do you take per day?	cup per day
How many cups of tea do you take per day?	cup per day

Domestic water use - indoors	
How many showers do you take each day?	number per day
What is the average length of each shower?	minute per shower
Do your showers have standard or low-flow showerheads?	○ Standard shower head
	○ Low flow shower head
How many baths do you have each week?	number per week
How many times per day do you brush your teeth, shave or wash your hand?	number per day
Do you leave the tap running when brushing your teeth and shaving?	○ Yes
	○ No
How many loads of laundry do you do in an average week?	times per week
Do you have a dual flush toilet?	○ Yes
	○ No
	○ No flushing. Use eco-toilet.
If you wash your dishes by hand how many times are dishes washed each day?	number per day
How long does the water run during each wash?	minute per wash
If you have a dish washer, how many times is it used each week?	number per week

Domestic water use - outdoors	
How many times per week do you wash a car?	number per week
How many times do you water your garden each week?	number per week
How long do you water your garden each time?	minute per watering
How long per week do you spend rinsing equipment, driveways, or sidewalks each week?	minute per week
If you have a swimming pool what is its capacity?	cubic meter
How many times per year do you empty your swimming pool?	number per year
Industrial goods consumption	
What is your gross yearly income? (Only that part of income which is consumed by you).	US$ per year

Calculate my water footprint

Exercise [INTERMEDIATE]

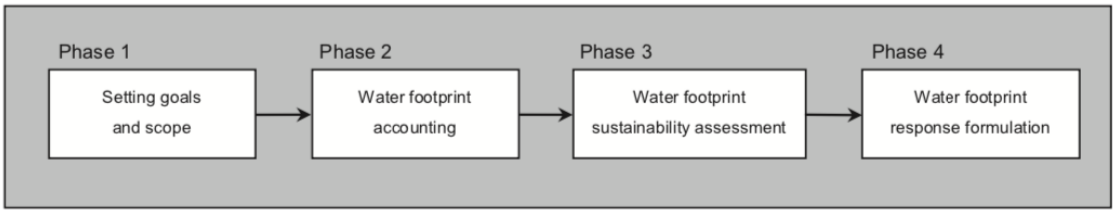
- Title: Water footprint calculator developed by Water Footprint Network
- Instruction:
  - Students are divided into few groups.
  - Based on the parameters stated in the extended water footprint calculator, each group are given 10-15 minutes to decide the inputs for (a) food consumption; (b) domestic water use – indoors; and (c) domestic water use – outdoors.
  - Representative from each group will share their inputs (based on group's decision) with the class, and then the teacher/lecturer will key-in the inputs into extended water footprint calculator. The water footprint will be calculated using the online software.
  - Compare the water footprints for different group and initiate discussion.
- Tips for educators:
  - Educators should have internet connection and able to access the extended water footprint calculator (https://www.waterfootprint.org/en/resources/interactive-tools/personal-water-footprint-calculator/personal-calculator-extended/).
  - The purpose of this exercise is not to compare which group have the highest water footprint.
  - The aim of this exercise is to teach students that different food/activities will lead to different values of water footprint.

Water footprint assessment [ADVANCED]

- The Water Footprint Network has published the 'Water Footprint Assessment Manual: Setting the global standard' (Hoekstra et al., 2011). The following information was retrieved from the manual.
- 'Water footprint assessment' refers to the full range of activities to:
  (ii) quantify and locate the water footprint of a process, product, producer or consumer or to quantify in space and time the water footprint in a specified geographic area;
  (iii) assess the environmental, social and economic sustainability of this water footprint; and
  (iv) formulate a response strategy.
- In general, the goal of assessing water footprints is to analyse how human activities or specific products relate to issues of water scarcity and pollution, and to see how activities and products can become more sustainable from a water perspective.
- Water footprint assessment is an analytical tool, it can be instrumental in helping to understand how activities and products relate to water scarcity and pollution and related impacts and what can be done to make sure activities and products do not contribute to unsustainable use of freshwater. As a tool, a

water footprint assessment provides insight, it does not tell people 'what to do'. Rather it helps people to understand what can be done.

- A full water footprint assessment consists of four distinct phases:
  1) Setting goals and scope.
  2) Water footprint accounting.
  3) Water footprint sustainability assessment.
  4) Water footprint response formulation.



- Please note that this training module does not intend to discuss further about water footprint assessment. Instead, we encourage educators refer to the 'Water Footprint Assessment Manual: Setting the global standard' published by Water Footprint Network 2011. This document can be accessed at: https://www.waterfootprint.org/media/downloads/TheWaterFootprintAssessmentManual_2.pdf .
- Furthermore, in this training module, we have compiled a list of resource persons (with their expertise) in Appendix A, and their short CV can be found in Appendix B.

Sources of information for water resources:

- Water Footprint Network. https://www.waterfootprint.org/en/
- Cool Australia. https://www.coolaustralia.org/
- US Environmental Protection Agency (USEPA) https://www.epa.gov/
- Department of Statistic Malaysia https://www.dosm.gov.my/v1/index.php
- UCAR. https://scied.ucar.edu/

3.3 Concerns related to Water

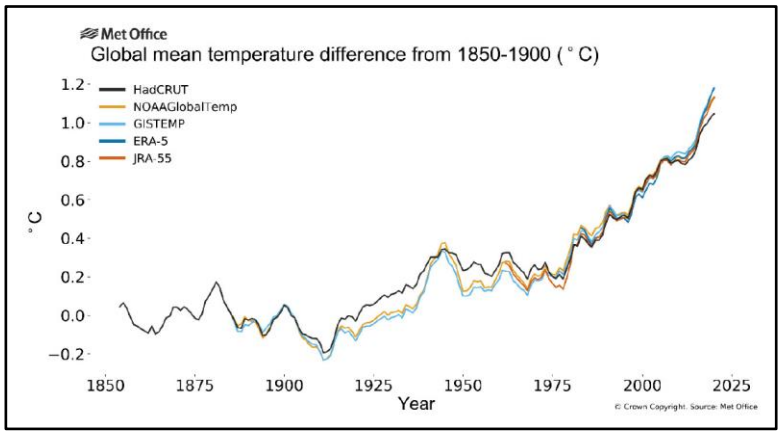
3.3.1 Water and climate change

Water and climate change [BASIC/INTERMEDIATE]

- Water is the primary medium where we will feel the impact of climate change. Climate change is affecting the water cycle where droughts, floods, melting glaciers, sea-level rise and storms intensify or alter, often with severe consequences.
- Some areas may experience heavier than normal precipitation, and other areas may experience droughts. Other parts of the water cycle such as clouds, the ocean, glaciers and sea ice are also affected by climate change.

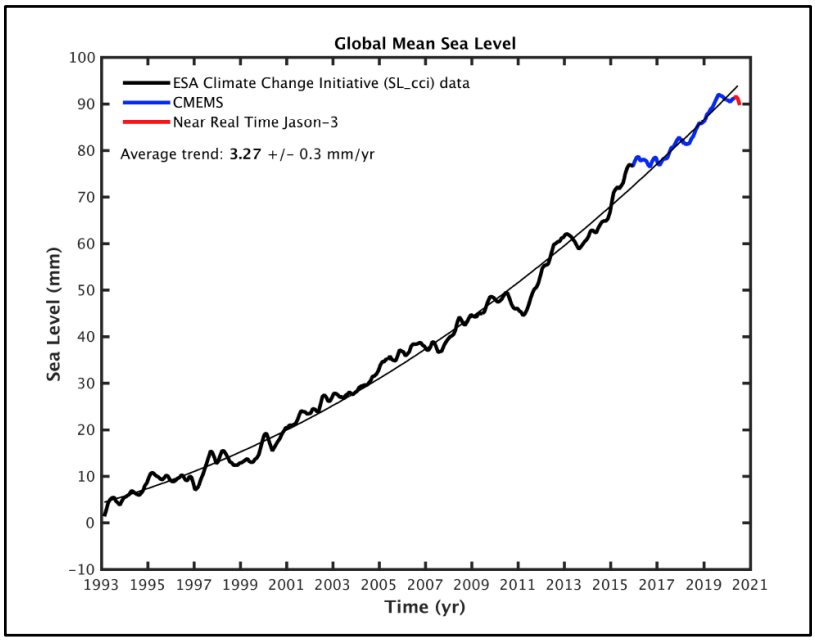
- Water availability is becoming less predictable in many places, and increased incidences of flooding threaten to destroy water points and sanitation facilities and contaminate water sources.
- In some regions, droughts are intensifying water scarcity and therefore adversely impacting on people's health and productivity.
- Warmer seawaters have contributed to the death of about a quarter of the world's coral reef in the last few decades. Corals and other marine life having difficulties to grow their shells and bonces as seawater takes in carbon dioxide from the atmosphere and becomes more acidic.
- Rising temperatures cause shifting ecosystems, either expanding or decreasing the geographical range of specific types of habitats, or changing the timing of seasons. Sometimes this expanding range brings new invasive species, which can cause native species decline or go extinct, which alters the ecosystem.
- The UNICEF has identified 10 things we should know about water and the global climate crisis:
    1. Extreme weather events and changes in water cycle patterns are making it more difficult to access safe drinking water, especially for the most vulnerable children.
    2. Around 74 per cent of natural disasters between 2001 and 2018 were water-related, including droughts and floods. The frequency and intensity of such events are only expected to increase with climate change.
    3. Around 450 million children live in areas of high or extremely high water vulnerability. This means they do not have enough water to meet their everyday needs.
    4. When disasters hit, they can destroy or contaminate entire water supplies, increasing the risk of diseases like cholera and typhoid to which children are particularly vulnerable.
    5. Rising temperatures can lead to deadly pathogens in freshwater sources, making the water dangerous for people to drink.
    6. Contaminated water poses a huge threat to children's lives. Water and sanitation related diseases are one of the leading causes of death in children under 5 years old.
    7. Every day, over 700 children under 5 years old die from diarrhoea linked to inadequate water, sanitation and hygiene.
    8. Climate change exacerbates water stress – areas of extremely limited water resources – leading to increased competition for water, even conflict.
    9. By 2040, almost 1 in 4 children will live in areas of extremely high water stress.
    10. Rising sea levels are causing fresh water to become salty, compromising the water resources millions of people rely on.

- The average global mean surface temperature for 2016-2020 is amongst the warmest of any equivalent period on record.



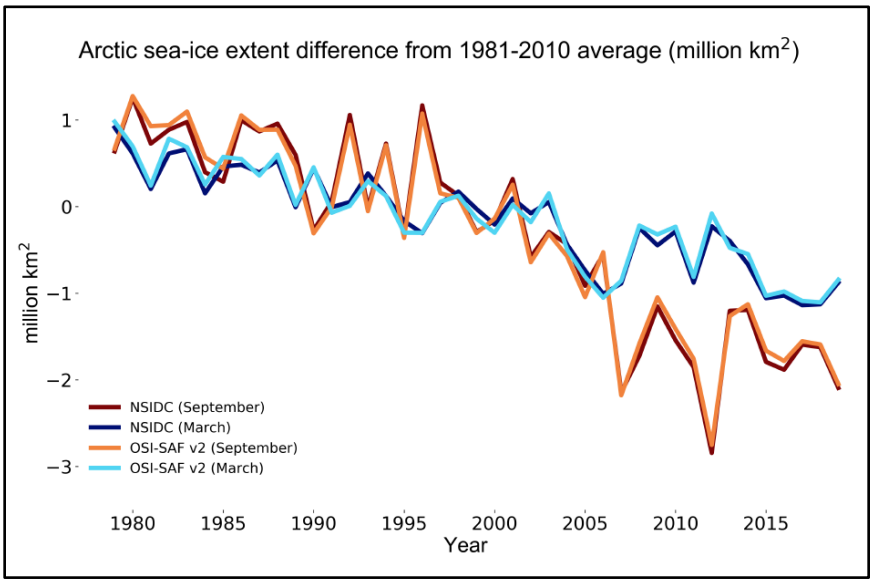
Source: World Meteorological Organisation

- The total elevation of the global mean sea level since January 1993 has reached 90mm. The average rate of rise is estimated to be 3.2 ± 0.3 mm/year over the 27-year period. The rate between 2011-2015 and 2016-2020 has increased from 4.1mm/year to 4.8 mm/year.



Source: World Meteorological Organisation

- The long-term trend over the 1979-2019 period indicates that Arctic summer sea-ice extent has declined at a rate of approximately 13% per decade.



Source: World Meteorological Organisation

Climate model [INTERMEDIATE/ADVANCED]

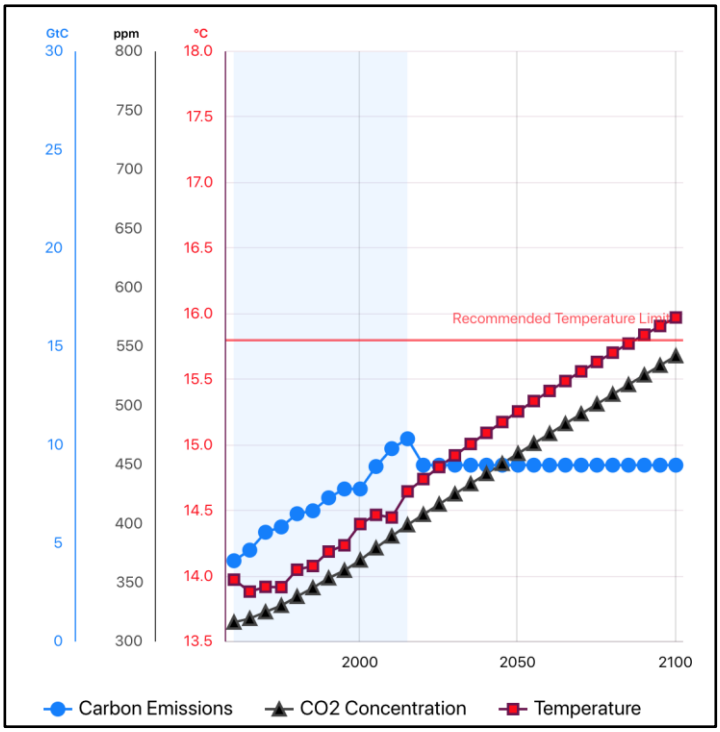
- Climate models are based on well-documented physical processes to stimulate the transfer of energy and materials through the climate change.
- Climate models are extension of weather forecasting. Weather models make prediction over specific areas and short timespans, and climate models are broader and analyse long timespans.
- Climate models include more atmospheric, oceanic and land processes than weather models. These models are typically generated from mathematical equations that use thousands of data points to simulate the transfer of energy and water that takes place in climate system.
- The UCAR (University Corporation for Atmospheric Research), Centre of Science Education has developed a very simple climate model (https://scied.ucar.edu/interactive/simple-climate-model), where this model:
    - adopts the approach that temperatures depend on the concentration of emission, which rises whenever emissions are greater than zero.
    - knows nothing of changing wind or precipitation patterns that might accompany and in turn influence warming. It doesn't care where in the atmosphere the CO_2 is; it ignores other greenhouse gases. In this simple model, the temperature is determined entirely by the atmospheric CO_2 concentration via greenhouse warming of the atmosphere.
    - While the assumptions behind the model are limited, they are valid. The starting values for concentration, emission rate, and the temperature are the actual values for the year 2015. The relationship between

atmospheric CO_2 and temperature uses a well-established relationship. Basically, temperature rises about 3°C for each doubling of CO_2 concentration (i.e. the climate change sensitivity). For example, of the concentration goes from 400 ppmv to 800 ppmv, we expect to see temperature go up by 3°C.

