Desertification and environmental geography

The seminal text for this section is Andrew Goudie's ***The Human Impact on the Natural Environment*** (1986). It encompasses one of the four traditions of Geography as expressed by Pattison (1964), namely the man-land tradition, 'one of the pillars of the discipline since the modern academic structure crystallised in 19th-century Germany' (Mosley et al 2014, 7). The others pillars being the spatial tradition, area studies tradition and earth science tradition (Pattison, 1964). Goudie traces the impact of humanity on Earth through the development of geographical thought which included George Perkins Marsh' ***Man and Nature*** (1864) and then mentions a number of Geography texts including ***Man's Impact on the Environment*** (Detwyler, 1971), ***Environment and Man*** (Wagner, 1974), ***Man and Environmental Processes*** (Gregory & Walling, 1979) and ***Biogeography: natural and cultural*** (Simmons, 1979).

However, the focus in this section is expressed more precisely by geographer Bill Adams, through his book ***Future Nature*** (1996) that argues that ' geographers should study human uses and abuses of the environment so as to fashion more effective conservation and restoration projects- effective because they are based on accurate understanding' (Castree, 2005, 178).

Goudie (1986, 46) explained that the debate about the question of the alleged expansion of deserts was keenly contested and highly contentious and yet geomorphologist, Geoff Pickup maintains that, in Australia, we rarely use the term, preferring to refer to land degradation (1998, 52). However, the locus of much of the discussion about desertification is Africa, in part because the newly established UNEP in the 1970s, with its headquarters in Nairobi, Kenya. The UNEP proclaimed desertification as the greatest single environmental threat to the future well-being of the Earth (Benjaminsen & Berge, 2005, 48). The debate was also circumstantial, because of savage 1970s droughts in the Sudano-Sahel region that resulted in 250 000 deaths, millions destitute and pronounced rural-urban migration. Furthermore, in Ethiopia, 1982-1986, the combined effects of severe droughts and civil war killed over a million people (Reynolds & Stafford Smith, 2002, 6).

Accurate understanding of desertification

Accurate understanding is essential. As recently as 2007 the UNEP still referred to the spread of the Sahara Desert across the northern half of Sudan as a 50 to 200 km southward shift of the boundary between desert and semi-desert occurring since rainfall and vegetation records began in the 1930s. Their source for this assertion was some very old geographical research (Stebbing, 1935). They did add the caveat that the evidence for the findings is piecemeal, anecdotal and/or based on site-specific data (UNEP, 2007, 64).

Much earlier a United Nations Food and Agriculture Organisation graphic maintained that, 'On the southern edge of the Sahara, an area the size of Somalia has become desert over the past 50 years. The same fate now threatens more than one third of the African continent. The main cause of desertification is not drought but mismanagement of land, including overgrazing and felling of trees and brushwood for fuel' (FAO, 1990).

Nick Middleton (1991, 6) explained that terms such as: desert encroachment, desert advance, desert creep, desert expansion, and spreading deserts all suggest that desertification involves the expansion of existing deserts at their edges. But David Thomas was adamant, 'the concept of an advancing desert front used to infer desertification and the spread of the Sahara is incorrect' (Thomas, 1993, 323). Indeed, a more recent assessment from the United Nations Convention to Combat Desertification (Kirby & Landmark, 2012, 12) stated that

'Contrary to popular perception, desertification is not the loss of land to desert or through sand-dune movement. Desertification refers to land degradation in arid, semi-arid and sub-humid areas resulting from various factors, including climatic variations and human activities.'

