L-Università ta' Malta

MATSEC Examinations Board

IM 11 SYLLABUS

ENVIRONMENTAL SCIENCE

2028

Contents

Introduction

This syllabus is designed to enable an understanding of the environment from a scientific perspective while acknowledging the importance of the economic, social, cultural, and political dimensions that inevitably characterise the issues that surround it.

This course programme assumes only a limited prior knowledge of science.

This syllabus is oriented to equip candidates with the basic scientific background that is expected at this level for a more objective and holistic evaluation of local, regional and global environmental issues that would hopefully arouse their curiosity and stimulate a renewed interest in these issues. At the end of this course candidates should be in a better position to assess environmental issues more critically, appreciate the multifaceted nature of these challenges and explore alternative strategies for their resolution.

Besides providing candidates with essential environmental literacy, this syllabus should also be viewed as a fundamental stepping-stone for those who, later on, may wish to follow tertiary education degree programmes and/or explore career possibilities directly or indirectly related to the environment sector.

Encompassing various scientific fields, the interdisciplinary approach that is adopted by this syllabus towards the study of the environment, is consistent with the need to bring the United Nations Agenda 2030 to the forefront hence raising awareness about the Sustainable Development Goals (SDGs).

Mainly, this syllabus seeks to help candidates:

- acquire and apply scientific knowledge to better and more fully comprehend the basis of local, regional and global environmental issues;
- develop a deeper understanding of environmental issues by integrating scientific knowledge with other perspectives from diverse fields of study that merge into the economic, social, cultural, and political dimensions;
- acquaint themselves with the essential skills and attitudes that are necessary to analyse environmental issues more properly and become familiar with alternative approaches to the diverse challenges that arise from these issues;
- engage in critical self-evaluation of their values, attitudes, and behaviour, to facilitate the adoption of more sustainable lifestyles that encourage and promote environmentally responsible citizenship.

List of Subject Foci

1. The atmosphere and air pollution
2. The hydrosphere and water pollution
3. Biodiversity
4. Population dynamics and human populations
5. Earth and management of its resources
6. Climate change

List of Learning Outcomes

- I can understand:
  - the structure, composition and properties of the atmosphere;
  - the causes and consequences of atmospheric pollution and how these can be mitigated.
- I can understand how water is:
  - recycled and stored in the natural environment;
  - polluted and treated.
- I can understand:
  - the properties of ecosystems;
  - the causes and consequences of biodiversity loss;
  - how biodiversity loss can be mitigated through conservation and restoration.
- I can understand:
  - the basic dynamics of biological populations;
  - the characteristics and growth of the human population.
- I can show an understanding of:
  - the Earth and the implications that arise from the extraction and use of abiotic resources;
  - biotic resources, soil and agriculture, impacts on the environment and relevance for food production;
  - the sustainable use of energy resources;
  - solid waste management.
- I can understand:
  - that climate change results from natural and anthropogenic factors;
  - that anthropogenic greenhouse gases contribute to global warming which is impacting life on the planet;
  - the consequences of climate change and how it can be mitigated.

Learning Outcomes and Assessment Criteria

Subject Focus:	**The atmosphere and air pollution**
Learning Outcome 1	**I can understand:** • **the structure, composition and properties of the atmosphere,** • **the causes and consequences of atmospheric pollution and how these can be mitigated.**

Topic	Sub-Topic	Assessment Criteria
1.1 The Earth's Atmosphere	1.1.1 Structure and composition of the atmosphere	1. Name the 4 strata that make up the atmosphere in the correct order (troposphere, stratosphere, mesosphere, and thermosphere). 2. Identify the areas of transition between the different layers of the atmosphere (tropopause, stratopause and mesopause). 3. Describe the chemical composition of the atmosphere with reference to the principal gases and their relative abundance. *Limited to the troposphere.* 4. Describe how temperature changes with altitude resulting in atmospheric stratification. 5. Sketch the temperature profile of the atmosphere.
	1.1.2 Earth's energy budget	6. Explain the electromagnetic spectrum as a continuous range of radiation travelling at the same speed, but varying in frequency, wavelength, and energy. 7. Describe Earth's energy budget with reference to the balance between incoming and outgoing radiation. *Limited to qualitative treatment.* 8. Explain albedo and how different surfaces and environments have different albedo. 9. Outline how global air circulation patterns distribute solar radiation. 10. Recognise the significance of Hadley Cells, Ferrel Cells, and Polar cells.
	1.1.3 The greenhouse effect	11. Explain the natural greenhouse effect. 12. Describe how the natural greenhouse effect maintains temperatures suitable for life.

Topic	Sub-Topic	Assessment Criteria
		13. Recall the naturally occurring greenhouse gases in the atmosphere. *Limited to: water vapour – H_2O; carbon dioxide – CO_2; methane – CH_4; nitrous oxide – N_2O*
	1.1.4 Weather and climate	14. Distinguish between weather and climate. 15. Explain the relationship between insolation, seasonality, and latitude.
	1.1.5 The ozone layer	16. Relate the photochemical processes involving the formation and destruction of ozone with incoming solar radiation and with the temperature gradient in the stratosphere. 17. Write chemical equations for ozone formation and destruction in the stratosphere. *The chemical equations limited to the following:* <u>Formation</u>: $O_2 \xrightarrow{\text{UV light}} 2O$ $O + O_2 \longrightarrow O_3 + \text{heat energy}$ <u>Destruction</u>: $O_3 \xrightarrow{\text{UV light}} O_2 + O$ $O + O_3 \longrightarrow 2O_2 + \text{heat energy}$ 18. Recall that ozone formation and ozone destruction are naturally in equilibrium. 19. Describe how stratospheric ozone shields life on Earth from harmful solar radiation.
1.2 Atmospheric pollution	1.2.1 Anthropogenic and natural sources of air quality degradation	1. Define atmospheric pollution as the release of energy or matter into the atmosphere with the potential to cause adverse effects on human health and ecosystems. 2. Define an atmospheric pollutant as a substance or form of energy that when released into the atmosphere may (directly or indirectly) have adverse effects on human health and ecosystems. 3. Distinguish with examples between primary and secondary pollutants. 4. Distinguish with examples between natural and anthropogenic, stationary and mobile, and point and non-point (diffuse) sources of pollution. 5. Explain how atmospheric pollution has local, regional, and global dimensions.
	1.2.2 Acid precipitation	6. Explain why unpolluted rain is slightly acidic including the chemical equation for the formation of carbonic acid. $H_2O + CO_2 \longrightarrow H_2CO_3$

