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## DESERTS AND DESERTIFICATION: CHALLENGES BUT ALSO OPPORTUNITIES

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### ABSTRACT

The UN decision to couple ‘deserts’ and ‘desertification’ in addressing the year 2006 (as well as the following decade) as ‘Year (or Decade) of Deserts and Desertification’ sends several wrong messages regarding both the nature of deserts as natural ecosystems and of desertification as a human-driven process that reduces the provision of ecosystem services of soil conservation and of biological productivity, specifically in non-desert areas, more than in desert ones. A new approach to addressing sustainable development in the drylands was presented in an international conference that took place at the end of the ‘International Year’ and hosted by the Blaustein Institutes for Desert Research in Sede Boqer, Israel. This approach (a) qualifies drylands as ecosystems whose biological productivity is constrained by water and hence it is naturally low compared to that of most other terrestrial ecosystems; (b) qualifies desertification as a further persistent reduction of productivity in the drylands brought about mainly through human impact mostly driven by population increase; (c) observes that within the drylands natural productivity linearly declines with aridity, and suggests that sensitivity to impact linearly increases with aridity; (d) further suggests that population density generates the impact, and observes that population density in drylands increases exponentially as aridity declines; and (e) suggests that the product of the linear sensitivity and the exponential impact generates a desertification peak at the transition between non-desert drylands (where desertification and poverty are high) and the desert drylands (where both are very low). Given these, the Sede Boqer approach suggests that (a) rather than be construed as an adversity, desert drylands offer opportunities to their inhabitants since their environmental conditions are conducive for livelihoods mostly independent of the desert’s very low productivity; this includes solar energy development and tourism, but also (counterintuitively!) desert aquaculture; (b) non-desert drylands, on the other hand, face a serious challenge of becoming desertified, mainly due to increasing population; and (c) global climate change further increases the success of alternative livelihoods in deserts, may create opportunities in some of the non-desert drylands too, but amplifies the challenges facing non-desert drylands people. Caution and prudence are required to meet these challenges, especially since currently socio-political measures are in shorter supply than technological fixes. Copyright © 2009 John Wiley & Sons, Ltd.

### INTRODUCTION

‘Deserts and desertification—challenges and opportunities’ is the title of an international conference convened in the Blaustein Institutes for Desert Research, the Sede Boqer Campus of Ben-Gurion University of the Negev, Israel, in 6–9 November 2006. The year 2006 was declared by the General Assembly of the United Nations as the international year of deserts and desertification (IYDD), and the Sede Boqer Conference was convened as one of the IYDD events, specifically commissioned by those country parties of the United Nations Convention to Combat Desertification (UNCCD) that implement the UNCCD under the Northern Mediterranean implementation annex to this convention. This issue of the journal *Land Degradation & Development* presents a sample of the many papers delivered during the plenary and working group sessions of the Sede Boqer Conference. This paper provides an overview of the conference’s theme, in which, where appropriate, the reader is directed to the papers in this issue.

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## ‘DESERT’ AND ‘DESERTIFICATION’ —USE AND MISUSE OF TERMS

### *The ‘Desert and Desertification’ Coupling*

United Nations ‘environmental’ or ‘Rio’ conventions have proven to be effective in creating public awareness to their subject matters by transforming scientific terms confined to the academic domain, into public domain buzzwords. Similarly to ‘biological diversity’ (first coined by scientists in 1985 but acquiring a wide popular usage only a decade later when the Convention on Biological Diversity was already in force), ‘desertification’ was coined by technical experts in the 1950s but has emerged as a political banner only as of 1996, the year in which the UNCCD entered into force. The year 2006 was declared as the IYDD to commemorate the first decade of functioning of the UNCCD and to amplify the global significance of the processes to which the term ‘desertification’ stands.

However, the choice of the title for this decadal anniversary year aimed at expanding the visibility of the UNCCD and its subject matter ‘desertification’ is rather strange. This is because the combination ‘deserts and desertification’ may imply that desertification is a phenomenon confined to deserts. This is unfortunate not only because desertification is most prevalent in non-desert areas (Safriel and Adeel, 2005), but also because some 40 per cent of the global desert area (the hyperarid lands) are excluded from the mandate of the UNCCD, whose text explicitly confines desertification (and hence the need to ‘combat desertification’) to the arid, semiarid and dry subhumid areas only. Thus, the chosen title sends a contradictory and erroneous message, that a huge area which apparently cannot suffer from desertification (as attested by the UNCCD restricted mandate), is actually tightly linked to desertification.

### *The Drylands and Desertification Coupling*

It has never been explicitly spelled out why, when the UNCCD was being negotiated, the convention was dissociated from a large part of the global deserts. The prevailing explanation is that since the hyperarid areas are already a desert, they cannot be further desertified. This explanation, too, is unfortunate, since desertification is not ‘the advancement of the desert’ or the transformation of non-desert ecosystems to desert ecosystems. Rather, as defined by the UNCCD desertification is not a climatic but a biological phenomenon, to which areas characterized by certain climatic conditions can be vulnerable. Namely, ‘*desertification is land degradation*’ in ‘*arid, semiarid and dry subhumid areas*’, land degradation is a ‘*reduction or loss*’ of ‘*biological productivity*’, and ‘*arid, semiarid and dry subhumid areas*’ are areas ‘*in which the ratio of annual precipitation to potential evapotranspiration (i.e. the so called aridity index) falls within the range from 0.05 to 0.65*’.

