COMBATING DEGRADATION IN ARID SYSTEMS

N. Juergens
Faculty of Natural Sciences, University of Hamburg, Germany

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Summary

Degradation in arid systems, known as “desertification”, is politically covered by the United Nations Convention to Combat Desertification (UNCCD). Desertification is defined as the human-made degradation of natural resources in arid to semi-humid ecosystems. Processes of desertification are driven by a complex interaction of many factors, including human activities in the first place but also involving non-linear feedbacks based on ecosystem properties and natural climatic changes. Desertification involves processes and mechanisms at various scales, ranging from the single field or pasture to the global biosphere; decision makers are found at various levels, including the local farmers as well as global players on the worlds financial markets. Similarly, combating desertification integrates ecological, technical, social and political measures, based on knowledge from natural and socio-economic scientific disciplines.

1. Introduction

1.2. Arid Ecosystems

Arid ecosystems (the UNCCD covers hyper-arid, arid, semiarid and sub-humid systems) are characterized by specific ecosystem properties. Obviously, arid systems are water-limited systems, during at least long periods of the year. However, limited availability of water causes a wide array of secondary induced properties, especially the lack of a denser vegetation cover and, in most cases, a limited and very specific biodiversity. This, in interaction with water scarcity, controls soil properties in an adverse sense, especially with regards to very high salinity and/or crust formation.

Besides water, other environmental factors also contribute to the high sensitivity of arid ecosystems. Drylands are rarely limited with regards to the influx of energy. On the contrary, very high radiation can cause direct damage to organisms; high air temperatures reach levels beyond the eco-physiological thresholds and therefore limit the occurrence and activity patterns of many organisms. Wind speed can reach extreme levels within the open arid landscapes. Furthermore, direct mechanical impact, sand blasting, dune formation and dust layers cause additional problems for the productivity of plants.

Besides the problematic characteristics of the above-mentioned environmental phenomena, their temporal distribution also creates a problem. Especially in the more tropical dryland regions, high spatial and temporal variability is observed—characteristics of unpredictable environments. Unpredictability is just another limiting factor, as only a limited spectrum of plants and animals provide adequate risk strategies. Stability (continuity) or resilience (the ability to return to earlier states) are therefore based on both the degree of unpredictability of environmental factors and the avoidance and coping strategies of organisms, including humans.

Such environmental rules are also valid for humans and their survival in drylands. Early development of risk strategies allowed hunter-gatherer groups to live in arid ecosystems. Later, adapted forms of pastoral and finally agricultural land use were developed. Such human cultures and land use systems underlie the same limitations as plants and animals. Insurance systems, transhumance, nomadic lifestyle and isolated populations near scattered resources are frequently observed phenomena. These specific challenges often resulted in local innovations and technological, cultural and linguistic diversity.

1.2. Desertification

The degradation of natural resources within arid ecosystems has been identified as one of the major threats for ecosystem functioning and for the life conditions of humans. While droughts are generally understood as being periodically developing natural processes of sometimes dramatic impact on humans, a new perception was created over the past 50 years.

The catastrophic drought events in the northern African Sahel region, which resulted in the death of several hundred thousand people during the 1970s, created a wider public understanding that, in addition to natural climatic variability, at least a part of the disaster was human-made. It was also understood that degradation processes in arid ecosystems are often the result of complex interactions between natural dynamics and

socio-economic factors and processes like demographic dynamics, globalized economic developments, policy failure, conflicts, health systems, development aid programs, technological progress, and inadequate land use types, to name just a few. Therefore, the perception of a syndrome of causes and their consequences was born and resulted in the formulation of the term "desertification".

"Desertification" is derived from the Latin "facere" (to make, to do) and conveys the idea of human-made growth of desert conditions; it is thus different from the natural climatic variability of arid ecosystems. In spite of the fact that no robust scientific definition of this term is available, the syndrome of desertification gained increasing public awareness. At the highest political level, the United Nations Convention to Combat Desertification (UNCCD) was initiated at the UN Conference on Environment and Development (UNCED) in 1992 and entered into force in December 1996. Following UNCCD, "desertification" means "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities".

"Land degradation" is defined by UNCCD as "reduction or loss of the biological or economic productivity and complexity of rain fed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: (i) soil erosion caused by wind and/or water, (ii) deterioration of the physical, chemical and biological or economic properties of soil; and (iii) long-term loss of natural vegetation".

Based on the high visibility of this UN convention, the problem and the term desertification became even more popular. With increasing tendency, the term is now used for the degradation of natural resources within a wider range of ecosystems than those defined in the UNCCD's definition above, even beyond the boundaries of arid climates. Meanwhile, it has become a topic for development aid programs in many countries, to combat desertification. And, the combat against desertification could also be seen as a flagship exercise with regards to the global challenge to develop sustainable management of natural resources in terrestrial ecosystems.