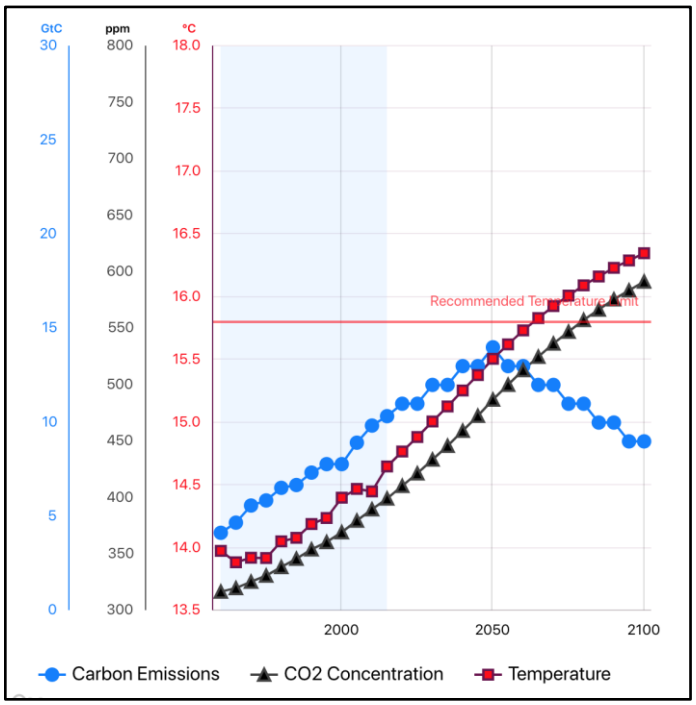
Exercise [INTERMEDIATE/ADVANCED]

- Title: The Very Simple Climate Model developed by UCAR
- Instruction:
  - Students are divided into few groups.
  - If possible, students have the access to the Very Simple Climate Model developed by UCAR (https://scied.ucar.edu/interactive/simple-climate-model)
  - Give instruction for the 2 scenarios below. Students can try all the scenarios.
  - Scenario 1: *What if we consistently add 9 gigatons of carbon per year (9 GtC/yr)*?
    1. Set the carbon emission to 9 GtC/yr on the bar under "Select an emission rate"
    2. Remain 3 degree Celsius under "Change climate sensitivity"
    3. Click the play button at the bottom of the left side. What do you notice?
  - Scenario 2: *What if our emissions get worse before they get better? Let's assume that people will keep emitting carbon dioxide at an increasing rate until 2050, and then we will have figured out how to reduce the emission*.
    1. Start with carbon dioxide emission to 11 GtC/yr on the bar under "Select an emission rate"
    2. Click the "Step Forward" button (lower left) twice to create 10 years cycle (one decade). (note: meaning constant emission from year 2015-2025)
    3. Increase carbon emission by 1 GtC/yr (to 11 GtC/yr) and advance for 10 years (i.e. 11 GtC/yr for the duration 2025-2035)
    4. Continue to increase the emission rate by 1 GtC/yr for each decade, until you reach year 2050 (note: assuming no action taken until 2050)
    5. Once you reach the year 2050, start decreasing the emission rate by 1 GtC/yr for every 10 years.
    6. Continue to decrease the emission rate by 1 GtC/yr for each decade until year 2100. What do you notice about the temperature?
- Tips for educators:
  - Educators should have internet connection and able to access the very simple climate model (https://scied.ucar.edu/interactive/simple-climate-model).

- The climate change sensitivity is initially set at 3°C. The climate sensitivity represents the amount of temperature change estimated to occur when carbon dioxide doubles. For example, of the concentration goes from 400 ppmv to 800ppmv, we expect to see temperature go up by 3°C. There is some uncertainty about the climate system will behave as carbon dioxide increases, so scientists test models with different climate sensitives.
- Always click the "Start Over" button to start a new scenario.
- For Scenario 1 – Students should notice that the carbon emission makes a horizontal line; CO_2 and the temperature steadily increase. Students should get the following graph where the temperature is above the recommended limit at year 2090.



- For Scenario 2 – Students should get the following graph. It is noticed that the carbon emission (blue) increased until 2050, then decreased through 2100. The concentration of CO_2 in the atmosphere (black) continued to rise even carbon emissions dropped. That's because we were still pouring CO_2 into the atmosphere, just at a slower rate. Temperature (red) follows similar trend to that for CO_2 concentration.



3.3.2 Water pollution

Water Pollution [BASIC]

- Water pollution happens when harmful substances, such as chemicals or microorganisms, that contaminate stream, river, lake, ocean, aquifer, or other body of water, and then lead to degrading of water quality and rendering it toxic to humans or the environment.
- The Water-pollution.org.uk has identified several types of water pollution:

1. Suspended matter
    - Some pollutants do not dissolve in water as their molecules are too big to mix between the water molecules. This material is called particulate matter and can often be a cause of water pollution.
    - The suspended particles eventually settle and cause a thick silt at the bottom. This is harmful to marine life that lives on the floor of rivers or lakes.
    - Biodegradable substances are often suspended in water and can cause problems by increasing amount of anaerobic microorganisms present.
    - Toxic chemicals suspended in water can be harmful to the development and survival of aquatic life.

2. Chemical water pollution
    - Industrial and agricultural work involves the use of many different chemicals that can run-off into water and pollute it.

- Metals and solvents from industrial work can pollute rivers and lakes. There are poisonous to many forms of aquatic life and may slow their development, make them infertile or even result in death.
- Pesticides are used in farming to control weeds, insects and fungi. Run-offs of these pesticides can cause water pollution and poison aquatic life. Subsequently, birds, humans and other animals may be poisoned if they eat infected fish.
- Petroleum is another form of chemical pollutant that usually contaminates water through oil spills when a ship ruptures. Oil spills usually have only a localised effect on wildlife but it can spread for miles. The oil can cause death of many fish and stick to the feathers of seabirds causing them to lose their ability to fly.

3. Microbiological water pollution

- Microbiological water pollution is usually a natural form of water pollution caused by microorganisms.
- Many types of microorganisms live in water can cause fish, land animals and human to become ill. These microorganism are such as bacteria, viruses and protozoa.
- Serious diseases such as chlorella come from microorganisms that live in water. These diseases usually affect the health of people in poorer countries, as they do not have the facilities to treat polluted water.

4. Ground water pollution

- A lot of the Earth's water is found underground in soil or under rock structures call aquifers. Humans often use aquifers as a means to obtain drinking water, and build wells to access it. When this water becomes polluted, it is called groundwater pollution.
- Groundwater pollution is often caused by pesticide contamination from the soil, this can infect our drinking water and cause huge problems.

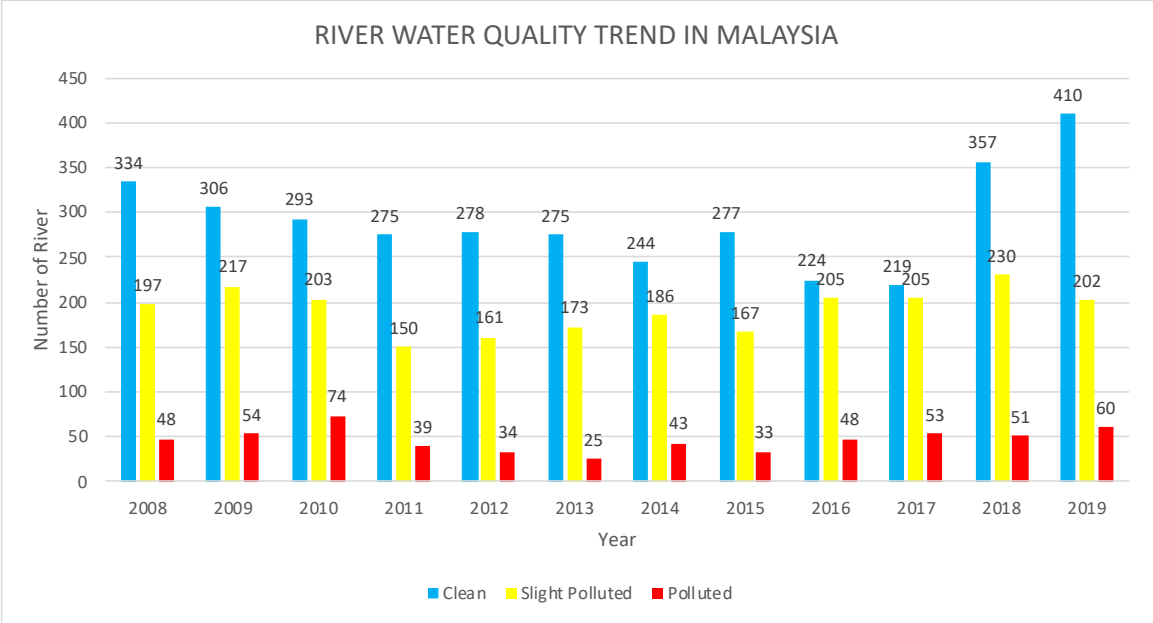
5. Nutrients and their effects on water

- Nutrients are essential for plant growth and development. Many nutrients are found in wastewater and fertilisers, and these can cause excess weed and algae growth if large concentrations end up in water.
- This can damage to other aquatic organisms as the algae use up the oxygen in the water, leaving none for the surrounding marine life.

6. Microplastic

- A microplastic is any piece of plastic smaller than 5mm in diameter.
- In general, the primary sources for microplastic are the consumer products (e.g. products like facial scrubs or toothpaste that contain microbeads), and the plastic breakdown (e.g. plastic bottles) into smaller pieces, that eventually becoming microplastic.
- The lifecycle of microplastic are still uncertain but most scientific experts estimate it to be between 450 years and forever.

- Status of rivers in Malaysia from 2008 – 2019:



Source: Department of Environment Malaysia

Water related hazards [INTERMEDIATE/ADVANCED]

- The Water-pollution.org.uk has identified causes of water pollution:

1. Industrial water pollution
    - Industry is a huge source of water pollution, where it produces pollutants that might cause adverse effects to human and the environment.
    - Many industrial facilities use freshwater to carry away waste from the plant and into rivers, lakes and oceans.
    - Pollutants from industrial sources include:
        - Lead – A metallic element and can cause health and environmental problems. It is a non-biodegradable substance so is hard to clean up once the environment is contaminated. Lead is harmful to the health of human and many animals.
        - Mercury – A metallic element and can cause health and environmental problems. It is a non-biodegradable substance so is hard to clean up once the environment is contaminated. Mercury is harmful to the health of human and many animals, and it can cause illness through mercury poisoning.
        - Nitrates and Phosphates – The increased use of fertilisers means that nitrates / phosphates are more often being washed from the soil and into rivers and lakes. This can cause eutrophication, which can be very problematic to marine environment.
        - Oils – Oil does not dissolve in water, instead it forms a thick layer on the water surface. This can stop marine plants receiving

enough sunlight for photosynthesis. It is also harmful for fish and marine birds.

2. Sewage and wastewater pollution

- Sewage is the term used for wastewater that often contains faeces, urine and laundry wastes.
- Untreated sewage water can contaminate the environment and cause diseases such as diarrhoea.
- Sewage is treated in water treatment plants and the waste is often disposed into the sea.
- Some people flush chemical and pharmaceutical substances down the toilet.

3. Oil pollution

- Ocean are polluted by oil on a daily basis from oil spills, routine shipping, run-offs and dumping.
- Oil spills make up about 12% of the oil that enters the ocean. The rest come from shipping travel, drains and dumping.
- An oil spill from a tanker is a severe problem because there is such a huge quantity of oil being spilt into one place.
- Oil spills cause a very localised problem but can be catastrophic to local marine wildlife such as fish, birds and sea otters.
- Oil cannot dissolve in water and forms a thick sludge in the water. This suffocates fish, gets caught in the feathers of marine birds stopping them from flying and blocks light from photosynthetic aquatic plants.

4. Eutrophication and water pollution

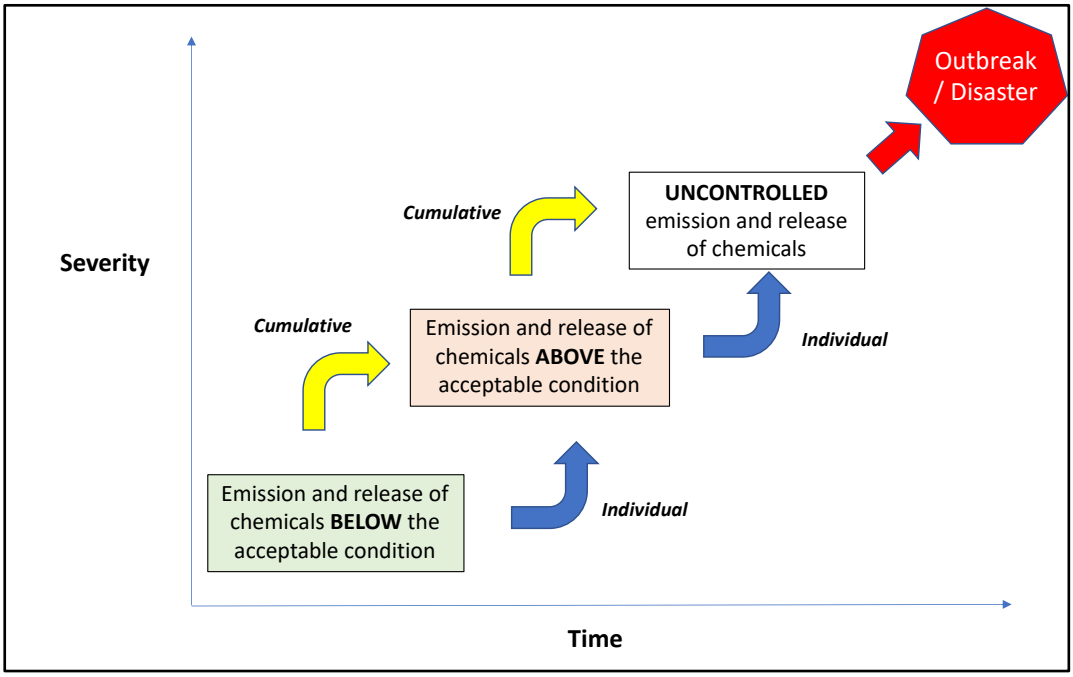
- Eutrophication is when the environment becomes enriched with nutrients. Thus, it can be a problem in marine habitats such as lake as it can cause algal blooms.
- Fertilisers are often used in farming, sometimes these fertilizers run-off into nearby water causing an increase in nutrient level. This can cause phytoplankton to grow and reproduce more rapidly, resulting algal blooms.
- The bloom of algae disrupts normal ecosystem function, where algae may use up all oxygen in the water, leaving none for other marine life.
- The bloom of algae may also block sunlight for marine plants from receiving enough sunlight for photosynthesis.
- Some algae even produce toxins that are harmful. This can cause problems along the food chains.

- Case studies:
  - *Minamata incident (1956, Japan)*
    The contamination of methylmercury at Minamata Bay, Japan that had resulted in chronic mercury poisoning, which was also known as the

Minamata Disease, had caused more than 900 deaths and 2 million people due to various health problems after consuming fishes contaminated by mercury. The mercury-contaminated effluent discharged by the company at Minamata Bay that used mercury as a catalyst in the production of acetaldehyde (a component of plastic) had undergone biotic and abiotic processes, and then formed methylmercury. This incident was also later known as the Minamata incident.

- *Pasir Gudang incident (2019, Malaysia)*

  In less than 4 months, there were 2 chemical incidents occurred at Pasir Gudang in Malaysia. The first incident happened in March 2019 at Sungai Kim-Kim, Pasir Gudang, Johor, and the cause of the incident is due to illegal dumping of chemical wastes. This incident has affected approximately 6,000 residents, and a total number of 111 schools were temporary closed due to the incident. The second incident happened in June 2019 at Pasir Gudang, where 15 students from Sekolah Agama Taman Mawar were reported having breathing difficulties and vomiting. Based on the media reports, for the first incident, there were 8 chemicals detected in the river water at Sungai Kim-Kim, namely methane, hydrogen chloride, acrylonitrile, acrolein, benzene, toluene, xylene and limonene. Whereas for the second incident, a total number of 3 chemicals were detected in the ambient air, namely methyl mercaptan, acrylonitrile and acrolein.



