

EN4105 17/18 Sem1 PYP Solution

Disclaimer: The answers suggested are for reference only, and are often more than sufficient to score (As I thought it would be better to provide a more comprehensive picture... I've also included the marks for each question in the brackets. The exam was 2.5h btw) If you encounter any uncertainty, please consult your prof/tutor, thanks and all the best! ☺

1. (a) What are the challenges faced by Singapore in meeting its total water demand from local catchment water? What are some potential practical measures that can increase the contribution from local catchment water to beyond the current 20% of total water demand? (4 marks)

Challenges:

- The small land area of Singapore, and hence a small catchment area which cannot be increased substantially
- Increasing population and economic growth which will increase water demand in future
- Inferior quality of urban runoff which is polluted and hence requires higher treatment costs
- Impact of climate change which could result in more severe, prolonged droughts
- Limited potential to increase reservoir storage capacity

The contribution from local catchment water could potentially be increased in future via:

- Harnessing technology that can treat water of varying salinity from remaining streams and rivulets near the shoreline which could potentially boost Singapore's water catchment area to 90% of land area by 2060
- Greater reservoir integration to enhance catchment yield
- Increasing storage capacity available through underground storage caverns, etc, to reduce spillage during wet seasons
- Explore the possibility of groundwater from reclaimed land masses, deep ground water, etc

(b) Singapore's PUB adopts 2 basic approaches in its water demand management, namely water conservation and reducing unaccounted for water (UFW). List some examples of water conservation measures, and measures for reducing UFW, as practised by PUB. (5)

Water Conservation measures practiced by PUB include:

- Public Education and Publicity Program
- Mandatory Installation of Water Saving Devices, examples:
 - Self-closing delayed action taps
 - Constant flow regulators

- Low capacity flushing cistern
- Fiscal Policy: Pricing water to encourage conservation
 - Cover cost
 - Water conservation tax
- Water Substitution & Recycling
 - Encourage substitution with NEWater, Industrial Water, High Grade Industrial Water and Seawater
 - Encourage recycling of process water
- Water Audit
 - Targeted at industry and households
 - Regular visits
 - Reduction of allowable flow rates
 - Water audit of commercial/industrial premises
- Water Efficient Homes (WEH) Programme
 - Spray taps, installation of thimbles
 - Shorter showers
 - Wash laundry on full load, etc
 - Installation of pressure reducing valves at landed housing estates
 - Water efficient washing machines
- Use of Water for Landscaping/Gardening
 - Recycled water
 - Control excessive use of lawn sprinklers

Measures to reduce UFW could include:

- Accurate metering
 - 100% metering will help to account for usage
 - Good quality meters with accurate output
- Reduce Water Leakage
 - Leakage control
 - Use quality pipes and fittings: Copper and stainless steel
 - Pipeline replacement programme for all cast iron mains and galvanised iron connections
 - Quick response and rectification of leaks
 - Leak detection
 - Checking connections and distribution mains (day time)
 - Detection of leak noise by Acoustic Leak Localisers (night time)
 - Proper accounting of water used
 - Strict legislation on illegal draw-offs

(c) What does WSUD stand for, and why is it considered more sustainable than conventional curd-and-gutter storm drainage? List 4 examples of ABC Waters Design Features. (6)

WSUD: Water Sensitive Urban Design (in Australia and Singapore). It can be more generally referred to as Sustainable Drainage System (SUDS), an integrated surface water drainage approach that addresses quantity, quality and amenity aspects of storm water management. It is considered more 'sustainable' than conventional 'curb-and-gutter' storm drainage because SUDS:

- attenuates runoff flow rates
- reduces impact of urbanisation
- mitigates pollution
- protects and enhances storm water quality
- is 'sympathetic' to environmental setting and needs of local community
- provides wildlife habitat in urban watercourses
- encourages rainwater infiltration, restores natural groundwater recharge and resource

Examples of ABC: (any 4)

- Rain gardens
- Infiltration trench
- Bio-retention systems
- Wetlands
- Rainwater harvesting
- Cleansing Biotopes

(d) Briefly discuss how water resource development in future could potentially be impacted by threat of global warming. (3)

- Higher temperature increases crop and other water demand
- Significant changes in rainfall patterns –extreme weather conditions: Floods and droughts
- Coastal areas experience permanent inundation as ocean water levels increase
 - Sea water intrusion into coastal reservoirs and aquifers
- Flooding of wastewater plants and septic tanks in low-lying areas
 - Severe pollution of water sources

2. (a) List 2 examples for each of abiotic, biotic and social factors which make up the total environment. (3)