Left: Somaliland drought, East Africa. Source: Wikimedia Commons

Drought conditions, Lake Hume, on the Murray River system. Source: Wikimedia Commons

The process of land degradation

The next step is to understand the process of land degradation. Alan Grainger (1990, 7) put it so succinctly enough, 'desertification is the degradation of lands in dry areas'. And, there is plenty of evidence of environmental degradation from the Australian context, for example, 'European agriculturalists in just five generations have altered the face of the Australian continent far more dramatically than had been done by all those who had gone before' (Graetz, Fisher & Wilson, 1992). In the 1980s Australian geographer John Holmes observed that, 'The cumulative effect of vegetation loss, gullying, scalding and sand drift can be termed 'desertification', or the transformation of semi arid ecosystems into desert' (Holmes. 1983, 51). But later most Australian geographers focused on accelerated land degradation in drylands. Geographers Arthur and Jeanette Conacher (Conacher, 2006, 1) defined land degradation as 'alterations to all aspects of the biophysical environment by human actions to the detriment of vegetation, soils, landforms, water, ecosystems and human wellbeing.'

Pickup (1998, 52) adds, also, that here is little contention about the causes of Australian rangeland degradation. He identifies unsuitable land use or poor land management. Although the triggering mechanism could be both unusually wet and unusually dry conditions, situations made worse by the roles of feral animals, especially the rabbit in the southern part of the continent.

More generally arid lands scientist Howard Dregne explains, that here are two classes of causes of land degradation in the world's drylands. The direct cause reflects Pickup's observations regarding poor land management but the indirect causes are more intractable and far more difficult to redress. 'The indirect causes of the mismanagement may be many: land tenure arrangements, export-import policies, political acts, drought, poverty, poor advisory services, little or no problem-solving research, population pressures, etc. Combating desertification and developing a sustainable management program depends upon removing both kinds of causes' (Dregne, 1999, 100).

What to conserve and restore?

Next, we should be clear about what we wish to conserve and restore. Degraded drylands continue to function as ecosystems but have a reduced capacity to provide ecosystem services: 'have a reduced capacity to supply the goods and services we are seeking, for example, food, habitat for threatened species and landscape amenity' (Lumb, 2012, 1). The United Nations Convention to Combat Desertification couches conservation and restoration in extremely general terms with references to combatting desertification as part of an integrated development objective that incorporates sustainable development in attempts prevent or reduce land degradation, rehabilitate partially degraded land and reclaim 'desertified land' (UNCCD, 1994, 4)

But, more importantly we should appreciate that the basis for an, 'accurate understanding' has deepened, Geographical research into the links between climate, management and degradation has taught us a great deal since the 1970s. Since then, there have been many detailed studies of human impacts on the natural environment. Particularly, those carried out at the local scale in drylands informed by advances in climatology, the soil biological sciences, spatial technologies, agronomy, and the social sciences (Batterbury & Warren, 2001a, 3527). The Millennium Ecosystem Assessment of dryland ecosystems has also contributed to improved understanding of the biophysical and socioeconomic factors that underpin land degradation in arid, semi arid and dry sub humid ecosystems (UNCCD, 2007, 8).

Where dryland degradation takes place

It is important to establish where dryland degradation takes place. The area prone to 'desertification' as opposed to land degradation in general is usually associated with the arid and semi-arid rangelands in Australia although Pickup (1998, 52) explains that it would extend well into the croplands if the climatic definition in the 1994 United Nations Convention to Combat Desertification were used (52). The Convention to Combat Desertification refers to land degradation in arid, semi-arid and dry sub-humid areas in which the ratio of annual precipitation to potential evapotranspiration falls within the range from 0.05 to 0.65. This follows the findings expressed in the ***World***

Atlas of Desertification (Middleton and Thomas 1992) that defined drylands as areas with an aridity index value of less than 0.65. When the potential evaporation rate is greater than annual precipitation, this ratio is less than 1. Hyper-arid climate zones have P/PE ratios of less that 0.05, arid 0.05 to 0.20, semi-arid 0.21-0.50, and, dry sub-humid 0.51 to 0.65 (Reynolds & Stafford Smith, 2002). Interestingly, hype-arid areas are not part of this analysis. They are deemed to be deserts already!

