River ranger

Dr H2O

WATER CONSERVATION PROGRAMME FOR SCHOOLS IN MALAYSIA

WATER CONSERVATION MODULE

INITIATED BY:

Global Environment Centre

HSBC

IN PARTNERSHIP WITH:

SPAN Suruhanjaya Perkhidmatan Air Negara

Kementerian Pendidikan Malaysia

CONTENT

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(SOURCE: Tanawat Pontchour, www.123rf.com)

MODULE 1:
MAN AND WATER

MODULE 1: MAN AND WATER

The molecular formula for water is H_2O. The polarized form of the water molecule (H^+ OH^-). The atomic structure of a water molecule consists of two hydrogen atoms joined to one oxygen atom. The hydrogen atoms are attached to the oxygen atom causing one side of the molecule to have a negative charge and the area in the opposite direction to have a positive charge. The resulting polarity of charge causes molecules of water to be attracted to each other forming strong molecular bonds. These attractive forces are known as hydrogen bonds. Hydrogen bonds are the reason for water's very special properties which make life on Earth possible.

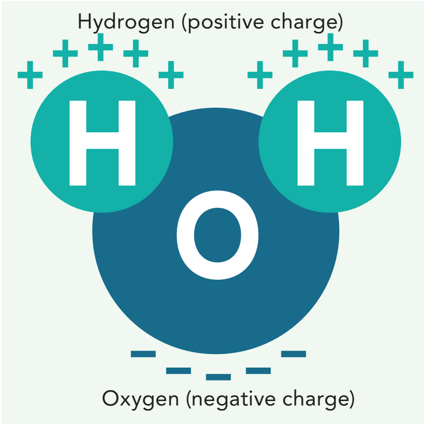


FIGURE 1: H_2O MOLECULE BONDING

1.1 WATER RESOURCES

Water resources are sources of water that are useful or potentially useful to human beings. These uses encompass agricultural, industrial, household and recreational activities. Water exists naturally in various forms and locations. They are everywhere: in the air, on the surface, below the ground and in the oceans.

The total volume of water on our Earth is about 1.4 billion km^3. Fresh water naturally occurs on Earth's surface in ice sheets, ice caps, glaciers, icebergs, ponds, lakes, rivers and streams, and underground as groundwater in aquifers and underground streams. The volume of freshwater resources is around 35 million km^3, or about 2.5% of the total water volume. This means only a small fraction of the world's freshwater resources is readily available as shown in FIGURE 2.

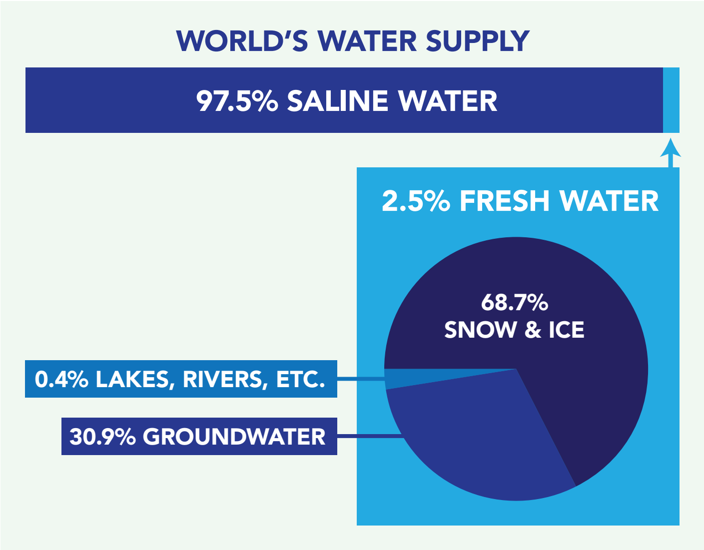


FIGURE 2: PERCENTAGE OF GLOBAL WATER RESOURCES

(SOURCE: UN WATER, 2012)

1.2 THE WATER CYCLE

The water cycle is a natural process that collects, purifies and redistributes water; therefore recycling all of our planet's water powered using solar energy. Water moves around the earth in a water cycle. Water rises up into the atmosphere by evaporation and back down to the earth's surface as precipitation.

Water evaporates from the ocean, lakes, reservoirs, rivers and streams (surface water) and rises into the atmosphere. As air reaches a certain level of the atmosphere, it condenses and become water vapour, forming rain clouds. When rain clouds become heavy, it falls in the form of rain and flows into rivers and streams.

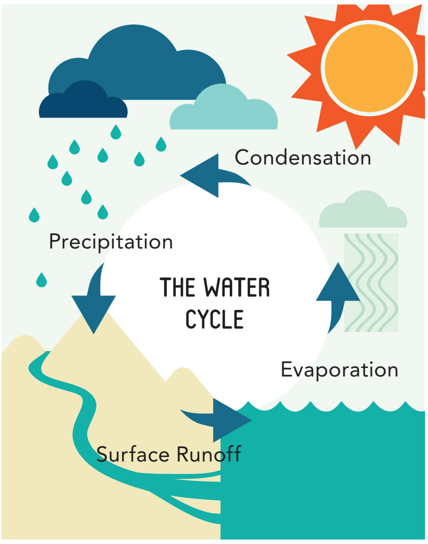


FIGURE 3: THE WATER CYCLE

The water cycle interactions include the continuous movement of water above, on, and below the surface of the Earth. The water on Earth's surface occurs as streams, lakes, and wetlands, as well as inlets and oceans. Water below the surface is primarily ground water, which also includes soil water. A sample of water interaction and connectivity on the surface and ground is illustrated in FIGURE 4.

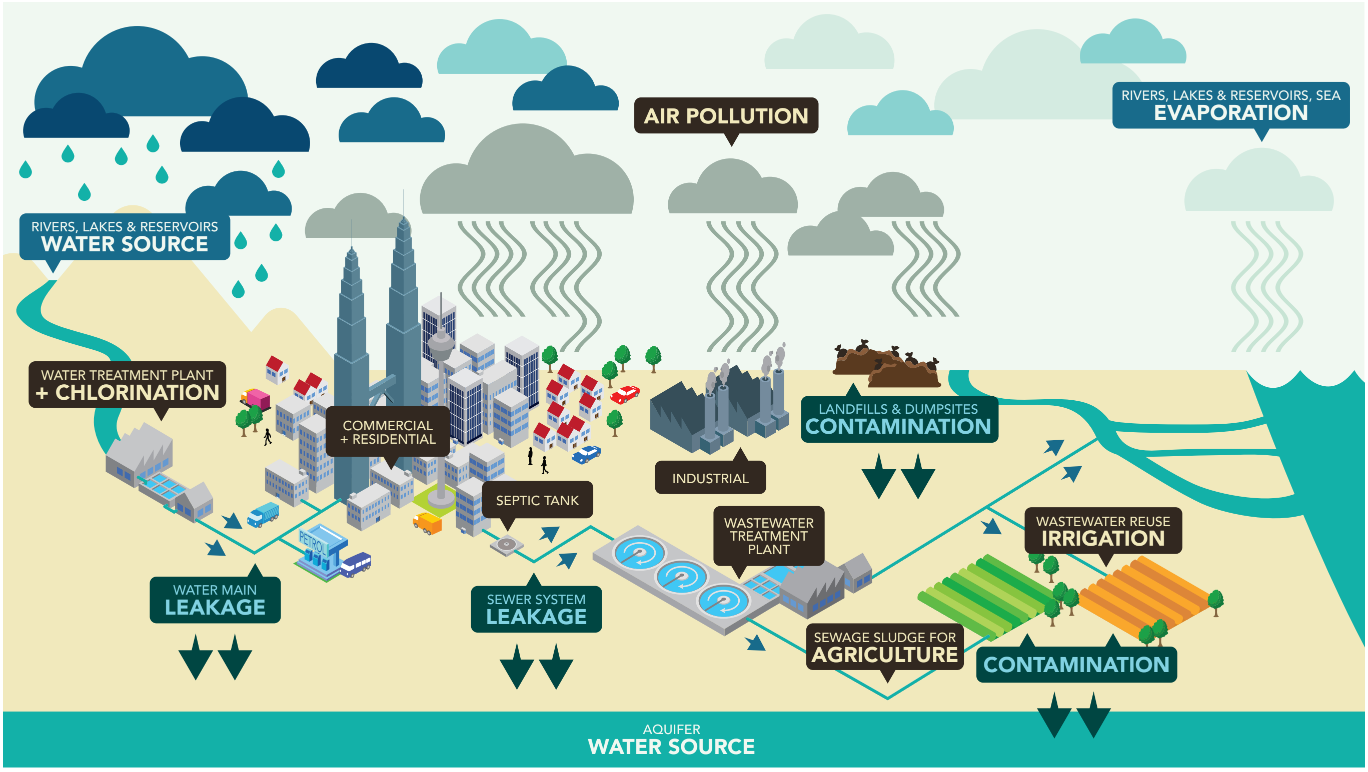


FIGURE 4: WATER INTERACTION

1.3 MALAYSIA WATER RESOURCES

The annual rainfall in Malaysia is up to 990 billion m³. Groundwater is about 90% of the freshwater resources with an estimated amount of 5,000 billion m³. The renewable water resources are 630 billion m³ which is the summation of surface runoff and groundwater recharge. Malaysia has 360 billion m³ which is being lost to atmosphere via evapo-transpiration. ***(SOURCE: Keizrul & Azuhan, 1998)*** Water resources in Malaysia are summarized in TABLE 1.

Annual rainfall	**990 billion m³**
Surface runoff	566 billion m³
Evapo-transpiration	360 billion m³
Groundwater recharge	64 billion m³
Surface artificial storage (dams)	**25 billion m³**
Groundwater storage (aquifers)	**5,000 billion m³**

TABLE 1: WATER RESOURCES IN MALAYSIA

(SOURCE: Keizrul & Azuhan, 1998)

The total land area of Malaysia is 329,847 km² with 1,200 km² or 0.37% is made up of water such as rivers, lakes, or other internal water body. 97% of total water resources in Malaysia are contributed by streams and rivers and the remainders are supported by groundwater. In order to secure the surface water, a dam is constructed across a waterway to confine and control the water. The dam will eventually raise the level of water in the river to form a reservoir. There are 47 single purpose and 16 multipurpose dams with a total storage of 25 billion m³. ***(SOURCE: Water Supply Branch, 1998)***

Number of Single-purpose dams		Number of Multipurpose dams	
Water supply	34	Water supply + Irrigation	6
Hydropower	7	Water supply + Flood mitigation	5
Irrigation	3	Water supply + Irrigation + Flood mitigation	2
Silt retention	3	Hydropower + Flood mitigation	2
		Hydropower + Water supply	1
Subtotal	**47**	**Subtotal**	**16**

TABLE 2: TOTAL DAMS IN MALAYSIA

(SOURCE: Water Supply Branch, 1998)

1.3.1 RIVER

River generally starts at a source, a point which will flow through downhill slope into a larger body of water, like an ocean, sea, or large lake with whole thing knows as watershed. The running water will continue to flow into rills, creating shallow channels which merged to form a stream. The stream is permanent whereby it is a continuously flowing body of water. Rivers end at a large body of water called the mouth. At the mouth, there is usually a river delta, a large, silty area where the river splits into many different slow-flowing channels that have muddy banks.

A river and its tributaries form a drainage basin, or watershed, that collects the runoff throughout the region and channels it along with eroded sediments toward the river. Sediments are typically deposited most heavily along a river's lower course, forming floodplains along its banks and a delta at its mouth. The FIGURE 5 explains the formation of river and its features.

There are about 189 main river basins comprising 74 main basins in Peninsular Malaysia, 75 in Sabah and 40 in Sarawak respectively. There are three different categories of river basins in Malaysia: Category 1 (wholly within a state); Category 2 (shared by more than one state) and Category 3 (shared with other countries). TABLE 3 shows the number of river basins in Malaysia into 3 categories based on the Provision of the Federal Constitution.

CATEGORY OF RIVER BASIN	NUMBER OF RIVER BASINS		MAIN RIVER BASIN (>80 KM²)	
	No.	Area (km²)	No.	Area (km²)
Within One State	2,958	263,498.7638	168	248,723.537
Shared By More Than One	22	56,840.5033	17	56,639.455
Shared with another country	6	7,557.7641	4	7,500.721
TOTAL	**2,986**	**327,897.0312**	**189**	**312,863.713**

TABLE 3: NUMBER OF RIVER BASINS IN MALAYSIA ACCORDING TO THE CATEGORIES

1.3.2 GROUNDWATER

The presence of perennial rivers and the abundance of rainfall in Malaysia led to the exploitation of surface water, leaving the ground water systems relatively 'untouched'. The most potential formation is the sandy or gravelly alluvium which exists in the coastal plains and valleys of the major rivers, followed by limestone and other sedimentary rocks. Other hard rock such as granite have very limited groundwater.

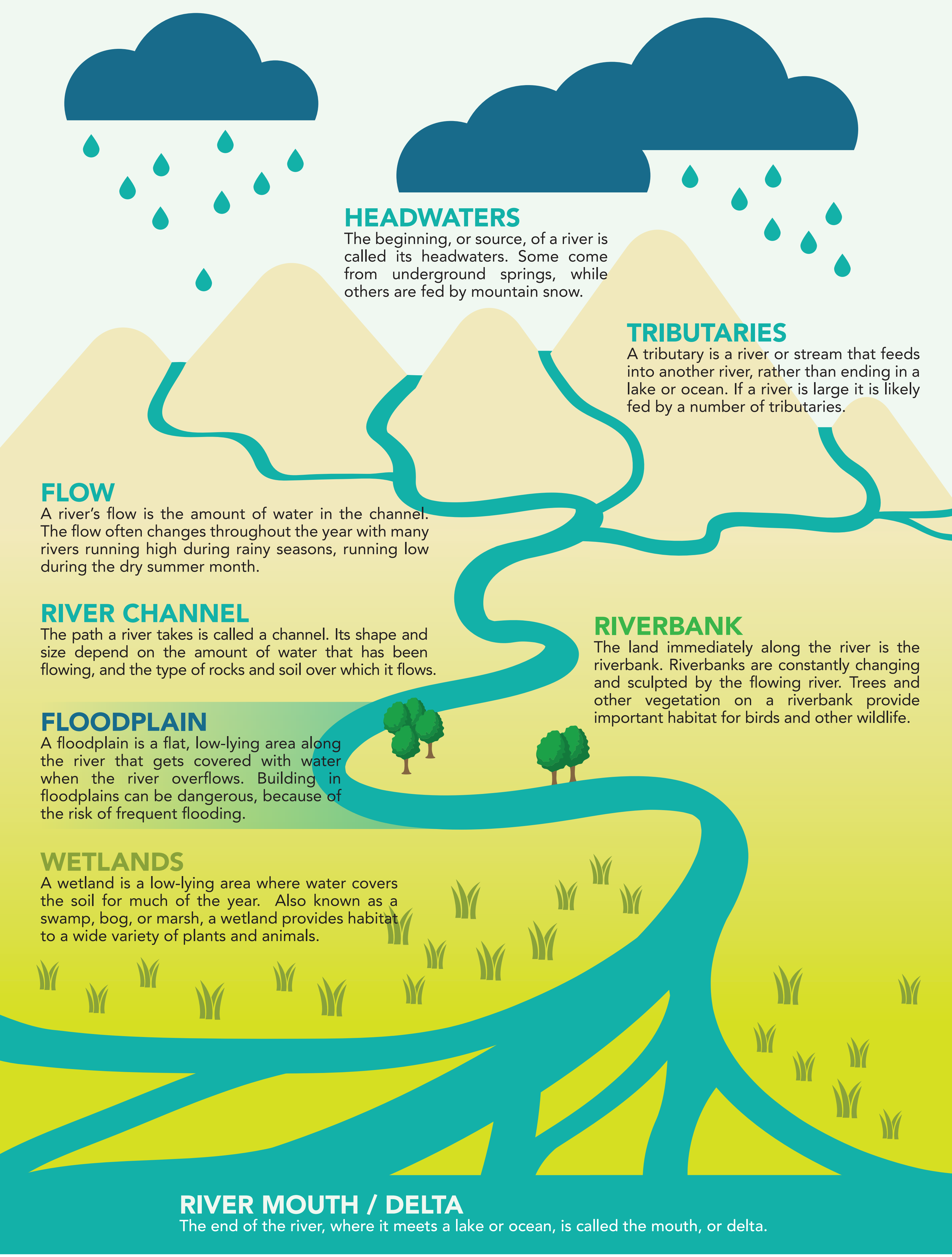


FIGURE 5: WATERSHED MODEL

Groundwater can be a backup water source in case of emergency. However to determine whether groundwater is safe for consumption, studies and investigations have to be done. Various threats to groundwater resources exist but are not limited to the following:

- Release of untreated or partially treated industrial effluents to soil/ groundwater (leaking tanks, spills into drains, etc)
- Contaminated landfill leachate
- Malfunctioning septic tanks
- Unsustainable abstraction rate
- Agricultural pollution
- Contaminated runoff into recharge areas
- Salt water intrusion

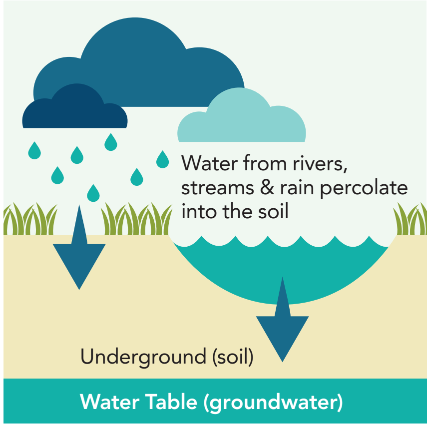


FIGURE 6: THE FORMATION OF GROUNDWATER

1.4 CATCHMENT AND WATER TREATMENT PROCESS

A catchment is an area where water is collected by the natural landscape. In a catchment, all rain and run-off water eventually flows to a stream, river, dam, lake, ocean, or into a groundwater system. Malaysia has two types of catchments that collect our drinking water: rivers (water intake) and dam systems which will then undergo the water treatment processes.

A. WATER INTAKE

Water intake is a point for obtaining water from a source of supply (river, lake, reservoir, and so on) for purposes of water supply, irrigation or hydroelectric power engineering. Water intake is intended to ensure the delivery of water into a conduit (a canal, pipeline, tunnel, and so on) in specified amounts, of proper quality, and according to a water-consumption chart.

B. DAM

A dam is a barrier that impounds water or underground streams. The reservoirs created by dams not only suppress floods but provide water for various needs which include irrigation, hydro power generation, human consumption, industrial use, and aquaculture. A dam can also be used to collect water or for storage which can be evenly distributed between locations. Dams generally act as holding ponds which release water into river when river's water level is low, while other structures such as floodgates are used to manage or prevent water flow into specific land regions.

1.4.1 WATER TREATMENT PROCESS

The water treatment process functioned as the removal of contamination to produce safe drinking water for consumption. Substances that are removed during the treatment process include suspended solids, bacteria, algae, virus, fungi, minerals such as iron, manganese and sulfur, and other chemical pollutants such as fertilizers. Measures taken to ensure water quality not only relate to the treatment of the water, but to its conveyance and distribution after treatment as well. It is therefore common practice to have residual disinfectants in the treated water in order to kill any bacteriological contamination during distribution.

FIGURE 7 illustrates the conventional treatment process, which is how the majority of our water treatment plants are being operated. The raw water is treated through a series of process such as aeration, chemical mixing, coagulation, flocculation, clarification, filtration and finally post chemical addition prior to supplying to consumers.