- Abiotic (non-living) factors:
 - Soil
 - Water
 - Atmosphere
 - Climate

- hydrology
- Sound
- Odors
- Tastes
- Biotic (living) factors:
 - Human beings
 - Fauna
 - Flora
 - Ecology
 - Bacteria
 - Viruses
- Ecological/Social factors
 - Quality of life
 - Cultural heritage
 - Material assets

(b) Using highway construction as an example, briefly explain the classification of direct, indirect and cumulative impacts. (6)

- Direct impacts
 - Noise from construction
 - Pollution (dust) in the nearby region
 - Construction site temporary close-down
- Indirect impacts:
 - Traffic congestion in downstream during construction
 - Urban growth near new highway
 - Influx of settlers
- Cumulative impacts:
 - Coupled with possible haze or other pollution, the area may become severely polluted during the construction period
 - Over the long run, with other development, the region may be more populated

(c) List 4 measures that help to mitigate effects of air pollution. (2)

- (any 4 from below) Regulatory control on open burning
- Vegetation cover (sand storm)
- Use of wind breakers
- Pave roads
- Alternative fuels such as methanol, ethanol, CNG, LPG
- Exhaust emission control technologies(e.g. catalytic converter for vehicles)
- Purifying air: Cyclones, scrubbers, fabric filter, precipitators, adsorption, absorption

(d) Describe briefly the different types of simulation models that can be used for EIA. (3)

- Physical Models
 - Small scale models of the environmental system in which experiments can be carried out to predict future changes
- Experimental models
 - For example, in-situ tracer experiments to monitor movement of releases into the environment.
- Mathematical models
 - Use mathematical equations to simulate behaviour of environmental systems
 - Can be deterministic or stochastic, stationary or dynamic, empirical or internally descriptive, homogeneous or non-homogenous, generalized or site-specific

(e) Define sustainable development in a sentence, and explain briefly how EIA aids in sustainable development. (3)

Sustainable Development can be defined as development that meets the needs of the present generation without compromising the ability of future generations to meet their needs.

EIA process allows better management of the use, renewal and conservation of all natural resources, and hence in the long term sustainable development.

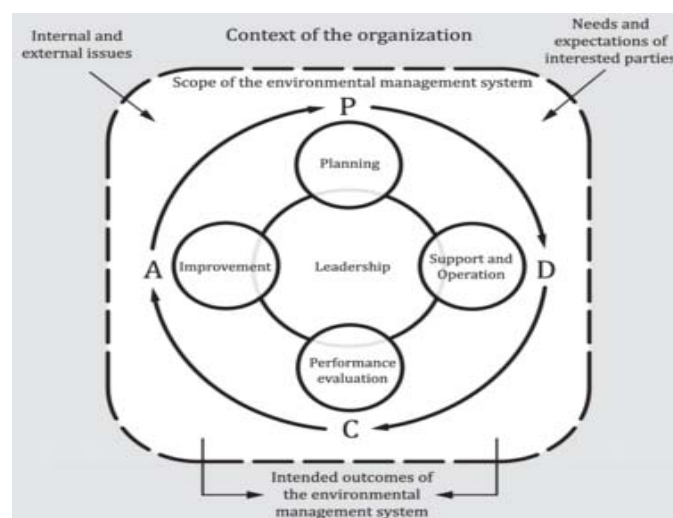
3. (a) Explain the 3 principles of the Workplace Safety and Health Act.

- Principle #1
 - Those who create risks must be responsible & held accountable to reduce, or eliminate the risks to prevent accidents
 - These responsibilities will involve persons along the whole process chain including top management
 - From “managing risks” to “identifying and eliminating risks before they are created”
- Principle #2
 - Industry itself must take greater ownership of safety outcomes
 - Management & workers should not merely follow the “letter of the law” but, also address safety aspects outside prescribed legislation.
 - From “compliance with the letter of the law” to “proactive planning & action to achieve a safe workplace”
- Principle #3
 - We should prevent accidents through higher penalties for poor safety management

- Current mindset- only safety lapses resulting in mishaps are severely
- Greater financial disincentives & penalties will be imposed on workplaces with unsafe systems, before any accident has occurred.

(b) How would you define a 'management system'? Briefly describe the 5 steps in implementing a safety management system. (11)

A management system is a network of interrelated elements, including roles, responsibilities, authorities, relationships, functions, processes, procedures, practices and resources used to establish policies and objectives that lead to the establishment of programs and procedures to manage particular areas of interest. (e.g. quality, environment, safety, etc.)



