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