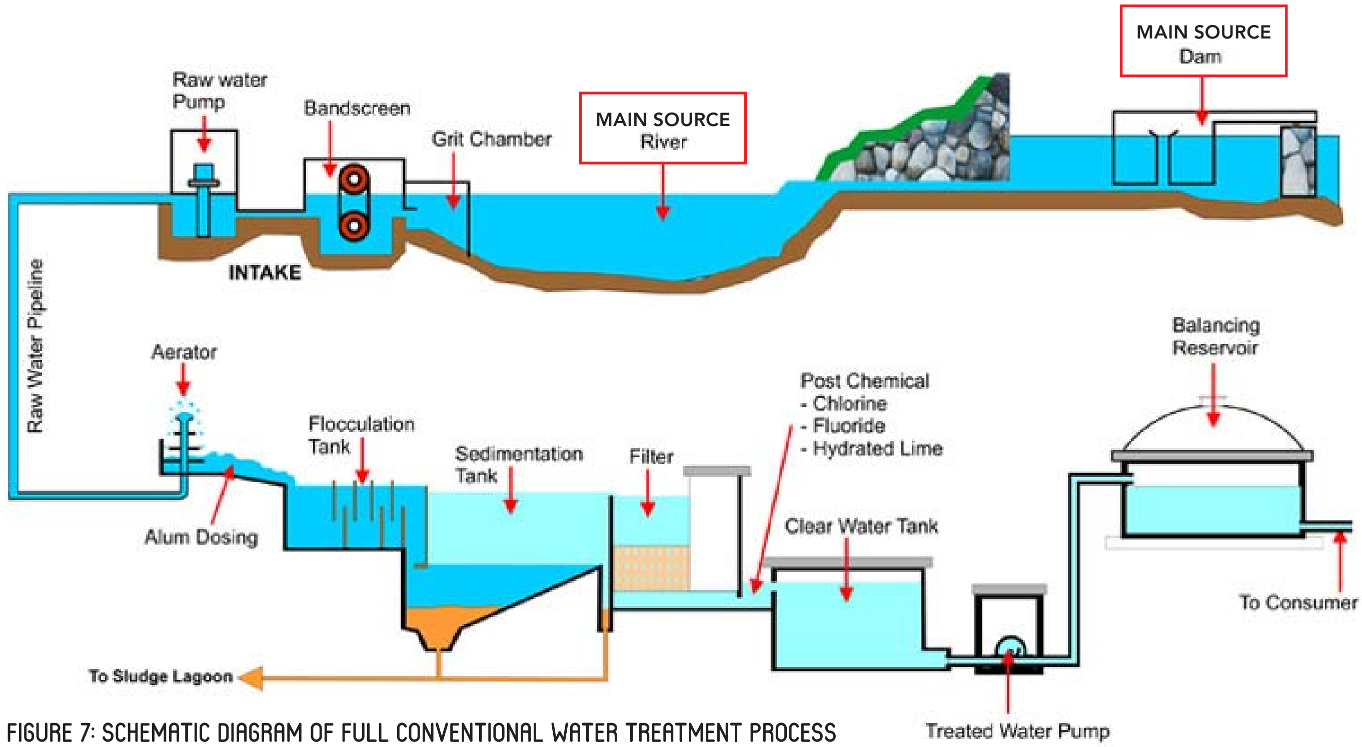


FIGURE 7: SCHEMATIC DIAGRAM OF FULL CONVENTIONAL WATER TREATMENT PROCESS

(SOURCE: truthvaccine.blogspot.my/2012/08/penjelasan-isu-krisis-air-di-selangor.html)

1.4.2 WATER TREATMENT ADVANCED TECHNOLOGY

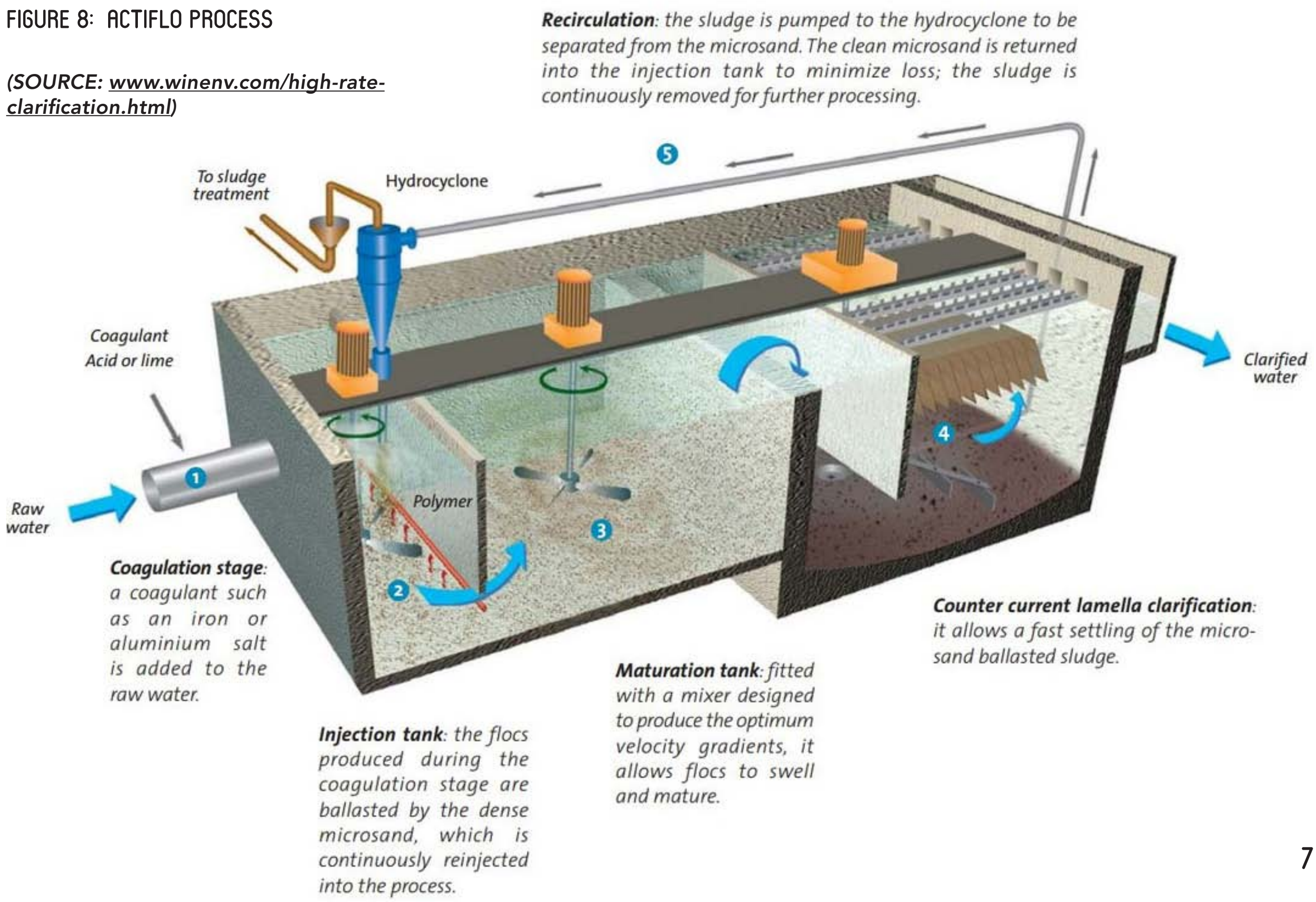
There are 2 advanced technologies in the water treatment processes applicable in Malaysia:

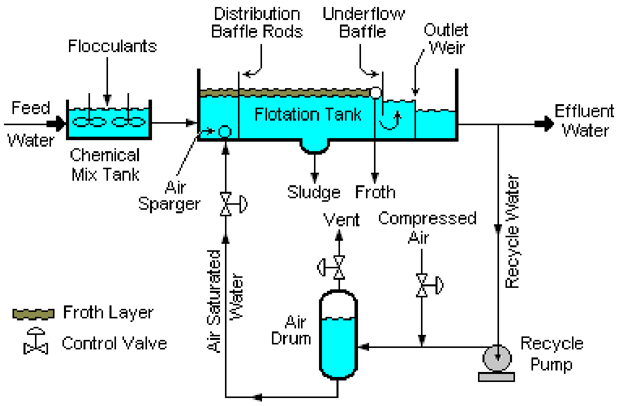
A. ADVANCE CLARIFICATION USING THE ACTIFLO PROCESS

Full conventional treatment and water clarification system with short retention time of less than 30 minutes due to high settling rate. The advantage of the system lies in its ability to consistently produce high quality treated water despite fluctuation of raw quality. Sungai Selangor Phase 2 WTP is the first WTP using the Actiflo clarification process in Malaysia.

FIGURE 8: ACTIFLO PROCESS

(SOURCE: www.winenv.com/high-rate-clarification.html)





B. ADVANCED CLARIFICATION USING THE DISSOLVED AIR FLOATATION (DAF) PROCESS

This system can be implemented in a small space, and is suitable for raw water with low colour and turbidity issues and is very effective for removal of high organic matter. Wangsa Maju WTP uses the following technology as its mode of operation.

FIGURE 9: DISSOLVED AIR FLOATATION (DAF) PROCESS

(SOURCE: Mbeychok at English Wikipedia)

1.5 SEWAGE TREATMENT PROCESS

Sewage is mainly water containing excrement consisting of harmful microorganisms, including bacteria, viruses and parasites. Sewage treatment reduces the water content and removes debris. Malaysians generate about six million tons of sewage every year. As about 97% of Malaysia's fresh water supply comes from surface water, proper sewage treatment is important. Raw surface water becomes contaminated as a result of excessive and indiscriminate discharge of waste water directly from households or factories into drains or rivers with minimal or no treatment. This reduces the usability of the water for ordinary purposes.

1.5.1 TYPE OF SEWAGE TREATMENT PLANT

In Malaysia, 38% of public sewage treatment plants in the country are mechanical plants. These plants operate using mechanical equipment that accelerates sewage break down. Estimation on the number and type of public treatment plants currently in Malaysia is as tabulated below:

NO.	TYPES OF SEWAGE TREATMENT PLANT	AS AT OCT 2014	POPULATION EQUIVALENT
1	Imhoff Tank	679	507,648
2	Oxidation Ponds	403	1,681,176
3	Mechanical Plants	4,902	18,665,408
4	Network Pump Stations	982	4,852,844
TOTAL		**6,966**	**25,707,076**
COMMUNAL SEPTIC TANK		**3,625**	**405,432**

TABLE 4: PUBLIC SEWAGE TREATMENT PLANTS IN MALAYSIA

Sewage treatment methods are classified into physical unit operations, chemical unit processes and biological unit processes. Physical unit operations are treatment methods, which use the application of physical forces to treat sewage. These include screening, mixing, flocculation, sedimentation, filtration and flotation. Chemical unit processes are treatment methods in which the removal or conversion of pollutants are done by the addition of chemicals or by chemical reactions. Biological unit processes describe methods which remove pollutants by biological activity. Biodegradable organic substances are converted into gases that escape to the atmosphere and cell tissue is removed by settling.

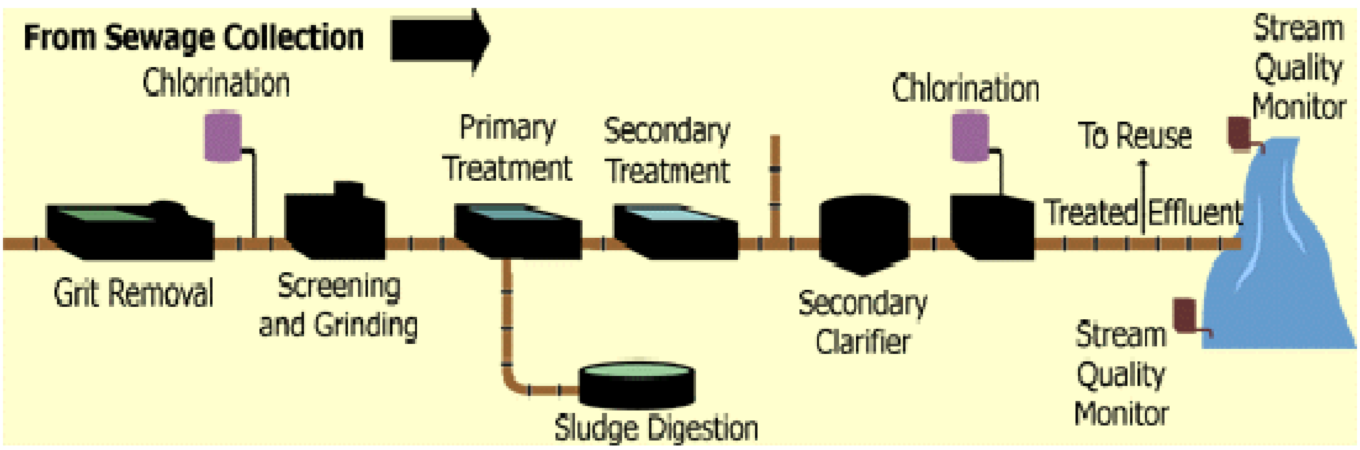


FIGURE 10: CHEMICAL UNIT PROCESSES

(SOURCE: www.ciklilyputih.com/2016/01/kenapa-kita-perlu-bayar-bil.html)

Current sewage treatment methods practiced in Malaysia focuses on preliminary, primary and secondary treatment. Preliminary and/or primary treatment refer to physical unit operations and is the first stage of treatment applied to any sewage. Secondary treatment refers to biological and chemical unit processes, while tertiary refers to the combinations of all three. The differences and the details of each type of treatment are tabulated below:

Preliminary Sewage Treatment	The removal of sewage constituents that may cause maintenance or operational problems with the treatment operations. This includes screening and commination (grinding) for the removal of debris and rags, grit removal by sedimentation and flotation for the removal of excess oil and grease.	• screening • grit removal • grease tank • pre-aeration • flow measurement • flow balancing • removal of rags, rubbish, grit, oil, grease
Primary Sewage Treatment	In primary treatment, screening and sedimentation remove some of the suspended solids and organic matter. The effluent from primary treatment will contain high amounts of organic matter.	• sedimentation • floatation • removal of settle able and floatable materials
Secondary Sewage Treatment	Secondary sewage treatment is directed at the removal of biodegradable organic and suspended solids, mainly using biological unit processes. Disinfection may be included in secondary sewage treatment.	• activated sludge • bio filtration • sedimentation • biological treatment to remove organic and suspended solids
Tertiary Sewage Treatment	Tertiary sewage treatment includes the removal of nutrients, toxic substances including heavy metals and further removal of suspended solids and organic material. Effluent from tertiary treatment is of a high standard and suitable for reuse.	• filtration • disinfection • tertiary ponds • biological and chemical treatment to remove nutrients and pathogens

TABLE 5: SEWAGE TREATMENT METHODS

MODULE 1 ACTIVITIES

ACTIVITY 1: BUILD YOUR OWN WATERSHED (PRIMARY + SECONDARY LEVEL)

A watershed is an area of land where surface water from rain converges to a single point usually the exit of the basin, where the waters join another waterbody, such as a river, lake, reservoir, estuary, wetland, sea, or ocean.

MATERIALS

- Stream table/Flat cardboard
- Crumpled newspaper
- Saran wrap (plastic)
- Spray bottle
- Blue colored water
- Clear acetate sheet/mahjung paper
- Sticky note
- Tooth sticks
- Erasable markers
- Tree/Plants
- Tape
- Glue
- Scissors
- Plasticine

PROCEDURE

1. Build your watershed in a stream table/flat cardboard.
2. Crumple some newspaper into a mountain-like form and tape to the bottom of container.
3. Using saran wrap, cover the watershed/mountain structure, making sure to fit the wrap into the "nooks and crannies".
4. Using a spray bottle, squirt blue coloured water over the watershed/mountain structure and make note where the water accumulates and runs down the watershed and makes streams and rivers to the base level.
5. Mark the components of the watershed at your model with the signboard and other stationary provided.
6. In addition, draw a diagram of your watershed and label the identified watershed components.

ACTIVITY 2: WATER WORD (SECONDARY LEVEL)

1. Refer to a dictionary and find out the definition of the following words:

A. SATURATED

B. EVAPORATE

C. ECOSYSTEM

D. CONDENSATION

E. SURFACE WATER

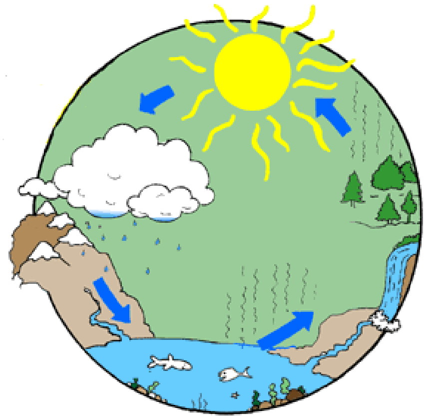
F. RUN-OFF

G. GROUNDWATER

2. With the words above, try to create a water process and present the cycle in a diagram.

ACTIVITY 3: MAKE A MINI WATER CYCLE! (PRIMARY LEVEL)

We know that water can be liquid, gas, or solid. Outside, water is always changing from liquid to gas and back again. This process is called the water cycle. You can see how the water cycle works.

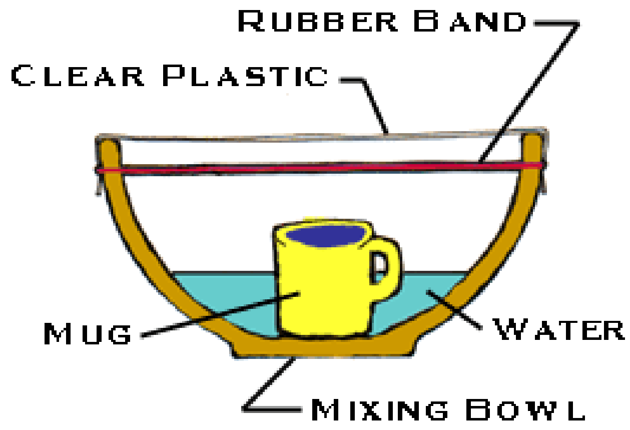


THE WATER CYCLE

The sun's heat causes water to evaporate from streams, lakes, rivers, and oceans. The water vapor rises. When it reaches cooler air, it condenses to form clouds. When the clouds are full of water, or saturated, they release some of the water as rain.

MATERIALS

- a large metal or plastic bowl
- a pitcher or bucket
- a sheet of clear plastic wrap
- a dry ceramic mug (like a coffee mug)
- a long piece of string or large rubber band
- water



PROCEDURE

1. Put the bowl in a sunny place outside.
2. Using the pitcher or bucket, pour water into the bowl until it is about ¼ full.
3. Place the mug in the center of the bowl. Be careful not to splash any water into it.
4. Cover the top of the bowl tightly with the plastic wrap.
5. Tie the string around the bowl to hold the plastic wrap in place.
6. Watch the bowl to see what happens.

The "mist" that forms on the plastic wrap will change into larger drops of water that will begin to drip. (You can speed up the dripping by carefully moving the bowl – don't splash! – into the shade) When this happens, continue watching for a few minutes, and then carefully peel back the plastic. Is the coffee mug still empty?

OBSERVATION: Water from the "ocean" of water in the bowl evaporated. It condensed to form misty "clouds" on the plastic wrap. When the clouds became saturated it "rained" into the mug!

This experiment adapted from resources provided by the Monroe County Water Authority (www.mcwa.com/MyWater/KidsWaterFun.aspx#cycle)

ACTIVITY 4: WASTEWATER (SECONDARY LEVEL)

MATERIALS

- 4 clear plastic cups
- water
- alum
- potting soil
- clean sand clean aquarium gravel
- measuring spoons
- paint filters
- cone shaped coffee filters
- disinfectant (very diluted bleach water – approximately 4 drops of bleach in one quart of water)

Demonstrates the process utilized to produce finished drinking water.

PROCEDURE

1. Prepare water to be purified by mixing one cup water with approximately ½ tsp potting soil.
2. **AERATION:** simulate aeration by pouring the dirty water back and forth between two cups. Water is sprayed into the air to release any trapped gases and to absorb additional oxygen.
3. **COAGULATION:** add one teaspoon of the alum to the dirty water. Mix well.
4. To remove dirt suspended in the water, powdered alum is dissolved in the water and it forms tiny, sticky particles called "floc" which attached the dirt particles. The combined weight of the dirt and the "floc" becomes heavy enough to sink to the bottom during sedimentation.
5. **SEDIMENTATION:** allow the sample to remain undisturbed for several minutes. While the sample is settling, prepare the filter materials described in step 6. The larger "floc" particles settle to the bottom.
6. **FILTRATION:** prepare the filter by lining the paint filter with two cone-shaped coffee filters and adding a layer of gravel to the bottom of the filter assembly followed by the layer of sand on top of the gravel.
7. Place the filter over a clean, empty cup. Pour the sample that has been allowed to settle into the filter.
8. The "floc" particles are trapped in the layers of sand and gravel.
9. **DISINFECTION:** add a small amount of very dilute bleach solution to disinfect the sample. At this point, you can use a pool kit capable of measuring chlorine to measure how much disinfectant is present in the "finished" sample.
10. A small amount of disinfectant is added to kill the remaining bacteria.

Note: DO NOT allow students to drink this water!

*Optional: Review the water treatment process using visuals provided at the training session. Give to student groups in random order and have them put them in the order they followed.

DISCUSSION

Hold a class discussion about the results of the investigation. Allow students to record observations and conclusions in their lab notebook. Use the following discussing points to guide their learning.

