IM SYLLABUS (2024)

ENVIRONMENTAL SCIENCE IM 11

SYLLABUS

Environmental Science IM 11	(* Available in September)
Syllabus	1 paper (3 hours)

Introduction

The syllabus is meant to offer an opportunity for candidates that may not have prior knowledge of science, to study a range of environmental issues from a scientific perspective. Although other dimensions (such as social, cultural, economical and political aspects) may be considered, the programme primarily seeks to provide scientific knowledge and understanding enabling the candidate to review environmental issues more objectively. This would enable them to assess the dimension of the issue and to consider alternative strategies for its resolution. The programme seeks to provide basic environmental literacy for candidates who would later pursue a wide variety of careers but it is also meant to encourage and provide basic knowledge to others who would opt for careers directly related to the environmental field.

To promote a more holistic framework of environmental issues, the approach adopted must necessarily be interdisciplinary, involving inputs from various fields related to the issues being studied. While ensuring that the programme provides a global perspective, candidates should also be familiarised with the local and regional dimensions of the environmental issues being studied.

Aims

The programme seeks to help candidates to:

- acquire and apply scientific knowledge about environmental issues so as to understand the underlying scientific concepts,
- develop a deeper understanding of environmental issues by relating scientific knowledge with other perspectives,
- acquire the necessary problem-solving skills that would enable them to examine and propose alternatives to a variety of environmental problems,
- develop pro-environmental values and attitudes that foster environmental responsibility, and
- critically evaluate their attitudes, behaviour and values and consequently adopt a more sustainable lifestyle.

Scheme of Assessment

The syllabus will be examined by a one three-hour paper. The paper will consist of two sections. Section A will comprise a number of short answer questions. This section carries 80 marks. Section B carries 40 marks and will contain six structured/essay type questions. Candidates are expected to answer all questions from Section A and to choose two questions from Section B.

Grade descriptions

Grade A	Grade C	Grade E
The candidate demonstrates overall above average ability in dealing with environmental situations. More specifically, candidates are likely to be able to demonstrate the ability to:	The candidate demonstrates average ability in dealing with the environmental situations presented. More specifically, candidates are likely to be able to demonstrate the ability to:	The candidate demonstrates very limited ability in handling the environmental situations presented. More specifically, candidates are likely to be able to demonstrate the ability to:

1. master all the scientific facts and principles related to the environmental issues tackled by the syllabus.	1. master most of the scientific facts and principles related to the environmental issues tackled by the syllabus.	1. understand only the very basic scientific facts and principles related to the environmental issues tackled by the syllabus.
2. recall a wide range of scientific facts and principles and shows that s/he understands their significance in dealing with environmental problems.	2. recall a good number of scientific facts and principles and handle satisfactorily most of the environmental problems presented.	2. recall the basic scientific facts and principles and have a limited ability in using this knowledge to solve environmental problems.
3. demonstrate above average ability at interpreting correctly any scientific information presented about an environmental situation.	3. demonstrate average ability at interpreting scientific data related to an environmental problem.	3. very weakly interpret scientific data related to an environmental problem.
4. fully recognise the extent of an environmental problem and suggest a wide variety of feasible alternatives in its resolution.	4. recognise the extent of an environmental problem presented and present at least some feasible alternative for its resolution.	4. recognise the extent of the environmental problem presented but cannot offer any alternative for its resolution.
5. very evidently show that s/he is very well informed about current environmental issues and how the local and global community is reacting to the situation.	5. show that s/he is reasonably informed about current environmental issues and how the local and global community is reacting to the situation.	5. show very poor or limited interest and knowledge about current environmental issues and about how the local and global community is reacting to the situation.
6. show above average ability in skills related to presentation of ideas particularly in essay writing.	6. show average ability in skills related to presentation of ideas particularly in essay writing.	6. show very limited ability in skills related to presentation of ideas particularly in essay writing.

Subject Content

Sustainable development is a cross-cutting theme throughout this syllabus. It is defined as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (Brundtland Report, 1987) and evidences an increasing interest and concern about the management of environmental resources worldwide. Whereas sustainable development remains an almost abstract concept that is never straightforward to implement, it is broadly described in terms of striking the right balance between economic growth, improved social welfare and environmental protection. A greater understanding of the themes outlined in this syllabus requires an appreciation of sustainable development principles.

Part A. *BASIC SCIENTIFIC CONCEPTS*

Basic Scientific Concepts are introduced at a level that will make it possible for candidates to understand and follow the subject matter presented in this syllabus.
These concepts will not be directly examinable, <u>but</u> the candidate's understanding of the applicability of the scientific principles listed will be tested through questions set on the other parts of the syllabus.

