14

International Desertification

Social Geographies of Vulnerability and Adaptation

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ABSTRACT

In this chapter we focus on how local vulnerability, expressed in land degradation, is related to international and global processes. We begin with a synopsis of vulnerability in the context of land degradation and desertification. The nature of international regimes that may affect vulnerable socioeconomic groups is presented. Analogues of local–global linkages in vulnerability are summarized, including the green revolution, climate change, and intellectual property rights for biodiversity. Methodologies for local–global understanding of vulnerability are suggested. Our conclusions suggest lessons learned in research on international vulnerability and identify issues for further consideration.

INTRODUCTION

What Is Vulnerability?

Desertification is one of the important global environmental changes affecting human populations. Hence, vulnerability is an essential component of the issue because it is at root a human condition, embedded in the way the world operates, including politics and the economy (Kasperson and Kasperson 2001). For a general review of vulnerability in the context of adaptation to global environmental change, see Downing, Butterfield et al. (2001), Kasperson and Kasperson (2001), and IHDP (2001).

The conventional treatment in defining vulnerability follows several (often conflicting) lines of thought:

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- Vulnerability implies an adverse consequence. This distinguishes vulnerability as a prescriptive term embodying an ethical position from more neutral terms such as sensitivity.
- Vulnerability refers to penultimate human values — loss of life, loss of health, and loss of livelihood.
- Vulnerability is a relative measure of the degree to which different socioeconomic groups and geographic regions are likely to experience adverse consequences.
- Patterns of vulnerability are best distinguished by the stratification of socioeconomic groups within a country or region. The explicit focus on socioeconomic groups facilitates interpretation of indicators and provides a link to appropriate responses.
- Profiles of vulnerability distinguish among socioeconomic groups, reflecting different combinations of causal factors and vulnerable situations.
- Vulnerability integrates across the elements of exposure and processes of risk, and across scales.

This construction of "social vulnerability" is a specific use of a widely employed term. It draws upon traditions of development and poverty analysis, leading to a formal definition of vulnerability as "an aggregate measure of human welfare that integrates environmental, social, economic and political exposure to a range of harmful perturbations" (Bohle et al. 1994, pp. 37–38). This implies that research on vulnerability focuses on human populations most at risk, which includes perhaps 25% of the Earth's population.

The term *vulnerability* is also used in the sense of assessment methods (see APPENDIX). For example, vulnerability may be defined as a set of relationships between exposure to an external threat (e.g., extended drought) and its consequences (e.g., human mortality due to starvation), or proxies may be combined or aggregated to form indices of relative vulnerability (as shown below). In this sense, vulnerability assessment is a way to quantify specific analyses.

Examples of Vulnerability

Several aspects of vulnerability are depicted in the following two examples. First, the World Hunger Programme is concerned with food security across multiple scales, including individual deprivation, households, and national food shortages. Here vulnerability is related to scale of social organization (Figure 14.1), where different processes are working at different scales. Processes that link these scales are, however, poorly defined and difficult to analyze.

In Figure 14.2 the Bohle-Watts-Downing (BWD) triangle is presented, which depicts vulnerability as the conjuncture of failures in the human ecology of production, exchange entitlement in economies (after Sen 1981; Dreze and Sen 1989), and the political economies that allocate resources and empower people within socioeconomic and political systems. This BWD triangle provides a strong integrative framework and is best applied for specific communities at particular temporal and spatial scales.

VULNERABILITY AND DEGRADATION

Vulnerability, in the above senses, does not refer to land degradation per se. An ecosystem might be sensitive to soil erosion — that is, processes in the ecosystem result in accelerated

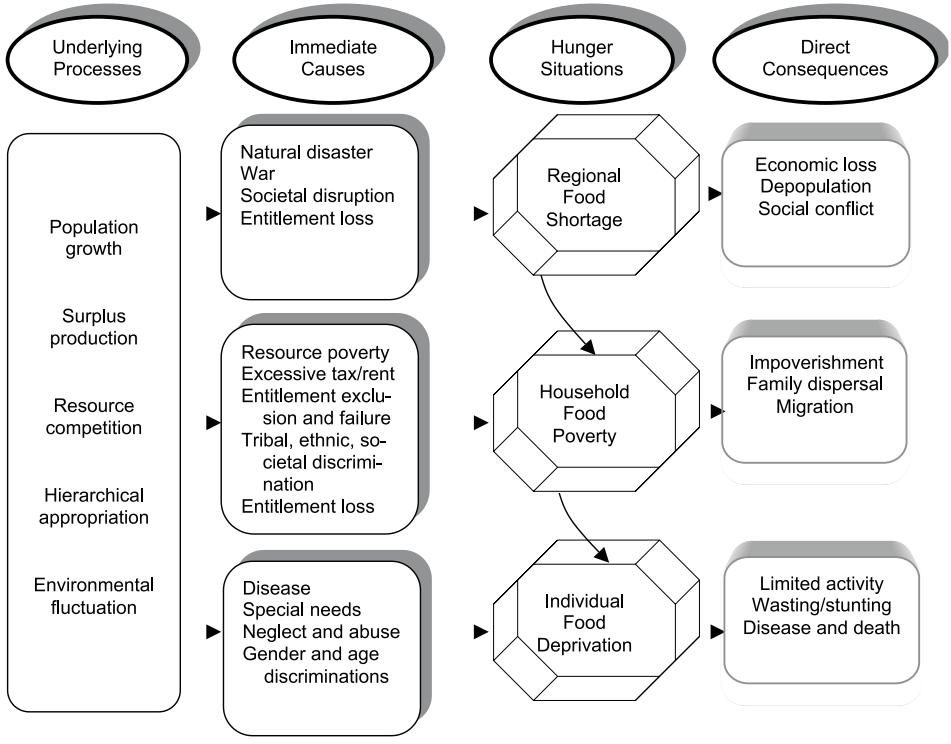

Figure 14.1 Situations of hunger. Source: model developed at the Brown University World Hunger Programme (see Downing 1991).

