

## 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 of *Hydrology, Atmosphere and Weather* and *Rocks and Weathering*.

**Context** The focus in this option is on both **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 Geofactsheets at <http://www.curriculumpress.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 3<sup>rd</sup> edition; Woodfield, J (2000) *Ecosystems and Human Activity* Collins 2<sup>nd</sup> edition *Geography in Focus (2000) Cook, I, Hordern, B, McGahan, H, Ritson, P Causeway Press Ltd*

AO	Learning outcomes	Suggested teaching activities	Online resources	Learning resources
4.1	<b>Distribution, characteristics of climate</b>	<p>Introduction-Definition of arid and semi-arid.            Traditional criterion: annual rainfall amount            Arid: less than 250mm per annum            Semi-arid: 250-500mm per annum.            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 ppt) 0 (areas where P=PET) +100 (areas where P&gt;PET). Arid areas are between -40 and -100 and semi-arid areas are</p>		<p><b>Waugh</b> p.178-good discussion on definitions</p> <p><b>Clowes and Comfort</b> p.309-10-excellent section on Thornthwaite's aridity index</p> <p><b>Money</b> p.48 Fig 3.3 is a useful map of semi-arid areas. p.85-6 is useful for semi-arid areas and rainfall variability</p>

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4.2	<b>DESERT PROCESSES AND</b>	<p>between -20 and -40.</p> <p>Global distribution of hot deserts. World map-<b>ideal teaching aid-June 2002 9696 Paper 2 Q8 (a).</b></p> <p><b>Distribution:</b></p> <ul style="list-style-type: none"> <li>• <b>Latitude (high altitude deserts within the area)</b></li> <li>• <b>West coast</b> – influence of cold ocean currents</li> <li>• Continental interiors</li> </ul> <p>Present climates</p> <p><b>Characteristics of an arid climate</b></p> <p>Temperatures: Annual, Diurnal range, Rainfall annual amounts, variability, convectional rainfall, flash floods</p> <p>P:E ratios,</p> <p>Rainfall reliability, water availability, effective precipitation, soil moisture budgets, albedos.</p> <p><b>June 2002 Q8 (a)</b> on Rainfall reliability. <b>Excellent teaching resource- map of rainfall reliability in deserts</b></p> <p><b>June 2003 Q8(b)</b> on flash floods</p> <p><b>Causes of aridity</b></p> <ol style="list-style-type: none"> <li>1. Descending limb of Hadley cell, related winds. (Seasonal movement of the thermal equator-ITCZ) relate to latitudinal distribution, e.g. Sahara desert</li> <li>2. Offshore ocean currents, relate to global distribution map, e.g. Namib desert</li> <li>3. Rain shadow areas and continentality-relate to continental interiors e.g. Gobi Desert</li> </ol> <p><b>Past Climates</b></p> <p>Climate change-Pleistocene period-continental ice</p>	<p>Geofactsheet 24 the causes of aridity</p>	<p><b>Goudie</b> p.113-5</p> <p>Waugh p.178 Fig. 7.1</p> <p><b>Waugh</b> p.179-has an excellent map</p> <p><b>Clowes and Comfort</b> p.310 has excellent maps of global distribution of arid and semi-arid areas and rainfall reliability.</p> <p><b>Waugh</b> p.178</p> <p><b>Small</b> p.290</p> <p><b>Goudie</b> p.116-8</p> <p><b>Goudie</b> p.113</p> <p><b>Money</b> p.85-7</p> <p><b>Waugh</b> p.179</p> <p><b>Small</b> p.290</p> <p><b>Goudie</b> p.115-6</p>

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	<p><b>LANDFORMS</b></p>	<p>sheets in N Hemisphere. 'Pluvials' wet periods-result of migration of wind and pressure belts south. Therefore N Africa influenced by mid-lat rainfall and s edge of Sahara migrated into the savannas.</p> <p><b>Link to 4.2</b> i.e. Weathering, erosion and landforms. Archaeological evidence should be separated from geomorphological evidence.</p> <p>Emphasise link between process and form throughout, also link back to climate <b>4.1</b> and link to <b>hydrological regimes</b> which could be the starting point here because it straddles climate and landforms</p> <p><b>Desert Environment hydrology</b></p> <p>Water flows and stores, groundwater, predominance of Hortonian overland flow because rainfall intensity invariably exceeds infiltration capacity. Hydrographs, water budgets. Mention of perennial, 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 <b>4.4</b> Water availability, tapping of groundwater supplies-wells etc irrigation.</p> <p><b>June 2002 Q7 (a) Nov. 2003 Q7 (a).</b> Both asked about hydrological regimes.</p> <p><b>Processes.</b> Throughout there has to be discussion about these processes, the extent to which they dominate in arid areas and the factors that influence the processes.</p> <p><b>Weathering: Physical- Exfoliation</b>-conductivity of rocks, coefficients of expansion of different mineral of</p>		<p><b>Small</b> p.291 short excellent section on 'pluvials'</p> <p><b>Goudie</b> p.118-9</p> <p><b>Waugh</b> p.190 Excellent map of evidence of climate change</p> <p><b>Waugh</b> p181-186</p> <p><b>Small</b> p 292-303</p> <p><b>Clowes and Comfort</b> p.312 has a good diagram of a water budget illustrating water deficit and therefore availability, 315</p>