Sources of information for concerns related to water:

- UN Water. https://www.unwater.org/
- IUCN. https://www.iucn.org/
- UNICEF. https://www.unicef.org/
- World Meteorological Organisation. https://public.wmo.int/en
- NOAA Climate.gov project. https://www.climate.gov/
- UCAR. https://scied.ucar.edu/
- Water-pollution.org.uk. https://www.water-pollution.org.uk/
- NRDC. https://www.nrdc.org/
- Department of Environment Malaysia. https://www.doe.gov.my/

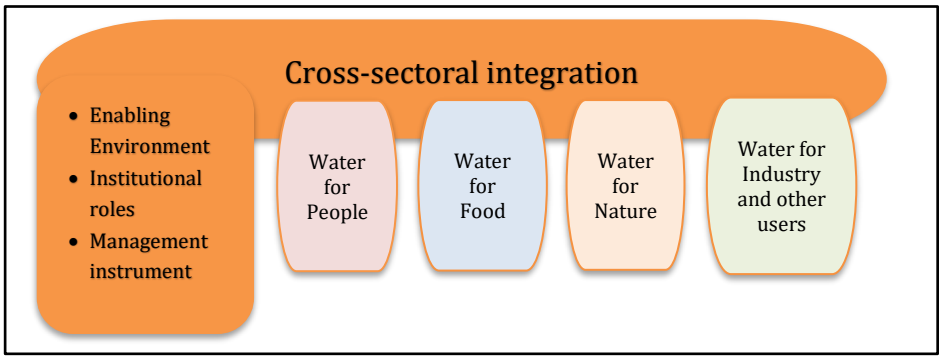
3.4 IWRM

Fundamental of IWRM [INTERMEDIATE/ADVANCED]

- The information of Integrated Water Resources Management (IWRM) in this section is retrieved from the document prepared by Global Water Partnership (GWP) Technical Advisory Committee (TAC) entitled 'TAC Background paper No.4: Integrated Water Resources Management' that was published in 2000.
- IWRM is a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.
- The IWRM principles have adopted the Dublin principles, where the Dublin principles significantly contributed to the Agenda 21 (Chapter 18 on freshwater resources) that adopted at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, 1992.
- The Dublin principles are:
    1) Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.
    2) Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels.
    3) Women play a central part in the provision, management and safeguarding of water.
    4) Water has an economic value in all its competing uses and should be recognised as an economic good.
- Principle I: Fresh water as finite and vulnerable resource
    - A holistic approach (e.g. recognising all the characteristics of the hydrological cycle and its interaction with other natural resources and ecosystems).
    - Resource yield has natural limits
    - Effects of human activities
    - Upstream-downstream user relations
    - A holistic institutional approach

- Principle II: Participatory approach
  - Real participation (e.g. involve in decision-making process)
  - Participation is more than consultation
  - Achieving consensus
  - Creating participatory mechanism and capacity
  - The lowest appropriate level (e.g. balance between top-down and bottom-up approach)
- Principle III: The important role of women
  - Involvement of women in decision-making
  - Women as water users
  - IWRM requires gender awareness
- Principle IV: Water as an economic good
  - Water has a value as an economic good
  - Values and charges are two different things
  - The goal of full cost recovery
  - Managing demand through economic instruments
  - Financial self-sufficiency versus water as a social good
- The 'integration' under IWRM can be considered under two basic categories:
  - The natural system, with its critical importance for resource availability and quality, and
  - The human system, which fundamentally determines the resource use, waste production and pollution of the resource, and which must also set the development priorities.
- The natural system integration:
  - Integration of freshwater management and coastal zone management
  - Integration of land and water management
  - Integration of 'green water' and 'blue water' (e.g. water that is used directly for biomass production and 'lost' in evaporation ('green water') and water flowing in rivers and aquifers ('blue water'). Terrestrial ecosystems are 'green water' dependent, whereas aquatic ecosystems are 'blue water' dependent)
  - Integration of surface water and groundwater management
  - Integration of quantity and quality in water resource management
  - Integration of upstream and downstream water-related interests
- The human system integration:
  - Mainstreaming of water resources
  - Cross-sectoral integration in national policy development
  - Macro-economic effects of water developments
  - Basic principles for integrated policy-making
  - Influencing economic sector decisions
  - Integration of all stakeholders in the planning and decision process
  - Integrating water and wastewater management

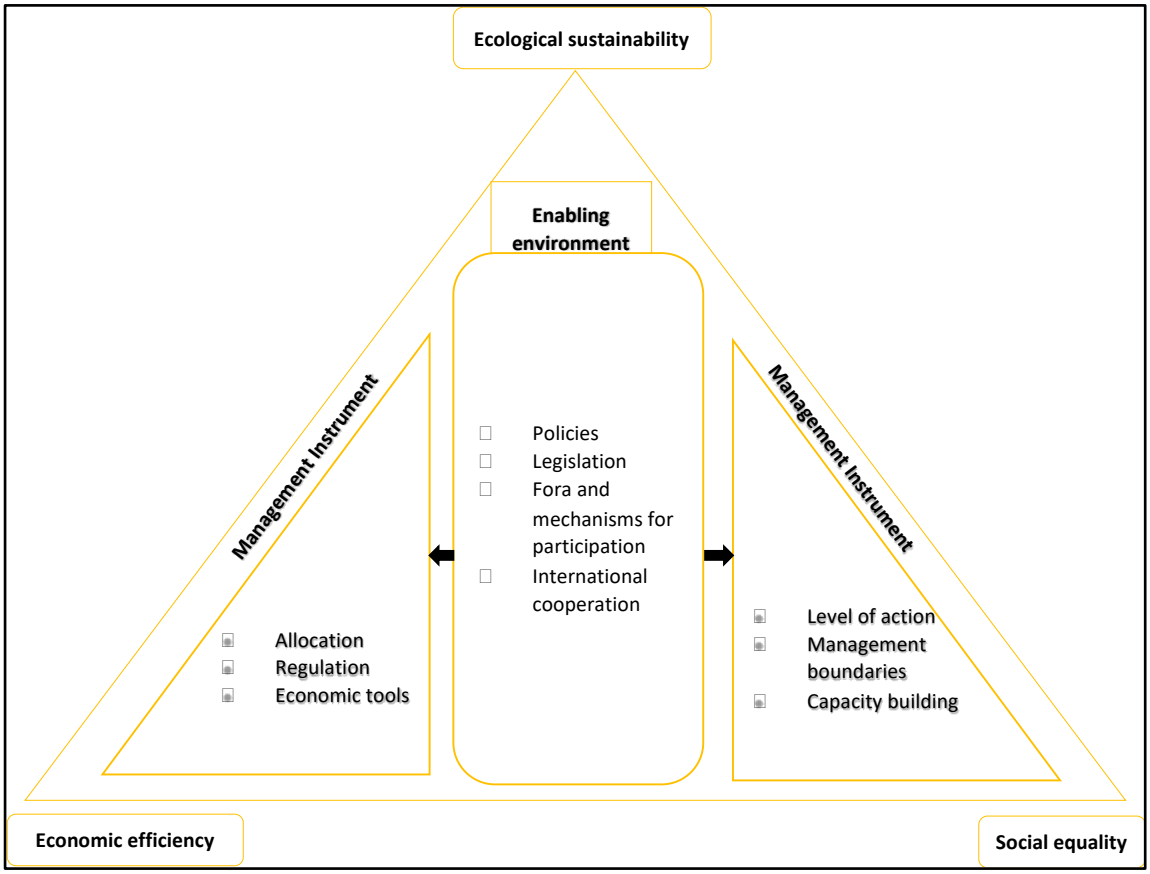
- The cross-sectoral integration between water use sub-sectors, and the role of IWRM in their linkage, is illustrated as below:



Source: Global Water Partnership (GWP)

- The overriding criteria for IWRM:
  - *Economic efficiency in water use* – Because of the increasing scarcity of water and financial resources, the finite and vulnerable nature of water as a resource, and the increasing demands upon it, water must be used with maximum possible efficiency.
  - *Equity* – The basic right for all people to have access to water of adequate quantity and quality for the sustenance of human well-being must be universally recognised.
  - *Environmental and ecological sustainability* – The present use of the resource should be managed in a way that does not undermine the life-support system thereby compromising use by the future generations of the same resource.
- The important elements of IWRM:
  - *the enabling environment* – the general framework of national policies, legislation and regulations and information for water resources management stakeholders
  - *the institutional roles* and functions of the various administrative levels and stakeholders
  - *the management instruments* – including operational instruments for effective regulation, monitoring and enforcement that enable the decision-makers to make informed choices between alternative actions

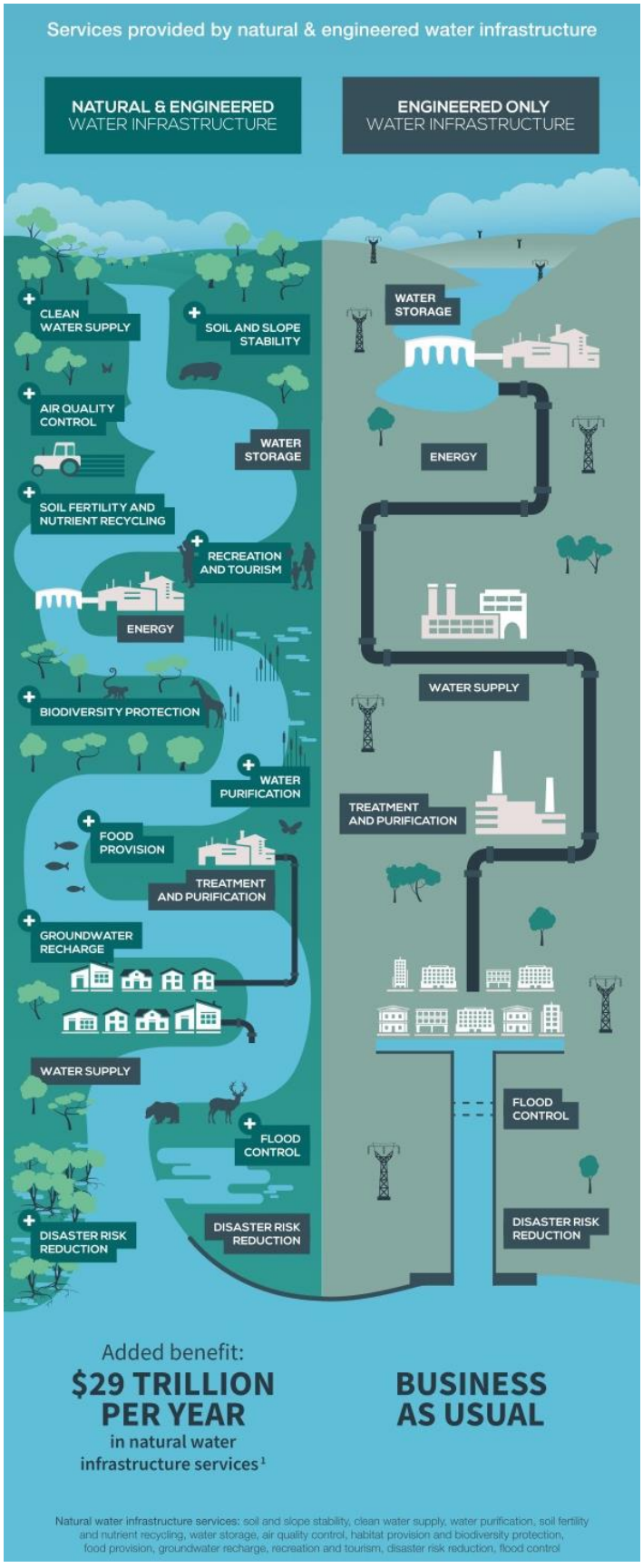
- The general framework for IWRM:



Source: Global Water Partnership (GWP)

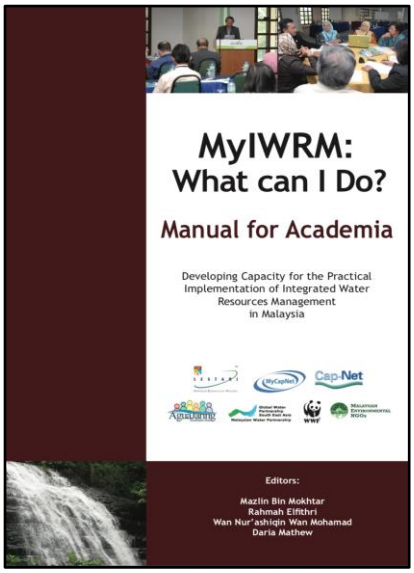
Implementation of IWRM [ADVANCED]

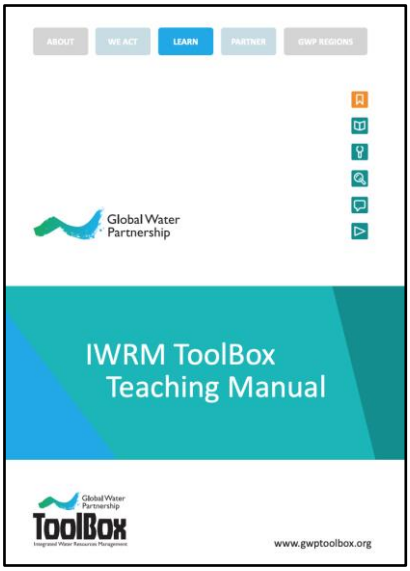
- The topics related to the implementation of IWRM is more relevant for lecturers and students from HEIs. This is because it requires advance knowledge and skills.
- The IUCN has developed infographic to compare 'Natural and Engineered Water Infrastructure' and 'Engineered Only Water Infrastructure' (as shown below).


Services provided by natural & engineered water infrastructure
NATURAL & ENGINEERED WATER INFRASTRUCTURE
ENGINEERED ONLY WATER INFRASTRUCTURE
CLEAN WATER SUPPLY
SOIL AND SLOPE STABILITY
AIR QUALITY CONTROL
WATER STORAGE
SOIL FERTILITY AND NUTRIENT RECYCLING
RECREATION AND TOURISM
ENERGY
BIODIVERSITY PROTECTION
WATER PURIFICATION
FOOD PROVISION
TREATMENT AND PURIFICATION
GROUNDWATER RECHARGE
WATER SUPPLY
FLOOD CONTROL
DISASTER RISK REDUCTION
WATER STORAGE
ENERGY
WATER SUPPLY
TREATMENT AND PURIFICATION
FLOOD CONTROL
DISASTER RISK REDUCTION
Added benefit:
$29 TRILLION PER YEAR
in natural water infrastructure services[1]
BUSINESS AS USUAL
Natural water infrastructure services: soil and slope stability, clean water supply, water purification, soil fertility and nutrient recycling, water storage, air quality control, habitat provision and biodiversity protection, food provision, groundwater recharge, recreation and tourism, disaster risk reduction, flood control

Source: IUCN

- In order to enhance the roles of Malaysia's academia to implement IWRM, a manual for academia entitled MyIWRM: What can I do? was jointly published by LESTARI, MyCapNet and Cap-Net in 2009. The manual identifies the role of academia (particularly at the university) in the implementation of IWRM in Malaysia. The possible actions by academia at the university stated as below:
  - Embedding the IWRM concept in university's courses
  - Identify suitable mechanisms for IWRM implementation
  - Distribution of information
  - Water wastage practices
  - Capacity building
  - Network and collaboration
  - Awareness raising
  - Getting funding mechanism
- Besides, the GWP has developed the IWRM Toolbox Teaching Manual (https://www.gwp.org/globalassets/global/toolbox/references/iwrm_teaching_manual.pdf). The manual aims to help educators designing and executing IWRM courses at the university, where the manual shares the guidance and inspiration on how to incorporate IWRM thinking and useful tools and case studies into a specific course or professional workshop. The manual has identified 6 IWRM disciplines (as below), and 13 specific lectures:
  - The natural environment and climate
  - Water law and policy
  - Social aspects
  - Planning and decision-making
  - Economics
  - Technical infrastructure
- Furthermore, in this training module, we have compiled a list of resource persons (with their expertise) in Appendix A, and their short CV can be found in Appendix B.





3.5 IRBM

IRBM [INTERMEDIATE/ADVANCED]

- A river basin is an area drained by rivers and tributaries. A river basin is made up by many different watersheds, where watershed is a smaller version of a river basin.
- There are total of 189 major river basins (>80km^2) in Malaysia:

Area	Total river basins	Total of major river basins (>80km^2)
Peninsular Malaysia	1235	74
Sabah	1468	75
Sarawak	283	40
TOTAL	**2986**	**189**

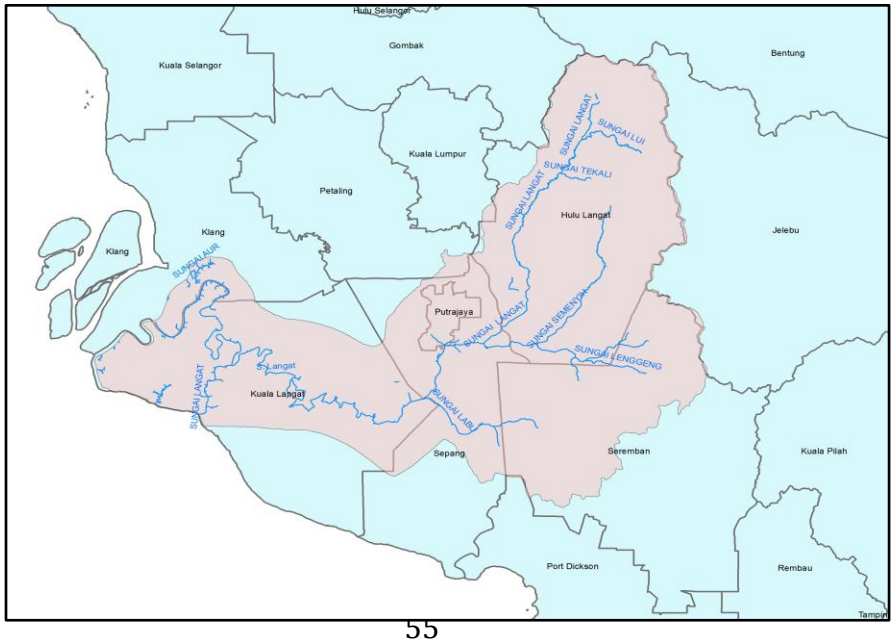
Source: Department of Irrigation and Drainage Malaysia

- The water quality of rivers in the river basins are being monitored by Department of Environment Malaysia:

Category	2015		2016		2017		2018		2019	
	No.	%	No.	%	No.	%	No.	%	No.	%
Total monitoring stations	891		891		891		1353		1353	
Total river basins monitored	140	100	140	100	140	100	143	100	144	100
Clean	71	50.7	58	41.4	54	38.6	79	55.0	85	59.0
Slightly Polluted	64	45.7	72	51.4	72	51.4	54	38.0	49	34.0
Polluted	5	3.6	10	7.2	14	10.0	10	7.0	10	7.0

Source: Department of Environment Malaysia

- Example: Langat River Basin



- Langat River Basin cross-cutting 3 different jurisdiction, namely Selangor, Negeri Sembilan and Putrajaya. It is situated approximately 27km to the south of Kuala Lumpur and it comprises 5 main districts, i.e. Hulu Langat, Kuala Langat, Sepang, Putrajaya and Seremban.
- The following information of Integrated River Basin Management (IRBM) was retrieved from the book written by Bruce Hopper entitled 'Integrated River Basin Governance: Learning from International Experiences' that was published in 2005.
- Integrated River Basin Management (IRBM) is a subset of IWRM, and IRBM is an application of IWRM that can be implemented nationally or internationally across borders at the river basin scale.
- IRBM is defined as an integrated and coordinated approach to the planning and management of natural resources of a river basin, one that encourages stakeholders to consider a wide array of social and environmental interconnections, in a catchment/watershed context.
- It is different from the traditional multi-purpose resource management as it addresses a broader set of issues including social impacts, varying values and ecosystem functioning.
- IRBM implies the inclusion of a full array of physical, biological and socioeconomic variables involved in managing a hydrologic region for environmental values and human use.
- IRBM will bring together stakeholders from the government, industry, community, NGOs and academia.
- Elements of IRBM:
    - *Basin-wide planning* – Basin-wide planning should balance all user needs for water resources, in the present and the long-term, and should incorporate spatial developments. Vital human and ecosystem needs have to be given a special attention.
    - *Participation in decision-making* – Local empowerment, public and stakeholder participation in decision-making will strengthen the river basin management.
    - *Demand management* – Demand management has to be part of sustainable water management. Managing the demand for water rather than continual expansion of water supplies will more likely achieve sustainable use.
    - *Compliance* – Compliance monitoring and assessment of commitments under river basin agreements and arrangements need to be developed.
    - *Human and financial capacities* – Long-term development of sufficient human and financial capacity is necessary.
- IRBM is characterised as:
    - Coordinated activities rather than amalgamated programmes of action.
    - Top-down management meeting bottom-up management.
    - Strategic planning rather than all-embracing efforts: being targeted and selective about actions and prioritisation work programmes.