The Millennium Ecosystem Assessment (MA) has refined this definition. First, the MA pointed out that periods of reduced biological productivity in the arid, semiarid and dry subhumid lands are often succeeded by natural restoration of productivity, and that fluctuations in productivity in these lands typically track the natural fluctuations in rainfall, which are one of the major climatic features of these lands. Hence only a *persistent* reduction or loss in productivity would qualify as desertification (Adeel *et al.*, 2005). The MA also suggested that the hyperarid areas can be at risk of desertification too (Safriel and Adeel, 2005), and following the *World Atlas of Desertification* (Middleton and Thomas, 1997) the MA used the term ‘drylands’ for an aggregate of the hyperarid, arid, semiarid and dry subhumid areas, i.e. all lands in which potential evapotranspiration is at least about 1.5-times greater than the annual precipitation.

Thus, desertification, defined as land degradation in the drylands, is expressed by a persistent reduction of biological productivity in the drylands (relative to the natural productivity typical to each of these dryland types). This means that desertification can occur, by definition, only in lands characterized by a potential water deficit (Middleton and Thomas, 1997). This potential water deficit has biological implications, namely—productivity in the drylands is limited by soil moisture, i.e. the amount of rainfall water still maintained in the soil following evaporative losses. Desertification thus is a further, human-induced lowering of the inherent low productivity of the drylands.

### *The Misuse of 'Desertification'*

For defining 'desertification' the UNCCD text allocated four paragraphs (paragraphs a, e, f and g of Article 1 of the Convention) comprising more than a 100 words, yet failing to distinguish between a *persistent* lowering of productivity and *natural fluctuations of productivity*. This might have contributed to a prevailing misuse of the term, that reflects failing to recognize desertification as a spatial subset of land degradation (which can occur in non-dryland areas too), and to distinguish between *low* productivity (typical of drylands) and *lower* productivity (which may signify desertification). Consequently 'desertification' and 'dryland' have been used interchangeably and the dryland areas are commonly described as suffering from 'desertification and land degradation'. No wonder then that the term was qualified as 'an open concept' (Warren and Olsson, 2003). There is no better example of this openness than that of a paper published in the journal 'Conservation Biology' by the name of 'effects of desertification' caused by *Lithophaga lithophaga* (Mollusca) fishery on littoral fish assemblages along rocky coasts of Southeastern Italy, dealing with the effects of shellfish fisheries on coastal algae. To quote: '*The major consequence*' of this practice '*...is the removal of the biological cover (macroalgae, zoobenthos), which ranges from bare patches to complete desertification*', and goes on to suggest that '*...pressing topics for future research ...*' is the '*...effects of desertification on fish ...*' (Paolo *et al.*, 2004).

Furthermore, 'desertification' was explicitly implicated in being '*used as a deliberate strategy to attract attention of funding; 'spin' is another word. ...*' (Warren and Olsson, 2003). This is exemplified by the proportion of non-dryland developing countries in the UNCCD membership, which increased from 20 per cent in 1996 (out of 56 countries ratifying the Convention by that year) to 36 per cent in 2003 (when the UNCCD had 190 contracting parties). To comply with their commitment to the Convention, many of the 93 dryland ('affected') developing country parties prepared and submitted for donors' support 'National Action Programs to combat desertification' (NAPs). This procedure was also practiced by many of the current 69 non-dryland country parties, in spite the fact that having no drylands, then by definition these countries can not be affected by desertification; yet, they claim to combat desertification within their territory (Safriel, 2007). The history of the evolution of the UNCCD and the term 'desertification', its emergence in the political discourse and in the scientific narrative, the denial of the phenomenon for which it is supposed to stand, as well as the socio-political events that led to its use and misuse, are analysed and discussed in this issue by Alan Grainger in his paper on 'problems with boundary management: explaining deficiencies in scientific inputs to the global desertification regime' (Grainger, 2008).

### *Deserts and Non-Desert Drylands*

Whereas the UNCCD attempted to provide a robust climatic definition for drylands, 'desert' has a wide range of definitions, hence also a wide range of area size values for its geographical extent. The MA aggregated the global 'ecoregions' defined by the World Wide Fund for Nature (WWF) classification, into 'broad biomes', one of which is the 'desert biome' (Safriel and Adeel, 2005). Overlaying the global 'desert biome' map on the global dryland map, reveals that 96 and 73 per cent of the climatic hyperarid and arid drylands, respectively are ecologically deserts (Figure 1). The MA used the climatic criterion, i.e. areas with aridity index (the ratio of precipitation to potential evapotranspiration) lower than 0.2, and defined the arid and the hyperarid drylands combined as desert drylands, jointly comprising 17.2 per cent of global land. Using the ecological criterion (ecoregions in which the dominant plants are of the desert-adapted physiognomy (Ezcurra, 2006)), the aggregated size of the global desert biome is 20.2 per cent, a value higher than that of the climatic deserts, since some areas of the desert biome are also embedded in the non-desert climatic drylands (Figure 1). Thus, though the climatic and the ecological criteria for deserts are not fully compatible, the geographical overlap is remarkable (Ezcurra, 2006), which justifies regarding deserts as a subset of the drylands.

