Paper 2 Physical Options

UNIT 4 Arid and semi-arid environments

Recommended Prior Knowledge As is the case for all of the Advanced Geography Options, completion of the core modules is expected. This option builds on knowledge and understanding gained in the compulsory core, Units 1 Hydrology and fluvial geomorphology, 2 Atmosphere and weather and 3 Rocks and weathering.

Context The focus in this option is on both **hot arid** and **semi-arid** environments, areas characterised by small amounts of rainfall and very high rainfall variability and reliability.

Outline Study of the physical environment is the starting point which begins with the climatic definition of these areas which then leads into their global location and distribution. The landscape of landforms vegetation and soils forms the core of the option. Water, or the lack of it, is the key element in the processes which produce the landforms and in the relationships which exist within arid and semi-arid ecosystems. Consideration should be given to the role of water throughout the option. Case study material and examples should be included wherever appropriate and **one** case study illustrating some of the problems of sustainable management of **either** an arid **or** a semi-arid environment is an essential part of the option.

Resources Geofile online at Nelson Thornes and Geo Factsheets at www.curriculum-press.co.uk are two excellent subscription online resources.
Textbooks referenced below Digby, B ed. (2000) *Global Challenges* Heinemann; Heelas, R (2001) *Tropical Environments: Contrasting Regimes and Challenges* Nelson Thornes; Meg and Jack Gillett (2003) *Physical Environment: A Case Study Approach* Hodder and Stoughton; Guinness, P and Nagle, G (1999) *Advanced Geography: Concepts and Cases* Hodder and Stoughton; Money, DC (2000) *Weather and Climate* Nelson; Nagle, G(2000) *Advanced Geography* Oxford University Press; O'Hare, G (1990) *Soils, Vegetation and Ecosystems* Oliver and Boyd; Warburton, P (2001) *Atmospheric Processes and Human Influences* Collins;Waugh, D (2000) *Geography: An Integrated Approach* Nelson Thornes 3rd edition; Woodfield, J (2000) *Ecosystems and Human Activity* Collins 2nd edition; *Geography in Focus (2000)* Cook, I, Hordern, B, McGahan, H, Ritson, P Causeway Press Ltd.
New recommended text: David Holmes (2006) *Ecosystems and Biodiversity* Philip Allan Updates

Content	Objectives and suggested teaching activities	Online resources	Other resources
4.1 The distribution and climatic characteristics of hot arid and semi-arid environments	**Introduction** **Definition** of arid and semi-arid. Traditional criterion: annual rainfall amount Arid: less than 250mm per annum (year) Semi-arid: 250-500mm per annum (year) Definitions now use P:PET ratios and the aridity index. Arid: 0.03-0.2mm P:PET ratio Semi-arid: 0.2-0.5mm P:PET ratio In semi-arid areas rainfall may vary up to 40% above or below the mean. Aridity index: -100 (areas with no precipitation (ppt)) 0 (areas where P=PET) +100 (areas where P>PET). Arid areas are between -40 and -100 and semi-arid areas are between -20 and -40. Global distribution of hot deserts. World map **-** ideal teaching aid - **June 2002 Q. 8(a) Fig 4A** **Distribution** • Latitude (high altitude deserts within the area) • West coast - influence of cold ocean currents, e.g. Humboldt, Benguela currents. • Continental interiors Present climates **Characteristics of an arid climate** Temperatures: annual, diurnal range, rainfall annual amounts, variability, convectional rainfall, flash floods P:E ratios. Rainfall reliability, water availability, effective precipitation, soil moisture budgets, albedos. High wind energy environments.		Waugh p.178 - good discussion on definitions. Clowes and Comfort pp.309-10, excellent section on Thornthwaite's aridity index. Money p.48 Fig 3.3 is a useful map of semi-arid areas; pp.85-6 are useful for semi-arid areas and rainfall variability. Goudie pp.113-5 Waugh p.178 Fig. 7.1 Waugh p.179, excellent map Clowes and Comfort p.310 excellent maps of global distribution of arid and semi-arid areas and rainfall reliability. Waugh p.178