Topic	*Subject Content*	*Knowledge expected*
Nature and organisation of matter	States of matter and their dependence on temperature.	Matter can exist in the solid, liquid and gas form and that these three states are interchangeable as a result of changes in temperature. Matter is made up of elements, compounds and mixtures.
	Atomic nature of matter.	The main atomic constituents are protons, neutrons and electrons. An understanding of the relationship between atomic particles, atomic mass and atomic number.
	Unstable atoms and radioactivity.	Atoms of some elements are unstable and as result of their instability they break down and release energy in the form of radioactivity. The positive use of radioactivity as an energy source.
	Formation of compounds	Elements are able to combine and form compounds by reacting together.
	The importance and profusion of the molecules of carbon.	The main organic chemicals, including naturally occurring materials. Candidates should be able to explain polymerisation and the formation of large molecules (e.g. proteins, nucleic acids polysaccharides and synthetic substances). The great importance of organic compounds.
	Chemical changes and conservation of matter.	A chemical change takes place when compounds are formed. Elements that combine to form compounds have not been destroyed, but are conserved in another form. Candidates are expected to be able to use and balance chemical equations in representing chemical change in a qualitative and quantitative manner in order to understand the concept of conservation of matter and the concept of the Mole. Candidates are also expected to be able to work out simple calculations on reacting masses using Moles.
	Important chemical processes.	The different types of chemical processes (combustion, precipitation and neutralisation)
	Energy changes accompanying chemical reactions.	Formation and breakdown of compounds by chemical reactions is accompanied by energy changes, which might be exothermic or endothermic.
	Acidity and the pH scale.	Chemicals are either acidic, alkaline or neutral. The use of the pH scale to measure the acidity, alkalinity or neutrality of a substance. (The mechanics and actual meaning of the units 1- 14 is not required).
	Important elements and compounds	The chemical formulae of the following: Lead Pb; Oxygen gas O_2; Nitrogen gas N_2; Mercury Hg; Methane CH_4; Sulphur Dioxide SO_2; Nitrogen Dioxide NO_2; Ozone O_3; Silicon Dioxide SiO_2; Water H_2O; Carbon Dioxide CO_2; Glucose $C_6H_{12}O_6$; Ammonia NH_3; Carbon Dioxide CO_2; Calcium Carbonate $CaCO_3$; Sodium Chloride NaCl.
Energy and energy flow	Forms of energy	Different forms of energy: potential (chemical, nuclear, and gravitational), solar, kinetic and heat.
	Energy and power and their units.	Energy as the ability to do work and measured in J (joules). Power as the rate of energy use and measured in W (Watts) or Js^{-1} (Joules per second). How energy consumption is measured in kWH.

Topic	*Subject Content*	*Knowledge expected*
Energy and energy flow (cont…)	Energy and its transformation.	The sun as the major source of energy. Photosynthesis as a process through which light energy is transformed into food energy which is taken up by animals. Energy transformations that must take place in order to use the energy stored in fossil and nuclear fuels. Comparison of the efficiency and losses of the different types of power plants (nuclear, fossil fuel, and solar). Candidates are also expected to be able to work out simple calculations on energy transformations applying the following formulae: $PE = m\ g\ h$ $KE = \frac{1}{2}\ m\ v^2$ $\text{Efficiency} = \frac{\text{Output}}{\text{Input}} \times 100$ $q = mc\theta$ (or $q = mc\Delta T$)
	Electromagnetic spectrum.	The relationship between wavelength and frequency of radiation ($V = f\lambda$). The electromagnetic spectrum as a continuous range of radiation ranging from low energy waves to high energy waves. Candidates must also understand that all waves have similar properties and travel at the same speed and that the difference is only in the frequency and wavelength.
The cellular basis of life. Cells and types of cells. DNA and heredity.	The cell as the basic unit of living things.	Differences between prokaryotic and eukaryotic cells. The great complexity of a cell. The presence of organelles in the cytoplasm and the role of the main organelles (nucleus, cell membrane, cell wall, and chloroplasts). Differences between plant and animal cells.
	Cell differentiation to cater for specialisation	Awareness of the presence of different cells that cater for different functions
	Presence of chromosome in cells. DNA as the blueprint of life.	DNA as a double-helix shaped molecule containing compounds that act as codes which determine all bodily functions. DNA's ability to replicate itself leading to transmission of genetic material. (Details of replicating process are not necessary.) DNA's proneness to mutations - bringing about an alteration of the genetic code (with beneficial, bad or neutral effects).
	Cell division – Important differences between Mitosis and Meiosis	Mitosis takes place in somatic cells and produces identical cells resulting in growth or cell replacement. Meiosis produces cells that will develop into reproductive gametes with half the number of chromosomes of parent cells. Detailed sequences of events which take place during these two processes of cell division are not required.
	Types of variation: inherited and environmental.	Variations that provide an advantage to organisms over the pressures of the environment bring about an evolutionary process resulting in a variety of life.