Topic	Sub-Topic	Assessment Criteria
		7. Explain the formation of acid precipitation from nitrogen oxide and sulfur oxide emissions, including the sources of such emissions. 8. Write chemical equations for the reactions involved in the formation of acid precipitation. *The chemical equations limited to the following:* $SO_2 + H_2O \longrightarrow H_2SO_3$ $2SO_2 + O_2 \longrightarrow 2SO_3$ $SO_3 + H_2O \longrightarrow H_2SO_4$ $2NO_2 + H_2O \longrightarrow HNO_2 + HNO_3$ 9. Describe the direct and indirect consequences of acid precipitation. *The description should include: phytotoxicity (damaging effects on vegetation); respiratory disease; acidification of soil/depletion of soil nutrients/damage to microbial communities; damage to aquatic ecosystems; corrosion of materials.* 10. Recognise that the impact of acid rain on Maltese soils is minimal due to their alkaline nature.
	1.2.3 Atmospheric pollution and greenhouse gases	11. Recognise that common atmospheric pollutants (carbon dioxide, methane, nitrous oxide, tropospheric ozone and chlorofluorocarbons) are also greenhouse gases.
	1.2.4 Smog	12. Distinguish between industrial smog (classic or London type) and photochemical smog (Los Angeles type). 13. Recognise the role of nitrogen oxides and volatile organic compounds in the formation of secondary pollutants (PANs and tropospheric ozone) in photochemical smog. *Chemical equations are not required.* 14. Explain how a certain land topography and urban structures can enhance smog formation. 15. Describe temperature inversion and how it enhances smog formation. 16. Recognise the harmful effects of smog and particulate matter on human health and the natural and urban environment (respiratory disease and impaired lung function; reduced photosynthesis; erosion of buildings and corrosion of materials).
	1.2.5 Depletion of stratospheric ozone	17. Recall the main agents of stratospheric ozone depletion (chlorofluorocarbons and nitrous oxide) and the sources of these substances (e.g.: aerosol propellants, refrigeration, agriculture, and aircraft). 18. Recognise that ozone depleting gases migrate to the stratosphere.

Topic	Sub-Topic	Assessment Criteria
		19. Describe, using chemical equations, how chlorofluorocarbons react with stratospheric ozone. *The chemical equations limited to the following:* $\text{CFCs} \xrightarrow{\text{UV light}} \text{Cl atoms}$ $\text{Cl} + \text{O}_3 \longrightarrow \text{ClO} + \text{O}_2$ $\text{ClO} + \text{O} \longrightarrow \text{Cl} + \text{O}_2$ 20. Describe the consequences of stratospheric ozone depletion on human health and the natural environment.
1.3 Reducing and controlling atmospheric pollution	1.3.1 Cleaner energy and increased energy efficiency	1. Explain how increased use of renewable energy together with increased energy efficiency can reduce atmospheric pollution from fossil fuel combustion. 2. Explain how electric vehicles can reduce smog in cities but may not necessarily lead to lower carbon emissions unless charged with electricity from clean sources.
	1.3.2 Abatement technologies	3. Recognise that: electrostatic precipitators remove particulate matter from emissions; flue gas desulfurization removes oxides of sulfur from power plants working on coal or Heavy Fuel Oil; flue gas denitrification is used to remove oxides of nitrogen from power plants using natural gas. 4. Describe the role of catalytic converters as devices in modern vehicles that convert pollutants (nitrogen oxides, carbon monoxide and hydrocarbons) into safer emissions (nitrogen gas, carbon dioxide and water). *Chemical equations are not required.*

Subject Focus:	**The hydrosphere and water pollution**
Learning Outcome 2	**I can understand how water is:** • **recycled and stored in the natural environment;** • **polluted and treated.**

Topic	Sub-Topic	Assessment Criteria
2.1 The hydrological cycle	2.1.1 Recycling water	1. Recall the special properties of water: a. high specific heat capacity; b. the solid form is less dense than the liquid form; c. universal solvent. 2. Define the terms evaporation, transpiration, condensation, precipitation, interception, infiltration, percolation and run-off. 3. Draw a diagram of the hydrological cycle to show how all the processes involved are related to each other.
	2.1.2 Human interference	4. Relate solar radiation and gravity to the hydrological cycle. 5. Recognize that deforestation impacts the water cycle. *Limited to the terms mentioned in 2.1.1.2.* 6. Recognize that overextraction of fresh water from streams, lakes and underground sources disrupts the water cycle.
2.2 Human activities that lead to the contamination of surface runoff	2.2.1 Toxic metal pollution	1. Name Zinc, Lead, Copper, Mercury, Cadmium as examples of substances that bioaccumulate. 2. Give one anthropogenic source for each of these metals. 3. Distinguish between bioaccumulation and biomagnification. 4. Recognise the physiological effects of lead and mercury on humans.
	2.2.2 Excessive use of fertilisers in agriculture and discharge of untreated sewage	5. Identify nitrates and phosphates and their sources (fertilizers and untreated sewage) as the main cause leading to algal blooms. 6. Describe eutrophication. 7. Recognise how algal blooms increase water turbidity and may contribute to toxin release. 8. Explain why algal blooms lead to a depletion of oxygen in a water body and disrupts an aquatic ecosystem. 9. Define Biological Oxygen Demand (BOD) as the amount of oxygen required by decomposers to break down organic biodegradable waste in aquatic environments.