1. A water company must go through several steps to insure safe and pure drinking water for the community.
2. The water that is processed comes from the natural water cycle and has usually been transferred and stored in a reservoir before processing.
3. The following steps are followed in a typical water treatment plant:

    a. Aeration

    b. Coagulation

    c. Sedimentation

    d. Filtration

    e. Chlorination

MAKING THE CONNECTION

Questions:

- Summarize what we learned about the water treatment process.
- Why are there so many steps?
- Why is each step important?
- Why is water treatment important for human health?
- Do we need to treat water for other uses other than drinking?

ACTIVITY 5: FIELD VISIT (PRIMARY + SECONDARY LEVEL)

Check out the Open Days conducted by the nearest water and wastewater treatment plant and grab the opportunity to visit! Have a tour and identify the type of treatment carried out. Identify the process and have a discussion on the advantages and also the issues faced by the plant in treating your water and wastewater respectively.

(SOURCE: www.bloomberg.com)

MODULE 2:
WATER USAGE AND CHALLENGES

MODULE 2: WATER USAGE AND CHALLENGES

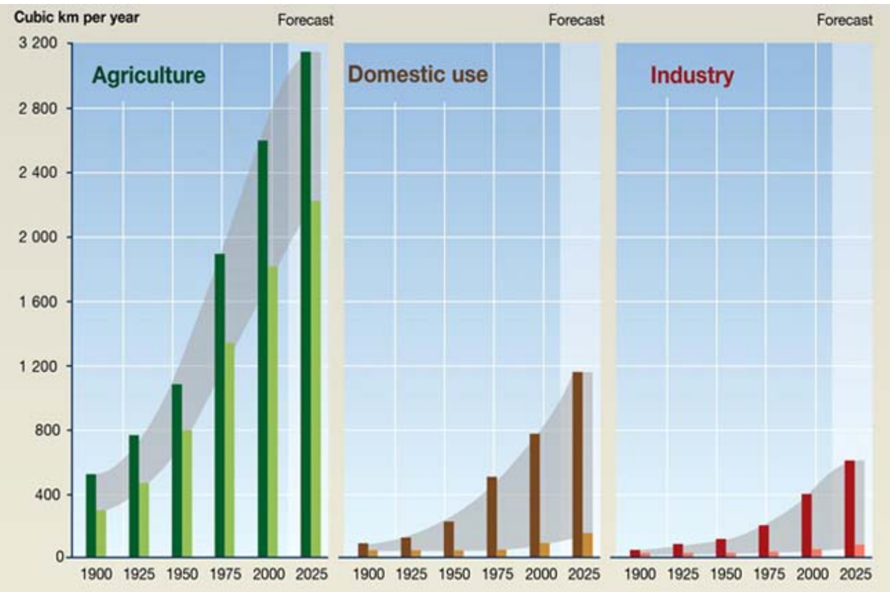
2.1 INTRODUCTION

Malaysia's rich water resources have always played a vital role in the socio-economic development of the country. Dams and kilometres of pipeline and canals divert water from rivers to sustain domestic, industrial and agricultural needs. 97% of Malaysia's fresh water supply comes from rivers, which are becoming increasingly polluted and begs the question of the state of our raw water quality.

In Malaysia, agriculture uses up to 76% of water, followed by 13% for industries and 11% for municipal water supply. Overall, only less than 1% of available water resources are used for supplying drinking water.

2.2 GLOBAL PERSPECTIVE ON WATER

More than a billion people currently live in water-scarce regions, and as many as 3.5 billion could experience water scarcity by 2025. Increasing pollution has degraded freshwater and coastal aquatic ecosystems. Climate change has poised to shift precipitation patterns and speed glacial melting, altering water supplies and intensifying floods and drought.



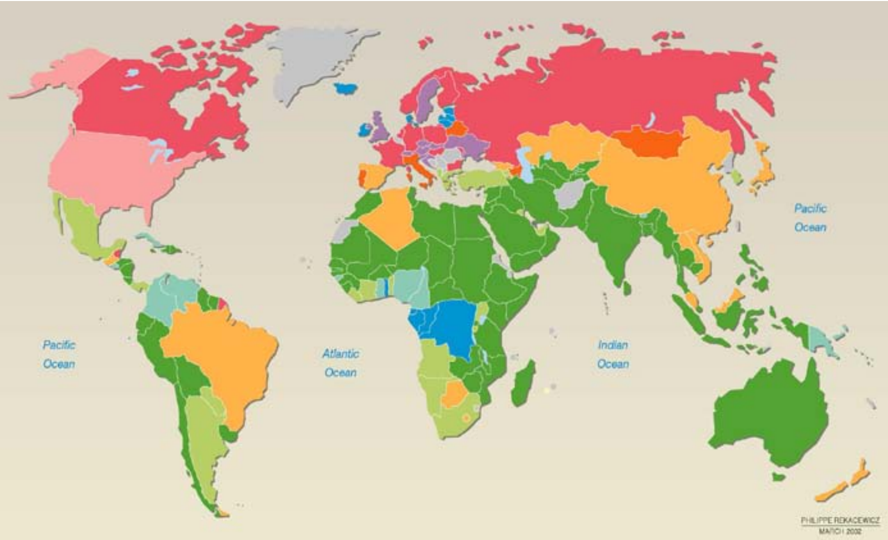
Extraction | Extraction | Extraction

Consumption | Consumption | Consumption

The gray band represents the difference between the amount of water extracted and that actually consumed. Water may be extracted, used, recycled (or returned to rivers or aquifers) and reused several times over. Consumption is final use of water, after which it can no longer be reused. Extractions that have increased at a much faster rate is an indication of how much more intensely we can now exploit water. Only a fraction of water extracted is lost through evaporation.

FIGURE 11:: WATER USAGE ON AGRICULTURAL, INDUSTRIAL, HOUSEHOLD, RECREATIONAL & ENVIRONMENTAL ACTIVITIES AT GLOBAL LEVEL

(SOURCE: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational, Scientific and Cultural Organisation (UNESCO, Paris), 1999)



Industry widely dominant
Industry and agriculture equally dominant
Industry dominant with a significant use by the domestic sector
Domestic use widely dominant
Domestic use and agriculture dominant
Agriculture dominant with significant use by the domestic sector
Agriculture widely dominant
Agriculture dominant with a significant use by the industrial sector
Agriculture widely dominant with significant use by the industrial sector
Data not available

FIGURE 12: GLOBAL FRESHWATER WITHDRAWAL

(SOURCE: Based on data from Table FW1 in World Resources 2000-2001, People And Ecosystem: The Fraying Web Of Life, World Resources Institute (WRI), Washington DC, 2000)

2.2.1 WATER USAGE

In Malaysia, irrigation mainly caters for the double cropping of paddy to meet the dual objective of increasing food production and raising farmers' income. Irrigation efficiency is about 50% for the larger schemes, and some of the smaller schemes operate at an efficiency of perhaps less than 40%. ***(SOURCE: Malaysia's Water Vision: The Way Forward – The Malaysian Water Partnership)***

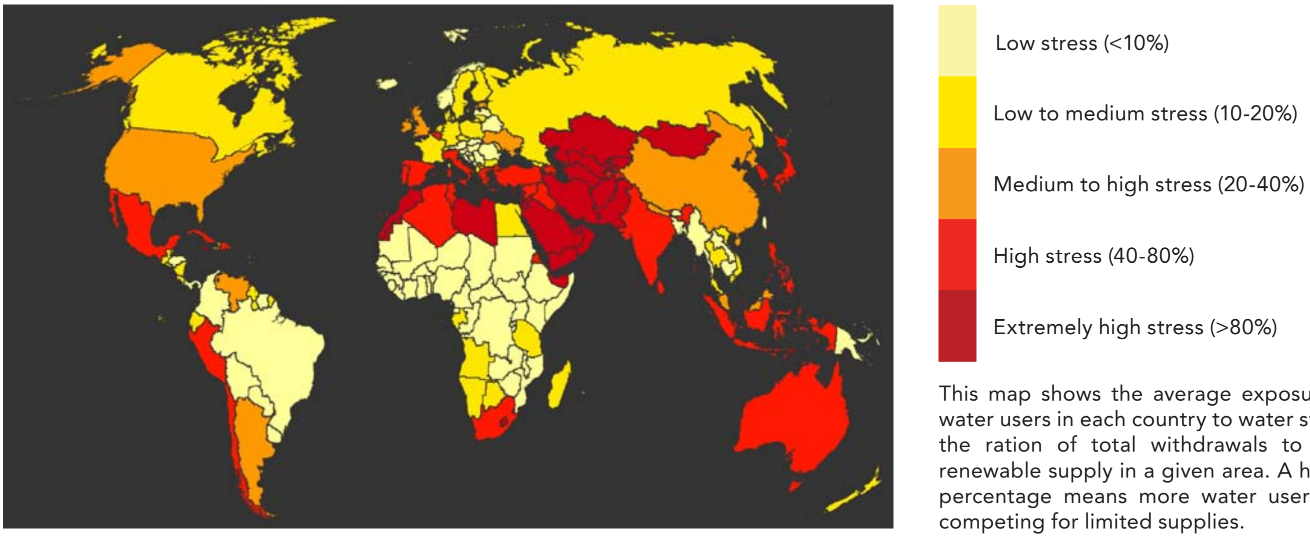
Traditionally, irrigation has been a key component of the green revolution that has enabled many developing countries to produce enough food to feed everyone. However, in future, even more water will be needed to produce more food because the Earth's population is projected to rise to 9 billion by 2050. Competition for water and inefficient irrigation practices could constrain future food production.

2.2.2 WATER STRESS

Water stress or scarcity can be physical (lack of water of sufficient quality), economic (lack of adequate infrastructure, due to financial, technical or other constraints) or institutional (lack of institutions for a reliable, secure and equitable supply of water).

Globally, the highest water demand comes from the agriculture sector (irrigation, livestock and aquaculture), followed by the industries sector and municipalities. At present, municipalities account for 12% of total freshwater withdrawal globally and industries for 19%, while agriculture takes up the remaining 69%, mostly through irrigation (***SOURCE: www.fao.org/nr/water/aquastat/water_use/index.stm***).

Once a country reaches a withdrawal level above 100%, it starts depleting its renewable groundwater resources, relying on non-renewable fossil groundwater or non-conventional sources of water, such as desalinated water, wastewater and agricultural drainage water. Currently, water scarcity affects more than 40% of people around the world, and it is projected to increase. Water scarcity already affects every continent and hinders the sustainability of natural resources as well as economic and social development. The most water scarce or stressed areas are typically those with few water resources, high population densities, and high population growth rates. Population growth limits the amount of water available per person, drives people into marginal regions (which are already water stressed) and also into cities.



This map shows the average exposure of water users in each country to water stress, the ration of total withdrawals to total renewable supply in a given area. A higher percentage means more water users are competing for limited supplies.

FIGURE 13: GLOBAL WATER STRESS

(SOURCE: World Resources Institute (WRI) Aqueduct, Gassert et al., 2013)

2.2.3 MAIN CAUSES OF WATER STRESS

A. POPULATION GROWTH

Water is a key element of life for everyone on Earth. As the world's population grows, the demand for water mounts and pressure on finite water resources intensifies. Climate change, which is also closely tied to population growth, will also lead to greater pressures on the availability of water resources. Water is also required for agriculture and industrial use, and for the evacuation of waste materials.

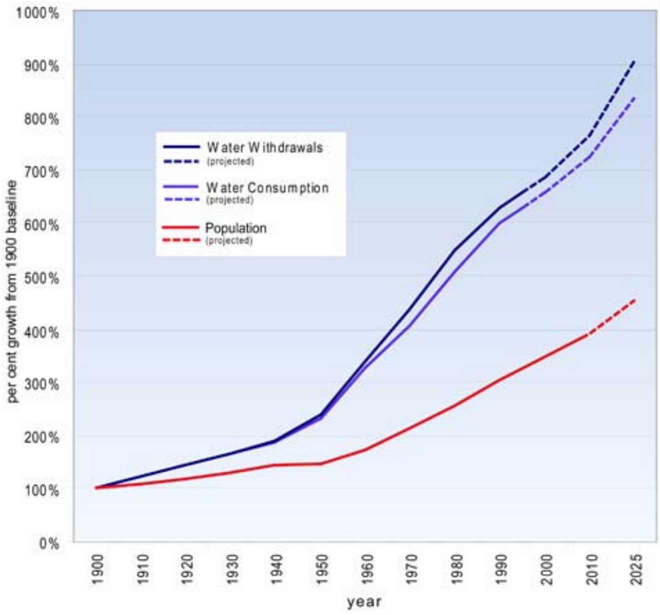


FIGURE 14: GLOBAL WATER USE AND GLOBAL POPULATION PERCENT GROWTH SINCE 1900

Due to the growing population, demands for water, food, housing, heat, energy, clothing, and consume goods are increasing alarmingly. Rapid population growth not only lessens available calorie supply from food per person but also risks the present food production with pollution. Increasing demand forces farmers to exhaust the soil or to use marginal land. The only way to product food to all this population is to create more effective agricultural production. We will have to manage water in a sustainable way while taking into account the impact of climate change, and other environmental and social factors.

B. RAPID URBANIZATION

The urbanization rate is about 50% with half of the population living in the urban areas and the other half in the rural areas with the world population at 6 billion people. This means that the other half of the population, in rural areas, has to produce the food to the population in urban areas. Most of the population growth takes place in urban areas, which means more pressure to the rural people to produce food for the growing amount of urban people ***(SOURCE: Varis 1998, Vakkilainen and Varis 1999)***. Growing urbanization means more consumption and need of different products. The production of these needs water and creates more pollutants. In developing countries where the urbanization is occurring most rapidly the technology is not advanced enough to take responsibility of water treatment and clean production.

C. CLIMATE CHANGE

Water is already over-appropriated in many regions of the world. More than one-third of the world's population – roughly 3.5 billion people – live in water-stressed countries and by 2025 the number is expected to rise to two-thirds. Groundwater tables and river levels are receding in many parts of the world due to human water use. Regions affected by drought are also increasing, causing natural water storage capacity and declining long-term annual river flows due to glacial/snowcap melting. Glacial melting is one of the reasons that many of Asia's largest rivers are projected to recede in coming decades. Climate change will likely:

- Decrease natural water storage capacity from glacier / snowcap melting, and subsequently reduce long-term water availability for more than one-sixth of the world's population
- Increase water scarcity due to changes in precipitation patterns and intensity.
- Increase the vulnerability of ecosystems due to temperature increases, changes in precipitation patterns, frequent severe weather events, and prolonged droughts. This will further diminish the ability of natural systems to filter water and create buffers to flooding.
- Affect the capacity and reliability of water supply infrastructure due to flooding, extreme weather, and sea level rise. Furthermore, climate change will concentrate snowmelt and precipitation into shorter time frames, making both water releases more extreme and drought events more sustained. Current infrastructure often does not have the capacity to fully capture this larger volume of water, and therefore will not be able to meet water demands in times of sustained drought.
- Contaminate coastal surface and groundwater resources due to sea level rise, resulting in saltwater intrusion into rivers, deltas, and aquifers.
- Increase water temperatures, leading to more algal and bacterial blooms that further contaminate water supplies.
- Increase extreme precipitation and flooding, which will increase erosion rates and wash soil-based pollutants and toxins into waterways.
- Contribute to environmental health risks associated with water. For instance, changes in precipitation patterns are likely to increase flooding, and as a result mobilize more pathogens and contaminants.

D. WATER CONFLICTS

According to the 1992 International Conference on Water and the Environment (Dublin Statement) water is a vital element for human life, and human activities are closely connected to availability and quality of water. Water conflict is a term describing a conflict between countries, states, or groups over an access to water resources. Water conflicts occur because the demand for water resources and potable water can exceed supply, or because control over access and allocation of water may be disputed. Elements of a water crisis may put pressures on affected parties to obtain more of a shared water resource, causing diplomatic tension or outright conflict.

Study conducted by World Resources Institute indicates that the top 11 water-stressed countries in 2040, are to be Bahrain, Kuwait, Palestine, Qatar, San Marino, Singapore, United Arab Emirates, Israel, Saudi Arabia, Oman and Lebanon with Chile, Estonia, Namibia, and Botswana could experience an especially significant increase in water stress by 2040. The Middle East, North Africa and south Asia are all projected to experience water shortages over the coming years because of decades of bad management and overuse. The region, already arguably the least water-secure in the world, draws heavily upon groundwater and desalinated sea water, and faces exceptional water-related challenges for the foreseeable future.

With regional violence and political turmoil commanding global attention, water may seem tangential. For example, drought and water shortages in Syria likely contributed to the unrest that stoked the country's 2011 civil war. Dwindling water resources and chronic mismanagement forced 1.5 million people, primarily farmers and herders, to lose their livelihoods and leave their land, move to urban areas, and magnify Syria's general destabilization. Water is a significant dimension of the decades-old conflict between Palestine and Israel.

Extremely high water stress creates an environment in which companies, farms and residents are highly dependent on limited amounts of water and vulnerable to the slightest change in supply. Such situations severely threaten national water security and economic growth.

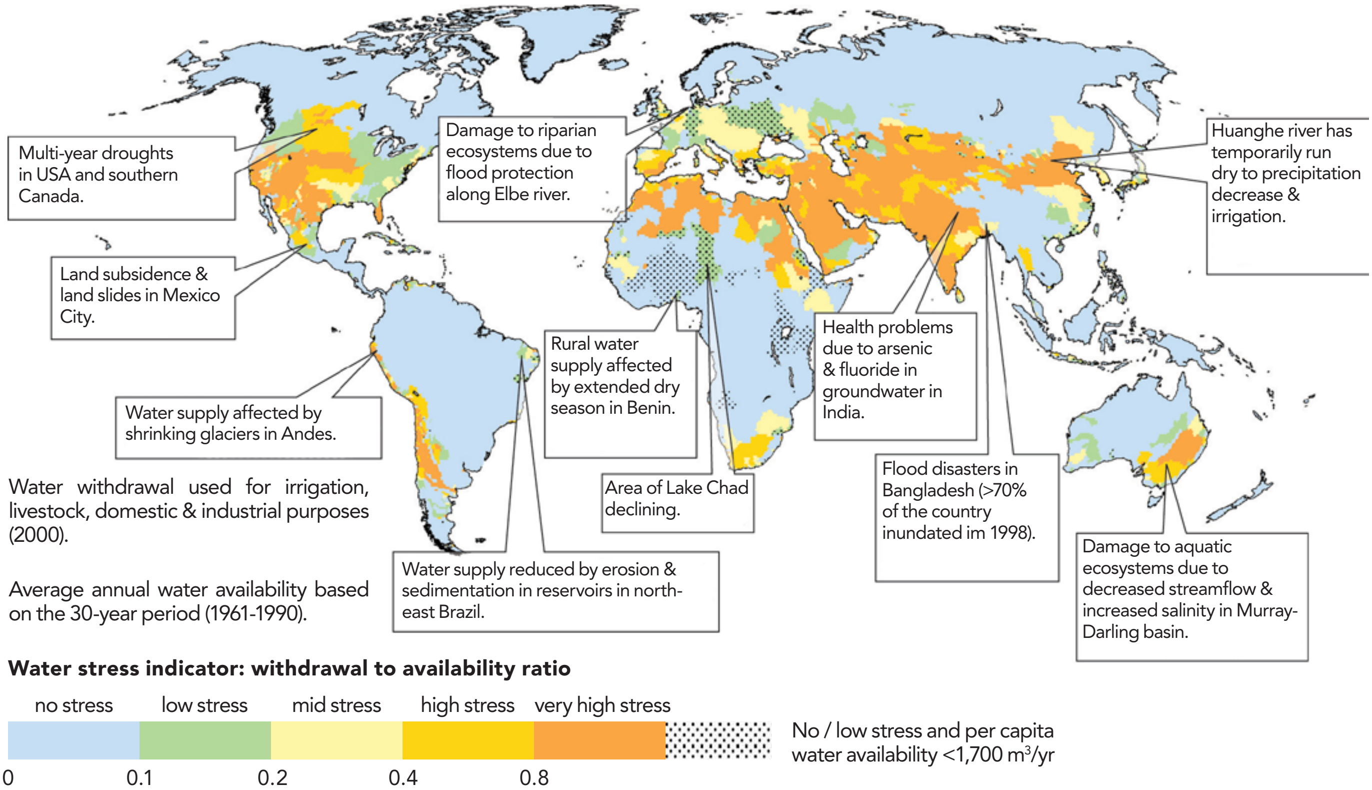


FIGURE 15: EXAMPLES OF CURRENT VULNERABILITIES OF FRESHWATER RESOURCES AND THEIR MANAGEMENT & WATER STRESS MAP

(SOURCE: Intergovernmental Panel on Climate Change, www.ipcc.ch, Alcamo et al., 2003)