The extent of desertification

The extent of desertification is paramount if accurate understanding is to be achieved. The United Nations Conference on Desertification, held in Nairobi in 1977 resulted in a burst of publicity and much controversy among the geographic and wider scientific community. There were a number of alarmist claims forthcoming. The newly established UNEP was prone hyperbole with 'at least one third of the present global deserts are man-made, […], the result of human misuse of the land' (UNEP, 1991) and some ten years after the conference the UNEP estimated that in a little less than 200 years at the then current rate of desertification, 'there will not be a single fully productive hectare of land on earth' (Scoging, 1991, 58).

On the other hand, fieldwork evidence indicated that there was no uniform land degradation and that agricultural production actually increased in places that were designated as being subject to desertification (Herrman & Hutchinson, 2005, 539). Geographer Michael Mortimore, for example, wrote ***Adapting to Drought*** (1989) examining first hand a 25-year long time period that covered the Sahel famines and droughts in the 1970s and 1980s concluding that African smallholders adapted more or less successfully to climate change and 'desertification'. Geographer Bill Adams Michael Mortimore discussed land degradation management measures in four farming villages in northeast Nigeria. (Mortimore & Adams, 2001). They described the farmer's technical expertise in adapting to erratic rainfall, their selection of numerous seed varieties of millet and sorghum that suited local conditions, and husbandry of livestock where 'everyone owns, or aspires to own, livestock' (2001, 54). More surprisingly they demonstrated that increasing population densities resulted in better land use rather than accelerated land degradation. They also established that farmers were most adept at adopting ways and means of diversifying their livelihoods in times of stress.

Another text ***More people, Less Erosion: Environmental Recovery in Kenya*** (Tiffen, Mortimore & Gichuki, 1994), a study conducted over sixty years, concluded that previously degraded land in the semi-arid Machakos

Drought conditions in Ethiopia. Wikimedia Commons

Hills benefited from human ingenuity 'through a fundamental transformation in farming practices, including: a reversal of erosion thanks to thousands of kilometres of farm terraces and field drains; improved productivity through integrated crop–livestock production systems; new or adapted farm technologies; increased labour inputs; and increased private investments, which were financed in part through off-farm incomes' (Dobie & Goumandakoye, 2007, 14). Local farmers and land managers were improving biodiversity and halting land degradation without expensive external solutions and inappropriate technological interventions.

Michael Mortimore now has his work published in United Nations documents such as ***Why invest in drylands*** (Mortimore, 2004), is cited in the UNEP Report, ***Global Environment Outlook, GEO4, environment for development*** (UNEP, 2007) and acknowledged as a critical expert in the UNDP's ***The Global Drylands Imperative*** (Dobie & Goumandakoye, 2007). The United Nations Millennium Ecosystem Assessment Report on desertification (Millennium Ecosystem Assessment, 2005) and the more detailed treatment in (Safriel, & Adeel, 2005, 623-680) are now much more circumspect about the extent of desertification and the active roles of local land managers in redressing land degradation problems.

Moreover, the extent of desertification is made ever more difficult by fluctuations in the boundaries of the Sahel. Mortimore and Turner (2005, 590) remarked on the 'greening' of the Sahel seen from space during the period 1982–2002. They were not sure how much of this 'greening' was attributable to rainfall effects and how much to more sustainable management practices? But, they did explain that they had documented many 'success stories' of environmental management carried out by smallholders in African drylands, local case studies undertaken in selected districts of Burkina Faso, Senegal, Niger, Nigeria and Kenya.