Part B. *THE PHYSICAL ENVIRONMENT*

Topic	*Subject Content*	*Knowledge expected*
The Lithosphere	Introducing Earth	The Earth's place in Space: the Earth as one of 8 planets orbiting the Sun, the Sun as a star in a galaxy, the galaxies forming the Universe. The formation of the solar system.
	Earth's internal structure	Inner and outer core; the mantle and convective currents in it; the lithosphere as a thin and shifting crust floating over the asthenosphere.
	Plate tectonics	Converging, diverging and conservative plate boundaries. Knowledge about paleomagnetism is not required. Earthquakes and earthquake belts; volcanism, mountain formation, ocean trenches and mid-ocean ridges as a process of plate tectonics. Candidates should be familiar with the following terms: epicentre, focus, magnitude and intensity of earthquakes.
	Rocks and minerals	The difference between rocks and minerals. Classification of rocks as igneous, sedimentary and metamorphic.
	The rock cycle.	An understanding of the rock cycle in terms of weathering, erosion, transport and sedimentation, volcanism, subduction and metamorphism.
	Biogenic sedimentation**.**	Biogenic sedimentation exemplified by the formation of Maltese sedimentary rocks.
	Soil	Soil formation, composition and soil type classification based on particle size. Soil horizons (A, B, C) in relation to stratification, water percolation, mineral content and root penetration. Soil type as exemplified by clay soil, sandy soil and loam soil. Types of Maltese soils: Terrarossa; Carbonate Raw Soil (ash grey soil); Xerorendzinas. Detailed descriptions of these soil types are not expected.
	The carbon cycle	Treatment should include fossil fuels as an integral component of the carbon cycle.
	The nitrogen cycle	Treatment should include the anthropogenic inputs of nitrogen compounds to the soil.
The Hydrosphere	The hydrologic cycle.	The hydrologic cycle in terms of precipitation, interception, infiltration, ground water, run-off and evaporation, together with the energy components of the cycle - solar radiation and gravitational force.
	The oceans – their composition and stratification.	Relation of ocean stratification to temperature variation with depth and the presence of a thermocline. The variation of light intensity with depth and the importance of the photic zone. Candidates are expected to be familiar with the meaning of the following terms: coastal zone, open sea, photic zone, bathyal zone and abyssal zone.

Topic	*Subject Content*	*Knowledge expected*
The Hydrosphere (Cont…)	Tides	Simple understanding of tides in terms of the moon's gravitational pull.
	Freshwater resources.	Strategies for providing adequate freshwater supplies including surface and aquifer storage, and desalination plants. An elementary treatment of reverse osmosis is expected. The effects of overuse and contamination of surface and groundwater.
	Groundwater use in Malta.	The use of groundwater in Malta in terms of a simple model of the Maltese groundwater dynamics, to include the upper (perched) and lower (mean sea level) aquifers.
The Atmosphere	Structure and composition of the atmosphere.	The physical and chemical nature of the atmospheric layers, especially the troposphere and stratosphere. Only a brief awareness of mesosphere, thermosphere and exosphere is expected. Candidates should be acquainted with, but not memorise, the various heights and temperatures associated with atmospheric stratification.
	Interactions of solar radiation with the atmosphere. The effects of ionising radiation on gases in the atmosphere and living organisms.	The wavelength, frequency and intensity of radiation at the outer limits of the atmosphere and at the Earth's surface.
	Albedo, reflection and scattering of radiation. The influence of gases and water vapour on re-radiated energy.	The greenhouse effect as a natural phenomenon.
	The Earth's overall radiation budget.	The total energy received by the Earth from the Sun is equal to that ultimately emitted back into space. Candidates do not have to memorise actual values.
	The formation and shielding effect of the ozone layer.	Simple chemical equations for ozone formation and destruction. Candidates should understand that these two processes proceed at equal rates in nature.
	Weather and climate.	Seasonal and diurnal variations in insolation.
	Global circulation with reference to global convection cells	The relation between the major circulation patterns: polar cells, Ferrel cells and Hadley cells.

Part C: *THE BIOSPHERE*

Any coherent study of the natural environment requires a sound knowledge of the ground rules, which regulate the varying abundances of organisms within habitats. At the end of this module, candidates should be familiar with the basic processes that operate in all natural environments. Candidates are expected to be capable of applying facts and principles learnt in this module to the resolution of situations with which they may be unfamiliar.

This module adopts a bottom-up approach, proceeding from the dynamics of populations through communities to ecosystems and biomes. Particular attention is to be paid to the recent dynamics of the human population. The inherent complexity of the material in all of the units listed necessitates a superficial treatment of each. Candidates would nevertheless be expected to have developed an appreciation of how the functional units of the natural environment are interrelated. As far as possible, candidates should also be able to cite locally occurring organisms and environmental issues.

Unit 1: The dynamics of biological populations		
Topic	***Subject Content***	***Knowledge expected***
Factors governing population size	Natality Mortality Immigration Emigration Recruitment	Awareness that, in nature, population sizes are generally in a state of stable equilibrium mediated by interaction between various factors.
Limitations to population growth	Environmental resistance Carrying capacity Density-dependence and density-independence in control of population growth	An appreciation of these concepts is required for interpretation of the population models which are to be presented at a later stage. No mathematical treatment of these concepts is required.
Selected models of population growth	Linear growth Exponential growth Sigmoid growth Irruptive growth	Treatment should be mostly qualitative, Nevertheless, candidates would be expected to handle simple calculations concerning linear growth and exponential growth. The ability to interpret population cycles from all four models is also expected.

Unit 2: The dynamics of the human population		
Topic	***Subject Content***	***Knowledge expected***
Patterns of growth of the human population	Growth patterns: - during the Palaeolithic period - during the Neolithic period - throughout recorded history up to the Industrial Revolution - following the Industrial revolution	Basic overview of changes throughout human history and prehistory. No elaborate details of human history are required, although candidates should be acquainted with growth patterns throughout the Palaeolithic period (500000 BP - 10000 BP), Neolithic period (from 10000 BP) and following the Industrial revolution. In all cases, candidates should be aware of the main limitations on the growth of the human population operating in each period of time. Candidates should be familiar with recent patterns of population growth but are not expected to memorise any dates or landmark sizes of the population.
	Crude birth and death rates	The use of crude birth rate, crude death rate and doubling time in simple calculations is expected.