- Integrating goals rather than planning resource use and conservation from either single or multi-purpose reasons.
- Proactive rather than reactive resource use planning: looking to identify problems before they occur and being cautions in resource use.
- Using cost-effective rather than prescriptive financial management mechanisms.
- Using partnerships and cost-sharing programmes wherever possible.
- Working with partners in a co-operative work environment, rather than using confrontational and directive management.
- Encouraging commitment in staff rather than suing command-and-control management styles.
- Empowering local and regional decision-making rather than centralising decisions and directing staff.
- Management based on problem-solving rather than functionality.
- Having flexible organisations rather than rigid inflexible structures.
- Providing appropriate, relevant, affordable information that is relevant to IRBM.
- Using equitable management methods which are sensitive to and respect cultural needs and gender issues.

CHAPTER 4 ACTIVITIES

4.1 Overview

In previous chapter, we discussed about topics related to water that educators can use for teaching in the class. In this chapter, we discuss about activities outside the class, where if educators conducting these project-based learning (PBL) activities, students are expected to have a better understanding on sustainable water resource management. In this regard, we have gathered and compiled existing activities that are related to water resource management that can be used at preschool, primary school, secondary school and higher education institutions (HEIs). In addition, we have also listed the sources of information in each section, where we have retrieved/adopted/adapted information from these sources to prepare this training module.

4.2 Know Your Rivers

Schools and universities are the place for students to gain knowledge and skills, develop talents, and meeting friends for social development. For the education in schools, the syllabus was designed and developed by the Ministry of Education Malaysia. Whereas at HEIs, respective HEIs can establish their own programmes, but these programmes must be approved by the Ministry of Higher Education Malaysia and then recognised by Malaysian Qualification Agencies (MQAs).

The syllabus for the schools is often based on specific subjects/topics, and it will not take into account the local information that is relevant for a specific school. For example, the textbook discusses about the cause and impact of river pollution, but it will not tell the students the quality of the river nearby their school. This is because the textbooks were designed for the entire nation, not for a specific school nor schools in a specific region. Due to this, students are not aware the status of river nearby their school. Furthermore, some students might not even aware the existence of rivers nearby their schools.

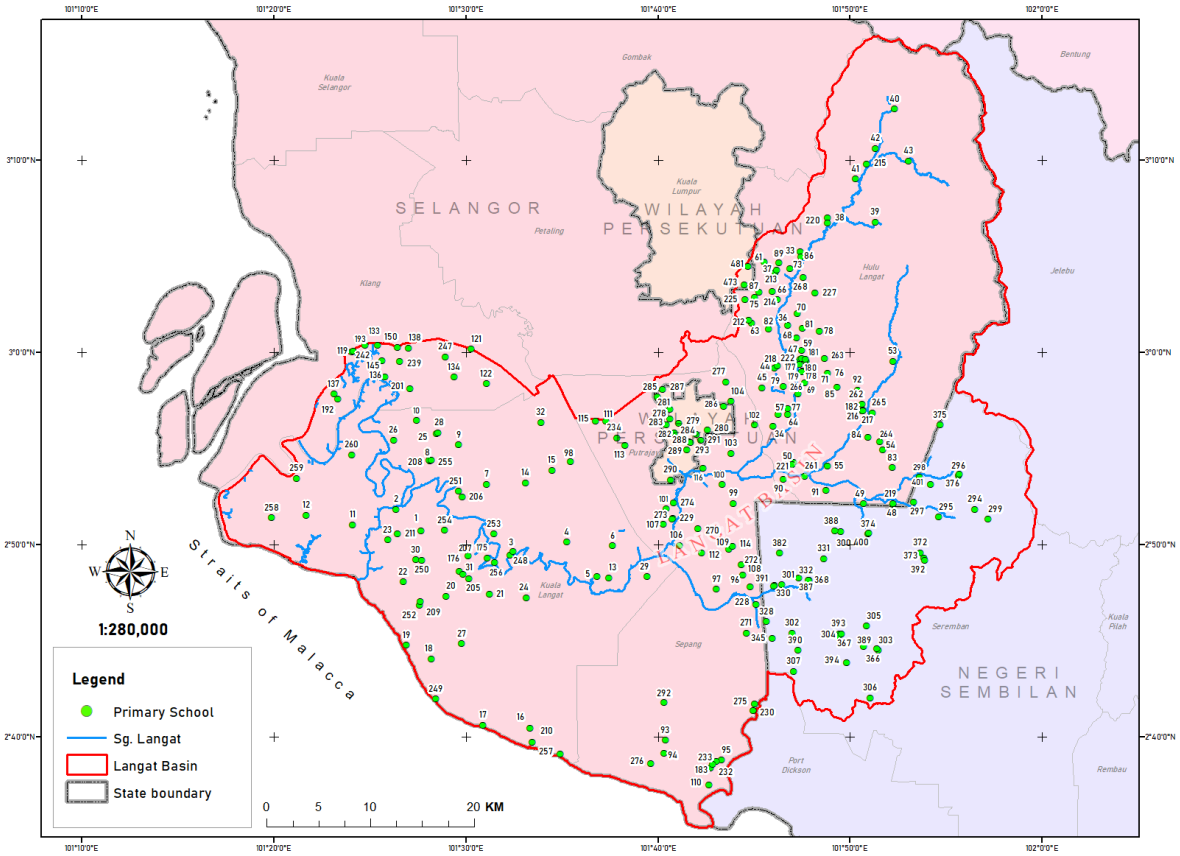
It is important for students to know the river nearest to their school, as well as other schools/HEIs that are located at nearby river. When such information is available, these schools and HEIs can establish a collaboration network, in order to protect and conserve the rivers in their vicinity.

In this section, we have selected Langat River as an example, where we demonstrate location of primary schools, secondary schools and HELs that are located in Langat River Basin. We have chosen river basin rather than rivers in a specific state because river basin takes into account the geological boundaries, and not administrative boundaries. The Langat River Basin cross-cutting 3 different jurisdiction, namely Selangor, Negeri Sembilan and Putrajaya. It is situated approximately 27km to the south of Kuala Lumpur and it comprises 5 main districts, i.e. Hulu Langat, Kuala

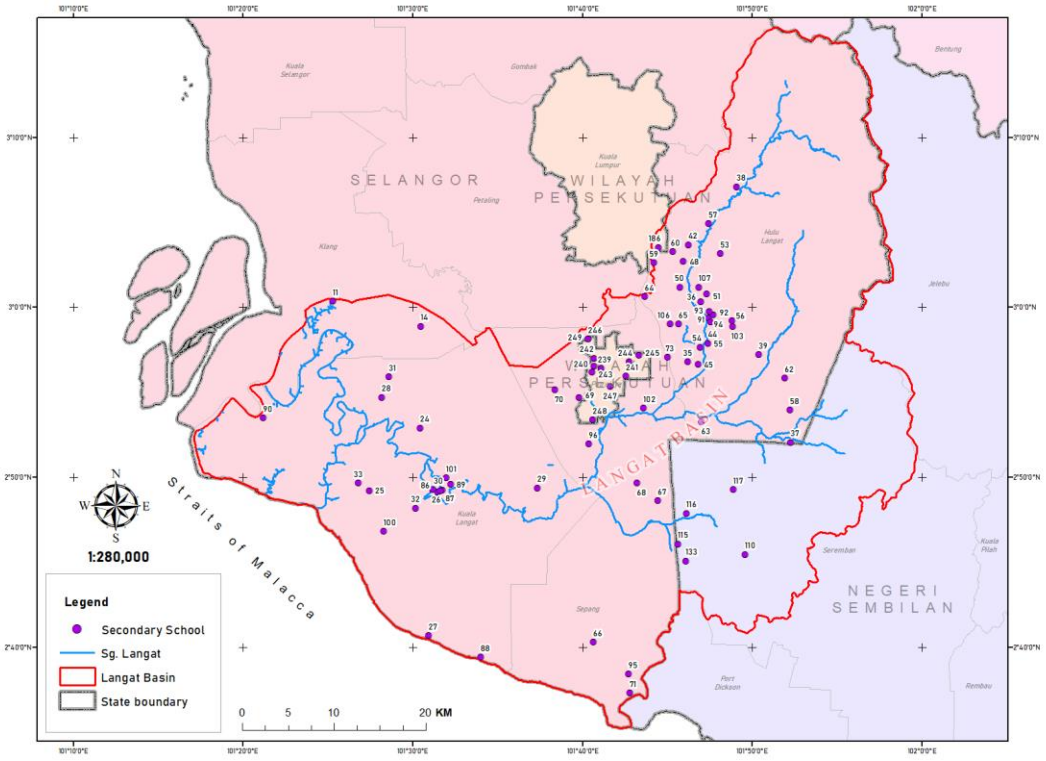
Langat, Sepang, Putrajaya and Seremban. Table 2.2 below shows the number of primary schools, secondary schools, and HEIs that are located in Langat River Basin.
Table 2.2 Primary schools , secondary schools, and HEIs

Type	Numbers
Primary school	236
Secondary school	76
HEIs	33
TOTAL	**345**

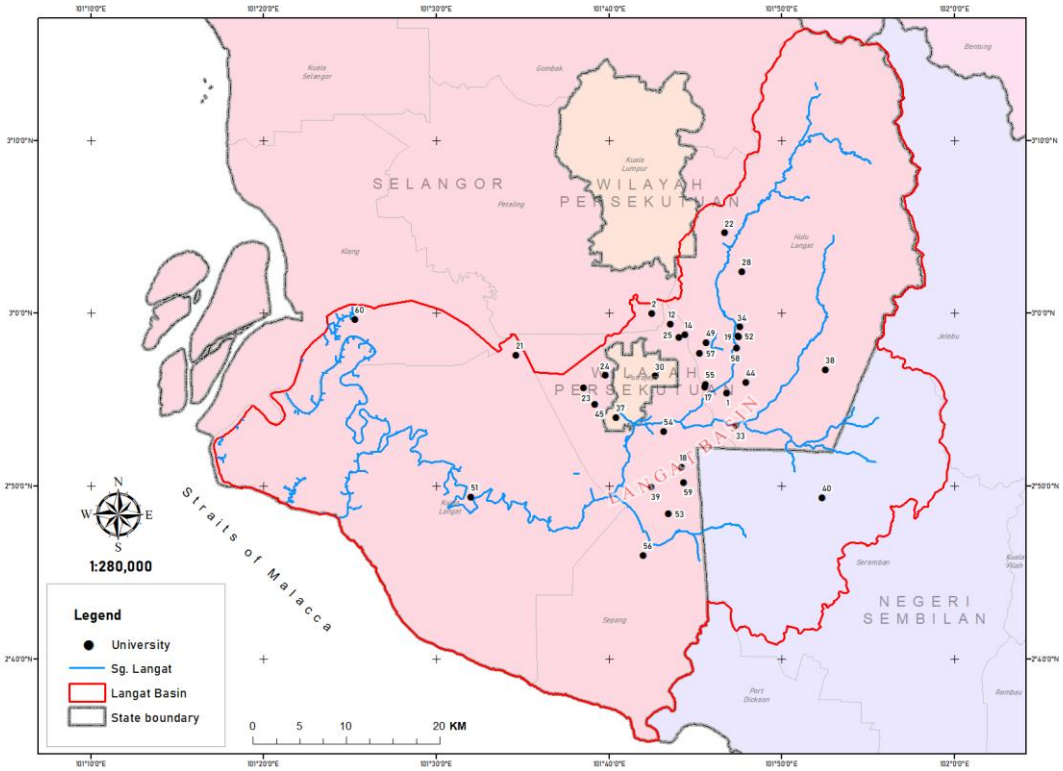
The location of 236 primary schools in Langat River Basin:



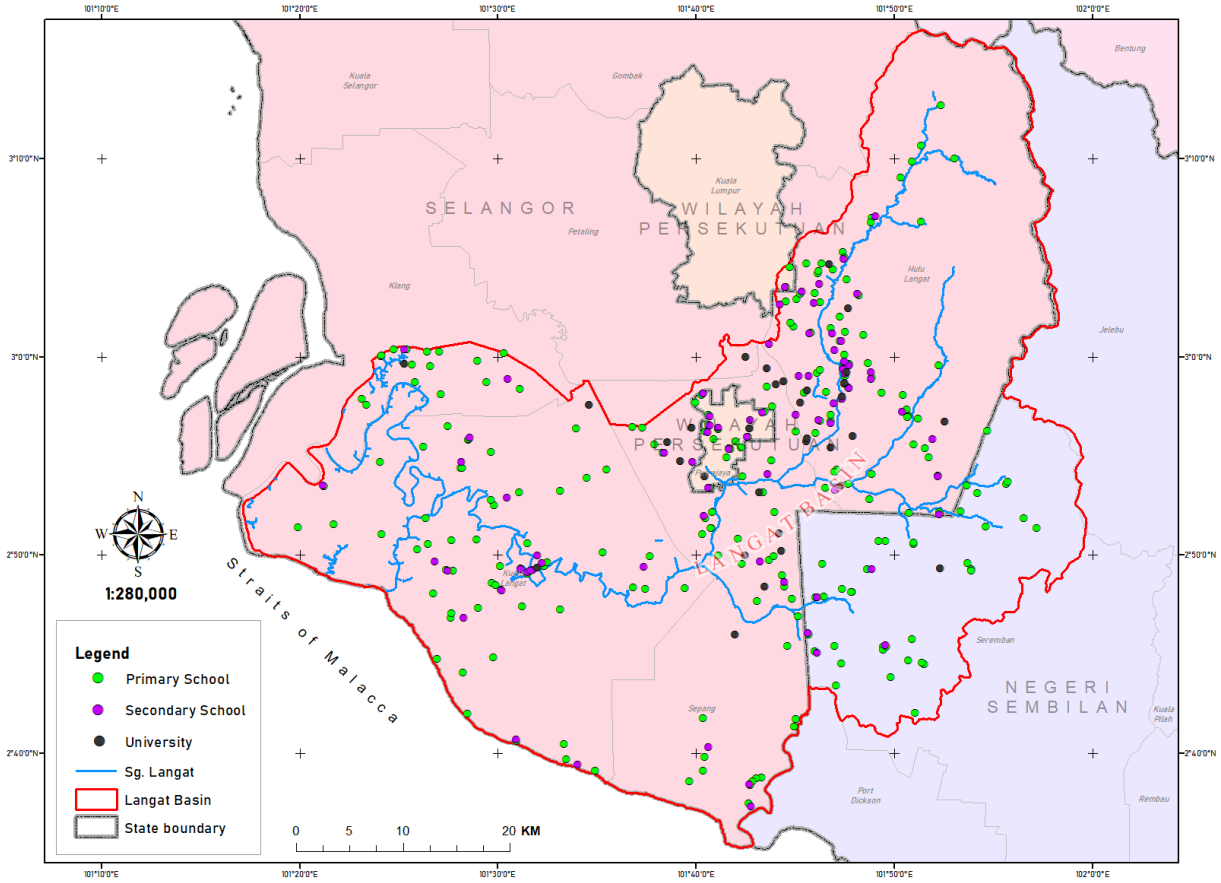
The location of 76 secondary schools in Langat River Basin:



The location of 33 HEIs in Langat River Basin:



The location of primary schools, secondary schools and HEIs in Langat River Basin:



By referring to the examples above, it is obvious that many schools and HEIs are located nearby the rivers and tributaries in Langat River Basin. Therefore, these entities can work closely together to protect and conserve the rivers nearby their schools/HEIs more effectively. Nonetheless, before establishing a collaboration network, students must first be aware and acknowledge the existence of rivers nearby them. The following are some simple guidelines to assist students to know their rivers:

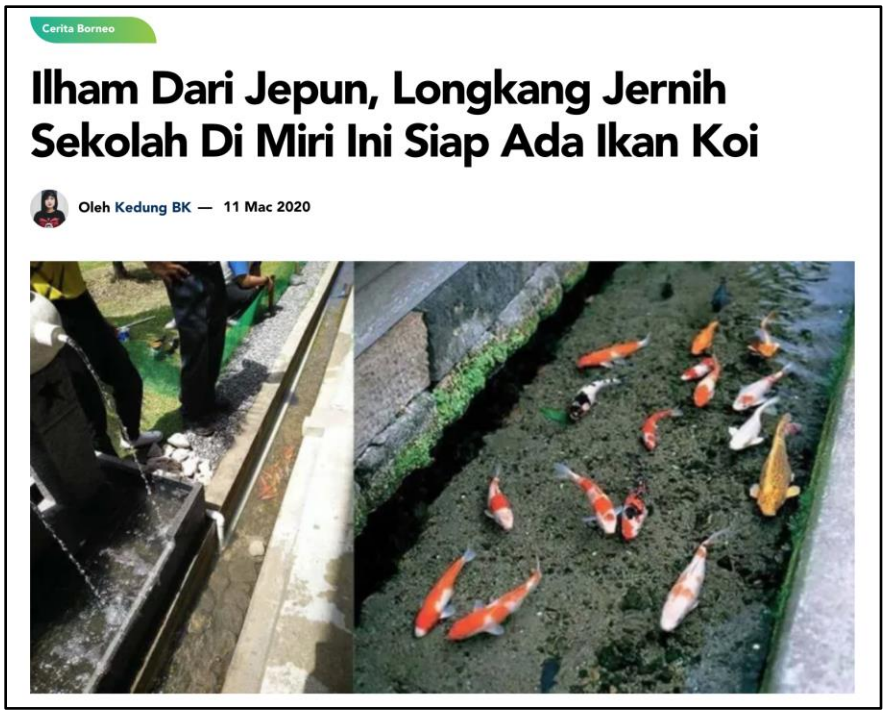
1) Surrounding of the school – Observe or recall the surrounding of the school. This includes the landscape and infrastructures. Do you notice there is a river nearby the school? Or have you been crossing a bridge on the journey going to the school? Why is there a bridge?
2) Parents and neighbour – Discuss with your parents and neighbours by asking them do they aware there is a river nearby. If yes, what are the changes of the river over the time, particularly on the aspect of development and environment nearby the river.

3) Friends and teachers – Based on the inputs you have collected, initiate discussion with your friends and teachers in school. Compile all the information collected and then identify the river nearby the school.
4) Consultation with authorities – With the assistance from teachers, conduct discussion with relevant stakeholders in order to have a better understanding on the river nearby the school. These authorities include state's Department of Irrigation and Drainage (DID), state's Department of Environment (DOE), water treatment plants in the state, state's Department of Education, etc.
5) Profile preparation – Prepare a profile of the river nearby the school and start to communicate with other schools in the vicinity.

4.3 Case Studies in Malaysia

Schools and HEIs in Malaysia have been conducting various activities to conserve water and to protect rivers. Nonetheless, due to the absence of a centralise platform, these activities are not deposited and communicated to the public. This has also impeded efforts when compiling case studies in this training module. Therefore, the following case studies are based on inputs during the stakeholder's engagement workshops and data availability from internet, so these case studies are not exhaustive, meaning that more case studies can be added in this training module as when information is made available.

4.3.1 SMK Agama Miri


Cerita Borneo

Ilham Dari Jepun, Longkang Jernih Sekolah Di Miri Ini Siap Ada Ikan Koi

Oleh Kedung BK — 11 Mac 2020

(Source: https://www.iloveborneo.my/)





(Source: Facebook SMK Agama Miri)

In 2018, inspired by the Koi fish in street drainage canals in Japan, SMK Agama Miri (SMKAMi) took the initiative to carry out a project entitled 'Longkang Bersih SMKAMi'. In this project, a group of students has cleaned up the drain in the school, and then modified and beautified surrounding of the drain before releasing Koi fish into the drain. According to Ustaz Fadly, he has witnessed the growth of Koi fish in the drain, and this has shown that the water in the drain is clean and suitable as growing environment for Koi fish. After the project has completed, SMKAMi reported that no litter or waste was found at the drain, and the place is well managed and monitored by a group of students. Besides, SMKAMi also adopted no dustbin approach in the class; and using slippers when going into toilet. According to the Facebook of SMKAMi, their approach to protect the environment is simple – 'Jika persekitaran bersih, kemas dan ceria, pelajar akan merasa seronok dan memberi kerjasama menjaganya'.

Besides the aforementioned, the toilets at SMKAMi are also clean and well maintained, as shown below:

(Source: Facebook SMK Agama Miri)

Source:
https://www.iloveborneo.my/cerita-menarik-dari-borneo/ilham-dari-jepun-longkang-jernih-sekolah-di-miri-ini-siap-ada-ikan-koi/
https://www.facebook.com/ustazfadly/videos/10213337501032610/ [video]
https://www.facebook.com/pratchai/videos/10159063528389618 [video]

4.3.2 SMK Tengku Mahmud Iskandar

(Source: The Star)

The SMK Tengku Mahmud Iskandar in Tangkak has successfully conserve water at their school and lead to savings in their water bill. According to teacher Mohamad Ridzuan Ali, he said that previously the school used clean tap water for all the school activities. However, with the rainwater harvesting system installed in the school, they are now using rainwater for the toilets. Also, the school is also pumping river water for plants and cleaning certain areas in the school. This has reduced the school's monthly water bill from about RM 3,000 to about RM 1,000. Besides, the school's student leaders board members also educating the public in nearby areas and night markets on the need to conserve water. With this effort, the SMK Tengku Mahmud Iskandar was selected as the winner in the competition to conserve water organised by SAJ Ranhill Sdn. Bhd. in 2018.

Source:
https://www.thestar.com.my/metro/metro-news/2018/01/13/saving-water-one-drop-at-a-time-students-work-hard-to-cultivate-practice-on-water-conservation

4.3.3 SJKT Ladang Highlands

(Source: New Straits Times)

A group of 4 students of SJKT Ladang Highlands in Klang has invented a nano-filter to treat wastewater from kitchen sinks, which can then be used at toilet flush tanks. This group of students, with the age range 9-11 years old has invented a product known as 'Eco-Reuse Nanotechnology Wastewater filter' that made from single use plastic bags, cigarette butts and dried oil palm fronds had won the Gold award from the Malaysia Young Scientist Conference and Exhibition (MYSCE) 2020. The nano-filters can be used by household to have a continuous water supply for their toilet flush tanks during any water supply disruption.

Source:
https://www.nst.com.my/news/nation/2020/10/631624/cut-above-water-cuts-inspire-klang-students-create-nano-filters

4.3.4 Department of Environment

(Source: Department of Environment Malaysia)

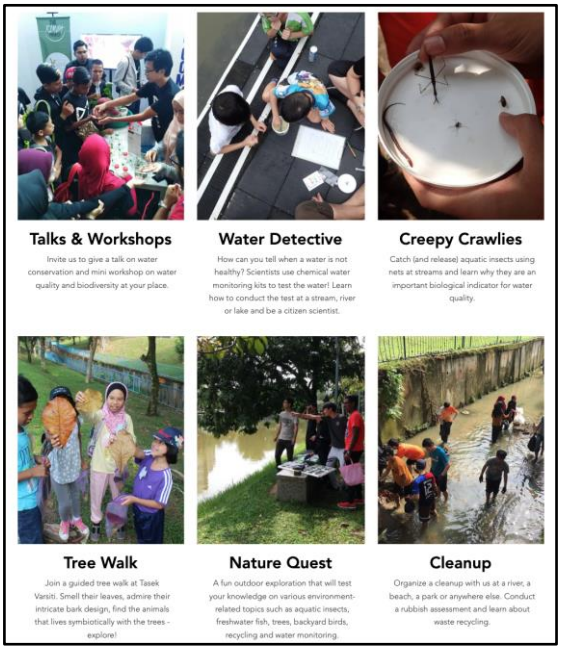
The Department of Environment Malaysia (DOE) acknowledge the importance of environmental education during preschool, therefore they have published series of modules under the initiative 'Modul Kesedaran Alam Sekitar untuk Tadika'. There are 5 modules that are related to the environment, namely:

1) Water module
2) Recycle module
3) Air module
4) Plant module
5) Animal module

The water module aims to educate preschool student in the importance to conserve and protect water. All the 5 environment modules for preschool can be downloaded at DOE website.

Source:
https://ras.doe.gov.my/v2/pra-sekolah-lestari/

4.3.5 Universiti Malaya (UM)

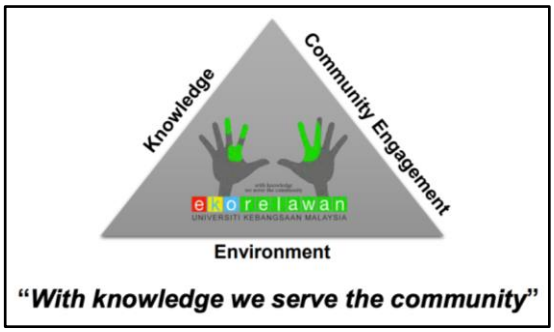


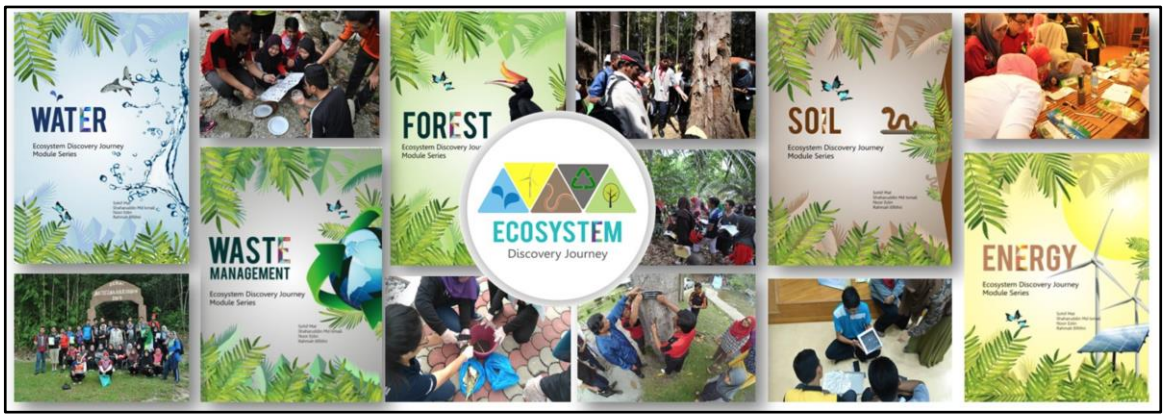
(Source: Water Warriors)

The Water Warriors project began in 2012, where it was a bottom-up approach that initiated by the students and lecturers in the University of Malaya (UM). Water Warriors is an environmental project in the campus for the protection and conservation of water bodies in UM. The Water Warrior started off as an outreach programme that builds public awareness and involvement in protecting water resources around the campus by engaging the community to conduct basic monitoring, namely the citizen science. As UM is located in the Klang River watershed, the Water Warriors not only focussing on monitoring, but also community engagement in order to enhance the sense of ownership. Water Warriors are also deeply passionate about documenting flora and fauna, especially freshwater habitat such as aquatic insects, waterfowl and wetland plants. At the early stage, Water Warrior started with the concept of shared values, and then slowly they are moving to the translational approach, where they are promoting 'heartware and hardware'. The Water Warriors is now recognised as UM Living Labs on water management in the campus.

Source:
https://umwaterwarriors.wixsite.com/tasek
https://www.um.edu.my/water-warriors

4.3.6 Universiti Kebangsaan Malaysia (UKM)





(Source: Ekorelawan)

In 2014, by recognising the importance of university in collaborating with the stakeholders (such as the government, industry and community) to conserve and protect the environment, Universiti Kebangsaan Malaysia (UKM) has established Ekorelawan that involved students, staff and alumni of UKM. The initiative of Ekorelawan was initiated at the student's college – Kolej Ibu Zain, and then it was recognised by the university. Ekorelawan focussing on the interaction between knowledge, environment and community engagement. In 2015, Ekorelawan has developed modules known as Ecosystem Discovery Journey (EDJ), that consists of 5 modules, namely water, waste, forest, soil and energy. These modules have been used to train students and community in order to enhance their awareness and knowledge related to the specific topics under EDJ.

Source:
http://www.ukm.my/ekorelawan/

4.4 Case Studies in Other Countries

4.4.1 Schools Water Efficiency Programme (SWEP), Australia

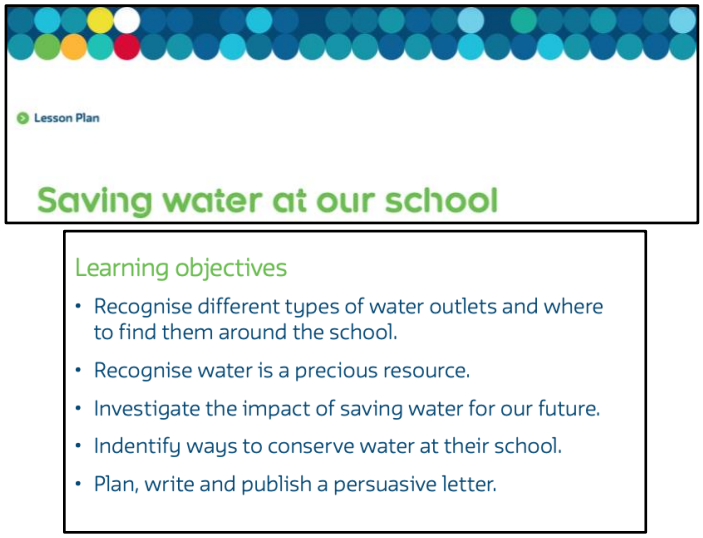
(Source: Schools Water Efficiency Programme)

The Schools Water Efficiency Programme (SWEP) provides data loggers to all schools located at Victoria, Australia for education and demonstration of water efficiency in practice. The SWEP programme also provides students with an opportunity to learn about water efficiency in a tangible and realistic environment. When water usage is being thoroughly monitored, schools can detect and rectify leaks, saving water and money. The SWEP is funded by Department of Environment, Land, Water and Planning and the Department of Education and Training in Australia.

The SWEP has been implemented in several schools at Victoria, including at Reservoir High School and Mill Park Secondary College. At Reservoir High School, after joining SWEP, in the first few months of water monitoring, the school able to identify issues related water tank at toilet that were periodically sticking causing water to run all night and wasting thousands of litres per day. With SWEP, Reservoir High School has saved more than 6.3 million litres of water that would have otherwise cost them $24,000 in water charges. The second success story happened at Mill Park Secondary College. After monitoring the water usage for few weeks, on one of the Tuesday morning, the administrator was alerted that huge overnight water usage at the school. This was due to multiple leaks that added up to more than 520 litres per hour being wasted. Immediate action was taken by the school to stop the leakage. Besides, after having the data loggers in place, the school water bills dropped by 50% as compared to their average bill for the last 12 months.

Source:
https://www.myswep.com.au/

4.4.2 Water Corporation, Australia



(Source: Water Corporation)

Water Corporation is the principal supplier of water, wastewater, drainage and bulk irrigation services in Western Australia. They are owned by the Western Australian Government and accountable to the Ministry of Water. Although Water Corporation is a water service provider, they have developed modules related to water supply and water conservation. 'Saving water at school' is one of the modules developed by Water Corporation to enhance student's awareness on water supply and water conservation. In this module, students will investigate the areas around their school where water is dispensed. Then, based on the information available on internet, students will create posters to educate their classmates about many ways to save water as a school community. Then, using the 5 Whys framework, students should give 5 reasons why the school should make such changes. Example is as below:

The school should change their toilets to dual flush:

a) Why should the school change the toilets to dual flush? So the students can use the small flush for wees and big flush for poos.
b) Why should students press small flush for wees and big flush for poos? So we don't waste water by using too much when we don't need to.
c) Why should we not waste water when flushing the toilets? Because we need to save water and not waste it.
d) Why do we need to save water? Because water is a precious resource and we need to look after.
e) Why is water a precious resource and why do we need to look after it? Because all living things need water to survive.