The Millennium Ecosystem Assessment report, sponsored by private foundations, the Global Environment Facility, the United Nations Foundation and The World Bank, is based on information generated by 1,300 experts from 95 countries over a four year time period. The collective judgements of the authors are couched in the following terms: v***ery certain*** (98% or greater probability), ***high certainty*** (85–98% probability), ***medium certainty*** (65–85% probability), ***low certainty*** (52–65% probability), and ***very uncertain*** (50–52% probability (Millennium Ecosystem Assessment, 2005, iv). They say that estimates of the geographical extent of desertification will vary according to the calculation methods and on the type of land degradation included in the estimate (2005, 7). There have been three assessments of the worldwide extent of desertification:

- the Global Assessment of Soil Degradation, (Oldeman, Hakkeling, & Sombroek, 1991), that reported that 20% of the drylands were suffering from human-induced soil degradation, depended entirely on expert opinion exclusive of remote-sensing and field studies;
- Another estimate from the early 1990s, (Dregne & Chou, 1992) based primarily on secondary sources, reported 70% of drylands (excluding hyper-arid areas) were suffering from desertification in terms of soil and or vegetation degradation; and
- A partial-coverage Millennium Ecosystem Assessment (Lepers, 2003), developed as a desk study from partly overlapping regional data sets and remote sensing data, estimated that 10% of global drylands (this time, including hyper-arid areas) were degraded.

The Millennium Ecosystem Assessment Report concluded that the actual extent of area subject to desertification might lie between the figures reported by GLASOD in 1991 and the 2003 study. This implies, according to the Millennium Ecosystem Assessment Report, that there is ***medium certainty*** that some 10–20% of the drylands are suffering from one or more forms of land degradation (Safriel, & Adeel, 2005, 637).

Further intelligence about the extent of land degradation in drylands will come from combining an analysis of satellite data with 'ground-truthing'. As Warren and Khogali (1992) explained, it is a relatively simple task to assess degradation in individual paddocks, but another matter to do so for whole countries and continents. Planners and agencies such as the UN require data at this coarse scale (Thomas, 1993, 324).

More usefully though, data obtained at a more local scale enables East African pastoralists make informed decisions about stocking rates and the movement of animals from place to place. They gain information from satellite-based weather monitoring systems, and associated geospatial technologies to inform them about standing crops and forage conditions. They can make proactive decisions on the basis of short-term weather changes extending over a number of days and longer-term predictions extending over months. Over this longer term period they can make informed decisions about predicted drought before the spectre of 'desertification' takes over. They can effectively consider their marketing or management options (Stuth, Kaitho, Angerer, & Jama, 2003, 106).

The 'greening' referred by Mortimore above is devised from an index. Earth-observing instruments carried on satellites map differences in NDVI, albedo and surface temperature. NDVI measures the amount of solar radiation absorbed by the vegetation and spatial scientists are able to estimate rates of net primary production from these data. The 'greenness index', the normalized difference between difference vegetation index, (NDVI), showed a strong increase in values from 1982-1999 (Mortimore, 2004, 29). Nicholson and her colleagues examined fluctuations in the greenness index across the Sahel (Nicholson Tucker, & Ba, 1998) to explain that the findings were caused by rainfall fluctuations rather than desertification. But there were a number of uncertainties expressed over these conclusions.

To what extent had the efforts of local land managers contributed to this 'greening'? There is some evidence from Niger to suggest that the popularity of trees on farms, discussed in the section below, have led to a reforested landscape whereas across the border in

Left: Stock losses during drought, Horn of Africa. Wikimedia Commons

Nigeria satellite images depicted a barren landscape. Chris Reij, an agroforestry specialist at the Free University of Amsterdam, remarked that the images depicted the same landscape, same people and same culture (Bilger, 2011). The only difference was the efficacy of tree planting efforts on farms in Niger.

It may be more feasible to examine desertification on a national scale using remote sensing? A desertification map of Zimbabwe was composed using values determined from the French SPOT satellite, between 1998 and 2002. The net primary production of each satellite grid square, or 1sq. km. pixel, was calculated. Grey or white shaded areas on the ***Local Net Primary Production Scaling Map of Zimbabwe*** appeared to indicate terrain experiencing desertification, with dark grey shading depicting the most 'green' grid squares, or near potential productivity levels. When comparisons were made with land use maps the communal farms tended to match with lighter shaded pixels and the commercial farms darker shading (Safriel, & Adeel, 2005, 638-9). The communal farms support high population densities and are known to be degraded as a result of fieldwork surveys on the ground. It should be stressed that there is a correlation between desertification and elevated population density but this does not imply a causal relationship. The work of Mary Tiffen, Michael Mortimore and others referred to above suggest exactly the opposite may be the case. Poverty may be the crucial factor in this instance? The formerly 'white'-owned commercial farms occupied the better soils and most amenable terrain.