The Risk Management Process:

- Preparation
 - form team: appoint leader, members and ensure RM team is trained and competent in risk management
 - identify tasks of each process: set RA scope, divide the workplace into distinct areas and assign RA team for each distinct area
 - RA team to prepare inventory of work activity
 - gather relevant information related to RM scoping & process: workplace layout plan, process or work flowchart, list of work activities, inventory of tools, machinery, chemicals, records of past incidents and accidents, WSH inspection records and audit reports, user manuals, safety data sheet, relevant legislation, codes of practice, safe work procedures, employee medical records etc.
- Risk assessment
 - Identifying and analyzing safety and health hazards associated with work, determine sources of hazards
 - Assessing the risks involved

- Prioritizing measures to control the hazards and reduce the risks, take action according to the recommended actions based on the current risk level
- Risk Control: Consider effective measures in the hierarchy of control
- Implementation
 - Obtain management approval and prepare an action plan to implement the measures
 - Implement the recommended risk control measures
 - Monitor the action plan
 - Communicate the hazards and their controls - Get manager to inform all persons exposed to the risk about nature of risks, measures/safe work procedures implemented and means to minimize/eliminate the risks
- Review: Audit/ regular inspections
 - Ensure regular inspection and audits are carried out so that the risk control measures are implemented and effective
 - Review RA on a regular basis
 - Record keeping
 - Ensure RA records are readily available upon request (RA forms, RA registers, Risk control measures records, Safe work procedures, Training records, Retain all RA records for at least three years)

4. (a) Briefly explain the following 2 concepts: (4 marks)

(i) Public Good

(ii) Contingent Valuation

Public Good: non-excludable, non-rival consumption. (e.g. Lighthouse, flood control)

The Contingent Valuation Method (CVM) is used to estimate economic values for all kinds of ecosystem and environmental services. It involves directly asking people, in a survey, how much they would be willing to pay for specific environmental services. In some cases, people are asked for the amount of compensation they would be willing to accept to give up specific environmental services. It is called “contingent” valuation, because people are asked to state their willingness to pay, contingent on a specific hypothetical scenario and description of the environmental service.

Contingent valuation is one of the only ways to assign dollar values to non-use values of the environment—values that do not involve market purchases and may not involve direct participation.

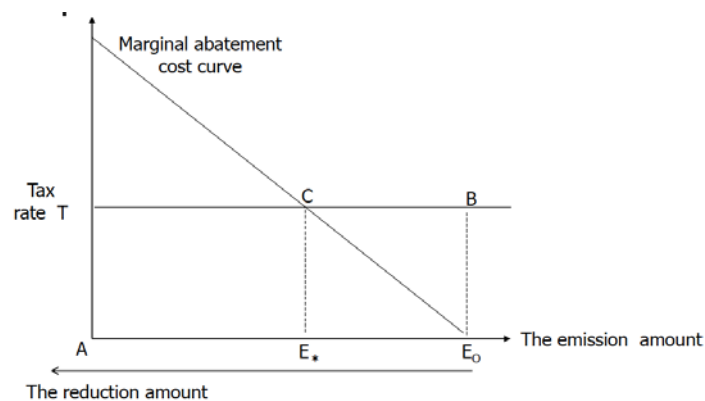
(b) Assuming there are 2 coal-fire power plants that emit GHG. The abatement cost function for each plant is $C_i = a_i + b_i(\text{Abatement}_i) + c_i(\text{Abatement}_i)^2$, $i = 1, 2$. The government imposes a tax rate t on each unit of emitted GHG. How many units of GHG will each plant

emit? If government requires both plants to abate by the same amount, is it efficient at the society level? If no, what can be done? (4)

After the introduction of tax policy, when the company emits at E_* , the amount of tax payment is equal to $AE \times CT$. The emission reduction cost is equal to $E''E \times C$. The company can save CBE'' by the reduction.

The company does not want to reduce the emission at the lower level of E_* because the additional reduction beyond E_* takes much reduction cost.

Hence, the companies will decide on the emission amount so that the marginal abatement cost equals the tax rate.



If government requires both plants to abate by the same amount of GHG, it would not be efficient at the society level unless the MAC curves for the 2 companies are exactly the same. Otherwise, the marginal abatement cost of each company should be considered. When the marginal abatement cost of each company is the same, the total abatement cost of the two companies is the smallest.

(c) (i) Which SG's regulation must be used for HWM? Briefly explain the regulation's consignment process involved in the transportation, treatment and disposal of HW. (5)

The Toxic Industrial Waste Regulations (TIWR) must be followed.