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		<p>different sizes and colours. Peeling of surface layers of rock- curvilinear sheets. May be aided by dilatation/pressure release. Relate to diurnal range of temp. Link to water-episodic rainfall, upward capillary movement of water as a catalyst of the process. Exfoliation domes/bornhardts in semi arid areas.</p> <p><b>Salt weathering</b>  <b>Frost shattering</b> in high altitude deserts</p> <p>Chemical- limited because of lack of water but present-Hydration especially in arid areas. Greater chemical weathering in semi-arid areas due to greater vegetation cover producing organic acids to facilitate processes.</p> <p>End products of weathering  <b>Block and granular disintegration</b>-link back to the process.  <b>Nov.2002 Q7(a)</b></p> <p><b>Erosion, transportation and deposition-agents wind and water.</b>  Link to landforms at every stage.  <b>Erosion</b>-abrasion, deflation, <b>transportation</b>-suspension, saltation, traction. <b>Deposition</b>  <b>Erosion and transportation-chief agent wind</b>  Process of <b>abrasion-mushroom/pedestal rocks.</b>  Discussion about role of wind, transportation of sand particles. Concentration within a metre or less of the surface. Changing view now thought role of water and chemical weathering is important. Yardang and Zeugen can be mentioned but structure as well as wind may be an influential factor.</p>		<p><b>Clowes and Comfort</b>  p313-4  <b>Goudie</b> p.124-5 has an excellent discussion</p> <p><b>Cook, Hordern et al</b>  376-384 is useful for this section</p> <p><b>Goudie</b> p.127-133</p> <p><b>Clowes and Comfort</b>  p.313</p> <p><b>Cook, Hordern et al</b>  344 - 349 is useful for this section</p>

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		<p><b>Deflation-</b> erosion of sand to produce deflation hollows. Dimensions large-other factors-structural and then chemical processes once the hollow has reached the water table.</p> <p><b>Deposition-</b> Sand dunes reasons for deposition, reduction in wind velocity, initiator of velocity reduction-changing gradient of the surface (an obstacle!), changing atmospheric conditions.</p> <p><b>Variety of form according to local conditions.</b> Barchans, seif (linear), transverse, star etc Annotated diagrams is an ideal way to present the description of these landforms.</p> <p>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.</p> <p><b>A typical desert profile-</b> mountain front with embayments, knick, pediment with veneer of alluvial material, bahada (peripediment) playa See Fig 1</p> <p><b>Evolution of the profile-theories of formation.</b></p> <p><b>Pediplanation.</b> To include <b>parallel retreat of slopes (scarp retreat)</b> and <b>pedimentation</b> i.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</p>	<p><a href="http://geoimages.berkeley.edu/">http://geoimages.berkeley.edu/</a> Excellent images of the landforms</p> <p><a href="http://www.regolith.com">http://www.regolith.com</a></p>	<p><b>Small</b> p 300 <b>Clowes and Comfort</b> p320-322</p> <p><b>Waugh</b> p.185 Whole page devoted to the variety of sand dune form. Highly recommended. <b>Goudie</b> p.131 has excellent diagrams <b>Clowes and Comfort</b> 323-325</p> <p><b>Clowes and Comfort</b> p.316-Arroyos <b>Waugh</b> p.188</p> <p><b>Waugh</b> p.187-8 <b>Small</b> p.303-309 Fig.1</p>

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4.3	<b>SOILS AND VEGETATION</b>	<p>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.</p> <p>Importance of climatic change in the evolution of 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. <b>Link to 4.1</b> <b>November 2002 Q8(a)</b> <b>Questions on landforms:</b> <b>Nov 2003 Q8(a) June 2002 Q7(a)</b></p> <p>Functioning and structure of the ecosystem Productivity-NPP nutrient cycling (Gersmehl diagram-see Fig 2 in Tropical Environment Option) Biodiversity, trophic levels/food chain. Fragility/resilience.(Two theories-Fragile because food chains are simple or resilient because the organisms are highly adapted)</p> <p>Vegetation- characteristics and adaptations to high temperature and drought. Distinguish between physical and physiological drought. <b>Nov 2002 Q8(b)</b></p>		<p><b>Small</b> p. 291 This is the key text on the subject <b>Clowes and Comfort</b> p 327-8</p> <p><b>Small</b> p.309-316 <b>Clowes and Comfort</b> p319</p>

