1. (a)

i. Pm refers to the maximum population that can be sustained with the current Earth's carrying capacity

ii. Earth's carrying capacity is a big unknown and hence Pm cannot be accurately estimated.

Human's unique capability for innovation (e.g. automation, healthcare, food, energy) can increase the carrying capacity and hence increases the number of humans the earth can sustain.

The growth models use too few information while detailed statistics, e.g. birth/death rates, (im)migration rates are collected to give a more accurate reflection of Pm.

iii. $Pm/3 = Pm/(1+e^{-r(t0-tm)})$

$Pm/2 = 3/2 * Pm/(1+e^{-r(t0-tm)})$

$1+e^{-r(t0-tm)} = 3$

$e^{-r(t0-tm)} = 2$

$t0-tm = -(\ln 2)/r$

$tm = \ln 2/r + tm$

(b) Discuss key issues in the Brown vs Green agenda debate between developing and developed countries with regards to environmental pollution generated during industrialization

One key issue lies in which agenda is more critical in developed and the developing countries. Developing countries are more concerned with brown agenda issues where concerns are immediate and local, such as Inadequate local safe water supplies; poor sanitation; local air pollution; inadequate/lack of waste collection. This is to attain greater standard of living and equity which the richer countries have enjoyed for many years. The developed countries on the other hand are more concerned with the green agenda issues such as more distant sources of water /higher technology treatment of (waste)water, controls on air pollution/distant power generation, better waste disposal/more distant disposal sites.

Developing countries such as China and India are currently great polluters of the environment due to their rapid industrialization. However, developing countries such as US and UK have cumulatively more pollution to achieve their current standard of affluence. Hence there is a problem of who is to be responsible for environmental pollution, and whether developing countries should develop at the expense of the environment. There is also the critique that developed world should stop shifting environmental burdens onto distant people/ecosystems, and even into future generations.

Developed countries are also under the pressure to help the developing countries to resolve the brown and green agenda issues such as investing in green energy and improving the efficiency of industries.

2. (a)

i. Low impact development replaces the impervious surfaces with natural ecological landscapes (e.g. wetlands, bioswales, rivers) which increases infiltration rate and reduces runoff coefficient C, and hence the peak runoff Q.
Green roofs and pervious paving act as detention ponds which also reduces the runoff discharge Q by reducing C.
Greater infiltration also leads to a longer time of concentration tc to reach largest peak discharge, which also means the intensity I will decrease. This therefore reduces the peak runoff Q. Reduction in peak runoff will mean a lower risk of flooding as the drainage system will be less saturated before the rain stops.

ii. $R = 1-(1-1/20)^{50} = 0.923$

Doubling the frequency of occurrence, new return period = 10 years.
$R = 1-(1-1/10)^{50} = 0.995$

(b)

i. Municipal solid waste; Industrial waste; Hazardous waste.
Municipal waste by city, hazardous waste by the basal convention

ii. Aerobic processes require ample oxygen for decomposition of waste, while anaerobic processes refer to decomposition in the absence of oxygen. Bioreactor landfill allows for natural and accelerated decomposition through both aerobic and anaerobic pathways, which is achieved by controlled addition of supplemental air and/or water, and controlled recirculation of leachate. This leads to greater environmental protection, optimize waste degradation and ultimately reduces the amount of land required for landfills.

3. (a)

i. Bio-fixation of CO_2 refers to the conversion of gaseous CO_2 into carbohydrates, eg glucose, by plants via photosynthesis.

ii. In the natural carbon cycle, CO_2 is converted into sugar and stored in plants and phytoplankton matter via photosynthesis, and this stored carbon is released back into the atmosphere during decomposition.

iii. Respiration; decomposition

iv. Adv – Inexpensive method of carbon sequestration as it does not require heavy machinery or industrial support
The stored carbon can be used as biofuel and is hence carbon neutral.
Disadv – The CO_2 will eventually return to the atmosphere after decomposition/burning, hence is a short term storage
Requires large land areas to plant trees
Takes a long time to grow

(b)

i. Global climate variability refers to changes in the climate due to natural causes, while anthropogenic climate change refers to human induced climate change.

ii. Chlorofluorocarbon (CFC). CFC causes ozone layer depletion in the stratosphere and the harmful UV rays can penetrate into the Earth. This leads to many health issues as UV rays can cause mutations and lead to skin cancer.

4.

a) Trihalomethane (THM), Haloacetic acids (HAA), Haloacetonitriles (HANs).

b) Urine contains ammonia NH3 which can react with the chlorine in swimming pool water to form chloroamine, which is a harmful disinfection-by-product.

c) Yes it will help, as the disinfection-by-products in swimming pool water are formed by reaction of organic compounds with free chlorine in water (eg. $R\text{-}C(O)\text{-}CH_3 + HOCl \rightarrow R\text{-}C(O)\text{-}OH + CHCl_3$). Removing the organic compounds will reduce the risk of DBP formation. However, irresponsible practices such as urinating in the pool can still lead to formation of harmful and volatile DBP and needs to be discouraged.

d) Hydrogen peroxide will react with free chlorine to form oxygen, sodium chloride and water which are harmless products. $H_2O_2 + NaOCl \rightarrow O_2 + NaCl + H_2O$. Hence, there is no more chlorine or H2O2 for disinfection, leading to algae growth.

5.

a) Water, food and energy are intrinsically linked. Water is required for the production of food. For instance, 1kg of beef contains 15500L of virtual water, and agriculture is also water intensive. Without clean water, food production reduces and there can be no food security. Without water, energy security will also be compromised, as mining or extraction of oil also requires large amount of water. Similarly, energy is required to treat water and deliver water to all areas. Hence without energy access, water supply will no longer be secure.

b) Climate change leads to global warming, changing rainfall pattern, more frequent natural disasters and rise in sea levels.
Increase in temperatures lead to water shed shrinkage, resulting in less water to agriculture. Pest infestation may occur more frequently as they thrive better under warmer conditions. This thus reduces the food supply and eventually affects human health. Cooling energy also increases and with less available for other important sectors.

Changing patterns of rainfall can lead to droughts, hence affecting agricultural supply. High temperature and precipitation prevents crops from growing properly.
Climate change leads to also increase in frequency of extreme weather events like floods, hurricanes, heat waves, droughts. This can destroy the food supply and energy infrastructure, resulting in loss of food and energy production. Sea level rise can also destroy the energy infrastructure especially along coastal areas.

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