Since the four dryland types are defined by the aridity index, the drylands can be placed along a continuous climatic aridity gradient, with gradual transition between each of the types (Figure 2). Nevertheless, there is likely a non-linear ecological transition between the dry-subhumid and semiarid drylands, and the arid and hyperarid drylands, which justifies subdividing the drylands into non-desert and desert drylands (Figure 1). These two dryland aggregates differ in that the desert drylands are of very little vegetation cover and large surfaces devoid of

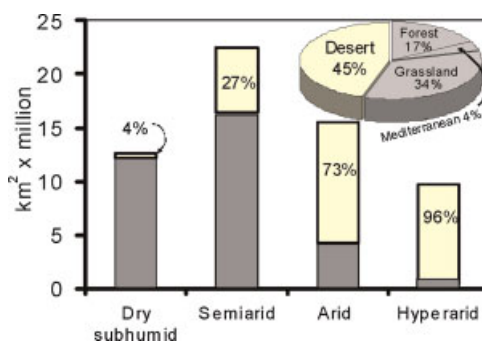


Figure 1. Global area covered by the dryland types and the (percentage) share of the dryland biome (bright section of columns) in each of them. The pie provides the aggregate percentages of each of the drylands 'broad' biomes, relative to the overall dryland area (After Safriel and Adeel, 2005). This figure is available in colour online at [www.interscience.wiley.com/journal/ldr](http://www.interscience.wiley.com/journal/ldr)

vegetation cover (Ezcurra, 2006), whereas in the non-desert drylands most land is vegetation-covered. In both however, productivity is limited by water, and is low compared to that of most of the other terrestrial ecosystems (Safriel and Adeel, 2005).

On top of the non-linear ecological transition there is also another obvious socio-economic non-linearity in the transition between desert and non-desert drylands. Whereas the difference in area between the desert and the non-desert drylands is not great, population size of the desert drylands is far lower than that of the non-desert drylands. Altogether 6 per cent of the global population lives in deserts as against 36 per cent of the dryland population that

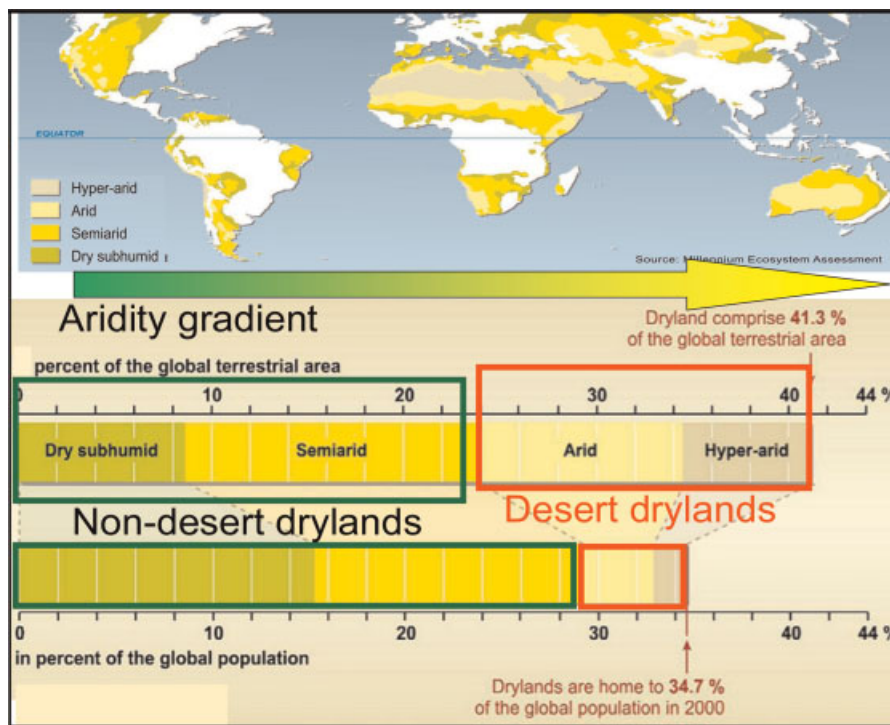


Figure 2. The drylands aridity gradient and their subdivision to desert- and non-desert drylands (from Adeel *et al.*, 2005). This figure is available in colour online at [www.interscience.wiley.com/journal/ldr](http://www.interscience.wiley.com/journal/ldr)

Table I. Comparison of proportional area and population size of the global deserts and non-desert drylands in 2000 (data from Safriel and Adeel, 2005)

|            | Desert            |                 | Non-desert        |                 |
|------------|-------------------|-----------------|-------------------|-----------------|
|            | Per cent drylands | Per cent global | per cent drylands | Per cent global |
| Area       | 42                | 17              | 58                | 24              |
| Population | 16                | 6               | 84                | 30              |

inhabits the non-desert drylands (Table I). Also, in the desert drylands the prevailing livelihood is nomadic pastoral, but in the non-desert drylands the pastoral livelihood is mixed with crop farming that may replace it as aridity decreases. Most remarkable is the observation that not only are there drastically fewer people in desert- than in non-desert drylands, but also far fewer people of industrial countries live in desert drylands (less than 1 per cent of the global desert population), than in non-desert drylands (a little more than 3 per cent, Figure 3).