Topic	Sub-Topic	Assessment Criteria
		10. Explain how BOD varies during episodes of an algal bloom. 11. Interpret a given oxygen sag curve from a point source of water pollution. *Limited to the relationship between dissolved oxygen and BOD.* 12. Name hydrogen sulfide (H_2S) and methane (CH_4) as gases that result from anaerobic decomposition (in the septic zone).
	2.2.3 Acid drainage from industrial processes	13. Recognize that acids are usually released as by-products of industrial processes. *Limited to metal smelting, plating, and coal mining.* 14. Explain how acidification of water causes an increase in the solubility of toxic metal ions, e.g.: Aluminium ions. *Chemical equations are not expected.* 15. Discuss how lowering the pH of water disrupts aquatic ecosystems and may directly harm certain aquatic species especially fish which depend on a specific pH range. 16. Explain how the acidification of water bodies can be mitigated by the addition of a suitable amount of lime or limestone. *Chemical equations are not expected.*
	2.2.4 Thermal pollution	17. Discuss the ecological consequences of introducing heated water in an ecosystem as it alters the physical conditions of the water body (by reducing the amount of dissolved oxygen, increasing the rate of metabolic reactions, causing stress in aquatic organisms). 18. Recognise the use of cooling towers as one way through which thermal pollution can be mitigated.
2.3 Human activities that reduce the contamination of water bodies	2.3.1 Sewage treatment	1. Identify the sources of sewage. *Limited to household, industrial and agricultural waste.* 2. Identify the constituents of sewage. *Limited to water, human and animal waste, oils, detergents, pharmaceuticals, and a variety of solid materials that legally or otherwise could end up in sewage.* 3. Explain how sewage treatment is important for: a. the removal of pathogens; b. the reclamation of clean water; c. the removal of organic and inorganic nutrients. 4. Name one major human disease caused by drinking contaminated water (e.g.: typhoid, cholera).

Topic	Sub-Topic	Assessment Criteria
		5. Describe preliminary (screening), primary (sedimentation), secondary (aeration treatment), and tertiary treatment (removal of inorganics and disinfection) which occurs in a typical sewage treatment plant in Malta. *Technical details of the processes above are not required.* 6. Distinguish between first-class and second-class water. 7. State how sludge from a sewage treatment facility can be utilised. *Limited to producing biogas in an anaerobic digester and landfilled as dry material.* 8. Recognise that microplastics are still released in the environment in spite of sewage treatment.
2.4 Freshwater resources	2.4.1 Supply, renewal and use of water resources	1. Recognise that only a very small fraction of the Earth's water resources is readily available freshwater. 2. Distinguish between surface water (such as streams, ponds, lakes, and wetlands) and ground water (such as aquifers and underground rivers). 3. Explain the terms: water table, zone of saturation, aquiclude, and recharge zone. 4. List the various ways how humans may collect and store surface water in wells, cisterns, and other artificial water reservoirs (such as the small dam structures found in Maltese valleys).
	2.4.2 Freshwater resources in Malta	5. Recognise that Malta has a semiarid climate that can worsen because of climate change. 6. Recall the average annual rainfall (average 50 cm) in Malta. 7. List other factors that contribute to scarce water resources in Malta. *Limited to: no freshwater lakes or streams, no mountains, large population density, tourism industry, inadequate collection of rainwater, overextraction, reduction of recharge zones.* 8. Recognise the importance of ground water in Malta for irrigation and drinking. 9. Explain how humans extract ground water by drilling boreholes as a strategy for providing adequate freshwater. 10. Distinguish between the upper (perched) and lower (mean sea level) aquifers. 11. Draw simple labelled diagrams of these aquifers.
	2.4.3 Activities which reduce both the quality and quantity of ground water in Malta	12. Explain how the excessive use of fertilisers rich in nitrates, and phosphates cause contamination and thus reduce the quality of ground water in both aquifers in Malta. 13. State the risks of drinking ground water with high levels of nitrate. *Limited to intestinal cancer and Blue baby syndrome.*

Topic	Sub-Topic	Assessment Criteria
		14. Explain how leachate from improper disposal of contaminated waste and pesticides contributes to the contamination of ground water. 15. Explain how over-extraction of ground water in the lower (mean sea level) aquifer leads to salt water intrusion and how this reduces the quantity and quality of ground water in that aquifer.
	2.4.4 Reverse osmosis	16. Describe the principle of reverse osmosis. 17. Discuss the role of reverse osmosis as a means of supplementing Malta's potable water supply. 18. Discuss the socio-economic and environmental implications of reverse osmosis in Malta. *Limited to:* *a. the costs of water production;* *b. the vulnerability of the reverse osmosis plants to marine pollution accidents;* *c. the increased dependence on reverse osmosis plants given climate change.*
2.5 Oceans and seas	2.5.1 The oceans and their stratification	1. Distinguish between the coastal zone (littoral zone) and open sea. 2. Describe the photic zone, bathyal zone, and abyssal zone. 3. Draw a labelled diagram to include the coastal zone, continental shelf, open sea, the photic zone, bathyal zone and the abyssal zone. 4. Explain how light intensity varies with depth. 5. Compare primary production in the coastal zone with that of the open sea. 6. Recognise the importance of nutrient upwelling zones in the open sea. 7. Describe ocean stratification with depth (warm layer, thermocline, and cold layer) in terms of temperature variation.
2.6 Marine pollution	2.6.1 Human activities that lead to the contamination of seas and oceans	1. Describe marine pollution in terms of chemicals and waste originating from land and sea-based sources. 2. Identify the most common pollutants and/or sources of pollutants in our seas and oceans. *Limited to toxic metals, plastics, synthetic chemicals, petroleum, urban and industrial wastes, pharmaceuticals, agricultural runoff (pesticides, fertilisers), fish farms and sewage.* 3. State the effects of synthetic waste on marine ecosystems. *Limited to ghost fishing and ingestion of plastics.* 4. Describe microplastics as tiny fragments of plastic less than 5 mm.