	June 2002 Q. 8(a) Figs 4A and 4B on rainfall reliability. Excellent teaching resource - maps of rainfall in deserts. **June 2003 Q. 8(b)** on flash floods. **Causes of aridity** 1. Descending limb of Hadley cell, related winds. (Seasonal movement of the thermal equator - ITCZ) relate to latitudinal distribution, e.g. Sahara desert 2. Offshore ocean currents, relate to global distribution map, e.g. Namib desert 3. Rain shadow areas, relate to continental interiors and high mountains, e.g. Andes Patagonia, Rockies 4. Continentality e.g. Gobi desert **Past Climates** Climate change - Pleistocene period - continental ice sheets in Northern Hemisphere. 'Pluvials', wet periods - result of migration of wind and pressure belts south. Therefore North Africa influenced by mid-latitude rainfall and southern edge of Sahara migrated into the savannas. i.e. weathering, erosion and landforms. Archaeological evidence should be separated from geomorphological evidence.	Geo Factsheet 24 The causes of Aridity **June 2008 Q. 7(a)** **June 2005 Fig. 4 Q. 8** Useful teaching resource, deserts, wind and pressure belts. **June 2004 Fig. 4 Q. 8(a)** Influences of past climates, useful for teaching.	Small p.290 Goudie pp.116-8 Goudie p.113 Money pp.85-7 Waugh p.179 Small p.290 Goudie pp.115-6 Small p.291 short excellent section on 'pluvials' Goudie pp.118-9 Waugh p.190 excellent map of evidence of climate change. Waugh pp.181-186 Small pp.292-303
4.2 Processes producing desert landforms	Emphasise link between process and form throughout, also link back to climate in 4.1 and link to **hydrological regimes**, which could be the starting point here, because the topic straddles climate and landforms. **Desert environment hydrology**		Clowes and Comfort p.312 has a good diagram of a water budget illustrating water deficit and therefore

	Water flows and stores, groundwater, predominance of Hortonian overland flow because rainfall intensity invariably exceeds infiltration capacity. Hydrographs, water budgets. Mention of perennial and ephemeral water courses, surface stores, oases, playa lakes, exotic rivers with seasonal flows. Wadi flows. Groundwater stores. Aquifers, fossil groundwater. Should make links with human activities e.g. semi-arid areas like the Sahel in 4.4. Water availability, tapping of groundwater supplies – wells, etc., irrigation. **June 2002 Q.7(a)** and **Nov 2003 Q. 7(a)** Both about hydrological regimes. **Processes** Throughout there has to be discussion about these processes, the extent to which they dominate arid areas and the factors that influence the processes. **Weathering** **Physical - Exfoliation -** conductivity of rocks, coefficients of expansion of different mineral of different sizes and colours. Peeling of surface layers of rock - curvilinear sheets. May be aided by dilatation/pressure release. Relate to diurnal range of temperature. Link to water - episodic rainfall, upward capillary movement of water as a catalyst of the process. Exfoliation domes, bornhardts, in semi-arid areas. **Salt weathering** **Frost shattering** in high altitude deserts. **Chemical** - limited because of lack of water but present. **Hydration** especially in arid areas. Greater chemical weathering in semi-arid areas due to	**June 2008 Q. 8(a)**	availability, p.315 Clowes and Comfort pp.313-4 Goudie pp.124-5 has an excellent discussion Cook Hordern et al. pp.376-384. Goudie pp.127-133 Clowes and Comfort p.313 Cook, Hordern et al. pp.344-349