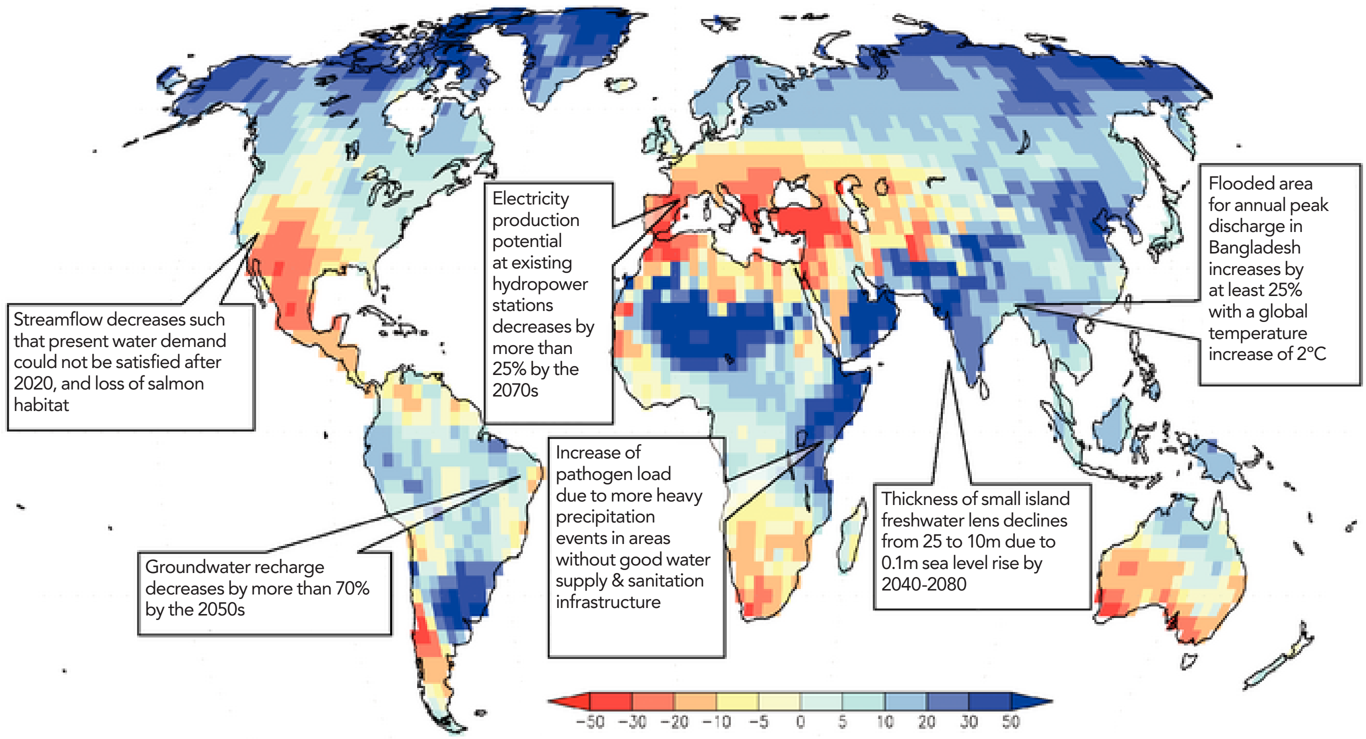


FIGURE 16: ILLUSTRATIVE MAP OF FUTURE CLIMATE CHANGE IMPACTS RELATED TO FRESHWATER WHICH THREATEN THE SUSTAINABLE DEVELOPMENT OF THE AFFECTED REGIONS

(SOURCE: Intergovernmental Panel on Climate Change, www.ipcc.ch)

2.3 MALAYSIAN PERSPECTIVE ON WATER

2.3.1 WATER USAGE

Due to rapid population increase and the rapid growth of industries, the annual water demand for the domestic and industrial sectors of Malaysia has been expanding at the rate of about 12%. By 2020, these sectors are projected to be the main water user in the country. ***(SOURCE: Malaysia's Water Vision: The Way Forward – The Malaysian Water Partnership)*** Please refer to TABLE 6 for detail water demand projection for Malaysia until 2050.

At average of 210 litres per capita every day, our wealth of water and good rainfall is taken for granted. Out of the this amount, only 30% are for actual consumption like for cooking and drinking, while the rest of it is just for utilities like washing cars, washing pools and washing clothes. Malaysians water consumption rate is high compared to our neighboring countries such as Thailand with only about 160 to 170 litres per day per person, Singapore (130-150 litres) and Indonesia (140-160 litres).

SECTOR	2010	2020	2030	2040	2050
Potable	5.29	6.78	7.67	8.27	9.30
Managed Potable	5.29	5.79	6.09	6.42	6.68
Irrigated Paddy	8.27	9.11	8.05	7.64	7.21
Irrigated Non-Paddy	1.18	1.12	1.11	1.15	1.18
Livestock	0.13	0.18	0.26	0.38	0.58
Fisheries	1.29	1.59	1.92	2.39	1.29
ALL SECTORS	**14.79**	**17.21**	**17.09**	**17.69**	**18.23**

TABLE 6: TABULATED WATER DEMAND PROJECTION (2010–2050)

Water is also used in large quantities by other industries in downstream activities. For example, oil palm may require a global average of 1,000 litres for every 1 kg of oil palm yield. However, to produce 1 kg of palm oil products requires an additional 4,000 litres of water to extract and process the oil from the oil palm bunches. TABLE 7 shows total water demands by all sectors in Malaysia.

STATES	LAND AREA (KM^2)	TOTAL CONSUMPTIVE WATER DEMAND (MCM)					EFFECTIVE RAIN (MCM/YEAR)	EXCESS / DEFICIT (MCM): UNREGULATED FLOWS				
		2010	2020	2030	2040	2050		2010	2020	2030	2040	2050
Perlis	821	306	299	286	284	281	60	(246)	(239)	(226)	(224)	(221)
Kedah	9,500	2,922	2,976	2,842	2,873	2,876	1,070	(1,852)	(1,906)	(1,772)	(1,803)	(1,806)
Pulau Pinang	1,048	765	829	835	874	894	130	(635)	(699)	(705)	(744)	(764)
Kelantan	15,099	1,632	1,619	1,586	1,600	1,604	2,650	1,018	1,031	1,064	1,050	1,046
Terengganu	13,035	884	975	970	999	1,026	3,310	2,426	2,335	2,340	2,311	2,284
Perak	21,035	1,949	1,923	1,798	1,801	1,811	3,140	1,191	1,217	1,342	1,339	1,329
Selangor	8,396	2,238	2,491	2,570	2,760	2,922	960	1,278	1,531	1,670	1,800	1,962
Pahang	36,137	726	946	897	911	959	6,460	5,739	5,514	5,563	5,549	5,501
Negeri Sembilan	6,686	340	361	358	366	374	640	300	279	282	274	266
Melaka	1,664	323	366	376	409	439	140	(183)	(226)	(336)	(269)	(299)
Johor	19,210	715	881	1,033	1,164	1,301	3,290	2,575	2,409	2,257	2,126	1,989
PENINSULAR MALAYSIA	**132,631**	**12,800**	**13,664**	**13,551**	**14,040**	**14,488**	**21,170**	**8,370**	**7,506**	**7,619**	**7,130**	**6,682**
Sabah	73,631	912	1,356	1,392	1,442	1,469	16,210	15,298	14,854	14,818	14,768	14,741
Sarawak	124,450	1,054	2,162	2,125	2,175	2,247	27,440	26,386	25,278	25,375	25,265	15,193
WP Labuan	91	18	24	26	28	29	30	12	6	4	2	1
EAST MALAYSIA	**198,172**	**1,985**	**3,541**	**3,542**	**3,645**	**3,745**	**53,190**	**51,205**	**49,649**	**49,648**	**49,545**	**49,445**
TOTAL MALAYSIA	**330,803**	**14,785**	**17,205**	**17,093**	**18,233**	**18,233**	**74,350**	**59565**	**57145**	**57257**	**56665**	**56117**

TABLE 7: TOTAL CONSUMPTIVE WATER DEMANDS IN MALAYSIA AS HIGHLIGHTED AGAINST TOTAL SURFACE WATER AVAILABILITY ALL SECTORS

2.3.2 MAJOR WATER ISSUES AND CHALLENGES IN MALAYSIA

Based on the study of effective implementation of IWRM in Malaysia (2008) and subsequent study in 2011, the main water related issues that been identified as listed below:

WATER RELATED ISSUES (NAHRIM, 2008)	
1	River Water Quality
2	Catchment / Landuse Management
3	Flooding
4	Potable Water Supply
5	Institutional Arrangement
6	River Corridor Management
7	Wetlands Management
8	Water Borne Diseases
9	Biodiversity
10	Drought
11	Environmental Flow

WATER RELATED ISSUES (DID, 2011)	
1	Water excesses
2	Water shortages
3	Water pollution
4	Threats from climate change
5	Current state of water governance

TABLE 8: WATER RELATED ISSUES

A. WATER EXCESS

Localised heavy monsoon rains from a series of storms continuously or frequently causes flooding when the rate of rainfall exceeds the drainage capacity of the area. When this occurs on open field, logged area or on-going development sites, it can result in a muddy flood where sediments are picked up by run off and carried as suspended matter.

Rapid flooding events, including flash floods, more often occur in smaller rivers, rivers with steep valleys, and rivers that flow for much of their length over impermeable terrains. Meanwhile, coastal areas may be flooded by storms at sea, resulting in waves over-topping defenses or, in severe cases, by tsunami or tropical cyclones.

Urban flooding, on the other hand, occurs in a built environment, particularly in more densely populated areas, and is caused by rainfall overwhelming the capacity of the drainage systems, such as storm sewers. Although sometimes triggered by events such as flash flooding, urban floods are a condition that causes systemic impact on the community, such as those in Cameron Highlands, Kelantan, Terengganu, Johor, Perak and some parts of Selangor.

The primary effects of flooding include loss of life and damage to buildings and other structures, including bridges, sewerage systems, roadways, and canals. Floods also frequently damage power transmission and, sometimes, power-generation facilities, which then has a knock-on effect caused by the loss of power. This includes the loss of water treatment and water supply, which may result in a lack of drinking water or severe water contamination. It may also cause the loss of sewage disposal facilities. Lack of clean water combined with human sewage in the flood waters raises the risk of waterborne diseases such as typhoid, giardia and cholera, depending upon the location of the flood. Floodwaters typically inundate farm land, making the land unworkable and preventing the planting and harvesting of crops, thus leading to shortage of food for both humans and animals.

B. WATER SHORTAGES

The seasonal distribution and variation of rainfall, both temporal and spatial, has rendered several regions in the country facing water stress related problems. Particularly severe in the smaller States and those that has been more extensively deforested as Melaka, Perlis, and Pulau Pinang. Extended periods of droughts cause water supply to fall short of water demands in States supporting large-scale agriculture for rice production such as Perlis, Kedah, and Selangor and those that are heavily industrialised as in the case of Pulau Pinang, Selangor, and the Federal Territories. Growing demands and pressure on water resources due to:

- Population growth (29 mil. 2010 - 42 mil. 2050).
- Economic activity.
- Intensifying competition among users.
- High per capita consumption (210 l/c/d).
- High non-revenue water average (36%).
- Pollution reduces water usability.
- Per capita availability of water is decreasing.
- Climate change (rainfall pattern).

C. WATER POLLUTION

Rivers and waterways are exposed to point and non-point sources of pollution. A recent estimate puts the waste dumped from the Klang Valley into its river system, amounting to 60 tons each day. Moreover 60% of lakes and reservoirs are 'entropic', primarily from nitrates and phosphates pollution originating from fertiliser and pesticide use in agriculture. River pollution is becoming a major cause of unscheduled water disruptions in the country. Factors that contribute to water pollution are as follow:

- Improper solid waste management.
- Illegal sewage discharge/poor sewage management.
- Illegal dumping.
- Untreated wastewater from wet markets, slaughter farms.
- Oil and grease pollution from car workshops, car wash centers, etc.

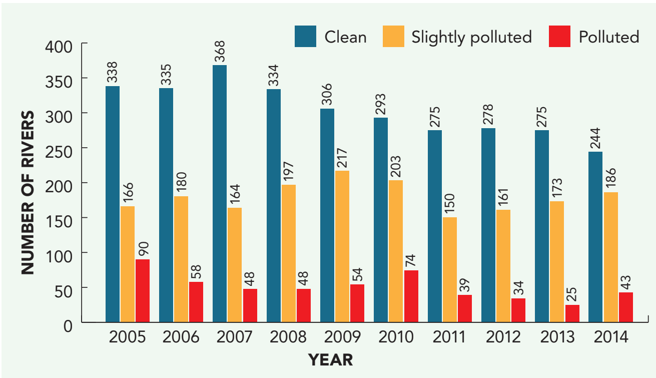


FIGURE 17: RIVER WATER QUALITY TREND IN MALAYSIA

- Untreated wastewater or effluent from factories/industrial activity.
- Food waste from restaurants & food stalls.
- Construction waste indiscriminately disposed of by developers.
- Recreational park.
- Concrete channelization of river: alteration of water flow and its natural characteristics.
- Excessive nutrients in water.

2.3.3 THREATS FROM CLIMATE CHANGE

El Niño and La Niña are the warm and cool phases of a recurring climate pattern across the tropical Pacific—the El Niño-Southern Oscillation, or "ENSO" for short.

The pattern can shift back and forth irregularly every two to seven years, and each phase triggers predictable disruptions of temperature, precipitation, and winds.

These changes disrupt the large-scale air movements in the tropics, triggering a cascade of global side effects ***(SOURCE: www.climate.gov/enso)***. These phases cause two main threats to the water source on the quantity or discharge rate as well as on the quality of the water. The threats are as tabulated below:

WATER QUANTITY / DISCHARGE	Water excess (extreme rainfall, flows)	• Increase in severity of floods • Increase in soil erosion: scouring of drainage structures and sedimentation in rivers
	Water shortage (drought)	• Reduced inflows to reservoirs • Reduced stream-flows: affect raw water abstraction • Reduced recharge of groundwater
WATER QUALITY	Water excess (extreme rainfall, flows)	• Increase in pollution: litters, nutrients and sediments
	Water shortage (drought)	• Concentrated pollutant level in streams

The cause and the impact of the climate change on the water source are inter-related with the cause of water excesses, shortages as well as the pollution factors. Leading cause of water quality impairment is nonpoint source (NPS) pollution. Pollution from nonpoint, or diffuse, sources is more difficult to control than pollution from point sources, which are discharges through pipes or channels from a distinct source. NPS pollution occurs wherever water flowing across the land or underground picks up nutrients, salts, metals, organic material, soil, or chemicals and delivers the accumulated pollutants to streams, lakes, wetlands or ground water aquifers in amounts greater than natural background levels. The excess pollutants may result in impacts such as nutrient enrichment, undesirable algae growth, higher total dissolved solids, turbidity, lower dissolved oxygen, pH changes, higher temperatures and increases in pathogenic microorganisms. These conditions negatively affect water supplies by fouling water systems and increasing treatment requirements such as ultrafiltration/microfiltration and operation and maintenance costs. Therefore, the management of nonpoint source pollution is an important water supply planning objective to mitigate climate change impacts. ***(SOURCE: KeTTHA, Impacts of Climate Change to Water Supply)***

2.3.4 CURRENT STATE OF WATER GOVERNANCE POTABLE WATER SUPPLY

There is no single formally constituted entity that is presently empowered to plan, coordinate, and execute IWRM. The National Water Resources Council ***(SOURCE: NWRC, June 1998)***, whilst constituting a good coordinating body for water affairs, has not been provided with legal mandate for carrying out this function (legal instrument is one of the enabling environment for IWRM). Water is a state matter as provided in Ninth Schedule, Article 74 of the Federal Constitution which allows states to manage water resources through gazette of water catchments and control of development. Water resources are presently regulated through an outdated legislation in most states with no uniformity in water resources legislation in the states.

Some of the proposed strategic to address the issues are: Integrated Water Resources Management (IWRM) – river basin management, Water Resources Governance and Water Demand Management as in the FIGURE 18.

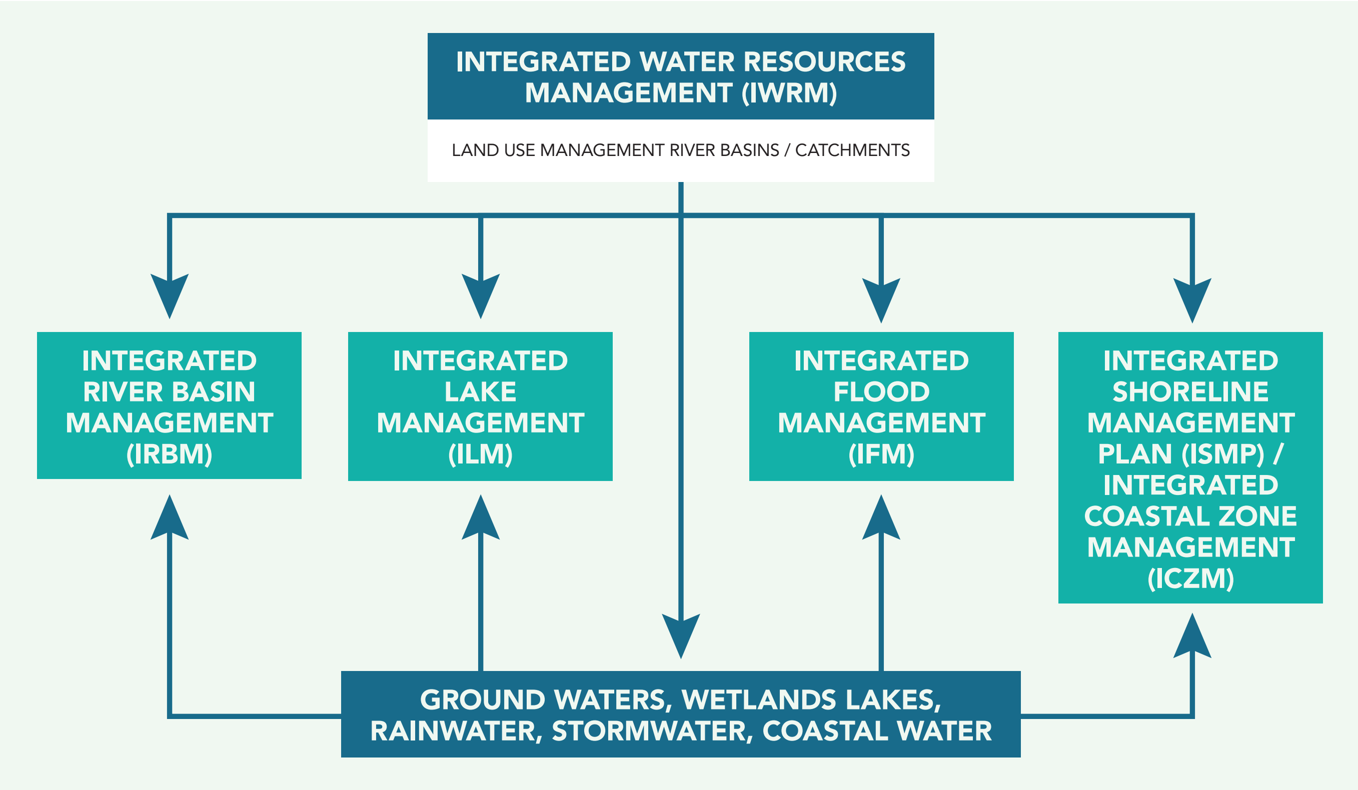


FIGURE 18: NATIONAL WATER MANAGEMENT AGENCIES

2.4 WATER AGENCIES IN MALAYSIA

There are many authorities and agencies involved in water management in Malaysia. Each of them carries a different responsibilities or task. Refer to TABLE 10 for more information on the relevant water agencies in Malaysia.

TABLE 9: AGENSI AIR DI MALAYSIA

(SOURCE: www.globalwaterintel.com/archive/10/6/general/malaysias-new-look-water-sector.html)

BODY / AGENCY	AREA OF RESPONSIBILITY	DESCRIPTION
National Water Resources Council (NWRC) chaired by Prime Minister	Water resources matters. Cross boundaries/interstate/issues of national interest.	Ensure coordination between various State Governments in the management of river basins.
Federal Government (Ministry of Energy, Water and Communications)	Policy matters.	Development of a holistic water policy for the country.
State and Territory Governments (13 states and three territories)	Raw water matters.	Regulates raw water abstraction and catchment management.
National Water Services Commission (SPAN)	Regulatory matters.	Regulate water services industry (water and sewerage services).
Ministry of Finance – Water Asset Management Inc – PAAB	Asset Management.	Acquire and manage all state owned water related assets.