Topic	Sub-Topic	Assessment Criteria
		5. Identify potential sources of microplastics. *Limited to the breakdown of plastic material and microplastics present in cosmetics and synthetic clothing.* 6. Recall that micro plastic particles accumulate in coastal and deep-sea sediments. 7. Describe microplastics as harmful to living organisms because of the multiple toxic chemicals (added to plastics to make them flexible, colourful, waterproof or flame-resistant) entering the food chain. *Names of the related chemicals are not required.*

Subject Focus:	**Biodiversity**
Learning Outcome 3	**I can understand:** • **the properties of ecosystems;** • **the causes and consequences of biodiversity loss;** • **how biodiversity loss can be mitigated through conservation and restoration.**

Topic	Sub-Topic	Assessment Criteria
3.1 Ecosystems	3.1.1 The levels of organisation in ecosystems	1. Define the terms: species, population, community, ecosystem.
	3.1.2 Biotic and abiotic components	2. Describe the biotic (living) and abiotic (non-living) components of an ecosystem. *Reference to local ecosystems is expected.*
	3.1.3 Transitional ecosystems	3. Define the term ecotone. 4. Recognise that borders of ecosystems are seldom well-defined giving rise to ecotone development where biological diversity is higher than in adjacent ecosystems.
	3.1.4 Biomes	5. Define the term biome. 6. Describe the characteristics of the main terrestrial biomes in terms of: a. temperature and precipitation; b. the adaptations of vegetation to cold, hot, wet and dry climates. *Reference to the following biomes is expected: Tundra, desert, temperate forest, tropical rain forest, Mediterranean scrubland.*
	3.1.5 Food chains, food webs and trophic levels	7. Distinguish between a food chain and a food web. 8. Draw a food chain. 9. Construct a food web from information given. 10. Define the term trophic level. 11. Identify different trophic levels: producers, primary consumers, secondary consumers, tertiary consumers, and apex (top) carnivores in a food web. 12. Recognise that an organism can occupy more than one trophic level. 13. Describe the role of producers and decomposers in the food web.

Topic	Sub-Topic	Assessment Criteria
	3.1.6 Energy flow in ecosystems	14. Write a balanced chemical equation to summarise photosynthesis. $6CO_2 + 6H_2O \xrightarrow{\text{light energy}} C_6H_{12}O_6 + 6O_2$ 15. Describe energy flow across trophic levels. 16. Explain how energy losses affect food chains in terms of ecological efficiency (10% Rule). 17. Recognise that energy flow in an ecosystem is unidirectional. 18. Distinguish between the pyramids of numbers/biomass/energy. 19. Draw pyramids of numbers/biomass/energy from information given.
3.2 Biogeochemical cycles	3.2.1 The carbon cycle	1. Recognise that biogeochemical (nutrient) cycling involves the movement of nutrients between the biotic and the abiotic environment. 2. Recognise why carbon is important to all living organisms. 3. Explain the carbon cycle including the following processes: photosynthesis, consumption, respiration, decomposition, sedimentation, volcanic eruptions, fossilisation and combustion. 4. Draw a simple diagram to illustrate the carbon cycle. *Limited to the following processes: photosynthesis, consumption, respiration, decomposition, fossilisation and combustion.* 5. Write a chemical equation to summarise the process of respiration. $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{energy}$ 6. Explain how human activities (mainly combustion of fossil fuels and deforestation) are disrupting the balance of the carbon cycle.
	3.2.2 The nitrogen cycle	7. Recognise why nitrogen is important to all living organisms. *Limited to proteins and nucleic acids.* 8. Explain the nitrogen cycle including the following processes: natural and industrial nitrogen fixation, feeding, decomposition, nitrification, denitrification. *Details of the industrial processes and products are not required. The scientific names of bacteria involved are not required. Chemical formulae of ions involved in the nitrogen cycle will not be examined.* 9. Draw a simple diagram to illustrate the nitrogen cycle including the following processes: natural and industrial nitrogen fixation, feeding, decomposition, nitrification, denitrification. 10. Explain how human activities (limited to the use of artificial fertilisers and combustion of fossil fuels) are disrupting the balance of the nitrogen cycle.

Topic	Sub-Topic	Assessment Criteria
3.3 Interactions between species	3.3.1 Ecological niche	1. Describe the concept of ecological niche. 2. Compare the niches of generalist and specialist species with specific examples.
	3.3.2 Competition	3. Describe competition as an interaction between organisms for access to limited resources. 4. Distinguish between intraspecific and interspecific competition. 5. Recognise the effect of competition on niche breadth. 6. Distinguish between fundamental and realised niche. 7. Differentiate between the two outcomes of competition: competitive exclusion and coexistence.
	3.3.3 Other basic interactions	8. Describe the terms predation, mutualism and parasitism with named examples. 9. Recognise the importance of predator-prey and parasite-host relations in the control of pest species and to ensure sustainable population growth.
3.4 Biodiversity and ecosystem stability	3.4.1 The different types of diversity 3.4.2 Ecosystem stability	1. Distinguish between species diversity, genetic diversity and habitat diversity. 2. Recognise that species, genetic and habitat diversity are essential for ecosystem stability. 3. Distinguish between the two main components of ecosystem stability: resistance and resilience. 4. Predict the possible outcome/s of removing or introducing alien species from or to the food web. 5. Describe the importance of keystone species in maintaining ecosystem stability. *Reference to Posidonia oceanica is expected.* 6. Recognise that ecosystem disturbances can greatly change an ecosystem, altering community structures. 7. Describe the process of primary and secondary succession. *Reference to pioneer species and communities, seral stages and climax community is expected.* 8. Recognise the role of disturbance in reverting a succession to an earlier seral stage. *Reference to woodland – maquis – garigue – steppe seral stages is expected.*