Topic	*Subject Content*	*Knowledge expected*
Patterns of growth of the human population (Cont…)	Approximate doubling time of an exponentially increasing population	t=70/G (where G is growth rate as a percentage and t is doubling time). The derivation of the relationship between doubling time and growth rate of an exponentially increasing population is not required. Candidates should appreciate why birth and death rates calculated in this way are 'crude'.
Present patterns of human population growth	Population growth in less developed countries (LDCs) Population growth in more developed countries (MDCs)	Candidates are expected to be aware of the different rates of growth in MDCs and LDCs and should also be capable of suggesting reasons as to why this is so. The implications of a high population growth rate on food supply and on the exploitation of land should also be stressed.
The demographic transition	Stage 1 (high birth rate and high death rate) Stage 2 (high birth rate and falling death rate) Stage 3 (falling birth rate and low death rate) Stage 4 (low birth rate and death rate) Stage 5 (death rate higher than birth rate)	A brief overview of the probable changes in population growth patterns with increasing economic development. Candidates should be capable of drawing and/or interpreting data, either graphical or in tabulated form pertaining to a demographic transition.
Age-gender structure of populations	Construction and interpretation of age-gender diagrams	Awareness of the age structure of a growing population, a stable population and a diminishing population. Comparison between age structures of LDCs and MDCs.
	Use of age-gender diagrams for predictions of future population sizes and future needs of a population.	Candidates should be capable of projecting the future growth of a hypothetical population using age-gender diagrams. Incidental reference to the main implications of various patterns of population growth is also expected.
	History of population growth in the Maltese Islands from the beginning of the 20th century.	Candidates should be acquainted with patterns of population growth in the Maltese Islands and should be capable of interpreting age-gender diagrams for the population of the Maltese Islands. (Age-gender diagrams for the Maltese Islands may be obtained from the *Demographic Review*).

Unit 3: Properties of biological communities		
Topic	*Subject Content*	*Knowledge expected*
Interactions between species	Competition. Interspecific and intraspecific competition Outcome of competition: coexistence or competitive exclusion	Treatment of competition should be neither mathematical nor elaborate. Nevertheless, candidates should be capable of interpreting hypothetical and real-life situations in order to distinguish between different modes of competition.
	Predation	Predation is defined as removal of prey organisms from their population. Candidates are expected to illustrate their accounts with examples.

Topic	*Subject Content*	*Knowledge expected*
Interactions between species (Cont…)	Parasitism	Treatment of parasitism should be basic and qualitative. Candidates should be familiar with the general process of parasitism and with the general characteristics of endoparasites and ectoparasites. Candidates are expected to illustrate their accounts with examples.
	Mutualism	Treatment of mutualism should not be elaborate. The general dynamics and evolutionary advantages of mutualism. Candidates are expected to illustrate their accounts with examples.
	Amensalism and Commensalism	Basic definition of these interactions. Candidates are expected to illustrate their accounts with examples.
Ecological Niche	Concept of ecological niche. Fundamental niche and realised niche. Effect of competition on niche breadth. Ecological release. Relative niche breadths of generalist and specialist species	Definition and scope. The niche as the role and relationships of an organism within its community. Definition of ecological release. Relative advantages and disadvantages of specialist species and generalist species.
Biological Diversity	Species richness Genetic diversity Habitat diversity Landscape diversity Patterns in species richness	Treatment of biological diversity need not be mathematical, but should stress the relative importance of species richness and associated evenness of species in a community. Other aspects of diversity should also be presented in order to familiarise candidates with different forms of variety in biological communities. Candidates would also be expected to have a very basic understanding of the increasing trend of species diversity from the poles towards the equator,
Ecological succession	Mechanism of ecological succession.	The treatment is qualitative and should be illustrated by examples of a terrestrial example (succession from grassland to woodland) **or** a transition from an aquatic ecosystem to a terrestrial ecosystem. Familiarity with the following terms in required: pioneer community, pioneer species, climax community, sere, seral stage.
	Forms of succession.	Primary and secondary succession. Autogenic and allogenic succession.
	Effects of disturbance of succession	Brief treatment of the role of disturbance in reverting a succession to an earlier seral stage.

Unit 4: ***Ecosystems***		
Topic	***Subject Content***	***Knowledge expected***
Definition of ecosystem	Scope of definition	Different implications of the term “ecosystem”. Candidates should be familiar with the scope of the term, from large-scale ecosystems to very small-scale ecosystems.
	Transitional ecosystems (ecotones)	Candidates should be aware that the borders of ecosystems are seldom well-defined and are therefore characterised by ecotone development, where biological diversity is often higher than in adjacent (“parent”) ecosystems.