To prevent illegal dumping and disposal of toxic industrial wastes, the movement of every consignment of wastes from a generator through a carrier to a collector is tracked by means of an Internet-based electronic submission of consignment note system (known as the e-Tracking System)

Generator:

- Shall prepare 5 copies of the consignment note
- Shall give 3 copies of the consignment note to consignor before transportation with 3 days

- Shall provide a statement regarding the safety requirements and action to be taken by carrier

Transporter/driver:

- Must be delivered by transporter to the recipient
- Note must be signed by transporter and recipient. The note must be kept by each transporter and recipient
- 2 copies of the consignment note to driver for delivery to the consignee
- Driver shall keep in the vehicle a copy the statement given to him
- Hazard warning panels and labels are needed

(ii) Determine whether the incinerator should be built. (10)

Cost: $7500000 + 550000 + 1000000 * [(1 + 0.075)^{20} - 1] / [0.075 (1 + 0.075)^{20}] = 18244491.36$

Benefit: $500000 * [(1 + 0.075)^{20} - 1] / [0.075 (1 + 0.075)^{20}] = 5097245.68$

Benefit/cost = $5097245.68/18244491.36 = 0.279 \ll 2.0$

Hence, it should not be built.

5. (a) (6 marks)

(i) Briefly elaborate on the function of global industrial economy in terms of resources/raw material, industrial process and consumer/users. Include the impact of such functions on the environment.



Industrial ecology: the study of flows of materials and energy in industrial and consumer activities

Based on personal understanding, try to explain the diagram above (close the loop). E.g. Waste from one industrial process can serve as the raw materials for another, thereby reducing the impact of industry on the environment

Their impacts on environment are generally good ones (reduce resource consumption and thus waste etc)

(ii) Illustrate with an example how an industry could benefit from forming a synergetic and collaborative relationship with another.

A synergetic and collaborative relationship, often referred to as “industrial symbiosis”, describes an industrial process in the context of an individual enterprise, between enterprises and in the regional or global level which brings “synergetic advantages”.

Industrial symbiosis: collective resource optimization such as byproduct exchange and resource sharing

It offers opportunity for collaboration and synergistic proximities based on geographical location, so as to promote sustainable developments.

Examples: clustering of similar industries to share energy and waste management facilities (example – wafer and electronics park, aerospace park); co-location of utilities (water reclamation plant and incineration plant)

(b) (6 marks)

(i) Illustrate with an example the role of water as a resource.

* this question is under MFA, so just use an appropriate example to explain e.g. making coffee needs water as input (raw material/resource)

(ii) Elaborate with examples the functions of MFA and LCA, and differences between them.

Mass balance analysis considers the amount of materials (including energy consumption) that flow through the industry process. [Mass flow analysis. MFA]

MFA provides information on the inventories (may be qualitative and/or quantitative) while LCA is deployed to evaluate the material and processes, from cradle and grave. Depending on the target of the analysis, LCA may be expanded to include primary resources and energy used for selected components of the resources included in the current process.

Example: MFA of a water reclamation plant includes influent water, chemicals used, energy consumed and the amount of water treated, recycled, reused and sludge produced.

Whereas LCA may include all of the above, including the materials of the various tanks, machineries and cost of disposals of the gases emitted, treated water and sludge.

(c) What is the usual cause of land contamination? Name 6 broad categories of HW. (6)

Land contamination refers to the inappropriate handling of hazardous waste that leads to land that contains sufficient quantities or concentrations of substances in or under the land that are actually or potentially hazardous to direct or indirect receptors.

Hazardous wastes refer to waste (solids, sludge, liquids, and containerized gases) that pose a substantial present or potential hazard to humans or other living organisms because such wastes are non-degradable or persistent in nature; they can be biologically magnified; they can be lethal; they may otherwise cause or tend to cause detrimental cumulative effects.

6 broad categories: (*NEUMIC)

- Nuclear waste
- E-waste
- Universal waste (household haz. waste)
- Medical waste
- Industrial waste
- Construction waste (e.g., asbestos, lead paint, mercury lights)

(d) Describe what industries need to do to comply with EPMA. (7)

EPMA requires industries that store/transport toxic substances:

- Use a method of storage, operation or process to prevent water pollution
- Install and operate pollution monitoring equipment to prevent and detect any leakage or discharge
- Carry out specific tests on equipment, tanks or any other related facilities and to submit the results of these tests
- Prepare and submit contingency plan for events of accidental discharge
- Conduct studies on pollution control
- Self-monitor
- Take mandatory insurance
- NEA can arrest offenders, enter any premise for investigation, search or seize any records if they believe discharges are being made without license