Topic	Sub-Topic	Assessment Criteria
	3.4.3. Causes of biodiversity loss	9. Describe human activities which result in loss of biodiversity. *Activities limited to:* *a. clearing land for agriculture (deforestation), overdevelopment and mining;* *b. introduction of invasive alien species and genetically modified organisms;* *c. pollution and climate change;* *d. intensive agricultural practices (eutrophication, pesticides, overgrazing);* *e. overfishing, destructive fishing practices, fish farming and overhunting.*
3.5 Mitigation measures	3.5.1 Conservation of biodiversity	1. Describe biodiversity conservation. 2. Recognise the various reasons why conservation of biodiversity is important. *Reasons given should be limited to the following:* *a. growing forests act as carbon sinks and mature forests act as carbon stores;* *b. provision of clean air and oxygen;* *c. pollination services;* *d. pest control;* *e. role in water cycle;* *f. prevention of soil erosion;* *g. biodiversity as a genetic resource;* *h. provision of food, medicine and industrial raw materials;* *i. ecotourism;* *j. ethical reasons;* *k. aesthetic importance.* 3. Recognise the significance of local and international stakeholders in conservation. *Local e.g. Environment and Resources Authority (ERA), Environmental Non-Governmental Organisations (eNGOs).* *International e.g. IUCN (International Union for the Conservation of Nature).*

Topic	Sub-Topic	Assessment Criteria
		4. Outline methods of conservation of biodiversity: a. Designation of land/marine protected areas. *Limited to local examples, such as: Buskett, Għadira Nature Reserve, Majjistral Park, Irdum Majjiesa, Id-Dwejra, etc. Knowledge of the different types of local protected areas under the different legal frameworks is not required.* b. Captive breeding and release programmes / propagation programmes. *e.g. i. cultivating indigenous Maltese trees and plants;* *ii. breeding projects of local importance e.g. killifish, Maltese freshwater crab.* c. Legislation to protect habitats and species, to control trade and to achieve sustainable exploitation of biological resources. *e.g. The Environment Protection Act ; The EU Habitats Directive; The EU Birds Directive; Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); Convention on Biological Diversity (CBD). Details of legislation are not required.*
	3.5.2 Restoration ecology	5. Define restoration ecology as the study of renewing a degraded, damaged, or destroyed ecosystems through active human intervention. 6. Distinguish between direct intervention and non-intervention restoration. 7. Outline the steps involved in ecological restoration as follows: <u>*Research phase*</u> • *What is causing the disturbance?* • *Identifying keystone species, better farming practices, and removal of toxic chemicals as ways of stopping/reducing disturbance.* • *Compare site to similar intact sites or consult historical sources that describe the pre-disturbance community.* • *Research abiotic factors (Limited to: sheltered vs exposed sites, amount of soil).*

Topic	Sub-Topic	Assessment Criteria
		<u>Rehabilitation stage</u> • *Decontamination/bioremediation;* • *Eradication of invasive species;* • *Cleaning up littering /excessive dumping;* • *Introduce native species or facilitate breeding programs to increase population of existing ones.* *<u>Monitoring and maintaining</u>* • *Regular monitoring both during the work phase and post rehabilitation.* 8. Name a local example of an ecological restoration project.

Subject Focus:	**Population dynamics and human populations**
Learning Outcome 4	**I can understand:** • **the basic dynamics of biological populations;** • **the characteristics and growth of the human population.**

Topic	Sub-Topic	Assessment Criteria
4.1 Population	4.1.1 What is a population?	1. Define a population as all the organisms of the same species that live in a specific area, at a given time, and can interbreed to produce fertile offspring.
4.2 Population dynamics and human populations	4.2.1 Factors influencing population size	1. Explain how population size fluctuates over time as a result of changes in: a. Natality and Immigration (increase population size); b. Mortality and Emigration (decrease population size). 2. Recognise that a population reaches a state of dynamic equilibrium when factors promoting its growth and factors inhibiting its growth are balanced.
	4.2.2 Limitations to population growth	3. Define biotic potential as the maximum reproductive capacity of the population under optimum environmental conditions. 4. Define environmental resistance as all those factors that limit population growth. 5. Explain how environmental resistance factors limit a species from reaching its full biotic potential. 6. Define carrying capacity as the maximum population size that an environment can support.
	4.2.3 Models of population growth	7. Identify that a population growing by a constant percentage per unit time exhibits exponential growth and is represented by a J-shaped curve. 8. Infer that an exponential population growth indicates that the population has no restrictions on its growth, depends on an infinite supply of resources to be maintained and is realising its biotic potential. 9. Recognise that when the growth of a population is controlled by a finite supply of resources (carrying capacity) it exhibits Sigmoid (or logistic) growth that is represented by an S-shaped curve. 10. Sketch a labelled graph to show Sigmoid growth. *Limited to: lag phase, exponential phase, transition phase, stationary phase.* 11. Explain the terms referred to in 10 above.