	greater vegetation cover producing organic acids to facilitate processes. End products of weathering. **Block and granular disintegration** - link back to the process. **Nov 2002 Q. 7(a)** **Erosion, transportation and deposition - by the agents wind and water** Link to landforms at every stage. **Erosion** - abrasion, deflation. **Transportation** - suspension, saltation, traction. **Deposition** **Erosion and transportation -** chief agent wind. Process of **abrasion** – produces mushroom or pedestal rocks. Discussion about role of wind, transportation of sand particles. Concentration within a metre or less of the surface. Changing view, it is now thought that the role of water and chemical weathering is important. Yardangs and zeugen can be mentioned but structure as well as wind may be an influential factor. **Deflation -** erosion of sand to produce deflation hollows. Dimensions large - other factors - structural and then chemical processes once the hollow has reached the water table. **Deposition -** sand dunes. Reasons for deposition, reduction in wind velocity, initiator of velocity reduction - changing gradient of the surface (an obstacle), changing atmospheric conditions. **Variety of form according to local conditions** Barchans, seif (linear), transverse, star, etc.	**Nov 2005 Q. 7** **June 2007 Q. 7(a)** wind erosion. **Nov 2006 Q. 7(a)** **June 2006 Fig. 4** dune diagrams. **June 2005 Q. 7(a)** a popular question.	Small p.300 Clowes and Comfort pp.320-322 Waugh p.185 Whole page devoted to the variety of sand dune form. Highly recommended. Goudie p.131 has excellent diagrams. Clowes and Comfort pp. 323-325 Clowes and Comfort p.316, arroyos. Waugh p.188 Waugh pp.187-8 Small pp.303-309 Fig.1

	Annotated diagrams are an ideal way to present the description of these landforms. **Specified landforms** Wadis, alluvial fans, arroyos, pediments, piedmont zones, bahadas, salt lakes, playas, inselbergs. A diagram is ideally suited. Landforms produced due to the action of water Wadis and arroyos - flash-floods, relate to discharges and relative importance of erosion, amount of load and debris removal. **A typical desert profile** - mountain front with embayments, knick, pediment with veneer of alluvial material, bahada (peripediment), playa. **Evolution of the profile - theories of formation.** **Pediplanation** To include **parallel retreat of slopes (scarp retreat)** and **pedimentation** .e. the formation and extension of the pediment. Theories of pedimentation. (i) An erosional feature as the result of lateral planation by stream and sheet floods and (ii) the possible role of the pediment as a transportational slope. Discussion of scarp retreat as the result of weathering and formation of a boulder controlled slope which retreats parallel to itself over time, thus extending the pediment, as opposed to the undercutting of the mountain front by lateral corrasion. Relate the theories to the form of the desert cross profile e.g. the slightly concave pediment seems to indicate the action of running water. Residual masses of mesas, buttes, inselbergs. These masses represent different stages in the evolution of pediplanation. Importance of climatic change in the evolution of	**Nov 2005 Fig. 4 Q. 8(b)** useful teaching aid. www.geoimages.berkeley.edu Excellent images of the landforms. www.regolith.com **June 2006 Q. 8(b)** the importance of water.	Small p.291, the key text on the subject. Clowes and Comfort pp.327-8 Small pp.309-316 Clowes and Comfort p.319

	desert landforms – pluvials, wetter period coincidental with the glacials of the Pleistocene - movement south of mid latitude rainfall, southern extension of the desert into the savanna. Evidence for climate change ranges from geomorphological to geological to archaeological. Link to 4.1. **November 2002 Q. 8(a)** Questions on landforms **Nov 2003 Q. 8(a)** and **June 2002 Q. 7(a)**		
4.3 Soils and vegetation	Functioning and structure of the ecosystem Productivity - NPP nutrient cycling. Biodiversity, trophic levels/food chain. Fragility/resilience: two theories - fragile because food chains are simple or resilient because the organisms are highly adapted). Adaptation of animals to aridity and extreme temperatures. **Vegetation** Characteristics and adaptations to high temperature and drought and salinity in soils and soils generally, shallow and nutrient deficient. Distinguish between physical and physiological drought. **Nov 2002 Q. 8(b)** **Nov 2007 Fig 2** for **Q. 8(a)** **Soils** Evaporation is greater than precipitation therefore there is upward movement of water by capillary action. Halomorphic/saline soils - process of salinisation, i.e. evaporation of water to produce saline crusts. **A typical desert soil** - shallow, grey, saline and nutrient poor. Solonchaks, solonetz, solod, important to appreciate and account for the variations.	**June 2008 Q. 7(b) Figs 4A and 4B** **Nov 2006 Fig. 3 Q. 8A** shows adaptations useful for teaching	Tivy and O'Hare p.158 Goudie pp.119-121 has excellent diagrams of the flora and fauna Waugh p.322 Waugh p.323 has a profile diagram O'Hare pp.127-130 Goudie pp.138-143 'Plant distribution in the Sonoran Desert' Jane Dove *Geography Review* Nov 2001 pp.10-13 Excellent source.