'Green belts' or 'trees on farms'

Batterbury and Warren (2001a, 3528) explained that academic research papers, government policies and interventions are strongly linked. They said that when scientists foregrounded advancing deserts, the policy response was to plant green belts. In the United States, after the Dust Bowl years, a study was drawn up for the establishment of a colossal green belt stretching from Texas to North Dakota. Edward Stebbing, in ***The Encroaching Sahara, the Threat to the West African Colonies*** (1935) recommended the same sort of scheme for Africa, and the United Nations Convention to Combat Desertification subsequently proposed a green belt across the Sahara, with the New York Times reporting on plans for the revival of a green belt across the Sahara in 1977 (Veron, Paruelo, & Oesterheld, 2006, 753). 'Where scientists believed that herdsmen or farmers were irrationally causing degradation, policy-makers and government officials prohibited goats, tree cutting or grass burning, and destocked herds, or, on a much more massive scale, they enforced soil conservation programs' (Batterbury & Warren, 2001a, 3528) such as green belts.

In Australia, Matthew Tonts and his colleagues (cited in Conacher, 2006, 13-14) examined a range of socioeconomic as well as environmental consequences of extensive tree planting on land previously used for agriculture in two Australian regions. Ostensibly a solution to redress problems cause by dryland salinity, they were actually export wood-chipping projects in disguise. The plantations contributed to rural population decline and set in train a suite of potential biophysical problems:

- destruction of remnant vegetation and wildlife habitats;
- demolition of conservation works on farms turned over to plantations;
- impact of chemical sprays on water courses;
- hydrological and environmental implications of the draw-down of groundwater aquifers;
- reduced biodiversity associated with single species plantations;
- little attention to weed control;
- soil erosion following timber harvests; and
- water and nutrient depletion from adjacent soils.

Elsewhere, the United Nations Convention to Combat Desertification provides examples of tree planting projects that are deemed to be successful. In Niger between 1975 and 2003 200 million trees were planted in more than five million hectares of land in the Sahel (Kirby & Landmark, 2012 49). But, it is more effective to think of these as tree planting projects rather than 'green walls'. Paul Harrison wrote about the potential success of such projects in 1987. In ***The Greening of Africa*** he listed numerous small scale innovations including stone lines, planted bunds, grassed strips, water harvesting, alley cropping and hand dug wells at dispersed watering points. In alley cropping, for example, 'food crops are grown between pruned hedgerows of fast growing, nitrogen-fixing trees. The leaves are used as mulch, and act as free fertiliser, improving soil structure and boosting crop yields by upwards of 35%' (Harrison, 1987, 192).

Desertification may be an appropriate term for land degradation of drylands at a national, continental or global scale but land degradation is a much more apposite term at finer scales. At the household, farm or local scale it becomes increasingly apparent what needs to be conserved and restored. The combination of forestry, cultivation, and livestock rearing is regarded as a sustainable land use option for farmers in the Sahel.

Such practices are built on traditional land use systems and practices, for example, the use of small planting pits or *zaï*. The 30cm wide and 20 cm manure filled deep pits funnelled water and nutrients to millet and sorghum crops grown in the Yatenga region of Burkina Faso. The resulting yields were so impressive that neighbouring farmers adopted the technique. NGOs spread the news of this innovation as well introducing the notion of stone lines built along the contours of the fields, which reduced erosion and protected the *zaï*' (Hutchinson & Herrmann, 2008, 151). A further emphasis on trees on farms improved the soil, conserved water and yielded fuelwood, timber and fodder supplies. The grazing animals are introduced to the fields in the dry season to feed off the stubble and add fertiliser to the fields.