Department of Irrigation and Drainage (DID)	Water resource planning and development. Water supply, water pollution control, water quality management, drainage and flood control, water catchment and irrigation.	Provides technical consultancy services in the following area: • Water Resource • Irrigation & Drainage System • Farm Road • Flood Problems • Structure • Technical Advisory Services
Department of Environment (DOE)	Water Pollution Control. Water Quality Management.	To prevent, control and abate pollution through the enforcement of the Environmental Quality Act 1974. • Part IV Section 25: Restriction on pollution of inland waters. • Part IV Section 29: Prohibition of discharge of wastes into Malaysian waters
Forest Department (FD)	Water catchment.	Conserves forests for flood protection and water catchment for maintaining water quality.
State Economic Planning Unit (SEPU)	Socio-economic planning.	Extension of Federal EPU and in charge of the actual planning of social-economic development programme in the respective states.
Local authorities/ State Water Authorities **There are two types of local authorities:** **a. Municipal Council** **b. District Council**	Drainage and flood control.	Responsible for the construction and maintenance of the local drainage system which is mainly of trunk drains and secondary Drain. Flooding caused by choked drains and culverts fall under the responsibility of the local authority.

MODULE 2 ACTIVITIES

ACTIVITY 1: WATER BORNE ILLNESS (SECONDARY LEVEL)

What are 5 types of water-borne illnesses that can affect our well-being if our water supply is contaminated or polluted? Describe these ailments, how infection (if pathogens are involved) is spread, symptoms, how they can affect us and prevention measures.

1.

2.

3.

4.

5.

ACTIVITY 2: VOCABULARY (SECONDARY LEVEL)

1. Refer to a dictionary and find out the definition of the following words:

A. ENVIRONMENT

B. POLLUTION

C. CLIMATE CHANGE

D. PRECIPITATION

E. EUTROPHICATION

F. SEWAGE

G. LEACHATE

H. EXTINCT

I. RENEWABLE

J. SANITATION

2. For each word that you have learned, create two sentences using these words.

ACTIVITY 3: TYPE OF POLLUTION (PRIMARY + SECONDARY LEVEL)

1. Take a look at the pictures of polluted water bodies and make a list of water pollutants.

2. Are these pollutants also present in your house or school? Make a tour of your home or school and identify such pollutants. List them in your exercise book.

3. What can you do to reduce pollution of our rivers, lakes and seas? Give three solutions.

ACTIVITY 4: DROUGHT (PRIMARY + SECONDARY LEVEL)

1. Do you have a personal experience of the drought and water rationing in Malaysia? Perhaps you know of friends or family who experienced the water rationing not only recently but in the past. Interview these people and write a report on their stories.

CARRYING WATER CONTAINERS IN BALAKONG, FEB 25, 2014. PHOTO BY MOHD RASFAN, AFP, GETTY IMAGES

WATER RATIONING PIC BY REUTERS

ACTIVITY 5: MY ROLE (SECONDARY LEVEL)

Get in touch with water authorities or agencies close to you and interview them on how our water supply is managed. For example, here are some areas you can focus on:

1. River basin management
2. Conservation of water catchment areas
3. Raw water supply
4. Water pollution control
5. Flood control
6. Management of dams, especially during times of drought
7. Asset management

With the information that you have collected, present a report describing your findings.

(optional) **Other activities:** Identify the water issues at home / local level. Discuss which authority is responsible for the issues and how can it be resolved?

(optional) **Other activities:** Identify what type of industry activity uses more water than other.

(SOURCE: www.themalaymailonline.com)

MODULE 3:
WATER MANAGEMENT IN MALAYSIA

MODULE 3: WATER MANAGEMENT IN MALAYSIA

3.1 SURFACE WATER

Malaysia has sufficient surface water resources which are not managed properly. Our surface water resources (mainly rivers) are more abundant than groundwater resources. The budgeted amount of surface water resources in Malaysia is 566 km^2 compared to 64 km^2 of the groundwater resources ***(SOURCE: FAO, 2005)***. Therefore, Malaysia should emphasize on the preservation and conservation of surface water resources which encompasses protection of raw water resources, efficient management of rivers, ensuring the water needs of plants are met, and ensuring water catchment areas are gazetted as permanent reserves.

Water conservation refers to all the different ways that water and water resources can be sustained in sufficient quantity and quality. Water demand management is a subset of water conservation and a key means to achieving the goals of water conservation. It is a formal set of measures that are put in place with the aim of reducing the total amount of water that is used.

Installing a water efficient toilet is a typical demand management measure. But, installing a rainwater harvesting facility for irrigating one's garden or for other applications is not demand management measure. This is because overall use of water may increase although the demand for potable water may be reduced as a result. A sustainable and responsible utilization of surface water resources by all stakeholders would make better economic sense compared to investments to build new dams, reservoirs, treatment plants, and a distribution network system. Surface water that is contaminated will also directly impact groundwater, rendering it unsuitable for consumption.

3.2 INTEGRATED WATER RESOURCES MANAGEMENT (IWRM)

Integrated Water Resources Management (IWRM) is a process which promotes the coordinated development and management of water, land and related resources in order to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems ***(Source: Global Water Partnership 2012)***.

The basis of IWRM is that the many uses of finite water resources are interdependent. High irrigation demands and polluted drainage flows from agriculture means less freshwater for drinking or industrial use; contaminated municipal and industrial wastewater pollutes rivers and threatens ecosystems and there are many more examples but the underlying theme is that unregulated use of scarce water resources is wasteful and inherently unsustainable.

IWRM is based on the understanding that water resources are an integral component of the ecosystem, a natural resource, and a social and economic good. IWRM strategies are based on the four Dublin Principles presented at the World Summit in Rio de Janeiro in 1992.

1. **WATER IS A FINITE AND VULNERABLE RESOURCE**. It is essential to sustain life, development and the environment. This principle assigns a river basin or a catchment area to be a water management unit, called the hydrographical approach to water management.
2. **PARTICIPATORY APPROACH.** Water development and management should be based on a participatory approach, involving users, planner and policy makers on all levels. Everyone is

a stakeholder in the issue of water and real participation only takes place when stakeholders are part of the decision making process.

3. **ROLE OF WOMEN.** Women are known to play a key role in the collection and safeguarding of water for domestic and agricultural use yet they lack influence in the management, problem analysis and in the decision making process related to water resources.
4. **INTEGRATING THE 3 Es (*EQUITY, EFFICIENCY, ECONOMIC SUSTAINABILITY*).** Integrated water resources management is based on the equitable and efficient management and sustainable use of water. In the IWRM, water is perceived as an integral part of the ecosystem, a natural resource and a social and economic good, hence the 3E's are social equity, economy efficiency and economic sustainability.

3.2.1 MALAYSIA AND IWRM

Malaysia embraced the IWRM concept and approach as a consequence to the declarations of major global conferences (namely, the International Conference on Water and the Environment (in Dublin, 1992), Earth Summit (in Rio de Janeiro, 1992), World Summit on Sustainable Development (in Johannesburg, 2002) and World Water Forums (in Marakesh (1997); in the Hague (2000); in Kyoto (2003); in Mexico City (2006) and in Instanbul (2009)) that acknowledged the international consensus on IWRM as the way forward for sustainable management of water resources.

Malaysia, through its 10th Malaysian Plan, adapted IWRM and carried out the following:

"The management of resources across the entire water cycle will be reassessed from where water is drawn to how water is treated and supplied to citizens and how wastewater is returned to the environment."

"To expand the implementation of Integrated Water Resources Management (IWRM) and Integrated River Basin Management (IRBM) approaches in planning, managing, protecting and rehabilitating water resources."

"Moreover, Malaysia has developed Malaysia's National Water Policy where in support of Vision 2020 (towards achieving developed nation status), Malaysia will conserve and manage its water resources to ensure adequate and safe water for all (including the environment)."

The NWP policy stated that:

"The security and sustainability of water resources shall be made a national priority to ensure adequate and safe water for all, through sustainable use, conservation and effective management of water resources enabled by a mechanism of shared partnership involving all stakeholders."

These objectives are interrelated to the natural system, and are of crucial importance for resource availability and quality and human consumption, which fundamentally determines the resource use, waste production and pollution of the resource, and which must also set development priorities i.e., water use, waste generation, water pollution, and water development. This cross sectoral integration occurs both within and between these categories.

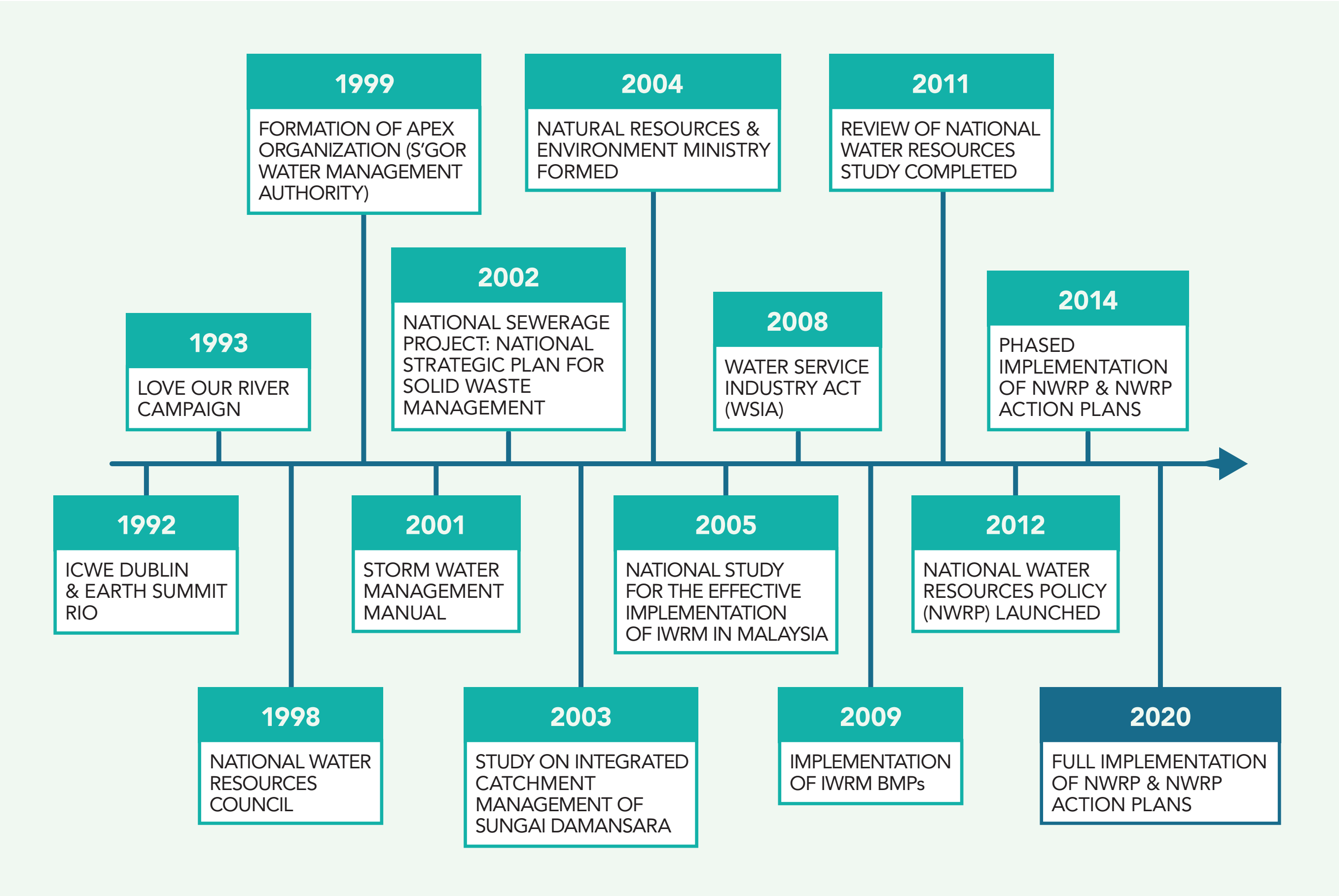


FIGURE 19: ROADMAP OF IWRM IMPLEMENTATION IN MALAYSIA

3.2.2 IWRM PROCESS IN MALAYSIA

FIGURE 19 shows a roadmap of the status of IWRM implementation in Malaysia over the past two decades as listed below, culminating in the National Water Resources Policy in 2012.

- Federal Constitution amended in Jan 2005 to shift water services from state list to concurrent list.
- New law on Water Services Commission passed by Parliament in 2007
- 2008: Water Services Industry Act enforced
- 2014: National Water Resources Policy launched

A. MAJOR REFORMS IN MARCH 2004

Separation of duties in terms of Water Resources Regulation & Water Supply Services involving 2 main ministries:

- Ministry of Natural Resources & Environment (NRE) (Responsibility: To oversee the country's natural resources and environment & look at alternatives in dealing with water related issues e.g.: Water shortages, deterioration of water quality etc)
- Ministry of Energy, Green Technology and Water (KeTTHA) (Responsibility: To manage the water utilities services, such as domestic and industrial water supply, sewerage and hydropower generation)

B. INSTITUTIONS / BODIES FORMED

- Selangor Waters Management Authority (LUAS): formed on 1st August 2000, aims to adopt and implement IWRM/IRBM at the river basin level within the State of Selangor, besides conserving coastal resources and the environment.
- Water Resources Department of Sabah.
- Natural Resources and Environment Board (Sarawak).
- Kedah Water Management Board (ISAN) – yet to be fully implemented.
- The Water Services Industry Act (WSIA) Bill 2006 and the National Water Services Commission (NWSC or SPAN, its Malay acronym) Bill 2006 are formed (Function: To monitor and regulate the whole water industry and sewerage system on the policy directions set up by the government)
- Under 9th Malaysia Plan, the Water Asset Management Company (PAAB) was formed to address the funding needs in developing the water supply infrastructures such as dams, weirs, and other facilities to tap raw water for enhancing the Water delivery system and safe and adequate water supply in the country.
- Malaysian Water Partnership (MyWP) formed in November 1993.
- The Malaysian Capacity Building Network for IWRM (MyCBNet).
- Malaysia Country Partnership.

C. FEDERAL CONSTITUTION

The Federal Constitution has defined the jurisdiction of the Federal and State Governments over water resources. They are as follows:

1. States have jurisdiction over water resources and related aspects such as land, forest, agriculture and rivers.
2. Federal Government also has jurisdiction over the following matters related to water resources:
    - International treaties and agreements.
    - Transboundary rivers.
    - Transfer of water (if not resolved between states).
    - Data and information collection and management.
    - Scientific research.
    - Setting of national standards, safety and security.

Thus, the current institutional status for water resources management in the country can be summarized as follows:

1. Each state is responsible for the management of its own water resources. Thus, some states have created their own state water resources management organizations to manage their water resources, such as Selangor, Sabah and Sarawak, whereas others depend on the Federal Government's water-related technical departments to provide the necessary technical support for the management of their state's water resources.
2. The key Federal water-related technical departments are as follows:
    - Department of Irrigation and Drainage (DID) for the physical management of rivers and coastal water resources.
    - Department of Environment (DOE) for the management of the water quality of the rivers, lakes, coastal and ground water resources.
    - Department of Mineral and Geosciences (DMG) for the physical management of ground water resources.

3. To facilitate co-ordination and uniformity of decision-making on water resources among the states the National Water Resources Council (NWRC) was set-up in 1998. The roles and functions of the NWRC are as follows:
   - Water management on a national basis to ensure long-term sustainability of water supply.
   - Resolution of water resource disputes among states, including the establishment of a mechanism for agreeing of terms.
   - Addressing legal and other issues needed to allow the increase use of water through inter-basin and inter-state water transfers.
   - Coordinate the implementation of water resources development projects.
   - Advise State Governments on the conservation, control and gazettal of water catchments areas.
   - Water resources data management.
   - Act as an apex body for water resources governance.
   - Set general policy directions on water resources (planning, development and management)
   - Inter-state matters and state water-related matters requiring advice and recommendations.
   - All international water-related matters.

Water resources though a state matter is also a vital national heritage to be sustainably conserved and preserved. Effective implementation of IWRM contributes to the realization of water security and water sustainability for Malaysia.

3.3 WATER DEMAND MANAGEMENT

The usage for water increases as population grows until the demand sometimes overshoots the supply or availability. Water demand grows at 4% annually and projected to reach 20 billion m^3 by the year 2020. Water demand includes the following factors:

- Population
- Per Capita Consumption (PCC)
- The Water Demand (domestic, industrial, irrigation and fisheries)
- Non-Revenue Water (NRW)
- Service factor

Discipline of demand management aims to maximize the beneficial use of a resource while minimizing the economic, social, environmental and sustainability impacts of its withdrawal. The benefits of implementing water demand management may be summarized as follows:

- Allows more water to be left behind in the environment for ecological services to be sustained;
- Reduces cost for water treatment and distribution as well as for sewage treatment;
- Reduces capital expenditure for large infrastructure projects; and
- Saves energy as less water has to be treated and pumped through the system.

Findings by the Federation of Malaysian Consumers Association (FOMCA) show that the average consumer needs only 80 litres a day, including three litres for drinking, to sustain a reasonable quality of life. 50% of households rarely took action to fix leaks while 70% did not have dual-flush systems which could reduce 30-60% of water usage. Over 70% did not use rainwater or recycled water (from the last rinse of clothes) to flush toilets. Other wasteful practices include not using controlled shower heads and not collecting rainwater for gardening. Water demand management is the key tool for water conservation.

3.4 WATER FOOTPRINT

The water footprint of an individual consumer refers to the sum of direct and indirect freshwater use by the consumer. The direct water use is the water used at home. The indirect water use relates to the total volume of freshwater that is used to produce the goods and services consumed by the consumer. A water footprint is generally expressed in terms of the volume of water use per year. Based on the bottom-up approach, the global average water footprint is found to be 1,385 m^3/yr per capita in the period 1996-2005 ***(SOURCE: Mekonnen and Hoekstra, 2011)***.

Water footprint consists of three components:

BLUE WATER FOOTPRINT: consumption of blue water resources (surface and groundwater) along the supply chain of a product. 'Consumption' refers to loss of water from the available ground-surface water body in a catchment area. Losses occur when water evaporates, returns to another catchment area or the sea or is incorporated into a product.

GREEN WATER FOOTPRINT: the volume of water evaporated from the global green water resources (rainwater stored in the soil as soil moisture)

GREY WATER FOOTPRINT: referred to pollution and is defined as the volume of freshwater that is required to assimilate the load of pollutants in given natural background concentrations and existing ambient water quality standards.

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.

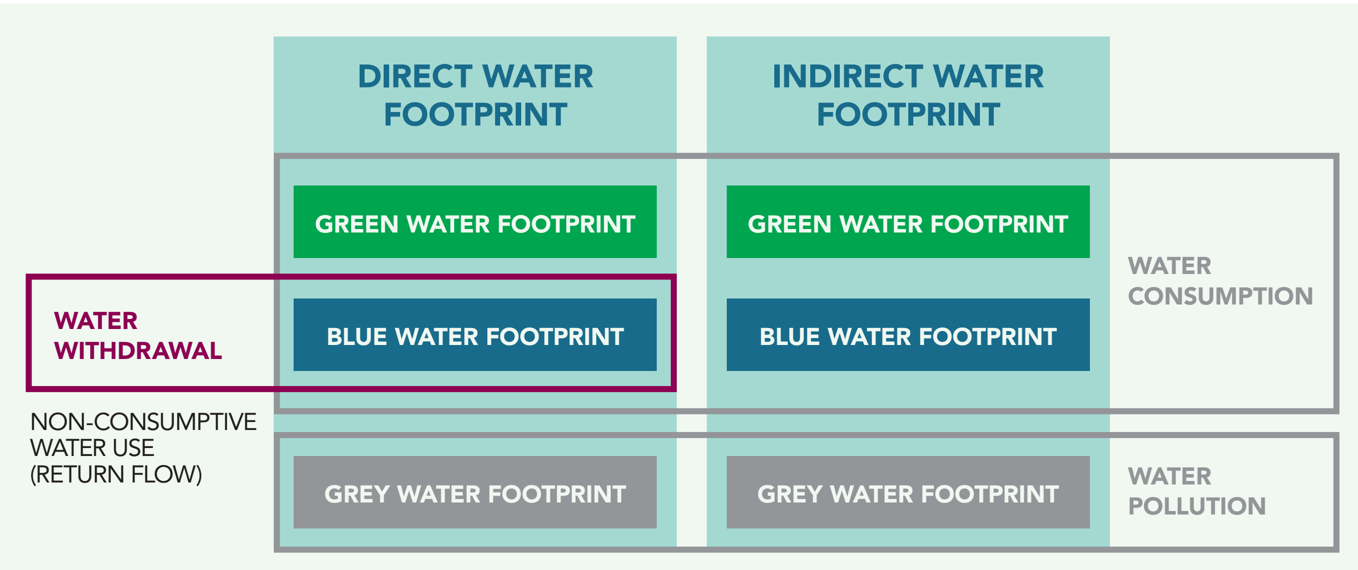


FIGURE 20: SCHEMATIC REPRESENTATION OF THE COMPONENTS OF A WATER FOOTPRINT.