Topic	Sub-Topic	Assessment Criteria
		12. Describe, using a labelled diagram, the relationship between exponential and Sigmoid growth taking into account biotic potential, environmental resistance and carrying capacity. 13. Recognise that Irruptive growth patterns are characterised by sudden population explosions (overshoots) followed by sudden population crashes (diebacks) as exemplified by locusts and algae.
4.3 Human population dynamics	4.3.1 Human population growth	1. Associate the low rate of global human population growth of the Palaeolithic period (500,000 BP – 10,000 BP) with the hunter-gatherer nomadic lifestyle adopted by humans that resulted in small populations, high infant mortality and fewer individuals reaching reproductive maturity. 2. Recognise that the domestication of animals and cultivation of crops (i.e., the agricultural revolution), during the Neolithic period (10,000 BP), increased the availability of food and helped establish the first permanent human settlements resulting in a faster increase in the human population.
	4.3.2 Present patterns of human population growth	3. Describe the trend in global human population growth since the beginning of the industrial revolution taking into account improved sanitation and hygiene and the control of disease resulting in decline in death rates, the increased availability of food and the generally improved economic conditions. 4. Describe how More Economically Developed Countries (MEDCs) have high economic productivity (industrial and services society), good healthcare services, good infrastructure, and a high standard of education, which relate to decreased birth rate, a stable or dwindling population, and extended life expectancy. 5. Describe how Less Economically Developed Countries, (LEDCs) have low economic productivity (rural society), poor healthcare services, weak infrastructure, and low accessibility to education, which relate to, high birth rates, rapidly increasing populations, but low life expectancy.
	4.3.3 Demographic transition	6. Define crude birth rate as the number of annual live births per one thousand people. 7. Define crude death rate as the number of annual deaths per one thousand people. 8. Recognise that the Demographic Transition Model is a dynamic representation showing the variation in population size with time resulting from changing birth rates and death rates as a country develops economically.

Topic	Sub-Topic	Assessment Criteria
		9. Label a given diagram of the Demographic Transition Model representing the following five stages: *Stage 1 – high stationary / fluctuating;* *Stage 2 – early expanding;* *Stage 3 – late expanding;* *Stage 4 – low stationary / fluctuating;* *Stage 5 – declining.* 10. Recognise that only very few isolated tribes are still at stage 1, most LEDCs are at stages 2 or 3, most MEDCs are in stage 4, and some MEDCs are going into stage 5 because of their ageing and declining population.
	4.3.4 Age-Gender structure of human populations	11. Interpret qualitatively age-gender diagrams of human populations, including those of the Maltese population from the beginning of the 20th century. *Limited to: rapid growth, slow growth, and declining populations.*

Subject Focus:	**Earth and management of its resources**
Learning Outcome 5	**I can show an understanding of:** • **the Earth and the implications that arise from the extraction and use of abiotic resources;** • **biotic resources, soil and agriculture, impacts on the environment and relevance for food production;** • **the sustainable use of energy resources;** • **solid waste management.**

Topic	Sub-Topic	Assessment Criteria
5.1 Sustainable use of resources	5.1.1 Sustainable development	1. Define sustainable development as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987). 2. Recognise Agenda 2030 and the Sustainable Development Goals (SDGs) as having a major role towards achieving sustainable development. *Knowledge of the individual SDGs and their targets is not expected.*
	5.1.2 Natural resources	3. Recognise a natural resource as any substance, form of energy, or object obtained from the environment which is useful to any organism. 4. Distinguish between abiotic and biotic resources. 5. Distinguish between renewable and non renewable resources.
5.2 The lithosphere	5.2.1 Earth's internal structure	1. Distinguish between the various layers that make up the internal structure of the Earth. *Inner and outer core, mantle, crust* 2. Draw a simple diagram showing the various layers that make up the internal structure of the Earth.
	5.2.2 Plate tectonics	3. Distinguish between the lithosphere and the asthenosphere. 4. Distinguish between continental and oceanic crust. 5. Describe the lithosphere as made up of tectonic plates floating on the asthenosphere. 6. Relate the movement of the plates to the ongoing convection currents inside the Earth's mantle. 7. Distinguish between convergent *(limited to oceanic-continental boundary)*, divergent *(limited to oceanic-oceanic boundary)*, and conservative plate boundaries.

Topic	Sub-Topic	Assessment Criteria
		8. Draw simple labelled diagrams illustrating the different plate boundaries mentioned in 7. above. 9. Relate the behaviour at the plate boundaries mentioned in 7. above with earthquakes, volcanoes, ocean trenches, and mid-ocean ridges.
	5.2.3 Rocks	10. Recognise the three main types of rock (igneous, sedimentary and metamorphic) including one named example of each. 11. Distinguish between physical, chemical, and biological weathering. 12. Explain what is meant by biogenic sedimentation. 13. Relate biogenic sedimentation to the formation of the rocks of the Maltese Islands. 14. Draw a labelled diagram of the rock layers that make up the Maltese Islands.
	5.2.4 The rock cycle	15. Describe the rock cycle mentioning all the processes (weathering, erosion, sedimentation, lithification, volcanism, subduction, metamorphism, melting, cooling, solidification, and uplifting) involved in the conversion of one rock type to another. 16. Draw a simple diagram illustrating the rock cycle.
	5.2.5 Impact of the extraction of abiotic resources	17. Relate the environmental impacts of quarrying and mining with: a. loss of land and habitats; b. subsidence and flooding; c. air and water pollution; d. noise. *Environmental impacts related to specific extraction processes are not required.*
5.3 Soil	5.3.1 Soil formation	1. Describe soil formation as the result of rock weathering and erosion. 2. Describe soil as a dynamic system comprising mineral particles, detritus, air, water and living organisms interacting together. 3. Discuss the five critical factors that are essential for soil fertility: minerals and mineral holding capacity, water and water holding capacity, aeration, pH and salinity.
	5.3.2 Soil texture type as exemplified by clay, sandy and loam soil	4. Mention sand, silt and clay as the three main mineral components that make up soil. 5. Distinguish between clay, sandy and loam soils in terms of relative particle size. 6. Explain why loam soils are typically the best types of soil for most plants.
	5.3.3 Soil erosion – causes and impacts	7. Recognise that soil erosion is the loss of soil through the action of wind and water