Source:
https://www.watercorporation.com.au/

4.4.3 Students clean their own classrooms and school toilets, Japan

(Source: India Today)

(Source: The Wire)

Students in Japan is responsible to clean and maintain their classroom, and for secondary students, they even have to clean the school toilets. Cleaning classroom and school is part of the education system in Japan, where they have a simple motto: 'If you are using a particular space, it is your responsibility and duty to ensure that you leave the space clean'. Furthermore, when students know that they have to clean frequently, they are less likely to litter in the classroom and school. The approach in Japan has encouraged a person to take care of their surroundings from the young age, and later when they grow up, they will love and respect the environment.

Source:
https://thewire.in/external-affairs/japan-cleaning-sanitation-work-swachh-bharat
https://casopisinterfon.org/schools-in-japan-teach-good-values-in-cleaning/
https://www.indiatoday.in/education-today/featurephilia/story/students-in-japan-clean-their-own-classrooms-and-school-toilets-and-the-reason-is-incredible-1227619-2018-05-06

4.5 Problems and Potential Solutions in Schools

Some of the schools in Malaysia might facing challenges related to water. However, it is not solely the responsibilities of school's administrators to address these challenges. Collective efforts from the entire school community that involve students and teachers are needed in addressing the challenges. Subsequently, the school can ask their students to go around the school and then identify problems that are related to water that the school encountering. Once the problems have been identified, it should be resolved. In this regard, below is the potential solution based on common problems facing in schools adopted from Robles et al. (2015).

Problems	Potential causes	Solution	Action required to implement solution	Result expected	Those responsible for carrying out or coordinating the plan
Water leaks in the toilets.	Equipment is old or in poor conditions.	Comprehensive diagnosis of leaks. Change faucets and washers.	Make a schoolwide schedule to fix leaks. Request support from a plumber to guide the work. Purchase materials.	Reduction of leakage and consumption.	Coordinated by the teacher with support from parents. Participation by students in the entire process.
Waste of water in the restroom and laboratories.	Students, teachers, and workers.	Campaign for responsible water use.	Prepare posters. Include the topic in the curriculum for all grades. Assign teams (of teachers and students) to monitor the ways in which water is use.	Decrease consumption. Raise the school community's awareness about the value of water.	Coordinated by the students' association.
Lack of knowledge about alternative technologies.	Inadequate tome to investigate. Lack of informative	Appoint either a member of the administrative staff to investigate or a	Find volunteers interested in the topic. Integrate the subject into the	Increase knowledge about the topic.	Coordinated by the science teacher with the support of administrative staff.

Problems	Potential causes	Solution	Action required to implement solution	Result expected	Those responsible for carrying out or coordinating the plan
	material on the subject.	group of students (as part of classwork).	school curriculum then plan and carry out a project with students.	Option for water use in the school.	Parents and students to lend support to the research.
Lack of financial resources to make repair or modifications to the water systems.	Insufficient budget to school for system maintenance and adaptation to new environmental conditions.	Investigate possible support programmes to develop alternative forms of water management.	Quote cost to make technical improvements in school. Obtain advice for the project planned. Contact potential sources of financial support and check requirements for support.	Organise financial support to carry out a plan or programme of technical improvement in the school's water management.	Coordinated by the parents' association with the participation of the school's teachers and administrators.

(Source: adopted from Robles et al., 2015)

Source:
Robles, M., Naslund-Hadley, E., Ramos, M.C., Paredes, J.P. 2015. Module5: Sustainable Water Management. Rise up against climate change. Inter-American Development Bank.

4.6 Potential Activities in Schools

In this section, we have retrieved/adopted/adapted some of the activities from existing sources, where these activities have the potential to be conducted in the schools of Malaysia.

4.6.1 Make a water filter

The following information was retrieved from https://kids.nationalgeographic.com/books/article/water-wonders that was prepared by Nat Geo Kids Book.

Purpose:

Students can understand how the water filter work by building their own water filter in class.

Introduction:
A water filter will remove the impurities in the water via different process, such as physical barrier process, chemical process or biological process. The tap water that reach the households has been filtered and purified at the water treatment plant.

Materials:

- 2 litre plastic bottles (empty and clean)
- Scissor or knife
- Dirty water (prepare your own such as waste that containing dirt, crunched-up old leaves, cooking oil, or tine pieces of foam)
- Measuring cup
- Spoon
- Stopwatch
- Pencil and paper
- As many of the following filter materials, such as activated charcoal, gravel, sand and cotton balls.
- Filter such as coffee filter, handkerchief, stock, napkin and paper towel.

Procedures:

1. Cut the bottle into half, and then flip the bottle's top half over and put in the bottom, so that the top looks like a funnel.
2. Place the coffee filter (or the handkerchief, stock, etc) at the bottle's top half.
3. Add cotton balls, charcoal, gravel, sand, and/or other materials in layers. You can use just one of them or all of them. Tips: Think about which order to add them. Bigger filter materials usually catch bigger impurities.
4. Write down which filter materials you used and in what order you layered them.
5. Stir your dirty water and measure out a cup of it. Meanwhile, get the timer ready.
6. Pour a cup of dirty water into your filter. Start the timer as soon as you begin.
7. Time how long it takes for all the water to go through the filter. Then write down how long it took.
8. Carefully scoop out the filter materials, one layer at a time. What did each layer take out of the water?
9. The filtered water is not clean enough to drink, but a plant will love it.

Discussion:

- The longer it takes for water to move through a filter, the cleaner it gets.
- Water slips easily through the filter materials, but bigger gunk, like dirt, gets trapped.
- The filter materials usually get finer and finer, so they can catch whatever was missed earlier.

- Activated charcoal can be near the end of the water's path, because it uses an electrical charge to grab particles too small for us to see.

4.6.2 Too many nutrients

The following information was retrieved from the document entitled 'Protecting Our Water Resources: Students Activities for the Classroom' that was prepared by US Environmental Protection Agency (EPA).

Purpose:

Students can observe the algae growth caused by excessive fertiliser use.

Introduction:
Due to excessive amount of the fertilisers and after heavy rains, fertilisers can wash into rivers and lakes and then supply aquatic plants with too many nutrients. As a result, algae can multiplying faster and cause algae blooms. Algae blooms can reduce the supply of oxygen in the water because oxygen is required for algae respiration and growth. This can deplete the supply of dissolved oxygen in the water.
Materials:

- Prepare 2 fish aquariums with the same size (e.g. 15L or 20L)
- Surface water from pond or stream
- Index card
- Permanent ink pen
- Tape
- Plant fertiliser
- Measuring spoon

Procedures:

1. In the class, select volunteers to help you fill 2 fish aquariums with 15 L (depends on the size of aquarium) of surface water from pond or stream.
2. Label one aquarium "A" and one "B" on an index card and then taped to each one.
3. Place 6 tablespoons of plant fertiliser in aquarium "A" as you explain that you are adding nutrients in the form of fertiliser in water.
4. Place one half tablespoons of plant fertiliser in aquarium "B".
5. Place both aquariums near a window of light. Note: Do not place them in a cold place.
6. Request students to record their observations on a daily basis for a week.

Discussion:

- Ask the students that which aquarium looks more polluted and discuss how nutrient pollution could aquatic life.
- Plant use oxygen to grow or respire and oxygen is used to decompose the dead plants.
- Lots of plant use lots of oxygen and this makes the oxygen unavailable to other aquatic life.

4.7 Potential Activities in HEIs

In this section, we have obtained write-up from 2 academics that discuss potential activities to be carried out at HEIs in order to enhance awareness of sustainability water resources management. Dr. Vivien Yew Wong Chin, from the Faculty of Social Science and Humanities, UKM, has prepared a write-up entitled 'Educating social

science students in promoting sustainable water resources management'. The second write-up, entitled 'Integrated Lake Basin Management (ILBM) challenges and opportunities for sustainable water resources management in Malaysian Universities' was prepared by Dr. Mohd Yusoff Ishak, Department of Environment, Faculty of Forestry and Environment, UPM.

4.7.1 Educating social science students in promoting sustainable water resources management – written by Dr. Vivien Yew Wong Chin, UKM

This write-up discusses sustainability in water resources management from the perspectives of social sciences and environmental humanities, meaning the value of water is assessed through the culture and social structure of the society. A comprehensive review of literature from scientific journal articles and authoritative reports was conducted between January and February 2021. The review is international in scope and focus on water resources management with the intentions to: (1) help students better understand water resources management; (2) help students gain empathy and critical thinking skills as they study successful or critical cases of water resources management from around the globe; (3) help students reflect upon their own culturally-embedded conceptions of water and their relationships with their local watershed so as to enhance their knowledge on sustainable water resources management; and (4) help students to propose essential guide to sustainable water resources management solutions and strategies.

Introduction

This write-up investigates the issue of sustainable water resource management around the globe in the perspective of social sciences and environmental humanities. In this context, discussion held in the classroom will bring awareness and enhancement of knowledge in water resource sustainability amongst students. Also, not confined to mere intellectual pursuits, the study will stir them out of comfort zone of seeming abundant water resource in Malaysia and bring realisation and empathy towards those living in water scarcity and trapped in its repercussions. In turn, it is hope the empathy and realisation amongst student will make them more responsible, sensitive to the environment and concern enough to make positive changes towards water resource management as well as water conservation.

The next gravity of matters will be for campuses to commit resources in generating sustainable infrastructures in regards to water use, where students through intensive learning and practice, endeavour to design and build them (Amaral et al., 2015). For example, constructing wetland models and other black and gray-water treatment ponds, identifying catchment area for rainwater harvesting, and incorporate native plant species into the campus landscape are all learning-centred activities that benefit not only the campus community, but the larger community beyond campus.

Researching and teaching about sustainable water issues can encourage students to take relevant courses in the natural and applied sciences, public health, social sciences, and humanities and further prepare them to participate in more complex water-related activities like river basin management plans and sewage system projects (Karleusa et al., 2009). Such an academic acumen also enable graduate to be more competitive on the job market, given the severity of water issues around the globe. In addition, the study of water as outlined above provides an opportunity to accomplish campus's mission statements, and can lead to potential beneficial discussions about how water resources are utilised at a campus level.

Subsequently, it requires that everyone who is employed by a campus and who is charged with guiding a campus, from local to State levels, realise that, "The road to sustainability is one of culture and values as much as it is about scientific and technological development. It must be guided by the arts, humanities, social and behavioural sciences, and religion as much as by the physical and natural sciences and engineering" (Cortese, 2012). As such, we must have the realisation that we share the earth and its "resources", there is no border where nature is concern, the water cycle envelops all and does not distinguish between countries or individuals, human or other species. "All for One" and "One for All" is applicable to all our action be it positive or negative towards sustainability of the planet (Mazziotta & Pareto, 2013).

Creating a campus community that focusses on the common good should be a guiding ideal, given the anthropogenic climate-related shifts already underway and may aggravate further in the coming decades. In truth, we need to "slow down" the deterioration and carry on living in ways that is less damaging to our planet. Campuses therefore provide the perfect living laboratory to educate communities about tight connection between resilience, diversity and sustainability of social-ecological systems. As Cortese (2012) explained, "Most higher education administrators and faculty members do not understand the urgency with which society must begin to reform the way it is operating and the extent to which their curricula need to focus on social, economic, and ecological sustainability in order to fulfil their obligation to society".

The resource in question for this write-up is sustainable water resources management, and the researchers hope to explain how teaching about sustainability via the social sciences can: (1) help students better understand about water resources management; (2) help students gain empathy and critical thinking skills as they learn about successful or critical cases of water resources management from around the globe; (3) help students reflect upon their own culturally-embedded conceptions of water and their relationships with their local watershed so as to enhance their knowledge on sustainable water resources management; and (4) help students to propose essential guide to sustainable water resources management solutions and strategies.

Methodology

This write-up was written from the lens of social sciences in educating individuals on the awareness of the value of water and water resources management. In order to assess the potential of social sciences as a different perspective to water issue, this write-up review literature of scientific journal articles and various reports published between 2005 and 2020. In this study, the inclusion criteria (Cooper et al., 2012) are literature in English language covering items like awareness of water resources management and sustainability through education. The preliminary review of literature was undertaken between January and February 2021.

Water Resources Management: Its Sources and Importance

Social sciences are concern with how people live in a community, the difficulties, challenges and adversity faced by the community and their predicaments, whether living in a state of poverty or in dire health risk (Stenseke & Larigauderia, 2018). And above all, if a helping hand can be extended to alleviate the dire conditions and bring improvement to the living standard of the community. In term of challenges or adversity faced by a community, the scarcity of water reigns supreme to the well-being of a community. Future leaders, decision makers, NGOs who are able to spearhead, apply multidisciplinary approach to create a cost-effective solution to sustainable water resources will bring untold benefits to the community both socially and economically. Nevertheless, keep in mind that endeavour or project of such importance, the concern and participation of stakeholders should be addressed amicably to ensure the continuity and success.

Water Sources

There are numerous types of water sources (as summarised below) in this world, but some of these sources may simply be unavailable due to its locality, climate condition or the prohibitive extraction cost.

(1) Surface Water Resources

Surface water resources include, rivers, lakes, dam, canals, reservoirs and wetlands. It is most common and easy to obtain and the water quality is variable depending on the geology, climate and surrounding land use (Edokpayi et al., 2017). Water filtering and treatment is usually required before they are ready to use.

(2) Groundwater Resources

Water percolated underground will be trapped when it reaches an impermeable bed (clay), the layers of rock that hold groundwater are called aquifers and the level of water below ground is known as water table. The quality of groundwater varies according to the types of permeable rock it had passed through. At times the quality of groundwater is better than surface water since it passes through many layers of soil and rock. However, groundwater may contain mineral or chemical due to its inherent filtering process. When water table reaches the surface, it will appear as spring. Also, wells or boreholes are

constructed by digging underground to reach the water table (National Water Commission, 2012).

(3) Stormwater Resources

Also known as rainwater or water runoff from the rain, snow or hail. Usually rainwater is collected from house roof and gutter or ground catchment and channelled to a collection tank, cistern or pond for storage. Measures may be necessary to maintain its cleanliness (Starzec et al., 2020).

(4) Wastewater Resources

Water used for household, manufacturing and agriculture activities may be collected for recycling purposes. One notable example is the Newater where Singapore government uses advanced membrane technology and ultra-violet disinfection to reclaim used water, it is suitable for drinking purposes (Lee & Tan, 2016). Nevertheless, in other countries, employing lesser technology, they are usually not for drinking purposes and use chiefly for crop and landscape irrigation (Tchobanoglous et al., 2003).

(5) Saltwater Resources

Seawater contains high salinity rendering it unsuitable for drinking purposes. Desalination plant through filtering technology remove salt and impurities produces freshwater suitable for drinking (Manish Thimmaraju, 2018). Nevertheless, desalination is expensive due to high electricity cost.

Water Cycle

Water cycle describes how water evaporates from the surface of earth, rises into the atmosphere, cools and condenses into rain or snow in clouds, and falls again to the surface as precipitation. The water falling on land collects in rivers, lakes, soil, and porous layers of rock, and much of it flows back into the oceans, where it will once more evaporate (Huntington, 2006).

Rainfall or precipitation in water cycle is the return of fresh water to the earth and it is a finite natural resource. However, this precious resource is frequently lost through the short sightedness of human actions as below:

(1) Stormwater runoff, jungle and forest serves as a water catchment area in the water cycle - when forests are fell for timber, rainwater is not retained and runoff on the surface quickly.

(2) Elimination of wetlands and lakes - wetlands and lakes are often converted to agricultural land denying the natural reservoir of water. Therefore, freshwater is lost to the sea.

(3) Exploitation of groundwater - water supply is taken from the aquifer system in an unsustainable manner, whereby withdrawal exceeds natural recharge causing water shortages in the future.
(4) Water is lost through burst pipes.
(5) Pollution of rivers and lakes - contaminated water cannot be used resulting in water wastages.
(6) Excessive use for agricultural irrigation and industrial use to the extent ecosystem collapse.

Importance of Water: Water is Life

Malaysia is rich in water resources, with an average rainfall of 3000 mm. 98% of the water is sourced from streams and rivers and remaining 2% contributed by groundwater (Chan, 2004). Also, with 92% of Malaysians with access to properly managed water supply (Borgen Project) coupled with low water tariff (Kamarudin, 2020). Therefore, water scarcity is unheard off and Malaysians are mostly oblivious of the quote "Water is Life". Yet, water shortages in Malaysia are not uncommon, states like Perlis, Kedah, Penang, Melaka and Selangor are not self-sufficient in water supply (Akademi Sains Malaysia, 2014). In arid and semi-arid areas, water scarcity can have severe social and economic consequences (Petruzzello, 2021).

Social Consequences:

(1) Man-hours loss - water is needed by every household for drinking, cooking, washing, bathing, etc. In areas of water scarcity, many hours are spent in gathering water resulting in limitation of educational and economic opportunities.
(2) During water scarcity, water is used sparingly for critical purposes only like cooking and drinking. Activities of bath taking and cleaning may be forgone causing unhygienic condition and deteriorating health condition.
(3) Limited job opportunities - business thrive in areas with abundant water resources only.
(4) Low productivity from agricultural activities. The productivity of irrigated land is nearly 3 times greater than those rain-fed land (FAO, 2010).
(5) Low household disposable income - many people living in water scarcity area are poverty stricken.