3.5 NON-REVENUE WATER (NRW)

Non-revenue water (NRW) is water that has been produced and is “lost” before it reaches the customer. Losses can be real losses (through leaks, also referred to as physical losses) or apparent losses (for example through theft or metering inaccuracies). High levels of NRW are detrimental to the financial viability of water utilities, as well to the quality of water itself. NRW is typically measured as the volume of water “lost” as a share of net water produced. However, it is sometimes also expressed as the volume of water “lost” per km of water distribution network per day. Malaysian’s current NRW is 35.6% ***(SOURCE: SPAN, 2014)***.

Benefits of NRW reduction, in particular of leakage reduction, include:

- Increased knowledge about the distribution system;
- Reduced property damage;
- Reduced risk of contamination; and
- More stabilized water pressure throughout the system.

MODULE 3 ACTIVITIES

ACTIVITY 1 : RIVER BASIN AUDITING (PRIMARY + SECONDARY)

1. Interview your local authorities to find out more about the river basin and/or water catchment area closest to your school. Using maps and information obtained from local authorities or the Drainage and Irrigation Department (DID), map the rivers that flow into the dam that supplies water to your area.

2. Locate your school, drains, lakes and rivers in the map.

3. Identify the land use surrounding your school and list down possible sources of pollution.

4. You may use a water monitoring kit to determine what kinds of pollution can be detected in a water source (a lake or river near your school), such as biological waste, chemical waste and physical waste such as rubbish from litter, and many more.

ACTIVITY 2 : WATER FOOTPRINT (PRIMARY + SECONDARY)

Check out this link to learn and calculate Water Footprint: www.waterfootprint.org and GEC Water Auditing Calculator: riverranger.my

After finding out your water footprint, list down at least 5 steps that you can take to decrease your footprint.

1.

2.

3.

4.

5.

ACTIVITY 3 : VIRTUAL WATER (PRIMARY + SECONDARY)

Choose ONE meal from each option (A & B) for your breakfast, lunch, evening tea and dinner. Please choose the menu that has lower water footprint content.

Breakfast	A	Half-boiled egg 	Thosai 	Sweet potatoes 
	B	Tomato juice 	Cocoa powder drink 	Sugarcane juice 
Lunch	A	Porridge 	Steamed chicken 	Steamed cabbage 
	B	Banana 	Watermelon 	Young coconut 
Evening Tea	A	Cheese 	Wheat bread 	Sweet corn 
	B	Black coffee 	Teh-O 	Soya milk 
Dinner	A	Mutton curry 	Chicken nuggets 	Pasta 
	B	Apples 	Plums 	Strawberries 

ACTIVITY 4 : POLLUTION MAPPING (SECONDARY)

Acts of pollution are happening everywhere. One of the reasons why this is happening is because there is a lack of enforcement and there is no one there to report them. As a citizen, you have the right to report any acts of pollution. We need people to help us catch the culprits because it is impossible for authorities to monitor every single household or factory.

Here are some steps that will help you monitor and report any illegal pollution from people or industries.

1. ENSURE YOUR SAFETY FIRST.
2. Take note of the registration number of the vehicle or which company it is.
3. Take note of the day, date, time and the site of the illegal act.
4. If you have a camera or camera phone with you, take as many pictures as you can of the illegal act happening or/and its effects.
5. Describe the impacts of the pollution and any other information that would be useful to the authorities.
6. Report everything you have seen to the Department of Irrigation and Drainage, Department of Environment, local government, Indah Water Konsortium, Alam Flora/Northern Waste Management/Southern Waste Management/Eastern Waste Management, local NGOs and local politicians.

ANSWERS FOR ACTIVITY 3 : VIRTUAL WATER

Breakfast	A	Half-boiled egg	Thosai	Sweet potatoes
		3,276	5,277	536
	B	Tomato juice	Chocolate drink	Sugarcane juice
		398	15,961	211
Lunch	A	Porridge	Steamed chicken	Steamed cabbage
		4,478	3,846	417
	B	Banana	Watermelon	Young coconut
		1,005	260	2,232
Evening Tea	A	Cheese	Wheat bread	Sweet corn
		5,060	1,608	700
	B	Black coffee	Teh-O	Soya milk
		1,301	271	3,762
Dinner	A	Mutton curry	Chicken nuggets	Pasta
		5,301	3,364	2,036
	B	Apples	Plums	Strawberries
		821	2,053	347

(SOURCE: Global Environment Centre)

MODULE 4:
WATER CARE – LET'S GET IT STARTED!

MODULE 4: WATER CARE – LET'S GET IT STARTED!

This module will give practical solutions on water issues. Teachers and respective parties can learn and practice suitable solutions provided here to enhance effective management of water. Before we start with water conservation and water care activities, it is good for us to know the details and issues of our own water supply before we start conservation activities.

4.1 RIVER/WATER ADDRESS

Each of us should know where our drinking water comes from. Our supply of drinking water is first treated before it reaches us and it will be interesting to know which treatment plant does the treatment of water that is directed to our houses. Besides that, the name and location of the river that provides us water need to be known too.

STATE	RIVER BASIN	RIVER / RESERVOIR / WELL	WATER INTAKE
Selangor/ Putrajaya/ N. Sembilan	Langat	Semenyih river	Semenyih Water Treatment Plant
Selangor/ Federal Territory Kuala Lumpur	Klang	Gombak river	Gombak Water Treatment Plant
Pahang	Rompin	Well	Groundwater
Kedah/Penang Island	Muda	Muda River	Pinang Tunggal
Johor	Pulai	Pulai Dam	Gunung Pulai Water Treatment Plant

TABLE 10: EXAMPLES OF RIVER ADDRESS

(SOURCE: Environmental Quality Report, DOE, 2013)

4.2 WATER AUDITING

4.2.1 WATER AUDIT

Water auditing is a way of looking at how all the water at a given site is being used. It investigates the quantity and the quality of the water coming in and out and how it can be used more efficiently. Water audits balance the amount produced with the amount billed and account for the remaining water (loss). It is an important step towards water conservation and, linked with a leak detection plan, can save the utility a significant amount of money and time. ***(SOURCE: GEC water auditing brochure, 2014)***

4.2.2 ELEMENTS OF WATER AUDITING

There are three main elements in a water audit:

A. WATER SOURCE QUALITY

Water quality refers to the 'cleanliness' of the water source. It can be measured by looking at three (3) different aspects:

PHYSICAL: colour, presence of rubbish/smell etc.

CHEMICAL: pH, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO).

BIOLOGICAL: Diversity of aquatic life such as invertebrates, fish and aquatic plants.

B. WATER QUANTITY

This is the measure of how much water you are using in your house/building. By measuring and timing the water flow from each appliance, you can measure how much water is used each time. By doing this, you will realize how much water you are actually using in your daily life. Beside that you can use the water bill to quantify your school/home total water usage.

C. WATER MAPPING

This involves mapping out all your sources of water, and where they are going to. It can be done in your school, house, and office building. With this knowledge, you can think about how you can re-do your pipes to carry certain types of water so that it's not all wasted.

Water quantity and water mapping are the two aspects that must be performed in a water audit. Water source quality is dependent on the capacity of the site and the person who carries out the water audit.

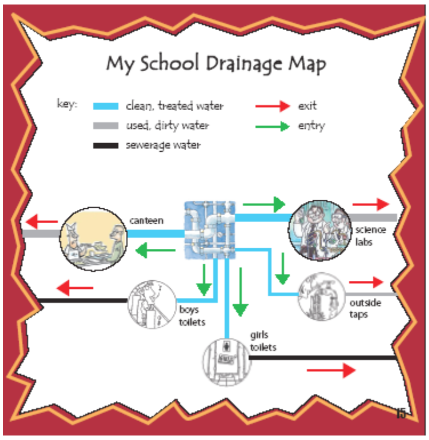


FIGURE 21: SCHOOL MAPPING

(SOURCE: GEC, 2009)

4.2.3 BENEFITS OF A WATER AUDIT

Benefits of an audit include improved knowledge and documentation of the distribution system including the problem and risk areas. The audit also becomes a valuable tool to manage resources, by getting a better understanding of what is happening to the water after it leaves the treatment plant. Leak detection programs are effective ways to minimize leakage and to fix small problems before they become major ones.

4.2.4 PERFORMING A WATER AUDIT

A. KNOW YOUR HISTORY

Look at all your previous monthly water bills and observe what your usage trends have been. Has it been increasing? If so, why? Have you been using water unnecessarily?

B. KEEP TRACK

Take a look at your monthly water bill and keep track of how many litres of water you are using every month! If the bill seems to be higher than usual, and there weren't events out of the ordinary, then you may have a leak somewhere.

C. MEASURE AWAY

Measure how much water is used in each location so that you are aware of how much water you are using each time. Also record the number of taps, showers and hoses you have so that you can estimate the water use in each part of your school/house/office.

D. SOURCES OF WATER

Identify where your water is coming from, and how much you receive from each source. This could be rainwater, surface runoff or spring water. Apart from using your tap water for everything, are there any other sources of water you can use?

E. CHECK FOR LEAKS

Leaking taps and pipes can waste hundreds of litres of water in one day! Find them and get them fixed immediately to avoid yourself from wasting water and money!

> **RECOMMENDED STRATEGY**
>
> *A preliminary audit should be undertaken to determine the amount of water loss, then followed up with congruous measures as determined by the findings of the audit. If water loss is significant, a more detailed study should be undertaken and measures should be taken to reduce the loss.*

4.3 WATER CONSERVATION

Water conservation is a big thing, but every little bit helps, so don't think that what you do doesn't matter. We must all make changes in our lifestyles and daily activities that will change the course of our water resources and its quality. Water conservation needs to be a way of life, not just something we think about once in a while. Since we all enjoy the benefits of having pure and clean water, we must help conserve water so that we may continue to enjoy these benefits. If we all do our part in conserving water, we can make a huge difference for the environment. The initiative to conserve water can be done by an individual, a school or a household.

4.3.1 WATER WASTAGE REDUCTION

Water wastage reduction is a direct and simple initiative by relevant parties to conserve water. Huge amounts of water are being wasted in our daily life due to our inefficient use of water. We can conserve water via simple and easy means if we give closer attention to how much water is being wasted daily. The initiative can be done individually or by any related parties. Some of the water saving tips are as follows:

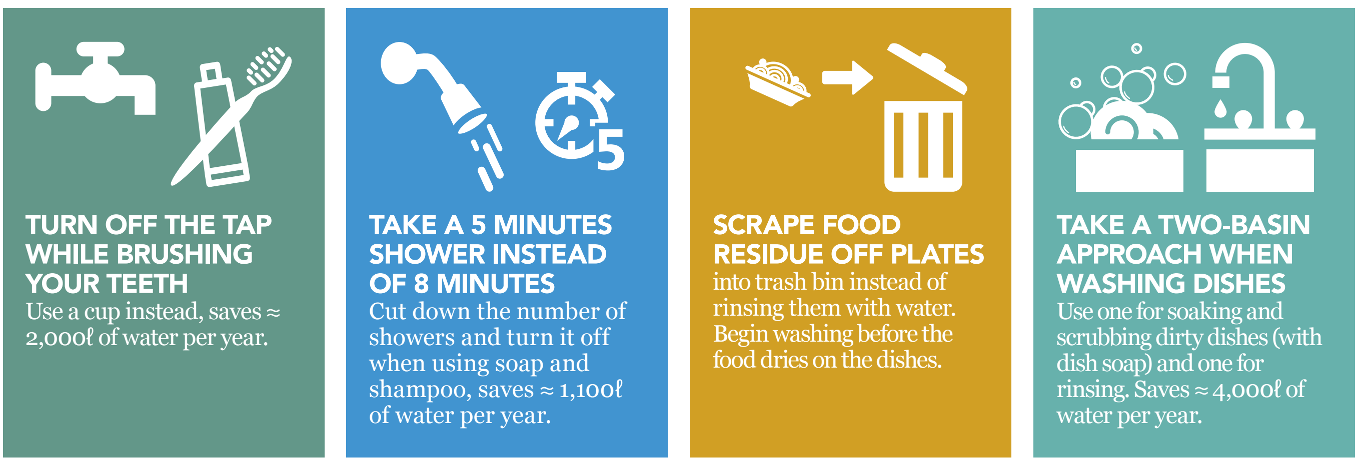
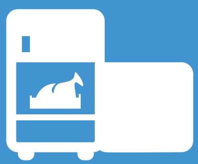


FIGURE 22: WATER SAVING TIPS

(SOURCE: GEC, 2014)

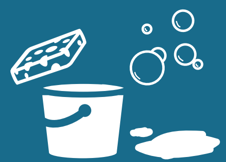
SOAK AND WASH YOUR FRUITS AND VEGETABLES IN A BOWL / CONTAINER
instead of running water from the tap.



DO NOT USE RUNNING WATER TO THAW FOOD
Defrost food overnight in the refrigerator or by using the defrost setting on your microwave.

INSTALL WATER SAVING DEVICES
like a half/full flush system for your toilet bowl. Avoid flushing the toilet unnecessarily.

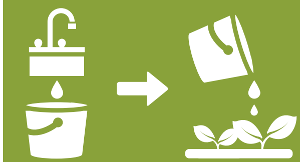
GO TO A CARWASH THAT USES A WATER-RECYCLING PROGRAM
An efficient green car wash that saves 50 - 60% or more on water and sewer discharge bill.



OR USE A PAIL OF WATER TO WASH THE CAR YOURSELF
instead of a hose. Even better, wash it on the lawn, and you will water your lawn at the same time.

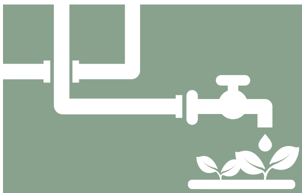
USE THE TRASH BIN
Do not use the toilet bowl to dispose tissues, insects and other such waste.

USE WATER TO WASH OFF THE SOAP WHEN WASHING HANDS
There is no need to pre-rinse or running the water when soaping your hands. Saves ≈ 90ℓ per day.



COLLECT USED / "OLD" WATER
(from washing hands, vegetables, fruits, rice) with a bucket beneath the tap. It can be used again for watering plants or for flushing the toilet.

DIRECT THE WATER DRAIN LINE FROM THE AIR CONDITIONER
to a flower bed, tree base or onto your lawn.



CONSIDER SETTING UP A GREYWATER SYSTEM
It allows you to re-use the water from your sinks, laundry machine and dishwasher for watering plants and flushing toilets.

CHECK AND REPAIR YOUR LEAKING TAPS OR SHOWERHEADS
A drop per second could add up to tens of liters in no time.

HARVEST YOUR RAINWATER
Place rain barrels beneath your downspouts. Rainwater can be used to flush your toilet, wash your car and water the plants during dry season!

WATER YOUR PLANTS IN THE MORNING OR LATE EVENING
to minimise evaporation. You will use less water when you water them at the roots instead of leaves.

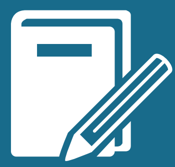
USE YOUR LEFTOVER ICE CUBES / WATER FROM A DRINK
to water a plant instead of pouring down the sink.

ACCUMULATE A FULL LOAD BEFORE WASHING CLOTHES
For hand wash, use water sparingly.

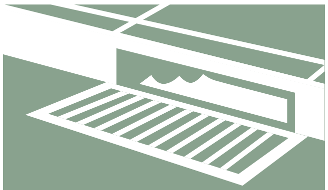
REPORT PIPE BREAKS / LEAKS / DAMAGES
and water thefts at once. This threatens our fire protection, putting water quality at risk, raises the possibility of increased water bills and the need for water use restrictions.

USE A MOP WHEN CLEANING FLOORS
Do not use a hose or pour water over the floor for washing. Advice to use a 'no-rinse' washing liquid.

BUYING GROCERIES FROM A LOCAL FARMER'S MARKET
supports local farmers, encourages local and regional food systems to grow and helps reduce water footprint.



KEEP TRACK OF YOUR WATER USAGE
every month and try to reduce it month to month.



ALL DRAINS LEAD TO RIVERS WITHOUT ANY PRIOR TREATMENT
So make sure nothing else except rainwater is going into your drains.

ACTIVITY	METHOD USED	QTY USED (ℓ)	METHODS TO BE ADOPTED	QTY REQUIRED (ℓ)	QTY SAVED (ℓ)
Brushing teeth	Running tap for 5 minutes	45	Water filled tumbler or glass	0.5	44.5
Washing hands	Running tap for 2 minutes	18	Half - filled wash basin	2.0	16
Shaving	Running tap for 2 minutes	18	Water filled tumbler or glass	0.25	17.75
Shower	Running shower while soaping	90	Wet down, tap off, soap up, rinse off	20	70
Flushing toilet	Using old fashioned large capacity cistern	13.5 or more	Dual system short flush	4.5	4.5 or more
			Liquid waste full flush solid waste	9	
Watering plants	Running hose for 5 minutes	120	Water can	5	115
Washing floor	Running hose for 5 minutes	200	Mop and bucket	18	182
Washing car	Running hose for 10 minutes	400	Two buckets	18	382

TABLE 11: WATER USAGE AND CONSERVATION

(SOURCE: Water Resource Management Module: Module 8A, U.S.A, 2007)

4.3.2 WATER SAVING DEVICES

Water conservation also means more than simply making sure your faucet does not drip. Cutting out wasted water is one step, such as turning off the faucet while you're brushing your teeth and another important step is making sure that the water you do use is used wisely. This is where water saving device comes in. These devices improve the efficiency of your water usage. It is impossible to cut out all water usage, but it is possible to use water more efficiently.

WATER SAVING DEVICES	PROCEDURE/USES
 **TOILET TANK BANK**	Fill this plastic bag with water and hang it in the toilet reservoir / tank. It will displace an amount of water equivalent to the bag size, which means every flush will use less water.

WATER SAVING DEVICES	PROCEDURE/USES
 **LOW-FLOW FAUCET AERATOR**	Low-flow faucet aerators, perfect for your bathroom sink. It reduces the flow of water from your sink.
 **LOW-FLOW SHOWERHEAD**	Adjustable low-flow showerhead with lower pressure.

WATER SAVING DEVICES	PROCEDURE/USES
 **SHOWER COACH TIMER**	This is an easy way to encourage water conservation in the shower. High-impact ABS plastic white sand timer helps change shower habits from long to short showers.

WATER SAVING DEVICES	PROCEDURE/USES
 **NOODLEHEAD LAWN & GARDEN SPRINKLER**	Utilizes water efficiently and effectively in your garden and lawn. Responsible watering with a clever twist! Noodlehead Sprinkler can be customized to cover any garden shape perfectly, without wasting water by sprinkling beyond the garden's boundaries.