#### *Where is there Desertification?*

The ambiguity of the definition of desertification and its resulting misuse also contributed to a controversy over the spatial distribution and magnitude of degradation in the drylands. Surely, when desertification is interpreted in different ways, researchers vary in what variables or parameters they measure for qualifying 'desertification'. Thus, available estimates of global desertification vary within a very wide range, hence claiming that global desertification is very high is just as good as claiming it is very low (Safriel, 2006a). Nevertheless, recent assessment of the literature suggests that the range is 10–20 per cent of the drylands (Adeel *et al.*, 2005); though the absolute values may still be contentious, spatial trends made across the aridity gradient may be instructive.

The major finding is that the spatial desertification curve is hump-shaped, biased towards the moist end of the gradient (Figure 4a). This is rather counter-intuitive, since desertification can be described as a non-desirable deviation from the natural state, related to the low resilience of the dryland ecosystem to withstand pressure. In this context it is reasonable to assume that resilience declines (or sensitivity to pressure increases) with increasing aridity. Thus, if pressure linearly increases with aridity, the desertification curve should be linear. The observed non-linearity suggests that the pressure along the aridity gradient is not linear. One variable that is expected to be associated with the pressure is population density. Indeed, the observation is that human density decreases with aridity, and exponentially so (Figure 4a).

Thus, desertification dimensions at any given point across the drylands' aridity gradient can be described as an interaction between ecosystem sensitivity and population density. A simple model of this interaction that describes

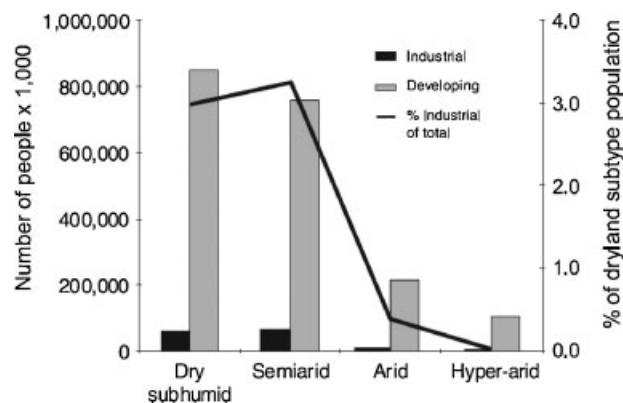


Figure 3. Population of developing and industrial countries in the drylands and population of industrial countries in the drylands as percentage of total global dryland population (from Safriel and Adeel, 2005).

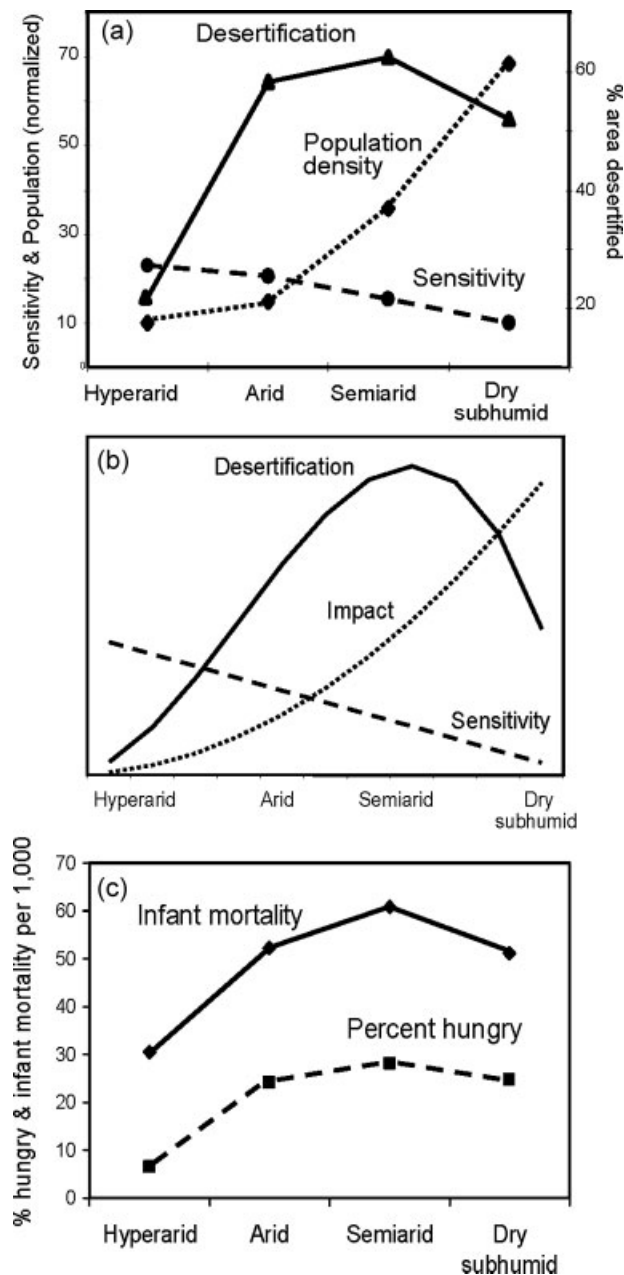


Figure 4. Desertification, demography and human well-being trends across the aridity gradient: (a) desertification, population densities and sensitivity (a normalized inverse function of the aridity index, after Safriel and Adeel, 2005), (b) a model simulation of desertification as a product of sensitivity and impact (after Safriel, 2006b), (c) indicators of human well-being—percentage of hungry children after the age of 5 and infant mortality per 1000 live births (After Safriel and Adeel, 2005).