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4.4	<p><b>SUSTAINABLE MANAGEMENT OF ARID AND SEMIR-ARID ENVIRONMENTS</b></p>	<p><b>Soils-</b> 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. <b>A typical desert soil</b>-shallow, grey, saline and nutrient poor.</p> <p>There is an excellent case study of semi-desert vegetation in Death Valley, Mojave Desert California in O'Hare. Sonoran Desert Geog Review article Nov 2001 <b>June 2003 Q7(b) Nov. 2003 Q7(b)</b></p> <p>Case Study will include problems of water supply and the management of that supply. It will 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 (sub-Saharan Africa) is a useful vehicle for discussion of the combination of physical (lack of rainfall) and human activities responsible for environmental degradation and the need for sustainable measures. Possible case studies are:</p> <ul style="list-style-type: none"> <li>• <b>Gezira Irrigation scheme Sudan</b></li> <li>• <b>Tunisia-water management</b></li> <li>• <b>Drought in Zambia</b></li> </ul>	<p><a href="http://www.curriculumpress.co.uk">http://www.curriculumpress.co.uk</a> Drought and Desertification in India and Pakistan April 2003 Number 446</p>	<p><b>Tivy and O'Hare</b> p.158 <b>Goudie</b> p.119-121 has excellent diagrams of the flora and fauna</p> <p><b>Waugh</b> p.322</p> <p><b>Waugh</b> p.323 has a profile diagram <b>O'Hare</b> p127-130 <b>Goudie</b> p.138-143</p> <p><i>Plant distribution in the Sonoran Desert</i> Jane Dove <b>Geog Review</b> Nov 2001 p.10-13 Excellent source.</p>

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		<ul style="list-style-type: none"> <li>• <b>Nile Valley</b>-this is the best documented example in accessible texts.</li> <li>• <b>Drought in the semi-arid Sahel</b> (sub-saharan Africa)</li> </ul> <p>However online information is readily available if key words are put into the search engine.</p>	<p><a href="http://www.un.org/ecosocdev/geninfo/sustdev/desert.htm">http://www.un.org/ecosocdev/geninfo/sustdev/desert.htm</a> has material on desertification</p> <p>Geofactsheet 28 Desertification – causes and control</p> <p>General web sites on deserts with images and factual information <a href="http://www.tooter4kids.com/Desert/sahara_desert.htm">http://www.tooter4kids.com/Desert/sahara_desert.htm</a></p> <p><a href="http://www.oxfam.org.uk/coolplanet/ontheline/explore/nature/deserts/deserts.htm">http://www.oxfam.org.uk/coolplanet/ontheline/explore/nature/deserts/deserts.htm</a></p> <p><a href="http://www.geo.ua.edu/intro03/winid.html">http://www.geo.ua.edu/intro03/winid.html</a></p> <p><a href="http://www.pacificislandtravel.com/nature_gallery/geomorphology.html">http://www.pacificislandtravel.com/nature_gallery/geomorphology.html</a></p> <p><a href="http://www.legend.net/oman/des.htm">http://www.legend.net/oman/des.htm</a></p> <p><a href="http://earthobservatory.nasa.gov/Observatory/#">http://earthobservatory.nasa.gov/Observatory/#</a></p>	<p><b>Bishop and Prosser</b> has general principles of water management <b>Hill</b> p 19 Nile Valley Case Studies can be found in <b>Waugh</b> The New Wider World p.274-5 <b>Digby</b>, Its a World Thing p.162-5 <i>Drought response in southern Zambia</i> Richard Byrne <b>Geog Review</b> Jan 2000 p.22-24 <i>Water Management in Tunisia</i> Woodland and Hill <b>Geog Review</b> Sept 2001 p.10-14 <i>Desertification in Southern Africa</i> Thomas and Dougill <b>Geog Review</b> Nov 2003 p24-7 <b>Geofile 339</b> Desertification <b>Waugh</b> p.191-2 on Desertification <b>Clowes and Comfort</b> p.328 <b>Waugh</b> p.273 and 323 <b>O'Hare and Sweeney</b> p.139-142 <b>Money</b> p.87 and <b>Warburton</b> p.100 have a case study of the</p>

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			<p>Amazing photos on  <a href="http://www.saharamet.com/desert/photos/Sahara.html">http://www.saharamet.com/desert/photos/Sahara.html</a></p> <p><a href="http://www.geog.nottingham.ac.uk/~michele/research/geomorphology/sand.htm">http://www.geog.nottingham.ac.uk/~michele/research/geomorphology/sand.htm</a></p> <p><a href="http://www.geo.arizona.edu">http://www.geo.arizona.edu</a></p> <p><a href="http://www.cwnp.org/adaptations.html">http://www.cwnp.org/adaptations.html</a>  has excellent photographs</p> <p><a href="http://www.rivenrock.com">http://www.rivenrock.com</a>  is very good on cactus plants</p> <p><a href="http://www.courseworkbank.co.uk">http://www.courseworkbank.co.uk</a>  has an essay on the Gezira Irrigation scheme</p> <p><a href="http://www.wad-medani.com/english/gezira_scheme.htm">http://www.wad-medani.com/english/gezira_scheme.htm</a></p>	<p>Sahel.</p>