Economic Consequences:

(1) Diminished agriculture activities - due to low productivity resulted in reduced cultivated areas, less cropping intensity.
(2) Not conducive for mining and industrial activities due to lacking of water resource.
(3) Not conducive for commerce and business activities as the communities are backward, poorly educated and mired in poverty.

Water and Sustainable Development

Water resource is critically linked to the socio-economic development of mankind as depicted in every development of ancient civilisation, which is located close to water

resource (Yevjevich, 1992). The more abundant of water resources indicates a better prospect in the development, or rather the extent of development is determined by the amount of water resources. Thus, a sustainable development where "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" is emphasised. In UN's SDGs on Water (Sustainable Development Goals), it is targeted for healthy people, increased prosperity and safeguarding of ecosystems.

Case Studies / Success Stories Used as Teaching Materials for Social Science Students

Case Study 1: Unsustainable Groundwater Usage in Bangkok, Thailand

Overview

The city of Bangkok and the adjacent 6 provinces of Samut Prakan, Nonthaburi, Pathumthani, Nakhon Pathom, Samut Sakhon, and Ayutthaya have experienced land subsidence for the past 4 decades. The cause of this land subsidence is due to the over-extraction of groundwater, which has been going on since the mid-1950s (Babel et al., 2006).

Initially, groundwater was extracted to supplement insufficient surface water supplies for public water purposes to meet rapidly increasing water demands. Failure to cope with the rising demand had resulted in a large number of private wells were bored without governmental control for household and industrial use. It was estimated by 1976 in the region of Bangkok and adjacent municipalities of Nonthaburi and Samut Prakan, water extraction had reached 937,000 cubic meters per day compared to only 8,360 cubic meters per day in 1954. The extraction level peaked around 2 million cubic meters per day in year 2001 by private wells; whilst public wells had dwindled ever since programme under the Mitigation of Groundwater Crisis and Land Subsidence in Bangkok Metropolis to phase out deep wells were implemented in 1983.

Repercussions of Unsustainable Groundwater Extraction

The excessive extraction of groundwater exceeding nature recharge had resulted in a rapid groundwater depletion, water quality deterioration, land subsidence and issues related to land subsidence such as flooding in low-lying areas near to coast during high tides, and damages to drainage system, irrigation canals, sanitary sewers and levees.

Mitigation Measures

As mentioned earlier, phase-out of deep wells was implemented through the programme "Mitigation of Groundwater. Crisis and Land Subsidence in Bangkok

Metropolis" in 1983 in order to re-store the piezometric levels (groundwater level), monitoring of groundwater levels, groundwater storage augmentation through artificial recharge, industrial estate to be built away from water shortage area and factories depended heavily on groundwater be relocated.

Conclusion

Understanding the dynamics of multi-aquifer system, behaviour of artificial recharge to form Groundwater management system for sustainable operation. Strict implementation of regulatory rules and legislation is required for effective management of water resources. In-depth socio-economic assessment affecting stakeholders and demand–side management.

Case Study 2: River Pollution in Selangor, Malaysia

Overview

Occurrence of water pollution in Selangor River had resulted in the suspension of work at water treatment plants on four occasions in this year and led to the disruption of water supply to millions of consumers. The water pollution was due to illegal discharge of effluents, dumping of chemicals, which causes contamination of raw water resource (Zainuddin, 2020).

Conclusion

As per condition in Thailand, it is the personal belief that strict implementation of regulatory rules and legislation is required in order to ensure adherence to existing rules and regulations to avoid pollution and contamination of water resources. Without which industries or individuals still believe that they won't be caught in the violation of rules and regulations and in case they were caught, they were able to escape unpunished or receiving light sentences only.

Case Study 3: Fog harvesting in Chungungo, Chile

This tiny fishing village of a population of 300 people of Chungungo, Chile is one of the driest places of inhabitable world. They used to pay for expensive water by truck-in water from other parts of the country. But Chungungo has a favourable topographic and geographical conditions where it receives fog from the Pacific ocean, thus, it was able to introduce fog harvesting system in 1987 (Fog Catchers, 2004).

By 1992, the system was functioning well enough to pipe water into the village and attempts to grow fruit crop was initiated and a public park was created. The project was successful for the village to dispense with the water delivery truck. Also, the price for water was affordable even by poor households.

Nevertheless, the project fell apart in the last few years as the population grew from 300 to 900 people.

Indeed, this project is "Open your eyes, open your mind" for fellow Malaysians who have a much favourable conditions. Thus, bring safe and clean water to every corner of Malaysia as per Sustainable Development Goal (SDG) 6 is achievable.

Case Study 4: W.A.T.E.R Project

Working Actively Through Education & Rehabilitation (W.A.T.E.R) Project is an initiative by SPARK Foundation with the support of the Global Environment Centre. Started in early December 2007, the project worked in collaboration with relevant government agencies and with the support of the local communities. The W.A.T.E.R Project aims to educate the public on the importance of water, and the "why" and "how" to conserve and protect its source (http://www.waterproject.net.my/).

Campus Activities Involving Student's Participation in order to Enhance Their Knowledge on Sustainable Water Resources Management

Proposed Activity 1: Wise Water Way

Goal: To enhance under-graduates' knowledge and awareness of water usage in a big institution and devise strategies for water conservation.

Target Audience: 1st year under-graduates of Social Sciences.

Objectives:

1. Participants will investigate where water is used in a big institution (focus on significant areas only).
2. Participants will discover whether water is used wisely or otherwise (element of wastage).
3. Participants will propose methods to reduce wastage of water.
4. Participants will propose alternative water source to reduce water usage.

Proposed Activity 2: Give River A Hand

Goal: To enhance under-graduates' knowledge and awareness of Water management and Community Engagement

Target Audience: Under-graduates of Social Sciences and Local Community

Objectives:

1. Participants to monitor adopted river environment such as physical characteristics and aquatic life and water quality. Educate and enhance community's knowledge in river protection.
2. To participate in river clean-up.

Proposed Solutions and Strategies to Enhance Awareness and Knowledge of Social Science Students in Promoting Sustainable Water Resources Management

1. To carry out study on Awareness Level of Water Resource Management amongst University Students. This involved distribution of questionnaire to university students to test their knowledge concerning water resources, importance of water, water conservation practices and individual water usage behaviour. Basing on the survey findings, specific educational programmes will be formulated to enhance and improve the shortcomings.

2. To carry out study in an institution on its water usage, presence of wastages, and proposed solution to reduce wastages or alternative water resources. Upon completion of the above activities, students will be well equipped with the knowledge of water resources management, as well as individually sensitive to water use and also able to contribute to the community.

Conclusion

This write-up has made clear the imperative of incorporating social sciences into water resources management. Much of what university students need to do in order to achieve successful implementation requires social science expertise to translate social and institutional information into actionable programme activities. Such change of paradigm, technological intervention, probable institutional reforms, coupled with community participation, water conservation and re-use, provides a holistic approach and feasible measures to a sustainable water resources management.

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4.7.2 Integrated Lake Basin Management (ILBM) challenges and opportunities for sustainable water resources management in Malaysian Universities – written by Dr. Mohd Yusoff Ishak, UPM

The complexity of water management issues often revealed that water resources were separated into distinct segment such as lakes, rivers and groundwater. In reality, each of these bodies are interconnected; depleting ground water for example, can lead to rising water demand which may reduce the quantity of water in the environment thereby leading to an increase in the concentration of pollutants and a decline in water quality. United Nations 2030 Agenda for Sustainable Development Target 6.5 to 'Implement Integrated Water Resources Management (IWRM) at all levels unravel the needs for young minds participation. As our future leaders, the youth hold distinct social uniqueness in their social strata and are facing formidable challenges due to their high number on demographic stature. However, there are still insufficient exposure to systematically introduces the existing knowledge of IWRM on the youth in Malaysia in view of sustainable water resources management. Leveraging on the abundant of lakes within their campuses, this write-up deliberated on platforms for IWRM and Integrated Lake Basin Management (ILBM) practical purposes and implementation and explained the importance of integrating youth into these strategies to encourage exposure for cross, trans- and multi-disciplinary knowledge and cooperation in aquatic ecosystem management.

Introduction

In Malaysia, the public discussion and in university education, the adaptation to and mitigation of global climate change tend to dominate over questions related to water quality and the state of aquatic ecosystems. However, water is not only a prerequisite for life on earth and many economic activities, but also a topic that has a large didactic potential (Karthe et al., 2016).

Aquatic ecosystems such as lakes provide pertinent environmental functions such as maintaining resources and regulating services. Wetlands improve water quality by

trapping sediments, filtering pollutants and absorbing nutrients while lakes supply water for consumption and irrigation, are used for harvesting fish and other food resources, and for recreational activities such as angling, boating and swimming. Both play a key role in the control of floods and prevention of droughts.

Despite its critical to the fulfilment of human needs for living, fresh water represents the smallest percentage of the total water available on our planet. Lakes contain 50.01 % of all the water on the Earth's surface, they hold 49.8 % of the liquid surface freshwater (Bhateria & Jain, 2016). Lakes add significantly to biodiversity on Earth and act as important foraging areas for many terrestrial animals and waterfowl. The extent and importance of inland water bodies across the landscape are increasingly appreciated with more multidisciplinary research with various methodologies.

An impoundment such as lakes are important and serve for variety of ecological role. These features significantly slow the rates of transport of water and contained dissolved and particulate materials from land to the sea; elevate water loss to evaporation; alter rates, pathways and locations of chemical reactions in freshwater; and disrupt freshwater aquatic habitats by fragmenting water flow to the ocean (Dynesius & Nilsson, 1994; Graf, 1999; Vörösmarty & Sahagian, 2000).

A growing number of authors highlighted the role of 'small water bodies' (loosely defined to have surface areas smaller than approx. $10^4 m^2$) that despite their size, has probable significance to sediment and sedimentary carbon deposition (e.g. Mulholland & Elwood, 1982; Dean & Gorham, 1998; Stallard, 1998; Smith et al., 2001). It is increasingly recognised that lakes are important in the global geochemical cycles (Cole et al., 2007), apparently making a disproportionately large contribution, in terms of area, as a carbon sink (Dong et al., 2012).

A particular effect of reservoirs is the enhanced trapping of sediments carried by rivers towards the ocean (Trimble & Bube, 1990). In the case of the Colorado River, for example, impoundments have reduced sediment delivery to the Gulf of California by ~100-fold (Smith et al., 2002). High loading of nutrients into lakes has resulted in turbid water, excessive blooms of, often toxic, cyanobacteria and loss of biodiversity (Jeppesen et al., 2000).

However, human action and activities often disturb the structure of the biotope, cause organic pollution and many of the world's aquatic ecosystem become fragmented. Due to rapid economic growth and increasing population, water resources has become one of the most significant issues faced by urban spaces in developing countries. Examples of human activities, inter alia: disposal of human and animal waste, burning of fossil fuels and the application of artificial fertilisers, have led to eutrophication of lakes (Davidson & Jeppesen, 2013).

The identification and investigation of declines in water quality associated with increased nutrient loading have a relatively long history (Moss, 1977). Recent and emerging global threats, such as biological invasions, climate change, land use

intensification and water depletion have added impact and endanger the sustainable future of lakes and reservoirs. The increase in water stress due to climate change across the world greatly complicates proper water resources management.

To deal with these threats, a multidimensional view on the management and protection of lakes is needed. The holistic approach needs to contain not just the development of economy and society but also take into account the negative impacts of this growth on the environment, from that, the balance between the people, profit and planetary dimensions can be sustained to reach a sustainable future.

Based on the understanding of what causes eutrophication and its consequences, many countries have introduced an integrated approach to Integrated Water Resources Management (IWRM) into their policies. This is also as a response to the hydrological, social, economic and environmental interdependences that occur in the catchment areas of rivers, lakes and aquifers. IWRM is a multifaceted solution comprising political, socioeconomic, institutional and environmental aspects. Integrated development and management of water resources within this country could close the gap in water resources knowledge and contribute to the success of water management, with important consequences in the next future of this country.

This write-up aimed to identify and analyse the challenges and opportunities for sustainable water resources management focussing on lakes in Malaysia from youth perspective, especially looking at the platform available in public universities. The water resources issues, awareness, attitudes and practice of Integrated Water Resources Management (IWRM)/Integrated Lake Basin Management (ILBM) in Malaysia would also be discussed.

The hypothesis is that students at tertiary levels have greater exposure to environmental issues thus leading to better conscience and attitude on environment. One of the main issues faced by youth is related to the awareness and later would lead to unsustainable consumption pattern of their water resources. This could be due to lack of exposure, awareness and understanding on the sustainable water resources management. Therefore, this write-up would explore platform for practical education of environmental issues to guide students to put IWRM into practice.

The introduction of Agenda 2030 for Sustainable Development in 2015, should not be viewed as sending the IWRM into the backstage. In fact, higher learning institutions have increasingly demonstrated their commitment by supporting SDG initiatives to compliment IWRM. The current UN emphasis on measuring IWRM implementation through numerous indicators including institutional should expand our understanding on the IWRM and links to other SDGs.

Integrated Water Resources Management (IWRM)

The IWRM is often practically interpreted to mean the integration of water-related management components at the river basin scale. IWRM as a framework is designed to improve the management of water resources based on four key principles adopted

at the 1992 Dublin Conference on Water and the Rio de Janeiro Summit on Sustainable Development. These principles hold that: (1) fresh water is a finite and vulnerable resource essential to sustain life, development, and the environment; (2) water development and management should be based on a participatory approach, involving users, planners, and policy makers at all levels; (3) women play a central part in the provision, management, and safeguarding of water; and (4) water has an economic value in all its competing uses and should be recognised as an economic good (ICWE, 1992).

IWRM is understood as 'a process which promotes the coordinated development and management of water, land and related resources to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems' (GWP, 2000; Benson et al., 2020). IWRM is not, therefore, a prescriptive description of how water should be managed, but rather it is a broad framework in which decision makers can collaboratively decide the goals of water management and co-ordinate the use of different instruments to achieve them (Lenton & Muller, 2009).

The socio-economic, political context and environmental characteristics of each country differs, therefore there is no single blueprint for IWRM and it can be adapted to resolve the problems faced in each local context (Pahl-Wostl et al., 2011). It should not, however, be thought that there are always trade-offs between these goals, and a more integrated approach to water security management can help in achieving win-win outcomes which promote more than one goal. As a result, the goals of IWRM vary across countries and different weights are placed on the importance of economic, environmental, and social impacts. While the differences in implementation across countries can make IWRM difficult to define, it can be broadly characterised by a number of key trends.

Command-and-control	• Incorporating demand side using economic instruments.
Sustainable development	• Awareness on sustainabilty and incorporation of social and environmental considerations.
Top-down, centralised	• Towards flexible, decentralised approaches involving governance structures.

Firstly, there has tended to be a move away from command-and-control instruments which focus on supply-side water management, such as large-scale water infrastructure, towards incorporating demand side management through the use of economic instruments.

Secondly, IWRM has led to an increased awareness of the importance of sustainable development and the incorporation of social and environmental considerations into water management.

Thirdly, IWRM has also tended to lead to a move away from top-down, centralised approaches to water security towards more flexible, decentralised approaches which involve a variety of diversified governance structures at a local, basin, national, and transnational level.

The IWRM framework has been increasing emphasis on stakeholder collaboration and the involvement of local communities in decision-making. Some of the benefits of wider collaboration include: incorporating specialised knowledge; encouraging more innovative solutions to problems due to greater diversity of viewpoints; encouraging co-operation and reducing the risk of conflicts over water resources; and developing solutions which are more open, inclusive, and democratic, thereby generating wider support and leading to more sustainable outcomes (Loux, 2011)

The Global Water Partnership (GWP, 2009), has established a 'toolkit' based upon a checklist of actions: establishing river basin management systems; defining the roles of river basin organisations; mobilising finance; ensuring stakeholder participation; strategic planning and developing management action plans; establishing monitoring and information systems; and communication. The most prominent process-oriented guidance for implementing the IWRM paradigm is provided by GWP and IWRM now constitutes the dominant paradigm for water management globally (Allouche, 2016) as a result of its global diffusion (Benson et al., 2020).

Goal 6 for SDG is 'ensure availability and sustainable management of water and sanitation for all'. Due to its sectoral cross-cutting nature, IWRM has the potential to not only support the achievement of SDG 6 but also other non-water related SDGs, by moving beyond its current water central focus to recognise the importance of water resources to wider sustainable development (Pires et al., 2017).

Bartram et al. (2018) argued that as UN Target 6.5 does not provide a conceptual interpretation of IWRM based on its normative principles, tracking its contribution to SDG implementation using current indicators could be difficult. It is good to note that the United Nations have recommended IWRM as a straightforward approach for meeting the Millennium Development Goals in their World Water Development Report 2006 (Anderson et al., 2008).

Therefore, for the purpose of SDG implementation, amongst the interesting questions would include how can Target 6.5 be quantitatively and objectively assessed and monitored using key principles of IWRM and how would Target 6.5 implementation support the wider SDGs.