4.3.3 LIFESTYLE

The indirect water footprint of a consumer is generally much larger than the direct one. Quite a number of terms such as 'hidden water', 'virtual water' or 'embedded water' will be discussed when we talk about indirect water footprint. Hoekstra and Chapagain have defined the virtual-water content of a product (a commodity, good or service) as "the volume of freshwater used to produce the product, measured at the place where the product was actually produced". The 'virtual-water content of a product' is the same as 'the water footprint of a product', but the former refers to the water volume embodied in the product alone, while the latter term refers to that volume, but also to which sort of water is being used and to when and where that water is being used. ***(SOURCE: Hoekstra AY, Chapagain AK, 2007)***

A consumer has basically two options to reduce his/her indirect water footprint. One option is to substitute a consumer product that has a large water footprint with a different type of product that has a smaller water footprint. This includes eating less meat or becoming completely vegetarian and drinking tea instead of coffee. Not wearing so much cotton and instead wearing clothes of artificial fibre saves a lot of water. These approaches have limitations, as many people won't just shift from meat-eating to vegetarianism and people like their coffee and cotton. A second option is to stick to the same consumption pattern but to select the cotton, meat or coffee that has a relatively low water footprint or that has its footprint in an area that doesn't have high water scarcity. This requires consumers to have proper information to make that choice. Since this information is generally not readily available, an important thing consumers can do now is demand product transparency from businesses as well as regulation from governments. When information is available on the impacts of a certain article on the water system, consumers can make conscious choices about what they buy. ***(SOURCE: www.en.reset.org/act/save-water-reduce-your-water-footprint)***

PRODUCT (1KG)	EQUIVALENT WATER NEEDED FOR PRODUCTION (ℓ) MALAYSIA /*GLOBAL
Carrot	195*
Tomato	273
Milk	1,329
Wheat	1,436*
Grape	1,945
Soybean	2,144*
Maize / Corn	2,607
Rice	3,104
Egg	3,276
Poultry	3,846
Beef	10,784

TABLE 12: HIDDEN WATER IN FOOD PRODUCTION

(SOURCE: Hoekstra AY, Chapagain AK, 2007)

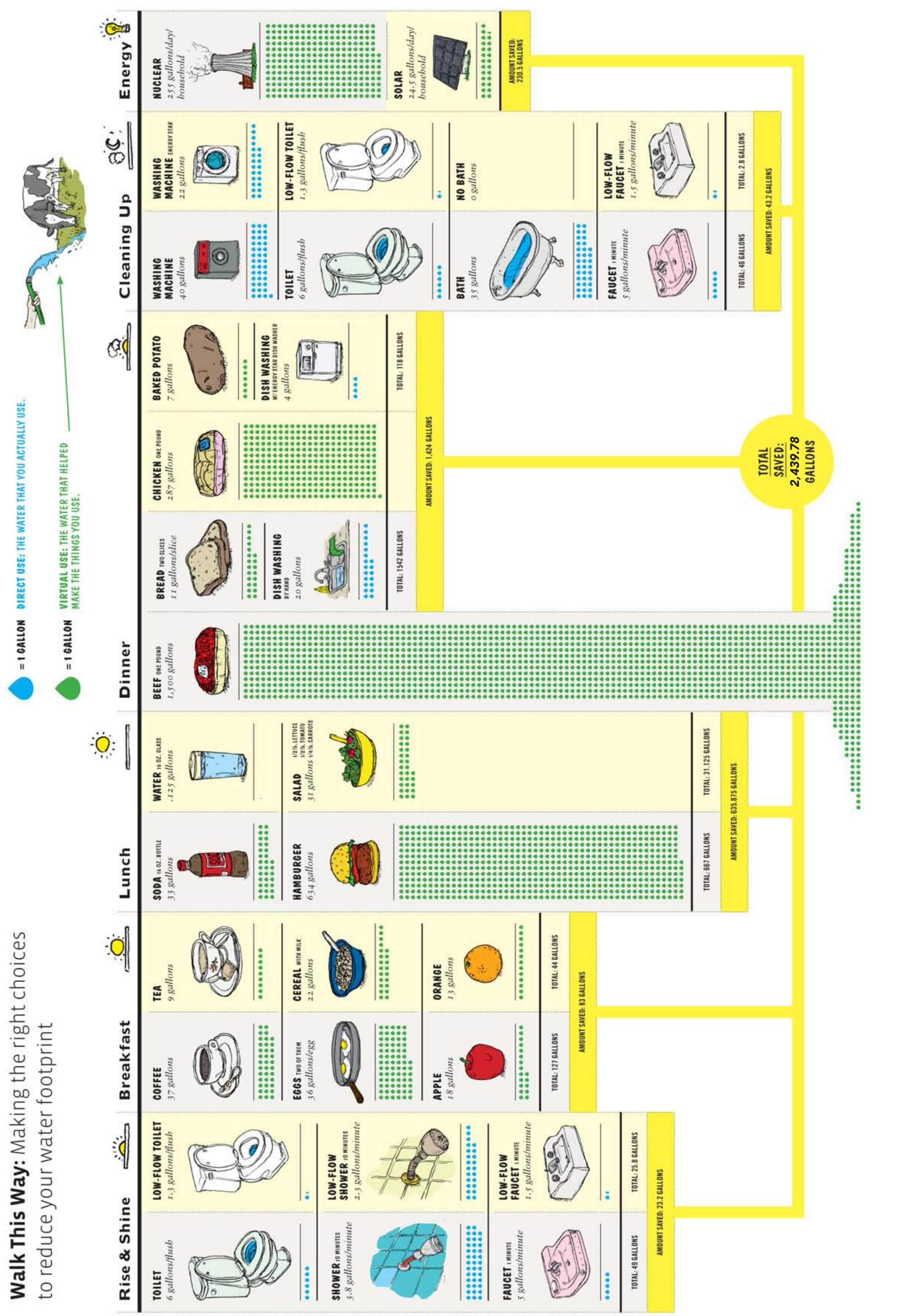


FIGURE 23: 'WATER WISE' LIFESTYLE

(SOURCE: www.waterfootprint.org)

4.4 ALTERNATIVE CHOICES

4.4.1 REUSE

Water reuse is often confused with the terms wastewater recycling and reclamation. This is due to different acceptance of these terms in different countries. For our context, there are three types of reuse categories. ***(SOURCE: Wang, Y. P. & Smith, R., 1994)***

1. **REUSE:** wastewater is reused directly within the process system subject to its quality being acceptable to operations within the process system.
2. **REGENERATION-REUSE:** wastewater is partially treated to remove contaminants and is reused in operations in which it has not been previously used.
3. **REGENERATION-RECYCLING:** wastewater contaminants are removed via regeneration and then is allowed to enter operations in which it has previously been used.

4.4.1.1 DOMESTIC REUSE

Conventional toilet flush water is mainly supplied water that is unnecessarily treated to drinking water quality standard, an expensive and energy intensive process. Greywater recycling is an innovative alternative whereby treated greywater is used principally for toilet flushing and watering gardens. Greywater is wastewater from showers, baths, wash basins, washing machines and kitchen sinks although for recycling purposes kitchen sink and washing machine water is normally excluded because it is too greasy and/or contains too many detergents to allow cost effective treatment. Unlike rainwater, greywater requires filtration to remove hair, skin and soap products from the water and chemical or biological treatment prior to reuse. The potential level of human contact with the water in its end use will determine what level of treatment is required. For example greywater used for hosing down vehicles will require a higher water quality because the risk of human contact with the water is greater in high pressurised systems. Similarly, black water (toilet effluent diluted by flushing water) is not recycled because of the higher level of treatment needed before it is safe for human contact. Public acceptance is also a major barrier here and in some societies only reuse for industrial purposes is accepted. ***(SOURCE: Zaini Ujanh et al., 2008)***

FIGURE 24A: EXAMPLES OF GREYWATER REUSE SYSTEM IN JAPAN

(SOURCE: www.mesym.com)

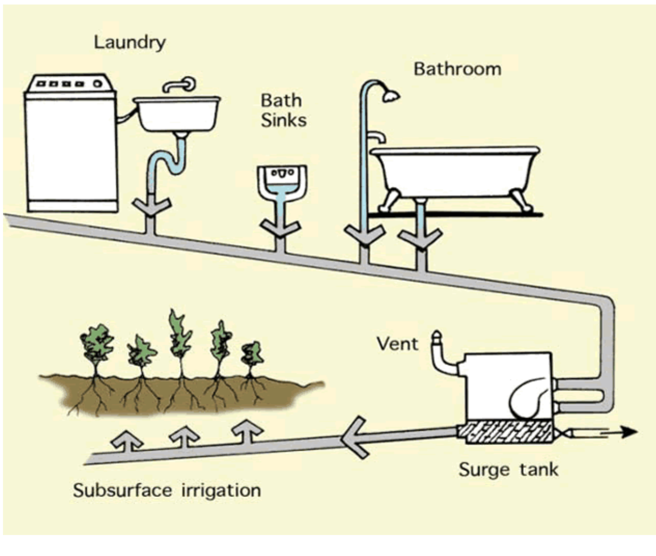


FIGURE 24B: EXAMPLES OF GREYWATER REUSE SYSTEM IN VARIOUS COUNTRIES

(SOURCE: www.cbs.state.or.us)

4.4.2 RAINWATER HARVESTING

Rainwater harvesting is a technique used for collecting, storing, and using rainwater for landscape irrigation and other uses. The rainwater is collected from various hard surfaces such as roof tops and/or other types of manmade above ground hard surfaces. This practice is currently growing in popularity and has been implemented in many countries such as the USA, Japan, China, India, Germany and Australia due to interest in reducing the consumption of potable water and the inherent qualities of rainwater.

4.4.2.1 RAINWATER HARVESTING BASIC COMPONENTS

Rainwater systems come in all shapes and sizes, from a simple catchment system under a downspout to large above and/or underground cisterns with complex filtration systems that can store thousands of liters of water. Most rainwater collection systems consist of the following basic elements:

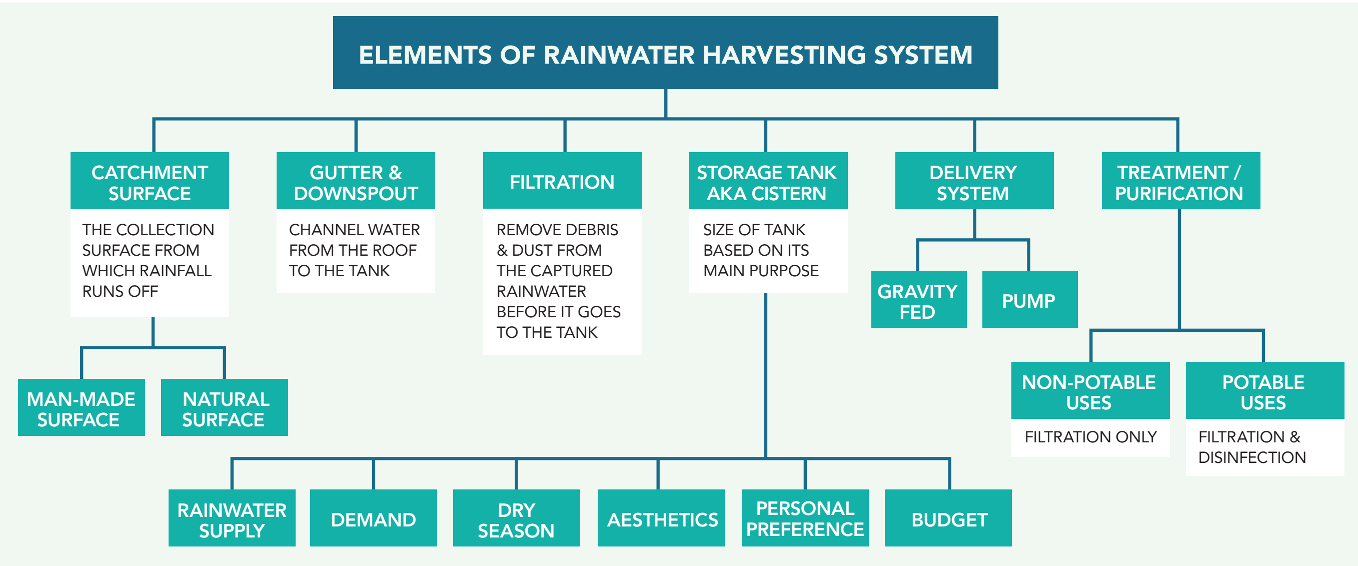


FIGURE 25: ELEMENTS OF RAINWATER HARVESTING SYSTEM *(SOURCE: Chen-Ani A.I etc., 2009)*

4.4.2.2 RAINWATER HARVESTING IN MALAYSIA

In 1984 and 1998 Malaysia experienced serious water crisis due to climate change and the El Nino phenomena. In response to this the Ministry of Housing and Local Government (MHLG) introduced the Guideline for Installing Rainwater Collection and Utilization System, which can be seen as the initial phase of the rainwater harvesting policy in Malaysia. The main aim of this guideline was to reduce dependency on treated water and provide a convenient buffer in times of emergency or shortfall in the water supply. Prior to this, there was not much attention given to developing a rainwater harvesting system because 95% of Malaysia has piped water in rural areas and 99% in urban areas.

In 2004, five years after the Guideline on rainwater harvesting was published, the Ministry of Housing and Local Government prepared another cabinet paper to the National Water Resources Council which sought to encourage government buildings to install a rainwater collection and utilization system. According to the research carried out by National Hydraulic Research Institute of Malaysia (NAHRIM) on the SPAH (Sistem Penuaian Air Hujan) pilot project for the double storey terrace house, which is occupied by six occupants, SPAH is able to save up to 34% of public water use, in addition to the 10% of reduction in peak discharge by assuming every terrace house has been installed with the same SPAH.

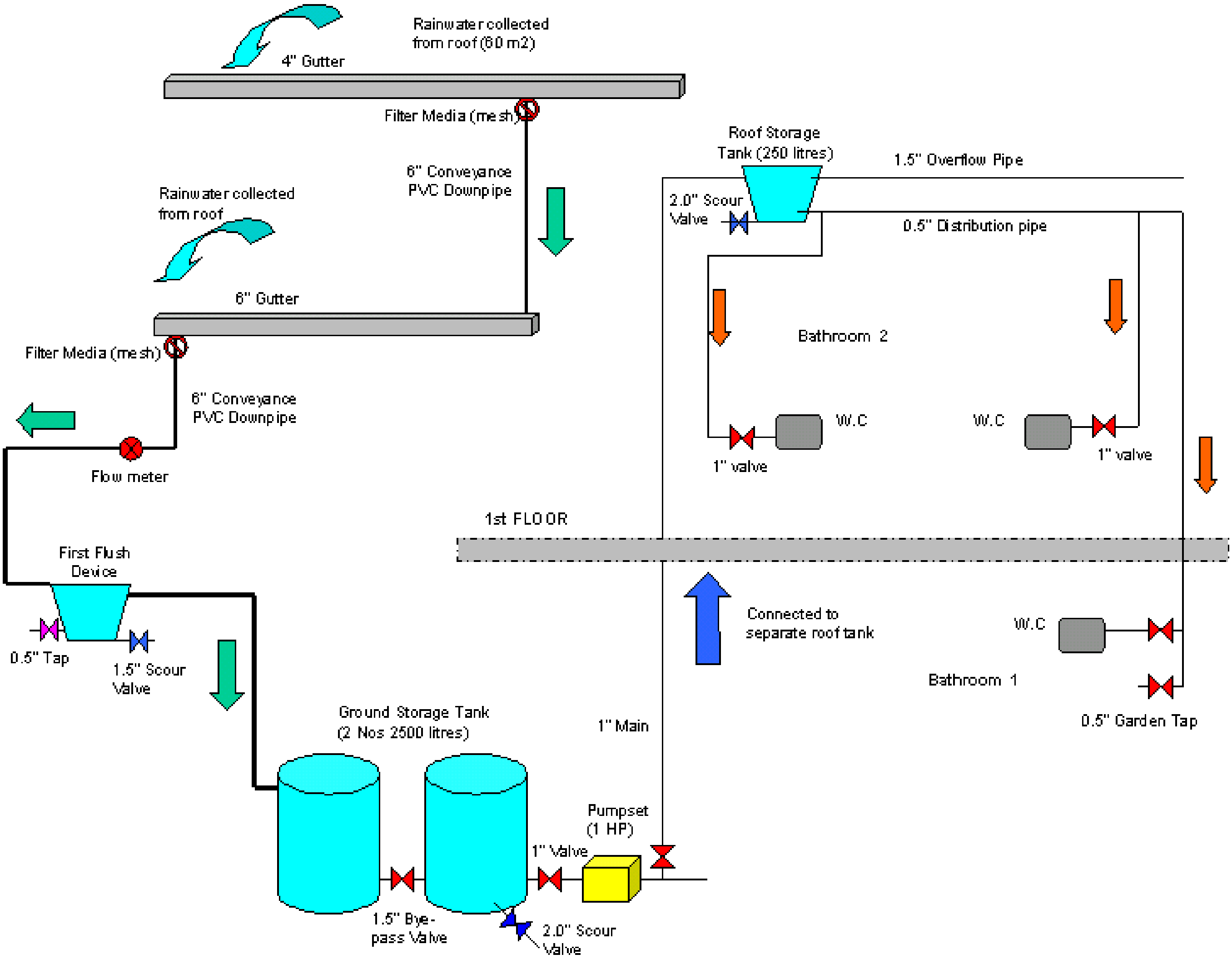


FIGURE 26: RAINWATER HARVESTING SYSTEM AT HOUSE, TAMAN WANGSA MELAWATI, KL

(SOURCE: NAHRIM website, 2014)

4.4.2.3 BENEFITS OF RAINWATER HARVESTING

Rainwater harvesting is a simple way to reuse the water and it is a part of sustainable architecture as shown in the table; the benefits of this system not only to users but for the government and environment as well.

USERS	GOVERNMENT	ENVIRONMENT
• Rainwater is relatively clean, independent and ample water supply. • Rainwater harvesting system uses simple technologies that are inexpensive and easy to maintain. • Rainwater harvesting system is very easy to handle and flexible. It can be modular in nature, allowing expansion, reconfiguration, or relocation. • Save money by reducing the volume of water purchased from public systems. • Save money by extending the life of plumbing fixtures and appliances. • Avoid interrupted service from centralized water system or overuse of water from a well.	• Reduce the burden for new investment to replace the ageing systems and adding the water supply infrastructures. • Potentially avoid the cost of accessing public water system when it is not economically feasible. • Rainwater harvesting system can reduce construction cost in each development because it can be easily retrofitted to an existing structure or built during new construction.	• By capturing rainwater, we reduce the abundant amount of rainwater that goes to the drainage and avoiding the floods phenomena • We can significantly reduce our reliance on water storage dam. This will avoid ecological damage to the area which has to be submerged to build the dam. • Rainwater is superior for landscape use and plants strive thrive on rainwater well rather than other sources that might have chemical compounds that polluted them and soils. This is because rainwater forces salts down and away from root zone when it percolates in to the soil.

TABLE 13: BENEFITS OF RAINWATER HARVESTING *(SOURCE: Chen-Ani A.I etc., 2009)*

4.4.2.4 SAFETY CONSIDERATIONS

The following steps can be taken to help rainwater quality:

1. Regularly inspect and clean gutters, roof catchments and tank screens.
2. Remove overhead branches.
3. Consider installing gutter screens or guards.
4. Ensure tank does not become a mosquito breeding site by preventing access and cleaning screens regularly.
5. Examine tank for accumulation of sludge every 2 to 3 years and remove by siphoning or by emptying the tank.
6. 40 mm of liquids Sodium Hypo-Chlorides or 7 gm granular Calcium Hypo-Chlorites per 1,000 liters of water.

(SOURCE: NAHRIM, 2008)

4.4.3 WATER RECYCLING

4.4.3.1 TAKING OUR CUE FROM MOTHER NATURE

When it comes to recycling waste water, no one is better at it than Mother Nature. She has been doing it since the beginning of time through her own purification system of lakes, streams and rivers. Through the natural water cycle, planet earth has reused and recycled water for millions of years.

Those familiar with recycling would imagine this term applied to aluminium cans, glass bottles and newspapers. However, water can be recycled as well. Recycled water is most commonly used for non-potable (not for drinking) purposes, such as agriculture, landscape, public parks, and golf course irrigation. Other non-potable applications include cooling water for power plants and oil refineries, industrial process water for facilities such as paper mills and carpet dyers, toilet flushing, dust control, construction activities, concrete mixing, and artificial lakes.

A common type of recycled water is water that has been reclaimed from municipal wastewater or sewage. Direct potable reuse (i.e. treated wastewater directly reused for drinking water) is very rare because of the increased potential risk to public health and the negative public perception, even though the technology is well proven and that river water can actually totally be made of treated sewage effluents. Direct potable reuse is only justifiable when there is no other option for example in the desert lands. One good example where direct potable reuse takes place on a municipal scale is in Windhoek, Namibia, where treated wastewater combined with surface runoff is treated to provide potable water (***SOURCE: Aquarec, 2005***). Direct reuse is common practice for non-potable applications in industry and irrigation. Meanwhile, indirect potable reuse can be planned or unplanned. Indirect potable reuse refers to projects that discharge recycled water to a water body before reuse. Hence these projects include recharging ground water aquifers and augmenting surface water reservoirs with recycled water. In ground water recharge projects, recycled water can be spread or injected into ground water aquifers to augment ground water supplies, and to prevent salt water intrusion in coastal areas.