desertification as a product of sensitivity that increases linearly and the human impact expressed by population density that increases exponentially with declining aridity indeed simulates the observed desertification trend (Figure 4b): the simulated desertification is lowest in the hyperarid, desert dryland where sensitivity is highest but human pressure is lowest, it peaks in the semiarid, non-desert dryland, and then declines in the least dry non-desert

dryland, the dry-subhumid one. Thus, though field data are still rather controversial, global desertification demonstrates a trend—it peaks once the transition between desert and non-desert drylands is crossed, and remains relatively high also in the least dry non-desert drylands. Furthermore, two indicators of low human well-being, e.g. of poverty—hunger in children and infant mortality demonstrate similar non-linear trends—low values of mortality and hunger in the desert drylands and peak poverty at the semiarid, non-desert dryland, which somewhat declines at the dry subhumid dryland (Figure 4c). In other words, desertification, including its impact on humans is apparent mainly in the non-desert drylands, where also most dryland people live. This strongly reflects on the inappropriateness of ‘deserts and desertification’ as a banner chosen by the UN General Assembly to mobilize the international community for ‘combating desertification’.

While human impact as driver of desertification is invariably invoked in all the papers in this issue, the linkage between population size and impact is not universal. An impact associated with an increasing population size is implicitly implicated in driving the widespread desertification expressed in soil sodification and salinization in both the desert drylands of Rajasthan and the non-desert drylands of Andhra Pradesh (India) described by Gurbachan Singh in his paper ‘salinity related desertification and management strategies: Indian experience’ in this issue (Singh, 2009). On the other hand, while the severe desertification in the Argentinean Caldenal non-desert dryland rangelands expressed in bush encroachment and loss of forage species described by Fernández and Gil (2009) in this issue’s paper ‘the challenge of rangeland degradation in a temperate semiarid region of Argentina: The Caldenal’ is attributed to severe human impact, this human impact was exerted by a relatively very small and sparsely distributed population (Fernández and Gil, 2009).

### LIFE IN THE DESERT—LIABILITY OR OPPORTUNITY?

#### *The Attitudes to Deserts*

On top of the uneasiness expressed earlier regarding the title ‘International year of deserts and desertification’, this linkage of ‘deserts’ and ‘desertification’ is unfortunate since it implies that not only desertification but also desert has to be ‘combated’. Namely, just as desertification is man-made, so are deserts. Hence, the implicit message may be that the objective of ‘combating desertification’ is ‘to make the desert bloom’. Indeed, in many cultures living in deserts is a liability and hence ‘greening the desert’ is a worthy and commendable human endeavor. Other cultures romanticize traditional desert lifestyles and livelihoods and strive to conserve rather than ‘conquer’ the desert (Herrmann and Hutchinson, 2006). Both approaches, however, seem to overlook the biological, climatic, cultural and economic effects of the deserts not only on its inhabitants, but on the rest of the planet (e.g. their effect on global climate, their function as corridors for biological, cultural and economic exchanges, as mineral reservoirs, as arenas for technological and scientific explorations, and as generators of cultural innovations and scientific discoveries, Safriel, 2006a). More importantly, there is a prevailing failure to recognize that several desert attributes habitually regarded as a liability, can be turned into economic opportunities.

#### *Desert Disadvantages Turned into Advantages*

The high evaporative losses of water as well as the high summer temperatures in deserts result from the high solar radiation, a major disadvantageous attribute of deserts. Another disadvantage of deserts is the very low precipitation, yet many deserts have rich reservoirs of fossil water, and water from non-desert areas (rivers or floods) flow through many deserts. However, the fossil water reservoirs are of relatively high salinity and often the river and flood water are saline, or their persistent irrigation use is of high salinization risk. Paradoxically, whereas high solar radiation and low quality water are disadvantageous for desert agriculture, they are highly advantageous for desert aquaculture. This is because the water demand of aquatic organisms, especially when the containers in which they are cultured are light—but not vapor—penetrable, is much lower than that of terrestrial plants. And when the cultivated organisms are unicellular algae that produce industrial chemicals, the desert’s intense solar radiation intensifies and maximizes photosynthesis (Adeel and Safriel, 2008).

Another disadvantage of deserts is its desolation, sparse settlement pattern, as well as impaired communication and transportation. These combined lead to low demand on land, and this together with the high solar radiation and the relative abundance of brackish water that is suboptimal for crops but excellent for many aquatic organisms, provides desert aquaculture an economic edge over non-desert aquaculture. Furthermore, solar radiation and the low competition for land in deserts provide a clear economic benefit for developing alternative energy sources on a wide commercial basis, specifically in deserts (Warren, 2006). Finally, the desolation, the wide uninhabited spaces and the pristine environments become increasingly attractive for tourism. For example, the projected loss of wilderness areas, highly valued by eco- and other tourists, is the lowest for deserts as compared to most other ecosystems highly valued by the tourist industry (Figure 5). All these livelihoods combined, and others like urban development and cash-crop greenhouse agriculture in deserts (Safriel and Adeel, 2005, Safriel, 2006a), are highly economic on land use, are of low environmental impact, and most important—of reduced dependence on land productivity, hence they fall under the category of ‘alternative livelihoods’. Not only do they not lead to desertification, but they have the potential of high economic viability and sustainability, especially since their practitioners have a competitive edge over those who practice them in the non-desert drylands and other non-dryland areas.