A number of workers have attended to offer solutions to this. For instance, according to Benson et al. (2020) IWRM could be re-conceptualise with an aim to objectively

measure the progress of SDG 6.5 that could also broaden the contribution of this management approach to associated SDGs such as: ending poverty (SDG 1); zero hunger (SDG 2); achieving gender equality (SDG 5); promoting sustainable cities (SDG 11); combatting climate change (SDG 13); protecting life on earth (SDG 15); promoting inclusive societies and accountable institutions (SDG 16); and supporting global partnerships (SDG 17) while Gain et al. (2017) argued that IWRM has become subject to significant expansion of its conceptual parameters within international and national water policy norms, with the term now used interchangeably to denote a variety of water governance models.

Target 6.1 of SDG 6 which refers to ensuring access to drinking water, while stating that such access should be 'equitable' and 'affordable' and Target 6.b, under stakeholder's participation which is aimed at supporting and strengthening local community's participation in managing water and sanitation all are related to IWRM. Even though the term 'participation' is considered another generic with vague practice and debated in some cases and more often misused within water management globally, it should be viewed as an opportunity for locals in Malaysia to involve in managing specific water body such as lakes and ponds.

The primary information on lakes in Malaysia is available from the National Hydraulic Research Institute Malaysia (NAHRIM). The nationwide census by NAHRIM consists of inland lacustrine water body for states in Peninsular and Sabah and Sarawak from the period of 2017. However, effort must be made to enumerate discrete water bodies not being counted in previous inventories, especially around 1-km buffer of the large water bodies identified in the NAHRIM database. This buffer would allow for slight inclusions of smaller lakes in the existing mapped locations of water features. National Hydraulic Research Institute Malaysia inventory stated that ~170 lakes across Malaysia with the definition dams as '…significant pond with 1 hectare in size.

In Malaysia, most of the water bodies are artificial and human made. Their abundance is increasing and constitute a fundamental transformation of the country landscape during the intensive mining industries and agriculture such as disused mining pond and holding ponds for irrigation water supply, respectively. While linear features that are clearly streams should be excluded, floodplain that seasonally feature as impounded water bodies yet are functionally parts of the river-lake systems, as well as coastal lagoons and wetlands should be included. These should allow inclusions of oxbows and swales that normally occur on the floodplains of large rivers lead to a better estimate of the total number, distribution and area of our water bodies.

Integrated Lake Basin Management (ILBM)

The Integrated Lake Basin Management (ILBM) is developed by ILEC (2007) as a guideline for lake managers and stakeholders to achieve sustainable management of lakes and their basins. This conceptual framework consists of the lake biophysical features and management requirements of lake basin systems that are associated with the lentic water properties and their dynamical changes, use and conservation of lake and basin resources. Moreover, this framework promotes the improvement of

lake basin governance continuously by integrated six pillars of institutions, policies, participation, technology, information and finance.

Institutions were required to manage the resources of the lake and its basin for all lake basin users. The policies have to be developed to govern people's use of lake resources and human impacts on lakes. The involvement of key stakeholders in lake basin management as well as community empowerment was the third pillar that will strengthen the ILBM. The use of technology, information from traditionally and scientific approach in some cases were the fourth and fifth pillar of ILBM. Last but not least was sustainable finance to support all the said activities.

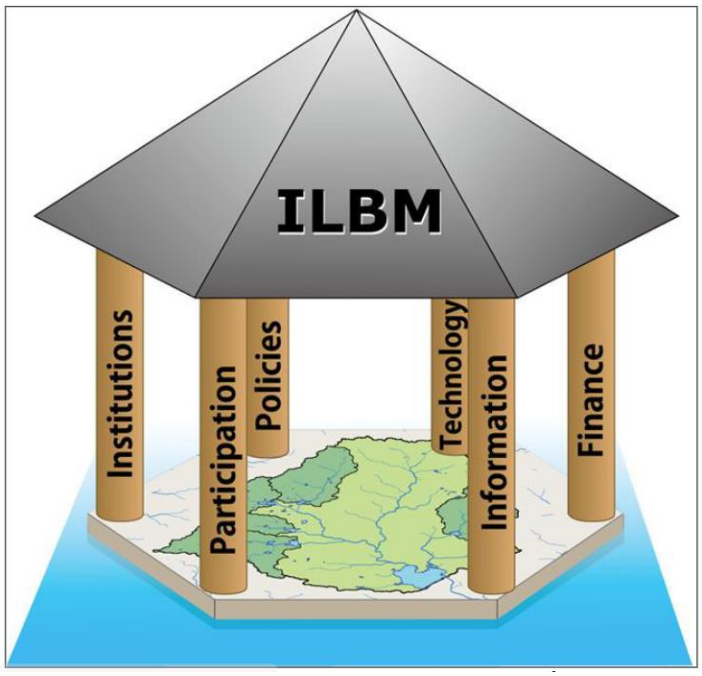

Figure 2.4 ILBM framework with 6 pillars

Figure 2.4 above shows the 6 pillars supporting ILBM representing cyclic process during the development of ILBM. Naturally one or more pillars could be broken, upon which the process are repeated again and again until all 6 pillars are able to stand strong.

Importance of lake in water resource management

The role of water bodies has been largely overlooked, in spite of their probable significance to sediment and sedimentary carbon deposition (Mulholland & Elwood, 1982; Ritchie, 1989; Dean & Gorham, 1998; Stallard, 1998; Smith et al., 2002). Specific sediment yield (sediment export from a catchment per unit of catchment area) and the related variable, sediment delivery ratio (ratio of sediment delivered to a catchment outlet to sediment eroded within the basin) tend to decrease with increasing basin area (Walling, 1983).

Water bodies in Malaysia in part represent local attempts to compensate for natural 'loss' of water and to ensure the water remains locally available. This management strategy may work at the site of the impoundment; however, the larger-scale aggregate effect of this local water trapping will be to elevate evaporation, rather than allowing this water to flow downstream or percolate (Smith et al., 2002).

The rapid build-up of the water-body sediments (primarily eroded topsoil) not only buries organic matter deeply in topographic depressions (which will be less subject to exhumation and erosion even when ponds are no longer present), but also causes a systematic shift in redox conditions in the deeper sediment that substantially slows oxidation of organic matter (Schlesinger, 1997).

The rapid sediment burial in the small water bodies, in combination with their typical proximity to human and agricultural sources of nutrient loading, will result in eutrophication and high organic input causing sub-oxic or anoxic conditions and diagenetic reactions which are very different than in larger water bodies with slower sedimentation (Smith et al., 2002).

Both natural and artificial lakes do not feature exactly the same roles for a variety of reasons, however the existence of permanent aquatic microenvironments across the country will be important to the survival, migration and future extension of a wide variety of species, both natural and invasive. Local water balance and sedimentation are influenced by the area and volume of lakes while geochemical and ecological impacts of water bodies continue to be impacted as well.

Amongst the consequences of water bodies are:

Hydrology	•Elevated evaporation, decreased downstream flow; •Altered groundwater recharge, •Redistribute anthropogenically lost natural wetlands
Sedimentation	•Significant sediment trapping; •More vertical accretion and infilling than large water bodies
Water storage	•Stronger redox gradients, diagenetic reactions (e.g. of organic material); •Ephemeral storage (decades vs. centuries)

Sustainable Development Goals (SDGs)

Since lakes and reservoirs contribute significantly to freshwater availability and use, their sustainability needs to be made central to the success of the Sustainable Development Goals (SDGs) (Florke et al., 2019). The UN's sustainable development goals (SDGs) inform the implementation of the 2030 Agenda for Sustainable Development, adopted in 2015 (UN, 2017). The 17 goals are each accompanied by specific targets, 169 in total, and supported by 232 indicators for monitoring progress (UN, 2017). Originally defined in the Brundtland Commission's report, Our Common Future, as development 'that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987).

SDGs adopt a more holistic 'triple bottom line' approach to sustainable development that integrates environmental and socio-economic objectives (Sachs, 2012). Sustainable development has evolved to become a key objective for policy-makers at multiple levels despite ambiguity over its exact interpretation (Baker, 2016; Mebratu, 1998; Redclift, 2005).

Target 6.5 for implementing 'integrated water resources management (IWRM) at all levels. Under Target 6.5, IWRM is measured by the degree of national institutional implementation and, in transboundary basins, the proportion of area subject to cooperation. Target 6.b is aimed at supporting and strengthening local community participation in managing water and sanitation. While the term 'participation' is generic and vague practice (Benson et al., 2020).

Teaching and learning of IWRM for sustainable water resources management

Today's students are tomorrow's decision-makers. Thus, it is important for universities to prepare them for vital task ahead. Youth is a key to the successful practice of integrated water resources management and represent the next generation of environmental champions. The gap in environmental knowledge amongst the youth and the old within this country could contribute to ecological issues or environmental management problems, resulting in unsustainable development, with important consequences in the future of our nation. However, the young generation can be enabled to develop a sustainability oriented behaviour based on knowledge, values and personal conviction both individually and in social groups (Potter, 2010). Therefore, universities constitute a very relevant target group for IWRM capacity development via environmental education.

The Malaysia Education Blue Print 2015-2025 for Higher Education have been targeting to: (i) produce holistic graduates who are entrepreneurial and balanced, (ii) improve students' learning experience, and (iii) expand collaboration between industries, government agencies and communities.

The lack of environmental education in most developing countries is partly caused by fragilities in practical environmental curricula of lecturers to respond to modern-day environmental issues for IWRM. Indeed, tertiary student's low environmental knowledge is related to a deficiency in lecturers' practical experience. To bridge this

knowledge gap, IWRM should be integrated into undergraduate curricular at all levels across the universities. Knowledge and awareness on environmental management tool such as IWRM must continue to be advocated through theory and practical cases to illustrates and articulate IWRM within a curriculum setting adopting a holistic approach. The concept of "learning by doing" which emphasises practicality and effectiveness towards students' cognitive and affective would be a suitable approach for this IRWM. This is evident from the study on solid waste management by (Debrah et al., 92021) which showed that students at both secondary and tertiary levels have positive environmental attitudes, and high awareness of environmental issues, but there is a lack of practical education of teachers to guide students to put the knowledge into practice.
The same could be alluded on IWRM where student's low environmental knowledge is related to a deficiency in teachers' practical experience in IWRM. When integrated water resources management is to be implemented in developing or transforming countries, common challenges include a lack of qualified staff in the water sector, and a limited public awareness of water-related problems as well as the role of civil society for their solution (Borchardt et al., 2013; Ibisch et al., 2016; Leidel et al., 2010).

On one hand, many lakes in universities are deteriorating due to sedimentation, pollution, eutrophication, and water quality and water quantity depletion. On the other hand, lakes inside higher learning institution are used mainly for aesthetics, recreational purposes. Therefore, a network involving universities could be set up with the intention to win both lecturers and students for the idea of a sustainable water resources management.

The role of fieldwork and SULAM hands-on experiences in the context of IWRM/ILBM

In a university context, water does not only allow for interdisciplinary learning and the acquisition of associated methodological competences, but also offers opportunities for hands-on learning in the vicinity (Karthe et al., 2015) and thus the identification of learners with their topic (Karthe et al., 2016). Learning activities outside the classroom facilitate the direct interaction of students with their study subjects and promote the development of admiration for nature and consciousness for environmental problems (Mannion et al., 2013) where activities such as SULAM help to reduce the distance between scholastic education and real life.

In line with the global development on high impact practices, Ministry of Education (MoE) Malaysia has been enhancing its teaching quality by introducing high impact practices that include service learning or better known as SULAM. SULAM is a method of teaching and learning that bridges classroom experiences with community activities. The primary aim of SULAM to produce holistically developed students through experiential learning and planned task involving improvement of assets of the selected community and co-creating knowledge. Service learning is one of the pedagogical strategies to enhance teaching and learning skills and has been identified as one of the High-Impact Educational Practices (HIEPs). HIEPs are techniques and designs for teaching and learning that have proven to be beneficial for student's

engagement and successful learning amongst students from many backgrounds. SULAM's innovative learning outcomes are meant to enhance student's learning and to narrow gaps in achievement across student populations.

In SULAM programmes, field-based 'experiential learning' with community partners is delivered through instructional strategy which often a required part of the course. Learning activities outside the classroom are known to improve an interdisciplinary character and are suited to convey multidimensional, holistic perspectives. The idea of SULAM is to give students direct experience with issues they are studying in the curriculum and with ongoing efforts to analyse and solve problems in the community. A key element in SULAM is the opportunity students have to both apply what they are learning in real-world settings and reflect in a classroom setting on their service experiences. These programmes model the idea that giving something back to the community is an important tertiary level education outcome, and that working with community partners is good preparation for citizenship, work and life (Kuh, 2008).

The development of lakes and other water bodies must support sustainable access to adequate quantities and qualities of numerous benefits to human society, environmental well-being, and economic welfare. Thus, multiple participants from varying background of study in SULAM could provide a positive opportunity for developing local partnerships through promoting greater translational technological cooperation around lake data provision and analysis. Students learning and applying big data, machine learning and artificial intelligence coupled with sociologist would open up new possibilities and paved way for rapid advances in both environmental and social scientists in aspect.

For this purpose, the existing curriculum, educational materials and monitoring equipment could be exploited for use in SULAM by students. As universities now keen on introducing SDG subject which are all IWRM-linked as elementary course, interested lecturers of all relevant disciplines should be given an interdisciplinary training providing them with ideas about how to encourage explorative learning in the context of water, lakes and its management.

In the context of environmental education, water resources and aquatic ecosystems are highly relevant topics (Kasimov et al., 2013). For the purpose of learning IWRM and ILBM, these water bodies inside and outside the campuses would present an empirical case study that would imply knowledge inquiry into global level and present a holistic sustainable transformation potential. Teaching and learning IWRM using a real experience based on local scenario at their respective lake campus would allow both students and instructors to move towards a verifiable and pragmatic contribution to sustainability at the local scale with global worldview.

Ideally, locations for learning activities outside the classroom should exhibit natural or man-made phenomena authentically and clearly in a way that is discernible to learners. For example, sciences and engineering students can collaborate with the local community to improve water quality of their lakes. This would enable the

students to handle the complex issues in eutrophication management and expose them to various new perspectives beyond their lecture hall. In the end, the service-based learning would challenge the students to not only achieve real outcome for the benefits of the society but also further explore their understanding towards themselves, community and the environment.

Conclusion

The complex sociocultural environment and recent advances in High-Impact Educational Practices implies that to bridge the knowledge gap in environmental sustainability, IWRM and ILBM should be integrated into tertiary curriculum at all levels in Malaysia.

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CHAPTER 5 CONCLUDING REMARKS

When we were developing this module, we acknowledged that there are many resources related to water available and accessible from the internet, where these resources are suitable to train educators and students at primary and secondary schools, and higher education institutions (HEIs). Hence, this module adopts and adapts information from available resources, and we have acknowledged references of these resources throughout the training module. By doing this, we are not reinventing the wheel, indeed we have made use of available information to contextualise information that are suitable for Malaysia's scenario.

When we were searching and gathering resources from the internet, we only focus on information that are related to water at schools and HEIs. There is other information such as environmental education, environmental awards, energy saving and energy efficiency, however, this information are not taken into account by this training module. This includes the Sekolah Lestari – Anugerah Alam Sekitar that is organised by Department of Environment and other partners, as well as the Program Sekolah Rakan Alam Sekitar (SERASI) that was held at Sabah. In order to select only relevant information, as well as to adhere with the scope of WST 2040, this module focus only on areas that are related to water.

This training module is not exhaustive, and it can be further improved from time to time. Also, when there are new topics that seems to be suitable for schools and HEIs, these topics can be added into this module. Regarding potential trainer, this module has also compiled a preliminary list of resource persons, where their expertise are also listed in this module as well.

Last but not least, hopefully this training module will be benefited to the educators and students in Malaysia, where information in this training module can enhance their awareness and capacity in the area related to water. In summary, based on current status, we have proposed way forward for academia cluster in the context of AACB (Advocacy, Awareness, Capacity Building and Public Participatory Platforms)

Component	Status	Way forward
Awareness	• The topics that are related to water already incorporated into the school curriculum. • At HEIs, the topics that are related to water already incorporated in selected programmes offered by HEIs.	• Share information related to sustainable water resources management with students at schools and HEIs.
Capacity Building	• Project-based learning activities at schools and HEIs are limited. • Some of the activities are ad hoc and not sustainable.	• Showcase existing project-based learning activities that are related to sustainable water resources management. • At HEIs, provide technical courses/trainings that are advanced and specific to targeted group of students.
Advocacy	• Advocacy for academia cluster is limited. • There are resource persons at the HEIs that could promote advocacy.	• Encourage knowledge-based competencies in promoting advocacy for academia cluster.
Public Participatory Platforms	• No specific public participatory platform for academia cluster. • Some of the platforms are ad hoc and not sustainable.	• Establish appropriate and sustainable public participatory platforms under ASM.