Topic	*Subject Content*	*Knowledge expected*
Food chains and food webs	Food chains and food webs. Relative stability of food chains and food webs. Keystone species	Elementary introduction to food chains and food webs. Distinction between grazer food chains and decomposer food chains. Candidates should be capable of interpreting simple food webs and should also be capable of predicting the possible implication of removing or adding species from or to the system in order to demonstrate the level of stability. Awareness of the unequal role of the organisms within a food web; keystone species as organisms exerting significant effect on the other components of the food web without necessarily being present in high abundance.
Energy flow in ecosystems	Trophic levels	Candidates should be aware of the basic trophic structure of food webs and are expected to be familiar with the following terms: producer, primary consumer, secondary consumer and higher, top carnivore, decomposer.
	Transfer of energy across trophic levels	Treatment of energy transfer across trophic levels should familiarise candidates with the concept of ecological efficiency. This would be supplemented by realisations as to why food webs do not have a large number of trophic levels and why organisms at the top of the food chain are rare.
	Pyramids of number and pyramids of biomass	Treatment of pyramids of number and pyramids of biomass is expected to be elementary.
Stability of ecosystems	Resistance and resilience of ecosystems	Candidates should be aware of the meaning and significance of resistance and resilience in determining the dynamics of ecosystems. The implications of resistance and resilience should be illustrated by examples. No elaborate treatment is necessary.

Unit 5: Biomes		
Topic	*Subject Content*	*Knowledge expected*
Physical, climatic and biological characteristics of the main terrestrial biomes	Tundra Desert Temperate forests Grassland Mediterranean scrubland Tropical rainforest	The influence of precipitation and temperature on biome development should be stressed as should the role of dominant vegetation in defining major terrestrial biomes. Discussion of each of the major biomes is not expected to be exhaustive, rather, candidates would be expected to acquire an appreciation of a broad spectrum of ecosystems which may be compared with one another in terms of vegetation and climate. Candidates would be expected to be familiar with the climatic patterns, dominant vegetation (in terms of lifeform, not species) and adaptations of organisms in each of the biomes that shall be treated.

Part D: *HUMAN ACTIVITIES AND THE ENVIRONMENT*

Human activities have significantly altered the state of the natural environment and possibly some of the processes that sustain it. The following themes are meant to help candidates develop awareness, knowledge and understanding of local and global environmental issues that are related to the impact of humankind on the environment due to emissions of substances from human activities and/or due to the alteration of the environment and the natural processes that sustain life.

The major themes discussed in this section are: 1. Pollution of the Environment; 2. Degradation & Depletion of Natural Resources & Utilisation of Land. Each theme focuses on a number of major issues, which in turn relate to some of the basic concepts in Environmental Science. The themes are complementary to each other and are mainly intended to (a) help candidates view the various perspectives of human environmental impacts, (b) promote an objective and, where possible, quantitative study of the environment, (c) Illustrate ways how people can manage their environment through the use of scientific knowledge, and (d) address the main targets and priorities of sustainable development which relate to the environmental issues listed above.

Theme 1: Pollution of the Environment		
Unit 1: Basic concepts about Pollution		
Topic	***Subject Content***	***Knowledge expected***
Nature of pollutants	i) Pollution ii) Pollutant	Candidates are expected to be familiar with the following definitions: • Pollution: The release of energy or matter into the environment with the potential to cause adverse changes to an ecosystem (ecosphere or biosphere). • Pollutant: A substance or form of energy that when released into the environment may (directly or indirectly) have adverse effects on the biosphere.
General characteristics of pollutants	i) Mobility ii) Persistence iii) Synergistic action iv) Bioaccumulation v) Biomagnification vi) Primary & secondary pollutants	Candidates are expected to be familiar with the following terms and processes (definition and explanation of each term).
General characteristics of sources of pollution	i) Natural and anthropogenic ii) Point or diffuse source ii) Stationary or mobile source	Candidates are expected to be familiar with the following terms and processes (definition and explanation of each term).

Unit 2: Atmospheric Pollution *The release of 'wastes', from human activities, that interfere with the dynamic processes occurring in the atmosphere causing problems beyond their source area (long-range transboundary pollution). Consequently, atmospheric pollution must include reference to problems caused on a local, regional as well as global scale.*		
Topic	***Subject Content***	***Knowledge expected***
Acid Rain	The major acid rain producing substances: a. Nitrous oxides NOx b. Sulphur oxides SOx	Candidates are expected to be familiar with the sources of these gases and with simple chemical reactions that explain how these react to give rise to acidity in the environment. Only a qualitative treatment is required. Knowledge of the intermediate chemical transformations of acid rain will not be assessed. A comparison with natural rainfall acidity highlights the seriousness of the problem.