2. Degradation of natural resources

The simplifying term "degradation of natural resources" involves a complex interactive bundle of structures and processes, as diverse as ecosystems can be. Therefore, in the beginning, the various manifestations of degradation should be brought into a structured system, allowing a more strategic view at the problem.

If we analyze scientific and political publications, there is a large number of processes and types of damage, all linked to desertification. In a first approach, such processes shall be listed here, sorted only by their fit to the basic resources of "soil", "biodiversity", "water", "climate", and "human dimension".

Soil-related: Decrease of soil fertility; decrease in nutrient cycling and availability; decrease in soil organic carbon; decreased infiltration; decrease of water storage

capacity and water transport capacity; formation of soil crusts; loss of soil structure, leading to soil compaction or erodability; soil salinization; decreasing buffer functions; soil erosion (gully erosion, sheet erosion); soil transport; sand and dust storms; soil deposition; dune formation; increased sediment load of rivers and dams.

Biodiversity-related: Overexploitation; habitat conversion; over-cultivation; overgrazing of natural vegetation; over-harvesting and clearing of woodlands and forests; decline of biodiversity (species, genes): decrease in land cover by vegetation; increase of overgrazing weeds; bush encroachment; decrease in plant regeneration and establishment rate; decrease in nutrient cycling and availability; depletion of soil seed banks; loss of nutritive value of rangeland; losses in productivity; losses in stabilizing and buffer functions; losses in adaptation potential; changes in fire regime; increase of biological invasions.

Water-related and **climate**-related: Global warming: Increasing maximum temperatures; increase of extreme weather conditions; decreasing rainfall amounts and or predictability; increased frequency or intensity of droughts; increased frequency or intensity of floods; groundwater over-exploitation; water pollution; increase of water-related diseases.

Human dimension-related: Inadequate resource utilization forced by demographic growth, shrinking resources, poverty, violent conflicts, and lack of training; changes in transhumance and nomadic movements and land-use patterns; poverty in rural areas; water-related health problems; conflicts over access to and control of resources; collapse of local system and environmental refugees; expansion of human activities into undisturbed systems.

The list shows that under the umbrella of “desertification” a wide range of very different processes and problems is summarized. At a closer look, this list is integrating very different properties and processes.

For example, the term “natural resource” is masking the fact that we talk about very different resources with different properties and controls. There are:

- Finite natural resources of limited quantity (e.g., ores, space)
- Finite resources renewed within natural cycles (“recycled resources”, e.g., water)
- Infinite external resources (“renewable resources”, e.g. solar energy)
- Evolution-based resources (genetic resources, biodiversity)

Similarly, the list includes processes which cover extremely different time scales. One should at least distinguish:

- Long term natural dynamics (evolution, global climate, evolution of atmosphere)
- Medium-term natural dynamics (glaciations, global warming)
- Short-term natural dynamics (dry and moist years, oscillations in fire regimes)
- Long-term man-made dynamics (introduction of fire, hunting, domestic stock, agriculture, leading to slow changes in vegetation composition, seed banks, etc.)

- Short-term man-made dynamics (over-utilization of rangeland, partly reversible).

Furthermore, degradation can be of very different quality and character. With respect to the different resources, there can be:

- Reduction of quantity/size/duration
- Reduction of quality
- Reduction of productivity
- Reduction of stability / predictability
- Reduction of accessibility
- Reduction of usability
- Increase of risks (health/conflicts)
- Increase of necessary efforts/investments

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Biographical Sketch

Norbert Jürgens was born in June 1953 in Rotenburg, Lower Saxony, Northern Germany.

Education and Experience:

1973 - 1980	University education in Biology at the University of Hamburg
1980	Diploma
1986	PhD / Dr. rer.nat. (Thesis: Ecology of African Succulent Plants)
1987-1992	Postdoc Research, Topic: Arid vegetation in the Namib region in South Africa and Namibia.
1992	Habilitation at the Faculty of Biology, University of Hamburg. (Thesis: Biogeography of plants of the Namib Desert Region)
1994	Full Professor of Botany (Systematics and Vegetation Ecology) at the University of Cologne.
Since 1999	Chair of the National Secretariat of DIVERSITAS Germany
Since 2000	Head of Department of Plant Evolution and Systematics, Director of the Herbarium Hamburgense and supervisor of the Botanical Garden at the University of Hamburg
Since 2000	Chair of the BIOTA AFRICA Project network

2001	Member of the DIVERSITAS International Task Force
2001-2004	Board Member of the German Competence Network to Combat Desertification "DesertNet"
Since 2002	Co-Chair of the German National Committee on Global Change Research
Since 2004	Co-Chair of Core Project 1 of the DIVERSITAS program