4.4 Sustainable management of arid and semi-arid environments	There is an excellent case study of semi-desert vegetation in Death Valley, Mojave Desert California, in O'Hare. **June 2003 Q. 7(b)**, **Nov 2003 Q. 7(b)** The case study include problems of water supply and the management of that supply. It should illustrate some of the problems of the physical environment and relate these to human activity and the ways in which the problems of rainfall reliability and drought have been overcome, e.g. dams and reservoir schemes, tapping of groundwater supplies, tube wells, irrigation. The process of desertification, typical of the arid margins (semi-arid areas like the Sahel in sub-Saharan Africa) is a useful vehicle for discussion of the combination of physical factors (lack of rainfall) and human activities responsible for environmental degradation and the need for sustainable measures. Possible case studies include: • **Gezira Irrigation scheme Sudan** • **Tunisia -** water management • **Drought in Zambia** • **Nile Valley** - the best documented example in accessible texts • **Drought in the semi-arid Sahel** (sub-Saharan Africa) Online information is readily available if key words are put into the search engine. **June 2007 Fig. 4** model/flow diagram of desertification very useful as an introduction to the topic. **Note** It is essential to have one case study that deals with the issue of desertification.	**June 2007 Fig. 4** Geofile Number 446 Drought and Desertification in India and Pakistan April 2003 www.un.org/ecosocdev/geninfo/sustdev/desert.htm has material on desertification. Geo Factsheet 28 Desertification: Causes and Control Geo Factsheet 191 Soil Degradation - A creeping concern? Geo Factsheet 199 Water issues in the Middle East **June 2008 Q. 8(b)** **June 2007 Q. 7(b)** discusses irrigation as a means to sustainable development. **Nov 2006 Q. 8 (b)** productivity of arid environments. General websites on deserts with images and factual information:	Bishop and Prosser has general principles of water management. Hill p.19 Nile Valley case studies can be found in Waugh *The New Wider World* pp.274-5 Digb**y** It's a World Thing pp.162-5 'Drought response in southern Zambia' Richard Byrne *Geography Review* Jan 2000 pp.22-24 'Water Management in Tunisia' Woodland and Hill *Geography Review* Sept 2001 pp.10-14 'Desertification in Southern Africa' Thomas and Dougill *Geography Review* Nov 2003 pp.24-7 Geofile 339 Desertification Waugh pp.191-2, on desertification. Clowes and Comfort p.328 Waugh p.273 and p.323 O'Hare and Sweeney pp.139-142 Money p.87 and Warburton p.100 have a case study of the Sahel.

		www.tooter4kids.com/Desert/sahara_desert.htm www.oxfam.org.uk/coolplanet/ontheline/explore/nature/deserts/deserts.htm www.geo.ua.edu/intro03/wind.html www.pacificislandtravel.com/nature_gallery/geomorphology.html www.legend.net/oman/des.htm www.earthobservatory.nasa.gov/Newsroom/New Images Amazing photos on www.saharamet.com/desert/photos/Sahara.html www.geog.nottingham.ac.uk/~michele/research/geomorphology/sand.htm http://pubs.usgs/gip/deserts/dunes www.geo.arizona.edu www.terragalleria.com/arizona/monument-valley/picture www.cwnp.org/adaptations.html has excellent photographs www.rivenrock.com very good on cactus plants www.courseworkbank.co.uk has an essay on the Gezira Irrigation scheme www.waddmedani.com/english/gezira_scheme.htm	.