Topic	*Subject Content*	*Knowledge expected*
Acid Rain (Cont…)	The direct and indirect consequences of acid rain: a. Phytotoxicity and damage to vegetation b. Respiratory diseases c. Depletion of plant nutrients d. Acidity in fields, acidification of soils and damage to microbial communities e. Damage to aquatic ecosystems & organisms f. Corrosion of certain building stones (especially limestone), materials & metals (e.g. Aluminium roofs)	Candidates should become aware of the type of damage caused by acid rain and the repercussions of these damages on the environment and on human life.
Global climate change	Causes and rates of natural climate change.	The Milankovitch cycle, solar activity and volcanic activity.
	Global climate change as a consequence of atmospheric pollution Greenhouse gases: a. CFCs b. Methane c. Water Vapour d. Carbon dioxide e. Tropospheric ozone f. Nitrous oxide	Comparison of this phenomenon with the enhanced greenhouse effect due to human activity. Candidates are expected to be familiar with the chemical composition of the greenhouse gases, relative importance to the greenhouse effect and relative quantities expelled into the atmosphere. Candidates should also understand and be able to explain what makes these gases greenhouse gases.
	Sources of greenhouse gases a. Landfills b. Deforestation/fires c. Methane production d. Combustion of fossil fuels e. Propellant, refrigerant gases f. Gut fermentation in intensive livestock production	Candidates should be familiar with the processes which lead to the formation of these gases from the sources mentioned (E.g. Deforestation $C + O_2 = CO_2$)
	Consequences of global warming: a. Salinization b. Rising sea levels c. Flooding of low-lying land d. Species migration and extinction e. Increased evaporation, precipitation & storms f. Change in global climate patterns	A discussion about consequences of global warming should lead candidates to acquire knowledge and understanding about the possible scenarios projections which might develop on Earth in the next half century or so. (Since these predictions may change from time to time a specific list would be inappropriate)
Stratospheric Ozone Layer	Ozone depleting gases: a. NO_x b. CFCs	Candidates are expected to be familiar with the sources of these gases and with simple chemical reactions that explain how these react with ozone reducing the ozone shield. Candidates should be capable of comparing stratospheric ozone with ozone in the troposphere as a dangerous pollutant derived from photochemical reactions of primary/secondary pollutants (NO_x) and causing serious damage or death to humans and plants (Impaired lung function; Eye/nose inflammation; Leaf lesions; Impaired photosynthesis).

Topic	*Subject Content*	*Knowledge expected*
Smog	Smog formation and composition: a. Formation of smog enhanced by topographic features such as basins or valleys surrounded by highlands. b. The phenomenon of temperature inversion and static air masses. c. Suspended particulate matter from deforestation and incomplete combustion of fossil fuels and organic matter. d. Photochemical smog resulting from formation of secondary pollutants, NOx, VOCs and other hydrocarbons. (*No details of chemical reactions are expected*)	Candidates should become aware of damages caused by smog as well as the chemical reactions that lead to its formation and harmful effects.
	Damages caused by smog: a. Corrosion of buildings. b. Leaf symptoms & reduction in the photosynthetic efficiency. c. Respiratory diseases & reduced lung functions. d. Impacted urban areas, reduction in visibility, damages to vehicles.	A short discussion about the serious problems caused by smog in some major cities and highways/motorways. Candidates should also be aware of abnormal reactions such as the synergistic behaviour of ozone and sulphur dioxide.
Reduction & Control of Air Pollution	Methods of control: a. Biofuels b. Catalytic converters c. Flue gas desulphurisation (flue gas scrubbing) d. Reduced energy consumption e. Efficiency of energy conversion, improved engines f. Electrostatic precipitators g. Legislation & enforcement	For each method of pollution control, reduction or elimination discussed, candidates should be aware of how the mechanism works (qualitatively) and its major applications. However, candidates are expected to be familiar with basic equations of FGD. Candidates should link the control mechanisms mentioned with specific pollutants (e.g. Electrostatic precipitators for SPM). Since effective controls require legislation & enforcement of law, candidates should be aware of at least one example of an international treaty that has significantly helped to reduce pollution. E.g. Kyoto Protocol, Montreal Protocol, Convention on Transboundary Air Pollution. (*Knowledge of the actual content of the convention/protocol is NOT expected here*) Candidates may also include examples from the local context. e.g. VRT.

Unit 3: Water pollution		
Topic	***Subject Content***	***Knowledge expected***
Water Pollution	The main bodies of water to be included here are: a) The oceans b) Subsurface water c) Coastal waters d) Lakes & rivers e) Enclosed & semi-enclosed seas	Candidates are expected to know examples of water pollutants and how these end up in the sinks mentioned. Particular attention should be given to the pollution of subsurface and coastal waters as the final sinks for pollutants. (To the pollutants originating at sea, land pollutants must be added due to run-off).

Topic	*Subject Content*	*Knowledge expected*
Water Pollution (Cont…)	General properties and dynamics of water pollutants: a) Dispersal b) Biodegradation c) Photodegradation d) Size of emissions e) Volume of water considered f) Residence time of water/pollutant	The relative mobility of pollutants in water and factors influencing their concentration and durability in the water column.
Specific water pollution issues	Thermal pollution: a) Ecological consequences b) Temperature dependence of gas solubility in water c) Increased rates of chemical reactions at higher temperature	Candidates are expected to become aware of how thermal pollution alters the habitats' physical conditions thus disturbing natural systems. The discussion should be purely qualitative. The use of cooling towers to lower water temperature should be briefly discussed.
	Acid drainage, mines and acid rain: a) Tolerance range of organisms to pH b) Increased solubility of toxic metals at low pH c) Use of pumps, and the addition of lime to contain the problem	Candidates are expected to become aware of how acidity disrupts natural systems. Candidates should also become aware of at least one technique of how to reduce acidity in water bodies.
	Toxic metal pollution: a) Biomagnification via food chains. b) Small tolerance range of most organisms to toxic metals. c) Acid water due to release of acidic compounds from waste, slag and piping. d) Bioaccumulation to toxic levels e.g. physiological effects of mercury and lead e) Control of pH to reduce solubility of the metals.	Candidates are expected to be able to understand the consequences of toxic metal pollution, the issues of biomagnification and bioaccumulation being so important due to their multiplying effect up food chains and food webs. Candidates are expected to be able to handle a quantitative treatment of these issues. The metals and compounds to be treated here are: Zinc, Lead, Copper, Arsenic, Mercury, Cadmium and Tributyltin (TBT).
	Nitrate, phosphate and organic pollution: a) Ground water nitrate pollution b) Biological, pathogenic organisms contamination c) Eutrophication, algal blooms and problems of toxin release d) BOD & COD, oxygen sag e) Sewage treatment	Candidates are expected to understand the importance of ground water, that it may also be polluted and that its recovery from pollution can be a very slow process. Candidates should be aware of the importance of clean water and that water is an excellent vector and host for some of the most dangerous pathogenic agents on Earth. A discussion about one major human disease caused by contaminated water. Candidates are expected to be familiar with primary, secondary and tertiary sewage treatment; and first and second class water