### *Climate Change and Desert Opportunities*

It has already been suggested that global climate change is likely to impinge on biological productivity in the drylands too (Adeel *et al.*, 2005), a claim that received even stronger support from the *fourth IPCC assessment report*. More importantly, following the publication of this report in late 2007, the recognition of the prevalence of the global climate change syndrome and the awareness of the need to mitigate it have become widespread. These developments are expected to further intensify the quest for solutions, which would rather paradoxically make the alternative livelihoods proposed for the desert’s drylands even more opportune for the desert inhabitants. This is due to the desert’s inherent potential and relative advantage in promoting the mitigation of climate change at the global scale, through the development of alternative, renewable energy sources. It has been estimated that 4 per cent of the global desert area can provide the whole current global annual energy demand (Safriel, 2004), or that an area of  $320 \times 320$  km of the Sahara Desert can provide all the annual energy demand of Europe (Warren, 2006), provided that available technologies are used and ongoing R&D improves means of electricity storage and transportation, compatible with conditions prevailing in deserts. Moreover, research into the cultural, social, economic and

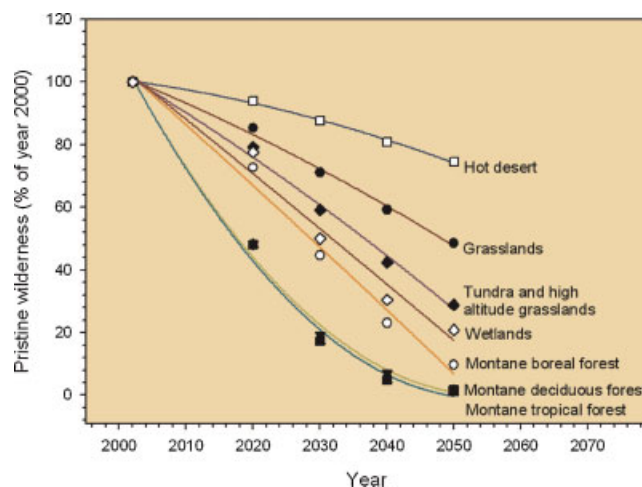


Figure 5. Projected declines in wilderness area in different global ecosystems (from Herrmann and Hutchinson, 2006). This figure is available in colour online at [www.interscience.wiley.com/journal/ldr](http://www.interscience.wiley.com/journal/ldr)

political issues needs to be resolved to guarantee that indigenous desert people receive their fair share of the accrued income, as well as rewarded for their contribution to the mitigation of global climate change.

Not only does solar energy export qualify as a lucrative desert alternative livelihood due to its potential for mitigating global climate change, but there is also high potential for deserts to produce biofuel on a large scale from culturing microalgae in aquaculture. Currently desert cultivation of aquatic microalgae is successfully practiced on a small scale, and this is for production of industrial pigments (Warren, 2006). Nevertheless, all advantages in cultivating fish in deserts (water use efficiency, cheap land, etc.) apply to aquatic microalgal desert cultivation. But furthermore, the need to develop it is becoming apparent given the current increasing global thirst for biofuel, concurrent with the emerging realization of the fallacy of allocating good agricultural land for cultivating biofuel crops at the expense of food crops. Of course much R&D is still required for production of biofuel based on unicellular algae, but such avenue pursued in deserts is highly promising.

## CLIMATE CHANGE AND THE NON-DESERT DRYLANDS

### *Climate Change and Desertification*

One of the impacts of global climate change is in the projected increased evaporation (and transpiration) and reduced precipitation in the drylands (Meehl and Stocker, 2007). These two processes combined would lead to reducing the already low soil moisture and hence water availability for primary productivity. This reduced productivity, especially in the non-desert drylands (where vegetation cover is more prominent than in the desert drylands), is likely to exacerbate both desertification and global warming in different ways, through positive feedback loops of mutual reinforcement (Figure 6). First, the global carbon sink, i.e. the function of photosynthesis in fixing atmospheric carbon, will be impaired by the reduced soil moisture, which in the drylands is the prime limiting resource of productivity. Hence a persistent reduction in biological productivity is expected in many non-desert drylands, i.e. desertification, but one that is not driven by the land users, but by all humanity at large.

Impairment of the sink function reduces its resulting carbon reserves, i.e. the carbon sequestered in biomass and in the soil organic matter. This reduction in the drylands, which will have global effects, is brought about in two ways. First, the overall plant biomass (including the above- and below-ground vegetation cover), which is the live carbon reserve will be reduced. Also, the transport of carbon from the live parts of plants to the soil, in the form of litter to be transformed to soil organic matter, will be reduced. In this way the effect of climate change on drylands will impair the maintenance and even slow down the rate of increase of the global carbon reserve. On top of this, the reduction of the non-desert drylands' vegetation cover due to reduced water availability would lead to intensified soil erosion, which in these drylands is one of the major expressions of desertification. Thus, beyond the challenges of the drylands' inherent low biological productivity and its further lowering due to human impact, climate change poses an additional challenge to dryland's people. Most significantly in this context, the carbon stored in the non-desert drylands soils is likely to be oxidized once soil is eroded and its stored organic compounds exposed to air and to running water. This soil erosion results in overall increased carbon dioxide emissions from the drylands to the global atmosphere, which intensifies global warming that in turn further impacts the drylands. Similarly, since soil organic matter increases the soil's water holding capacity, the overall loss of soil organic carbon caused by desertification further reduces soil moisture in the drylands. To conclude, two positive feedback loops are involved in the desertification-climate change linkages, whereby these two processes intensify their mutual exacerbation (Figure 6).