Mary Tiffen and Michael Mortimore (2002, 218) that there have been some positive trends emerging from long-term data obtained from the Sudano-Sahel. They point to case studies from Makueni, Kenya; Diourbel, Senegal; Maradi, Niger; and the Kano zone of northern Nigeria that demonstrate how adaptive small farmers are in maintaining fertility, conserving water, managing trees, increase livestock numbers, and taking advantage of changing market conditions. They explain that the farmers' efforts are all too often constrained by poverty and call upon provincial and national governments to improve market access and increase the scope of non-farm opportunities in efforts to cope with variable rainfall and the reoccurrence of drought. They concluded, 'The 21st Century will see more droughts in sub-Saharan Africa, but neither desertification nor a downward poverty spiral are inevitable' (2002, 232).

Batterbury and Warren (2001a, 3528) explained that, in Niger, authoritarian governments fully embraced green belt proposals despite the reservations expressed by local landholders and current views expressed by many scientists that the schemes were 'deeply irrational'. Similarly, in Mali military rulers banned burning off practices, practices that local pastoralists knew that enriched savanna grassland pastures. On the other hand, the restoration of savanna woodland, in the form of farmed parkland has been very effective. 'In the Maradi Department of Niger, there was rapid conversion of dry forest to farmland from the 1920s until the 1970s, along with in-migration and rapid population growth. Farmed parkland, however, is now well established on permanent fields especially close to the villages. In fact, the practice of protecting and nurturing valuable seedlings is widely popular and also supported by government policy' (Dobie & Goumandakoye, 2007, 28).

The United Nations Convention to Combat Desertification reported that farmers in Niger suffered 'less from dust storms compared with 20 years ago and that early in the rainy season the current tree densities protect their crops better against the impact of strong winds' (Kirby & Landmark, 2012, 49). When famine occurred in 2005 the villages with trees coped with the sale of firewood and fodder; when the rains arrived late in 2007 the farmers with many trees in their fields benefited from better harvests than those areas with fewer trees (Kirby & Landmark, 2012 49). Silviculture, agriculture and pastoralism are clearly compatible and complementary but this is very different from the erection of immense green belt of trees.

Nevertheless, the United Nations Convention to Combat Desertification refers to the 'Great Green Wall in China' as an example of best practice. Some of the 'advancing desert' rhetoric is still evident in this context where the 'livelihoods of 400 million people are either threatened or affected by desertification, land degradation, the encroachment of the Gobi, Taklimakan and Kumtag Deserts as well as other deserts and sandy lands in western China' (Kirby & Landmark, 2012, 16). To reverse this kind of land degradation the Great Green Wall of trees shrubs and grasses has been planted since 1978. The Chinese government reported in 2011, in '***A Bulletin of Status Quo of Desertification and Sandification in China***' that the degradation of huge swathes of desertification-prone land had been reversed (2012, 16).

Chinese academics are also open to hyperbole, 'Desertification plagues almost all arid, semi-arid and sub- humid areas of northern China and has become a challenge facing more than 1.6 million km^2 and 200 million people' (Wang, Xue, Zhou & Guo, 2012, 1). These scientists present a case study of Balinyou County in Inner Mongolia, an area that has suffered from aeolian desertification, where fine soil particles and soil organic matter has been eroded by the wind. The most efficacious control measures adopted were dune stabilization using wheat straw checkerboards, the erection of wind shelterbelts of trees and the protection of grasslands using fenced-off areas that prohibit or rotate grazing within the enclosed land. Over a seven year period the migrating dunes had become fully rehabilitated with grasses, the shelterbelts protected only the best selected farmlands on the low-lying alluvial soils and grain yields increased markedly, and, in the fenced-off land average vegetation cover increase from 40 to 85%. (Wang, Xue, Zhou & Guo, 2012,13).