Unit 4: Solid waste and its management

Solid waste is a general term used for the solid by-products produced by human activities. Managing enormous quantities of these substances has become a major challenge for today's society. Scientific knowledge can be applied to make this task more efficient and successful. On the other hand, mismanagement or accumulation of these waste products can become a serious concern since it creates a considerable number of environmental problems as well as health hazards.

Topic	***Subject Content***	***Knowledge expected***
Types and sources of solid waste	Sources of waste production a) Municipal (to include both domestic & commercial) b) Industrial c) Agricultural d) Mining and construction	For each source mentioned candidates should be aware of the approximate composition of the resultant waste stream and how this impacts the final comprehensive volume of waste produced by the entire community. (E.g. In Malta the fraction of waste originating from the construction industry accounts for a very large proportion of the total volume of waste produced).
	Properties of substances found in the waste stream a) Mobility b) Toxicity c) Degradability d) Hazardous nature (such as fire risk & pathogenic nature)	Candidates are expected to be able to classify waste items and to distinguish between them according to their nature. The terms toxic, hazardous, pathogenic and waste stream should be accurately defined and illustrated.
Control of solid waste	How the durability of items, the introduction of disposable products and over-packing affects waste production. The nature and composition of the waste stream and why it is important to monitor it in order to control waste production and disposal.	The waste management hierarchy: Reduce, Reuse and Recycle The **importance** of **reducing** waste production and **re-using** used items as part of a comprehensive long-term waste management programme.
	Methods of solid waste treatment: a) Incineration b) Encapsulation c) Landfill and land raising d) Recycling (to be treated in detail later)	Candidates are expected to: (a) discuss the advantages and disadvantages (mainly economic and environmental) for each of the options mentioned (b) have a wide background of the issue with knowledge from the local as well as the global situation (c) be aware of the links between waste, wealth, standard of living and general conditions of life found in the community. (d) be aware that there is no <u>one option</u> which by itself can be applied to solve the waste management problem (e) use their scientific knowledge and their evaluation and critical skills to come up with concrete and comprehensive proposals on how to resolve the waste management problem in small island states like the Maltese Islands.

Topic	*Subject Content*	*Knowledge expected*
Recycling	Separation of waste at source is an indispensable measure for achieving efficient waste management. Recycling is not always the best option. The nature of waste, recycling costs and resultant environmental impacts have to be considered before recycling waste items. Not all waste is recyclable. A sizeable volume of solid waste still has to be disposed.	Candidates are expected to acknowledge the advantages (in terms of environmental protection, resource consumption, energy consumption, waste production and social benefits) and disadvantages of recycling.
	Recycling techniques and recyclable materials:	Candidates are expected to know at least two recycling techniques (e.g. paper, iron, composting, aluminium).

Theme 2: Degradation & Depletion of Natural Resources & Utilisation of land		
Unit 1: Utilisation of Land and its Resources		
Topic	*Subject Content*	*Knowledge expected*
Agriculture	Soil erosion & desertification Major causes: a) Overgrazing b) Deforestation c) Climate change d) Over-cultivation Major impacts: a) Gullying, b) Loss of nutrients & top-soil, c) Water logging & salinization.	Candidates are expected to be aware of the major causes and resultant impacts of soil erosion. Candidates should appreciate the process of desertification as a result of loss of arable land and climate change.
	Water pollution: a) Silting of water bodies b) Leachates of pesticides & fertilisers c) Run-off of particulate & organic matter	Candidates should be aware of how agriculture affects water reservoirs. Discussions should refer to specific examples.
	Air pollution: a) Acid rain b) Methane c) Particulates	Candidates should become aware that agriculture has an adverse effect on air quality.
	Reduction of biodiversity: a) Monocropping b) Clearing of land c) Use of pesticides d) Genetically modified crops	An explanation on why and how each of these practices endangers biodiversity. Knowledge of the biotechnological principles of genetically modified crops will **NOT** be included or assessed here.
	Sustainable agricultural practices: a) Soil conservation techniques b) Biological pest control c) Reduction in the use of pesticides and herbicides d) Reduction in the use of chemical fertilisers e) Improved agricultural practices and reduction of arable land degradation	Awareness that sustainable agriculture is an attainable goal making more productive and less destructive agriculture possible. Treatment of soil conservation techniques should include reference to terracing, windbreaks, multicropping, contour farming, reducing ploughing and alternation of land use Organic farming as an example of sustainable agricultural practices.