Topic	Sub-Topic	Assessment Criteria
		8. Describe how the following processes facilitate soil erosion: a. Overgrazing b. Deforestation c. Over-cultivation d. Off roading 9. Relate the following to soil erosion: a. Gullying b. Silting of water bodies c. Loss of nutrients & top-soil d. Water logging & salinization e. Climate change f. Desertification
	5.3.4 Soil conservation techniques	10. Describe how the following mitigation practices minimise soil erosion: a. Terracing and rubble walls b. Wind breaks c. Contour ploughing d. Reduced tillage/ploughing e. Multicropping f. Alternation of land use (crop rotation and strip cropping)
5.4 Agriculture	5.4.1 The scope of agriculture	1. Define agriculture as the science and practice of cultivating the soil, growing crops, and raising livestock.
	5.4.2 Fertilizers and pesticides	2. Describe fertilisers and pesticides as agrochemicals manufactured on an industrial scale that enhance crop yield. 3. Distinguish between different types of pesticides (fungicides, herbicides, rodenticides, and insecticides). 4. Recognise the availability of natural alternatives to fertilisers (bone meal, fish meal, manures, rock phosphate and compost) and pesticides (neem oil and biological pest control).
	5.4.3 Negative impact of agriculture	5. Relate agriculture to the release of nitrous oxide (denitrification) and methane (mainly from ruminants and rice/paddy fields) to the atmosphere.

Topic	Sub-Topic	Assessment Criteria
		6. Relate agriculture to reduction in biodiversity mainly due to land clearance (deforestation), monocropping, and pesticides.
	5.4.4 Genetically modified organisms (GMOs)	7. Define a GMO as an animal, plant, or microbe whose genetic material (DNA) has been altered using genetic engineering techniques to have certain desired traits. 8. Recognise controversial issues related to GMOs. *Limited to hybridisation with wild species, reduction in agricultural biodiversity, dependency on GMO stocks.*
5.5 Biotic resources	5.5.1 Harvesting of biotic resources	1. Describe overharvesting as the unsustainable use of a resource with reference to fishing, hunting, and logging. 2. Define sustainable harvesting as the management of living resources to allow them to replenish and remain available for future generations. 3. Recognise that quotas, protected habitats, enforcement and monitoring, afforestation, aquaculture, and resource substitution (as exemplified by the consumption of fish species that are less threatened) have a role in ensuring sustainable harvesting.
5.6 Energy sources	5.6.1 Non-renewable and renewable energy sources	1. Define energy as the ability to do work. 2. Distinguish between non-renewable and renewable energy sources. 3. Define carbon footprint as the total amount of greenhouse gases released to the atmosphere as a result of anthropogenic activity (as exemplified by water and electricity bills). 4. Recognise that the EU energy label is a means of quantifying the energy efficiency of appliances and electrical goods. 5. Recognise the kilowatt-hour (kWh) as the unit of energy used to measure electrical consumption. 6. Explain the meaning of decarbonisation and the need to diversify the energy mix. 7. Recognise that despite sustainability issues the bulk of global energy demand is still met through non-renewables.
	5.6.2 Non-renewable (finite) sources	8. Identify the fossil fuels (coal, crude oil and natural gas), and nuclear as non-renewable energy sources. 9. Recognise the formation of fossil fuels as resulting from the decomposition of dead remains of organisms in the Earth's crust.

Topic	Sub-Topic	Assessment Criteria
		10. Recognise radioactivity as the spontaneous emission of radiation. 11. Distinguish between nuclear fission and nuclear fusion. 12. Outline how nuclear fission can be used as a source of energy. *Technical details of a nuclear reactor are not expected.* 13. Explain why nuclear power can be considered as one alternative to reduce greenhouse gas emissions. 14. Mention the far-reaching consequences (on health and long-term contamination) derived from major nuclear accidents (e.g.: Three Mile Island, Chernobyl and Fukushima nuclear disasters). *Details of the individual nuclear accidents are not required.*
	5.6.3 Renewable sources	15. Identify solar, wind, hydropower (including wave and tidal), geothermal and biomass as renewable energy sources. 16. Distinguish between passive (such as double glazing and orientation of buildings) and active (as shown by solar water heaters and photovoltaic systems) means through which solar energy can be harnessed. 17. Outline the advantages and limitations of windfarms. 18. Describe the environmental impacts of damming river flow for the purpose of constructing a hydroelectric power station. *Limited to: flooding of ecosystems upstream behind the dam; displacement of people if applicable; formation of a different ecosystem; trapping of silt and nutrients behind the dam.* 19. Describe geothermal energy and how it can be harnessed for electricity generation in specific locations. 20. Define biofuels as energy resources that have been produced by biological processes sufficiently recently that they can be renewable (i.e.: rate of harvesting does not exceed the rate of production). 21. List different types of biofuels and their sources. *Limited to: fuelwood (trees), biodiesel (cooking oil), bioethanol (sugar cane and corn), and biogas (anaerobic digestion of organic waste).*