The currently evident desertification expressed in soil erosion, irrespective of whether its spatial extent is small or large, or whether or not it has been exacerbated by climate change, already contributed and is contributing to an increase in carbon emissions to the global atmosphere. Similarly, the processes that have led and are leading to soil erosion in the drylands, i.e. reducing vegetation cover due to overgrazing and to transformation of rangelands to croplands, already reduced and are further reducing the sink function as well as the carbon reserve stored in the drylands, which also contributes to global warming and climate change. However, the proportional contribution of the drylands to the increased atmospheric concentration of atmospheric carbon dioxide so far has been small (only



Alon Tal in this issue, 'the logic and logistics of grazing regulation' too deals with dryland rangelands and reviews the utility of grazing regulations in reducing pressure and averting desertification.

Similarly, measures to combat desertification, in compliance with the UNCCD, mechanisms to both mitigate climate change and adapt to its effects, have been addressed through the UNFCCC (United Nations Framework Convention on Climate Change). Given the linkages between the subject matter of these two conventions (Figure 6), the measures to mitigate climate change are also expected to assist in avoiding the exacerbation of desertification and in promoting increased drylands' biological productivity.

However, by the year 2050 the projected persistent growth of the global human population is expected to make humanity short of 4.5 million square km of good cultivable land for providing its nutritional needs (Safriel and Adeel, 2008). This would bring added pressure on agricultural lands of naturally low productivity, mainly found in the non-desert drylands. Even without the effects of global climate change, the mounting population pressure and its impact on the non-desert drylands may prove to be beyond the ability of handling by all measures to 'combat desertification' aimed at responding to the need to increase land productivity for satisfying the nutritional needs of the global population. Thus, even if the current extent of desertification is relatively small and means to avoid it while promoting land productivity improve, an eventual widespread desertification and poverty in the non-desert drylands is inevitable, since land productivity is not limitless. It is therefore timely to explore how instruments developed under the UNFCCC can be used to increase the income from subsisting on the drylands' biological productivity without overtaxing it.

In this context the inherent drylands' potential and relative advantage over other areas, in promoting the mitigation of climate change at the global scale needs to be explored. This is done in detail by the Lal (2009) in his paper in this issue. The first relevant attribute of the drylands is in their potential for mitigation through increasing carbon sinks and reserves. Arresting desertification, restoring the sink function of degraded drylands and even promoting the sink function of the vast non-degraded drylands, for example through dryland afforestation (Safriel, 2004; Safriel, 2006b), can make a significant contribution to the global mitigation effort. More important to dryland people, promoting the drylands sink can generate a new source of income, under the clean development mechanism (CDM), and other carbon trading mechanisms under the outgoing Kyoto Protocol and the currently negotiated new international legal instruments under the UNFCCC (Lal, 2009, in this issue).

## DESERTS AND DESERTIFICATION – THE SEDE BOQER APPROACH

### *Where are the Challenges and Where are the Opportunities?*

Rather than expressing regrets at the unfortunate coupling of 'deserts and desertification' chosen to commemorate the end of the first decade of the UNCCD (as well as the whole following decade...), the Sede Boqer 2006 conference opted to use this banner of 'deserts and desertification' for highlighting, in a positive way, the difference between the desert- and the non-desert drylands. The conference on 'deserts and desertification—challenges and opportunities' set first to decouple deserts from desertification and then elaborate on how societal attitude to the future of deserts may differ from that addressing non-desert drylands. The Sede Boqer approach highlights the observation that deserts are inhabited by only 6 per cent of the global population and desertification and poverty there are negligible compared to these phenomena in non-desert drylands, inhabited by as much as 30 per cent of the global human population (Figure 4). Based on these observations, the conference's concept paper proposed that whereas desertification poses a serious challenge for people in the non-desert drylands, the desert drylands offer great opportunities for their inhabitants.

Climate change projections further challenge dryland peoples due to their biophysical implications, but at the same time their socio-economic implications would generate positive prospects and new opportunities, especially in the desert drylands. However, caution is required especially in the non-desert drylands, in order to avoid an overexploitation of biological productivity driven by financial instruments associated with climate mitigation mechanisms. It needs to be explored, for example, if dryland afforestation practiced in the semiarid drylands and in addition to timber and non-timber forest products also generates economic gains from carbon sequestration, is

also an effective measure to prevent or arrest desertification better than other, more traditional but improved land uses. For example, afforestation in the semiarid drylands proved to be successful in Israel in terms of arresting soil erosion, conserving water, providing firewood and forage and also sequestering carbon (ICARDA, 2007). Yet it would be necessary to assess if such land put to use for carbon sequestration is not at the expense of other land uses of a high potential to generate more income in sustainable ways that do not lead to desertification.

#### *The Mix of Alternative and Traditional Livelihoods along the Aridity Gradient*

It is important to recognize that the adoption of alternative livelihoods cannot completely substitute the improvement of traditional means of exploiting land productivity as measures to achieve sustainability in the drylands. Rather, the appropriate strategy for dryland sustainable development is to apply the two approaches jointly (Adeel and Safriel, 2008), but by a mix specific to the degree of aridity. Namely, the success of traditional livelihoods based on land productivity promoted with advanced methods will increase with decreasing aridity (i.e. the greater share of traditional methods in that mix is expected in the non-desert drylands and especially in the dry subhumid ones). At the same time the success of alternative livelihoods, with a decreasing dependence on land productivity will increase with aridity, and some of these alternative livelihoods will be more successful in hyperarid than in arid desert drylands. It is likely that the balance of the two approaches in the mix is to be found at the transition between the desert and the non-desert drylands, with the profitability and sustainability of alternative livelihoods increasing towards the arid end of the aridity gradient, and those of the traditional, strongly land-dependent livelihoods—towards the moist end of the gradient (Figure 7).