4.4.3.2 WATER RECYCLING PROCESS

A. PRIMARY TREATMENT: REMOVAL OF SOLID MATERIALS

When rain runoff first flows into a river, heavier solid particles settle to the bottom while lighter materials float to the top and are carried away. At the water reclamation plant, long concrete tanks duplicate what nature does in the river. After the solid materials (both that have sunk and floating) are removed for further treatment and the remaining wastewater containing dissolved and suspended materials (mostly organic) moves to the second phase of treatment.

B. SECONDARY TREATMENT: BIODEGRADATION OF ORGANIC MATERIALS

As water in a river flows downstream, naturally occurring microorganisms feed on the dissolved organic materials. Oxygen naturally enters the water so the organisms can breathe. At the water reclamation plant, air is fed mechanically. The same microorganisms in the wastewater grow as they feed on the organic materials in these tanks. In secondary treatment settling tanks, the microorganisms clump together and settle at the bottom, where they are removed and recycled back into the treatment process.

C. TERTIARY TREATMENT: ELIMINATION OF FINE PARTICULATES

In a natural river, clean water soaks into the riverbed and collects in the underground water supply. At treatment plants the ground is replaced by filters, which remove any remaining suspended materials from the water. The water is then disinfected and thus is free of harmful bacteria and patogen, and safe for human contact or recharging ground water and for a wide variety of other uses.

4.4.3.3 WATER RECYCLING IN MALAYSIA

In Malaysia, there are active studies conducted to investigate the water reuse potential. The Institute of Environmental and Water Resource Management (IEWRM), UTM proposed the idea of reusing treated ablution water and rainwater for the entire mosque in their campus except for kitchen services. The ablution water or rainwater were to be filtered for solid particles like hair, stones and dirt before going through a series of treatments using activated carbon and microfiltration processes. The treatment process was to ensure that water being recycled to the distribution tank was of acceptable purity for uses which involve bodily contact. ***(SOURCE: Manan, Z.A., 2006)***

4.4.4 GROUNDWATER ABSTRACTION

Groundwater is a very important source of drinking water in many countries. Some parts of Malaysia have not yet disturbed this resource due to the abundance of surface water. Groundwater is considered to be a potential alternative water resource, and some industries have altered their surface water utilization to groundwater ***(SOURCE: JICA and MGDM, 2002)***.

4.4.4.1 WELLS AND TUBE WELLS

A well is a dug or drilled hole that extends deep enough into the ground to reach water. Wells are usually circular and walled with stone, concrete or pipe to prevent the hole from caving in. They are sunk by digging or drilling through one or more layers of soil and rock to reach a layer that is at least partially full of water called an aquifer. The top of the aquifer, or the level beneath which the ground is saturated with water, is called the water table.

SITE CHOICE

The well should be located at a site that is:

- Water bearing;
- Acceptable to the local community;
- Suitable to the sinking methods available; Not likely to be easily contaminated.

TYPES OF WELLS

In general, there are two types of wells: dug wells and drilled wells. Dug wells are sunk by people working down in the hole to loosen and remove the soil. They need to be at least 1 metre wide to give people room to work. Drilled wells, on the other hand, are sunk by using special tools which are lowered into the ground and worked from the surface. These wells are normally less than 30 centimeter in diameter.

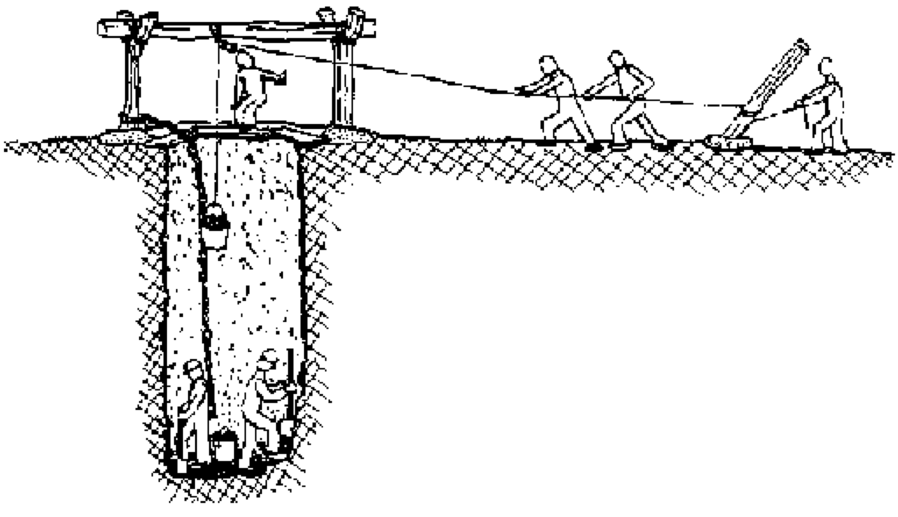


FIGURE 27: DIGGING A WELL

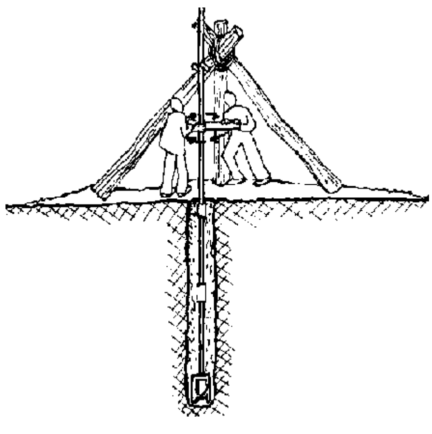


FIGURE 28: DRILLING A WELL

(SOURCE: Guidelines for Minimizing Impacts of Other Activities (Settlements) on Quality Specific Rivers in Sabah, 2011)

4.4.4.2 GUIDELINES FOR GROUNDWATER ABSTRACTION IN MALAYSIA

Any premise or individual or whoever wishes or already uses groundwater can apply this licence for their abstraction. The process is divided into two main categories as shown in the above diagram. This is the procedure used in Selangor and may slightly differ in different states. The licence received is valid for 1 year and needs renewal on an annual basis. For more information on specific forms as stated in the diagram, please refer to the Lembaga Urus Air Selangor (LUAS) website. For other states, please refer to respective water regulator agencies.

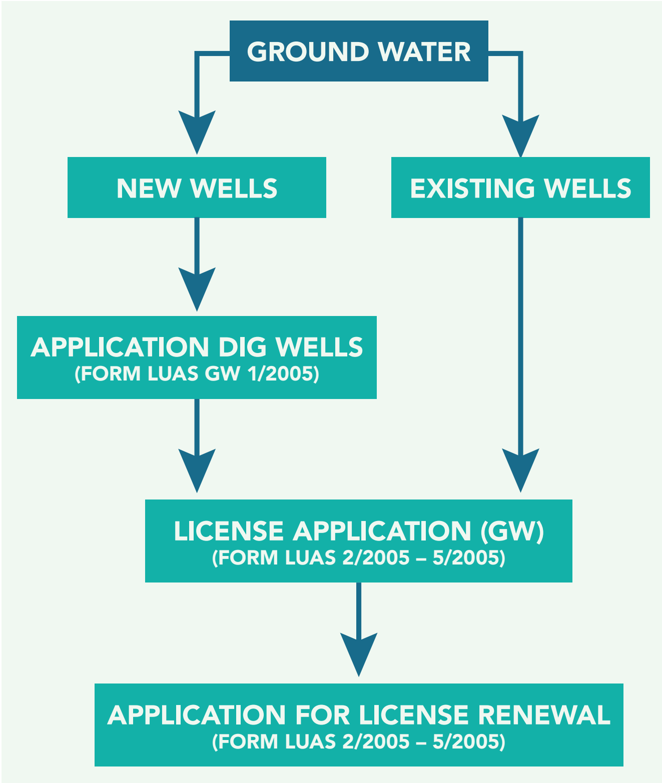


FIGURE 29: GROUNDWATER ABSTRACTION LICENSE PROCEDURE IN MALAYSIA

(SOURCE: www.luas.gov.my, 2014)

4.4.5 SURFACE WATER ABSTRACTION

Surface water abstraction is the usage of water from a lake, pond, wetland, coastal water and other water bodies, either natural or manmade for commercial and public utility purposes. It is a process of taking water from the source to the treatment plant through pipes.

4.4.5.1 SURFACE WATER ABSTRACTION IN MALAYSIA

At most places, river is the main water resource for abstraction. However, lakes and disused mining ponds sometimes used for abstraction. There is also an example of lake surface water abstracted to Semenyih River. During the prolonged drought of 1997, raw water storage at the Semenyih impounding reservoir was severely depleted to a very critical level and it was not possible to augment the flow at Semenyih River intake to enable adequate abstraction for public water supply. Therefore, surface water abstraction was proposed to solve this issue. The water was drawn from disused mining ponds and connected to act collectively as a reservoir to regulate the flow at the Semenyih River intake. It was then possible to pump the raw water from the storage ponds to upstream of the Semenyih River intake to solve the water shortage issue in Klang Valley area. Another good example of this practice was for Selangor River in 2014.

4.4.5.2 GUIDELINES FOR SURFACE WATER ABSTRACTION IN MALAYSIA

Any premise or individual or whoever wishes to abstract surface water can apply for a licence. This is the procedure used in Selangor and may differ slightly in different states. The licence received is valid for 1 year and needs to be renewed on an annual basis. For more information on specific forms as stated in the diagram, please refer to the Lembaga Urus Air Selangor (LUAS) website.

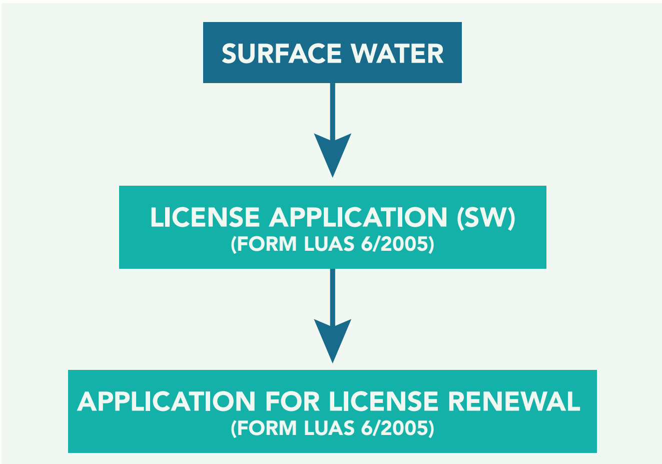


FIGURE 30: SURFACE WATER ABSTRACTION LICENSE PROCEDURE IN MALAYSIA

(SOURCE: www.luas.gov.my, 2014)

4.4.6 EXAMPLES OF ALTERNATIVE WATER SYSTEMS IN OTHER COUNTRIES

In old Europe, where cities are equipped with central infrastructure to supply water and to collect and treat wastewater, experiments with alternative water systems are burgeoning. ARENE (2005) reports on a number of them which share common water-related features:

- rainwater is harvested in tanks (in-house or underground) and used for flushing toilets, running washing machines and watering gardens;
- run offs are collected and treated so as to replenish aquifers;
- some experiments reuse water for indoor or outdoor non potable applications.

In BedZED (UK), renewable sources of water (rainwater, reclaimed water) supply 18% of the daily consumption of water. Wastewater is treated in a "Living Machine" (Green Water Treatment Plant) where water is treated biologically and through ultraviolet light to a level that complies with requirements for toilet flushing and gardens.

In Vauban-Fribourg (Germany) rainwater is harvested and used for toilet flushing, washing machines and gardens; in a pilot building, grey water is collected, treated and reused (for indoor and outdoor non potable applications); biogas is produced out of wastewater, which feeds gas appliances in the homes.

Singapore has developed one of the world's most advanced water reuse programmes. The reuse programme, called NEWater, relies on advanced microfiltration, reverse osmosis and ultraviolet exposure to clean and treat wastewater for potable consumption. NEWater has been recognized as an international model for innovation in water management, most recently winning the Environmental Contribution of the Year award from the London-based group Global Water Intelligence.

4.4.7 PROS AND CONS OF ALTERNATIVE WATER SYSTEMS

4.4.7.1 PROS

- From an environmental perspective, water reuse can reduce demand for fresh water resources, diversify water sources and enhance reliability of access to resource and it can also reduce the volume of wastewater discharged into the environment.
- A decentralised system, where water is produced where it is consumed, can reduce the high costs attached to water transport and network maintenance, including work on roads to repair underground infrastructure. It can also reduce greenhouse gas emissions due to energy savings.
- From a cost benefits perspective, alternative water systems require less infrastructure and reduces costs for the construction of networks while relieving public finance from part of the financial pressure, as new players can be engaged to invest their own money in the decentralised system.

4.4.7.2 CONS

- Alternative water systems may generate additional costs, especially when not integrated in the initial plans for service provision and building construction. Like conventional systems, the revenue stream from non-potable reused water is limited and willingness to pay is low, especially since non-potable uses are valued less by the community and customers than drinking water.
- They generate a number of risks, associated with public health and the economy of water services at the municipal level. From a social and economic perspective, decentralised systems do not encourage cross subsidies and financial solidarity between rich and poor, particularly when they are not being operated in a coordinated way.
- Of course, a real concern for decentralised water systems is their cohesiveness. What happens if the service provider goes bankrupt? How are tariffs set, revised, and approved? Who will undertake water quality testing at the customers' taps?
- It is uncertain how decentralised water systems can contribute to a sustainable network. However, a combination of decentralised systems with existing, central infrastructure already exists in Australia, Paris and Calcutta where wastewater treated locally can either be reused by the inhabitants or discharged into the municipal sewer.

Alternative water systems are familiar to rural folk, but they are obviously an option in new urban areas where no central infrastructures pre-exist. Alternative water systems might also be considered in city centres with decaying water infrastructures or with infrastructures with capacity constraints and in projects of urban renewal. Since one size does not fit all the different functions of urban water services (e.g., supplying potable water, non-potable water uses, rain water management, sanitation); a combination of centrally provided water system and alternative water systems is probably the most practical approach in many cases.

MODULE 4: ACTIVITIES

ACTIVITY 1: WATER AUDITING AT YOUR SCHOOL (PRIMARY + SECONDARY)

FOLLOW THESE STEPS:

1. Look at your school's water bills. Has it changed over time? If so find out why.

2. Ask cleaners and grounds staff what they use water for and how much they use. Examples:
   - Cleaning toilet cubicles and/or showers?
   - Cleaning concreted play areas, pathways and car parks, watering gardens?

3. Ask canteen operators if they have leaking pipes, how much water is used for cooking and cleaning.

4. Investigate the procedure at your school for identifying and fixing leaks. Is there someone in the school management to report leaks to? Are the leaks fixed quickly?

5. Go for a walk around the school to find out where water is used. Investigate if water-using fixtures are water efficient and note down any leaks you discover on a piece of paper. Water efficient fixtures might include:
   - Dual flush toilets.
   - Low flow taps (6ℓ/minute is low flow).
   - Spring loaded taps.
   - Outside taps where the handle can be removed.

6. Check that there are no leaking pipes that you cannot see. To do this, turn off all taps in the school at the end of a school day. Then take a reading of the school water meter (see diagram of a water meter). The next day read the water meter again before anyone has used any water. There should be little difference between these two readings. If water has been used, it could be a leak. How could this be fixed?

7. Use the following water auditing table to calculate total water consumption per capita per day at your school. You can use an online water calculator at www.riverranger.my for your water audit.

1: ACTUAL WATER USAGE

SCHOOL:													
PLACE	TYPE OF USAGE (MANIPULATED VARIABLE)	VOLUME (ℓ) (V) (FIXED VARIABLE)	TIME (SEC) (T) (RESPONDING VARIABLE)				FLOW RATE (A) [A = V / T]	DURATION PER USE (SEC) (B)				TOTAL WATER USAGE PER TYPE OF USAGE PER DAY (ℓ) (C) [C = A x B]
			T1	T2	T3	AVERAGE		D1	D2	D3	AVERAGE	
CORE ACTIVITIES												
TOILET / BATHROOM	FLUSHING											
	URINALS											
	HAND BASIN	1 ℓ										
	SHOWER	1 ℓ										
	WASH TOILET	1 ℓ										
CANTEEN	HAND BASIN	1 ℓ										
	COOKING	1 ℓ										
	WASHING DISHES UNDER A RUNNING TAP	1 ℓ										
	WASHING DISHES IN A FILLED SINK	1 ℓ										
GARDEN	GARDEN HOSE	1 ℓ										
SELECTED ACTIVITIES												
LABORATORY	HAND BASIN	1 ℓ										
	APPARATUS WASH											
COOKING CLASS	COOKING	1 ℓ										
	WASHING	1 ℓ										
'SURAU'	TAPS	1 ℓ										

2: WATER CONSUMPTION AT SCHOOLS

SCHOOL:					
PLACE	TYPE OF USAGE	ESTIMATED WATER USAGE (ℓ)	ACTUAL WATER USAGE PER USE (ℓ) (C)	FREQUENCY (NO. OF TIMES USED PER DAY PER CAPITA) (D)	TOTAL WATER USAGE PER TYPE OF USAGE PER DAY (ℓ) (F) [F = C x D x E)
CORE ACTIVITIES					
TOILET / BATHROOM	FLUSHING	6 / 9 / 12*			
	URINALS	6			
	HAND BASIN	10			
	SHOWER	10			
	WASH TOILET	9			
CANTEEN	HAND BASIN	19			
	COOKING	19			
	WASHING DISHES UNDER A RUNNING TAP	45			
	WASHING DISHES IN A FILLED SINK	12			
GARDEN	GARDEN HOSE	9			
SELECTED ACTIVITIES					
LABORATORY	HAND BASIN	19			
	APPARATUS WASH				
COOKING CLASS	COOKING	9			
	WASHING	10			
'SURAU'	TAPS	9			
TOTAL WATER CONSUMPTION PER CAPITA PER DAY (ℓ)					

*Please circle selected based on actual size

ACTIVITY 2: WATER CONSERVATION (PRIMARY + SECONDARY)

To determine cost saving from conserving water over a long time frame, you could track and chart your school's water bill over a period of six months.

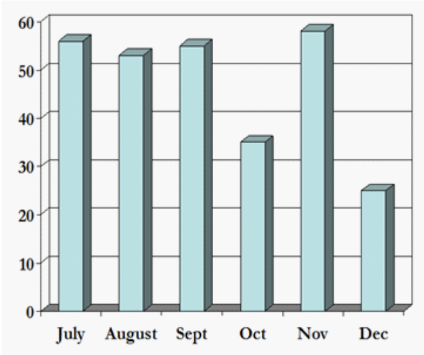


FIGURE 37: WATER USAGE GRAPH EXAMPLE

1. Record your monthly water bills for six months minimum.
2. Draw a graph to work out water usage.
3. Calculate the amount of water used by each of the users in the school for one day. For example:

STEP 1: Record the latest or current water meter reading. **(A)**

STEP 2: Retrieve the previous water meter reading. **(B)**

STEP 3: Calculate the amount of water usage. **(C)**
C = A – B

STEP 4: Calculate the daily water usage per user. **(D)**
D = C X 1000 ÷ (NUMBER OF SCHOOL DAYS X NUMBER OF USERS)

The D value from the table above will give water usage by each of the users in a school where the students are the majority users. Plan and discuss within groups on the ways to reduce water consumption per capita in the school and start conserving water by using some of the following tips and fix any leaks over the six months period.

ACTIVITY 3: RAINWATER HARVESTING SYSTEM (SECONDARY)

Build a rainwater harvesting system in your school. Refer to survivallife.com/2014/06/05/diy-rainwater-collection-system which contains a video on how to do this.

Or check out other types of rainwater harvesting system that may be more suitable at theselfsufficientliving.com/making-diy-rain-barrels

Here are some pictures of school rainwater harvesting systems:

ACTIVITY 4: WATER-EFFICIENT TREE (PRIMARY + SECONDARY)

Read up on which plants and trees are indigenous to Malaysia and which are introduced species. Usually indigenous or plants that come from a similar climate don't use up too much water to survive. Make a list of these plants and find out if your school houses these plants. For example: hibiscus or bunga raya, rose, lime, chili, elephant's ears or keladi gajah, mango, papaya, rain tree or pokok pukul lima, angsana, jacaranda and flame of the forest.

Add to the list more plants in your school if possible.

ACTIVITY 5: WATER CAPTURE (PRIMARY + SECONDARY)

Go on a field trip with your teacher.

In groups of ten (10), with a camera and a sketch pad: capture or draw as many images of water you and your team can see.

After the trip, have a show and tell in the classroom to discuss why you photographed or draw the images.