Unit 2: Degradation & Depletion of Natural Resources		
Introductory principle: The pressure on the environment due to human activities has been greatly enhanced due to the accelerated use and depletion of natural resources. Given the finite nature of all resources, the ultimate aim is to achieve sustainable use of the natural capital. *Classification of resources: Natural resources are classified into renewable and non-renewable resources.*		
Topic	***Subject Content***	***Knowledge expected***
Exploitation of natural resources	Harvesting of biotic resources: a) Logging b) Grazing c) Hunting & fishing (includes also the trade of exotic species for various reasons) Demand is greater than supply and the source takes a relatively long time to replenish itself. Management of biotic resources to allow them to replenish and last longer for future availability	Candidates are expected to know how these activities put pressure on the environment and how depletion occurs. A comparison between sustainable use and irreparable damage should be made. (It is suggested that the problem of decreasing fish stocks be taken as an example). Candidates should be aware that biotic resources (e.g. fish stocks) are not infinite and can only withstand a limited amount of pressure from human activities and demands. Specific examples to be used throughout, e.g. reducing fishing fleets and enforcing legislation regarding fishing techniques; fish farming; afforestation and wood substitutes.
	Extraction and use of abiotic resources: a) Fossil fuels b) Mineral resources (including metal ores and radioactive elements) c) Non-mineral resources (rocks & aggregates) Environmental Impacts: a) Loss of land & habitat b) Subsidence & flooding c) Air & water pollution (including substances released during purification processes) d) Hazards of nuclear energy use	The aim of this topic is to illustrate the general principles of pollution due to resource extraction and purification. Candidates are NOT expected to be familiar with specific extraction and purification processes. Candidates are expected to know the negative impacts of mining and resource extraction including fossil fuels. Candidates should also become aware that toxic by-products are produced during purification of minerals and fossil fuels. Roasting of metal ores should be used as an example to explain how the extraction and purification processes damage the environment. Brief treatment of nuclear accidents and nuclear waste disposal.
	The finite nature of physical resources. a) Alternative energy sources. b) Resource substitution; wood, metals, organic products (e.g. rubber) by plastics etc.	Issues considered here refer to practices aimed at conserving resources rather than depleting them as long as stocks last. Examples of energy sources should include solar (passive solar, photovoltaic, solar water heating), wind, hydro, biogas, biomass and geothermal. Candidates are expected to be capable of illustrating, with examples, how abiotic resources should be used sustainably within nature's limit of renewability. The concept of resource substitution should be included here as an example of strategies to reduce pressure on natural resources. (Synthetic organic & inorganic compounds).

Unit 3: Conservation biology & Restoration of the natural environment		
Topic	***Subject Content***	***Knowledge expected***
Conservation Biology	Basic principles: a) Definition of conservation biology b) The development of conservation biology	Candidates should be made aware that 'Conservation Biology' is a new branch in science designed to promote practical methods to protect/restore the natural environment.
	Reasons for conservation a) Aesthetic b) Ecological c) Economical d) Ethical/moral	Candidates should be able to explain that conservation of any resource (biotic/abiotic) is important for a variety of reasons. Each reason should be accompanied by a brief explanation.
Tools used in conservation biology (*This topic should make candidates aware that social, legal, moral and scientific issues all interrelate to produce effective environmental protecting mechanisms*)	Protecting the natural environment by establishing protected areas: a) National Parks b) Wildlife Reserves c) Conservation areas d) Marine protected/marine conservation areas	Candidates are expected to know about one example from Europe or elsewhere for (a) National parks (b) Wildlife reserves and one example from Malta for a (c) Conservation area (d) Marine protected/marine conservation area
	Legislative tools: a) CITES b) Agenda 21 c) Convention on Biological Diversity d) The Habitats Directive e) Maltese Flora, Fauna and Natural Protection regulations	Candidates should be aware that conservation biology must go beyond scientific principles and theory and must be assisted by a number of socio-political tools. The major principles underlining these programs/conventions and their ultimate aims should be briefly discussed to allow candidates to appreciate their worth as environmental- protecting tools. Knowledge about the actual content is NOT expected. Legal aspects should NOT be considered in this section.
Restoration ecology	Restoring damaged natural systems: a) Research & restoration b) Identification of keystone species & other key factors c) Reclamation of derelict & polluted land, decontamination and bioremediation d) Restoring by direct intervention, restoring by non-intervention	Candidates should investigate how damaged systems can be repaired and how polluted and abandoned land can be rehabilitated to its original state or to an alternative use. Candidates should assemble a comprehensive notion of how the state of the natural environment can be improved following specific scientific techniques.

Suggested textbooks

The following is a list of suggested books (latest editions recommended):

- Baldacchino, A.E. & Schembri, P.J. *Ilma, Blat u Hajja.* Malta University Services (Malta)
- Cunningham, W.P., Cunningham, M.A. & Saigo, B. *Environmental Science, a Global Concern*. (8th edition). McGraw-Hill (Boston)
- Nebel, B.J. & Wright, R. *Environmental Science: Toward a Sustainable Future*. Prentice-Hall.
- Pedley, M.; Hughes-Clarke, M. and Galea, P. *Limestone Isles in a crystal sea: the geology of the Maltese islands.* Publishers Enterprises Group: Malta
- Tyler Miller, G. *Living in the Environment: Principles, Connections, and Solutions*. Belmont, Calif.: Brooks/Cole
- Wright, R.T. *Environmental Science - toward a Sustainable Future*. Pearson Education International, Prentice Hall Publishers