#### *How is the Sede Boquer Approach Reflecting on the Future of the UNCCD?*

Following the IYDD, the UNCCD entered into its second decade, with the 8th conference of parties that took place in Madrid in September 2007 adopting a 10-year strategic plan and framework for the UNCCD (UNCCD, 2007). This plan is sufficiently flexible to encompass the Sede Boquer approach when designing and implementing a new mode of operation during this second decade. Several issues need to be considered. First, it is necessary to disseminate and internalize the recognition that there is no uniform solution for attaining sustainable livelihoods in the drylands. Rather, the recipe for a sustainable development path depends on the degree of aridity, coupled with population pressure, typical to each dryland area. Also, though the drylands constitute an aridity gradient, this

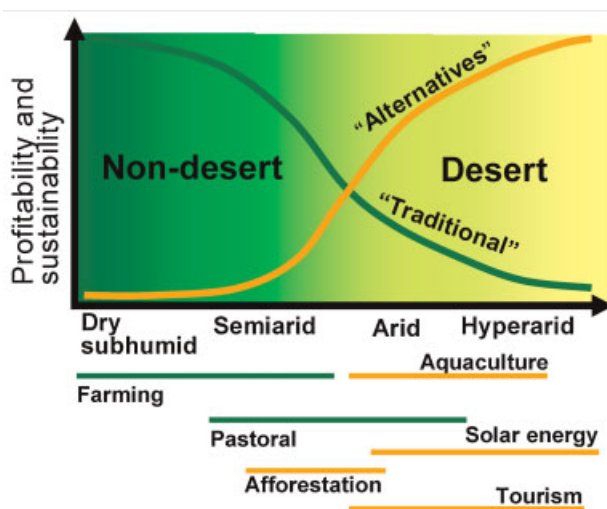


Figure 7. The mix of traditional and alternative dryland livelihoods, along the aridity gradient - a proposed scheme. This figure is available in colour online at [www.interscience.wiley.com/journal/ldr](http://www.interscience.wiley.com/journal/ldr)

gradient is not linear, such that the risk of non-sustainability, hence desertification, is much greater in the non-desert than in the desert drylands.

The second issue is the need to recognize and internalize the fact that climate change not only impinges on desertification, but that the two processes interact. This interaction not only poses an additional risk to drylands, but it also creates economic opportunities that support the prevention of desertification and promote the improvement of human well-being in the drylands. But as with desertification, there is a divide between the desert and the non-desert drylands with respect to climate change too. Namely, the difference between the two dryland aggregates in environmental conditions and demographic state, jointly with the effects of global climate change, create hitherto untapped opportunities in the desert drylands, but pose challenges in the non-desert drylands. The UNCCD therefore needs to profess a daring approach for devising measures for grabbing the desert drylands' opportunities, but a careful and prudent approach when addressing the challenges which the non-desert drylands face.

As can be inferred from the case study papers in this issue, mostly dealing with non-desert rangeland drylands (Olukoye *et al.*, 2009, Fernández and Gil, 2009), or with desert rangelands (Toderich *et al.*, 2009), as well as with desert and non-desert rangelands and croplands (Singh, 2009), there exists an impressive array of measures, either implemented or only proposed, to address the biophysical challenges of living in drylands and avoiding their desertification. Similarly, there is also much of the required knowledge for grabbing the climate change opportunities expressed in the rapidly emerging global quest for carbon sequestration, as described in the paper of Lal (2009) in this issue. However, speaking generically, most of the measures elaborated in these papers have not yet yielded the aspired and required results. The blame is not on insufficient knowledge and failed technologies but on the apparently non-conducive social and political atmosphere. This is expressed, for example, in the failure of most regulatory processes (or the lack of them) at the country level, for combating desertification of non-desert dryland rangelands through the control of grazing, as described in Alon Tal's paper in this issue (Tal, 2009).

But most importantly, the failure is also at the international, or the global-level, expressed in the inability of the UNCCD to meet the expectations of both the affected and non-affected, the developing and the industrial countries, during the first decade of its existence. The roots of some of these disappointments are touched upon in the paper of Alan Grainger in this issue (Grainger, 2009). But a major contribution of that paper is in pointing at the deficiency in the use of the existing scientific knowledge, which is due to the lack of effective mutual interaction between the scientific and the political communities, with the emphasis on 'mutual'. Surely, the strong interlinkages between the subject matters of the UNCCD and the UNFCCC, namely desertification and climate change, respectively, require interlinkages in implementation of the two conventions (e.g. UNCCD, 1999). However, Grainger (2009) further suggests that at the outset of its second decade the UNCCD would address its first decade's failure to benefit from science. This by using either the template or the facilities of the intergovernmental panel on climate change (IPCC, the entity that provides policy-relevant though not policy-prescriptive update of science to policy-makers) for enabling an updated science to direct policies that would mould a stewardship leading the drylands on the path to sustainability.

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