Topic	Sub-Topic	Assessment Criteria
5.7 Solid waste	5.7.1 Linear and circular economy	1. Distinguish between linear and circular economy. 2. Recognise that a circular economy aims at moving towards a zero-waste society that utilises all waste as a resource.
	5.7.2 Different types of waste and their properties	3. Differentiate between the following sources of waste production: municipal, industrial, agricultural, and construction and demolition waste. . 4. Differentiate with examples between biodegradable, non-biodegradable, photodegradable, hazardous and inert waste materials. *Hazardous waste limited to toxic, flammable, corrosive, radioactive and biohazardous/pathogenic materials.*
	5.7.3 Waste management	5. Explain what is meant by integrated waste management based on the waste hierarchy, as made up of the following stages: a. Reduce/Prevent b. Reuse c. Recycle d. Recovery (energy recovery – anaerobic digestion and incineration) e. Disposal (open dump and engineered landfill; encapsulation of nuclear waste) 6. Explain that waste separation (especially at source) is crucial for waste recycling to be successful for resource recovery. 7. Distinguish between a conventional (open dump) and engineered landfill. *Limited to measures taken to prevent leachate percolation and the collection and use of landfill gas.* 8. Sketch a simple labelled diagram of an engineered landfill. 9. Outline the modes of collection of municipal waste: bags, bring-in sites, civic amenity sites and bulky refuse. 10. Discuss the advantages and disadvantages of the following methods of waste disposal: a. recycling of waste (including composting); b. incineration; c. landfilling.

Topic	Sub-Topic	Assessment Criteria
		11. Discuss the challenges faced by Small Island States, like Malta, with regards to waste management. *Limited to the problems concerned with:* *a. economies of scale with respect to recycling;* *b. the high population density;* *c. limited space for disposal.*

Subject Focus:	**Climate Change**
Learning Outcome 6	**I can understand:** • **that climate change results from natural and anthropogenic factors;** • **that anthropogenic greenhouse gases contribute to global warming which is impacting life on the planet;** • **the consequences of climate change and how it can be mitigated.**

Topic	Sub-Topic	Assessment Criteria
6.1 Causes of natural climate change	6.1.1 Global temperatures 6.1.2 Events leading to natural climate change	1. Explain how the earth's temperature is the resultant balance between the greenhouse effect and global cooling factors. *Limited to global cooling factors: aerosols, particulate matter, cloud cover and planetary albedo.* 2. Relate that the earth experienced major climatic changes resulting in glacial and interglacial periods as a result of the Milankovitch cycles. *Details of individual Milankovitch cycles are not required.* 3. Outline asteroid impacts, the sunspot cycle, and volcanic activity as other causes of natural climate change.
6.2 Greenhouse gases (GHGs)	6.2.1 GHGs of anthropogenic origin	1. Identify different GHGs (Carbon dioxide, methane, nitrous oxide, water vapour, tropospheric ozone, CFCs, HCFCs, and other fluorinated compounds) resulting from human activities. *Only the formulae of the following are required: carbon dioxide, methane, nitrous oxide, water vapour, ozone.* *Specific names of fluorinated compounds are not required.* 2. Describe the main sources of anthropogenic GHGs. *Limited to: waste, burning of fossil fuels, agriculture (animal husbandry and crops), deforestation, and refrigeration.* *Chemical equations are not required.* 3. Distinguish between the natural and enhanced greenhouse effect. 4. Recognise that different GHGs have different contributions to global warming due to their concentration and their radiative properties. *Qualitative treatment only.*

Topic	Sub-Topic	Assessment Criteria
6.3 Global warming	6.3.1 Variable factors affecting global warming	1. Describe carbon sinks and carbon sources and the relationship between them with reference to the carbon cycle. 2. Explain how carbon sinks / sources can have a direct bearing on global warming. 3. Recognise the relationship between the historical increase in GHG and the warming effect in the atmosphere and oceans. 4. Recognise that such a warming effect varies between different regions around the planet and is also evident in the Mediterranean.
	6.3.2 Effects and consequences of global warming	5. Summarise the effects of global warming leading to: a. melting of ice sheets and glaciers and changing albedo levels; b. thermal expansion of the oceans leading to rising sea levels (coastal erosion, saltwater intrusion in sea-aquifers and impacts on the tourism industry); c. acidification of the oceans; d. bleaching of coral reefs; e. changing migration patterns (marine and terrestrial animals); f. increased frequency and severity of extreme weather events; g. disruption of the water cycle and precipitation patterns affecting productivity and ecosystems (drought, flooding); h. disruption of thermal oceanic currents; i. disruption in agricultural activity (drought, flooding, soil erosion, desertification); j. spread of famine, disease and displacement of human populations; k. increased vulnerability of populations in low-lying coastal areas due to sea level rise and flooding.
	6.3.3 Potential mitigation and adaptation measures to address global warming	6. Distinguish between climate mitigation (e.g.: shift to natural gas, use of renewable energy sources) and climate adaptation (e.g.: coastal defences, water conservation, seasonality of tourism). 7. Recognise that both mitigation and adaptation measures can also be undertaken at community and individual level. 8. Recognize that the implementation of mitigation and adaptation measures come at a financial cost.

Topic	Sub-Topic	Assessment Criteria
6.4 Role of United Nations (UN)	6.4.1 UN Framework Convention on Climate Change (UNFCCC) 6.4.2 Role of the Intergovernmental Panel for Climate Change (IPCC)	1. Recognise the UNFCCC as the first major step at an international level to tackle anthropogenic climate change. *Details of the convention are not required.* 2. Recognise the significance of the IPCC. *Details about individual reports produced over the years are not required.* 3. Recognise that the IPCC projections are based on scientific data which is continuously evolving.

Scheme of Assessment

The Examination consists of one written three-hour paper.

The paper will be divided into **TWO** sections as follows:

- **Section A**
  - consists of a number of compulsory questions of the fill-in type requiring short answers;
  - carries 80 marks.
- **Section B**
  - consists of six structured type questions of which candidates must choose **TWO**;
  - carries 40 marks.

Candidates are expected to have a calculator.