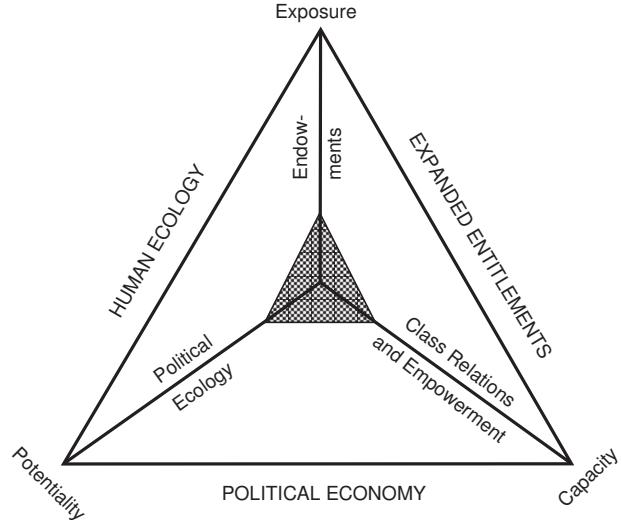

Figure 14.2 Three dimensions of vulnerability, implied in the conjuncture of the human ecology of production, exchange entitlement, and political economy (after Bohle et al. 1994).

soil erosion in response to disturbance of some sort. The term sensitivity does not contain the same connotations of human, ethical values as vulnerability. People in the ecosystem might be vulnerable — their livelihoods may be insecure, resulting in impoverishment if disrupted. Land degradation could be one component of a complex (or syndrome) of impoverishment but is rarely construed as a singular component that equates with vulnerability.

So what are likely interactions between this wider connotation of sociogeographic vulnerability and land degradation?

A good starting place is to locate vulnerability in the syndromes of degradation charted by the Potsdam Institute for Climate (PIK) Impacts Assessment (Table 14.1). Marked in the table with an asterisk (*) are syndromes that relate most strongly to aspects of land degradation.

Table 14.1 Syndromes of environmental degradation (Source: www.pik-potsdam.de/~gerhard/poster_ session.pdf).

Syndrome	Feature
Utilization Syndromes	
Sahel *	Overuse of marginal land
Overexploitation *	Overexploitation of natural resources
Rural exodus *	Environmental degradation through abandonment of traditional agricultural practices
Dust Bowl *	Environmental degradation through nonsustainable agro-industrial use of soils and water
Katanga *	Environmental degradation through depletion of nonrenewable resources
Mass tourism	Environmental degradation through development and destruction of nature for recreation
Scorched Earth *	Environmental destruction through war and military action
Development Syndromes	
Aral Sea *	Environmental damage of natural landscapes through large-scale projects
Green Revolution	Environmental degradation through introduction of inappropriate farming methods
Asian tigers	Disregard for environmental standards in rapid economic growth
Favela	Environmental degradation through uncontrolled urban growth
Urban sprawl	Destruction of landscapes through planned expansion of urban infrastructure
Disaster	Singular anthropogenic environmental disasters with long-term impacts
Sink Syndromes	
Smokestack	Environmental degradation through large-scale diffusion on long-lived substances
Waste dumping	Controlled and uncontrolled disposal of waste
Contaminated land	Local contamination of environmental assets at industrial locations

* Related to land degradation/desertification.

They are grouped by PIK under the heading of utilization syndromes — those processes of resource use that overuse marginal land in one form or another. The basic idea behind syndromes "is not to describe Global Change by regions or sectors, but by archetypical, dynamic, co-evolutionary patterns of civilization–nature interactions, which we call syndromes" (Petschel-Held, Block et al. 1999, p. 296). Syndromes are charted in dynamical process models that link state variables (that change over time and between states). The scale is intermediate and functional, reflecting processes in between household/micro and national/macro; the scale depends on the syndrome. The typology of syndromes reflects expert opinion, modified over time based on the modeling. Local case examples are used to generalize to mechanisms in the modeling and also to validate the syndrome results.

Desertification is a characteristic of several syndromes operating on their own, reflecting the internal dynamics of places, resources, economies, and populations. This is most notable for the Sahel, Overexploitation, Dust Bowl, Katanga, and Aral Sea syndromes (Table 14.2).

In this inventory, vulnerability maps clearly on to the local processes of impoverishment, and it would not be overly difficult to compile indicators of vulnerability for each syndrome of land degradation. For example, the BWD typology (Figure 14.2) would place the Sahel Syndrome closer to the axis of human ecology of production while the Dust Bowl is more strongly related to exchange economies and entitlements. However, this catalog of syndromes and vulnerability highlights the weak conceptualization of the linkage between local vulnerability and larger-scale processes.

Table 14.2 International trends related to desertification syndromes. Gradation from white (no significant relevance) to light and dark grey, to black (highly relevant).

International Trends: \ *Syndromes:*	Sahel	Overexploitation	Dust Bowl	Aral Sea
Introduction of alien species				
Loss of biodiversity				
Enhanced greenhouse effect				
Changes in terrestrial runoff				
Migration (human)				
International indebtedness				
Globalization of markets				
Spreading Western lifestyle and consumption patterns				
Increasing international social and economic disparities				
Increasing ethnic and national conflicts				
Increasing international agreements and institutions				
Knowledge and technology transfer				
Automatization, mechanization				

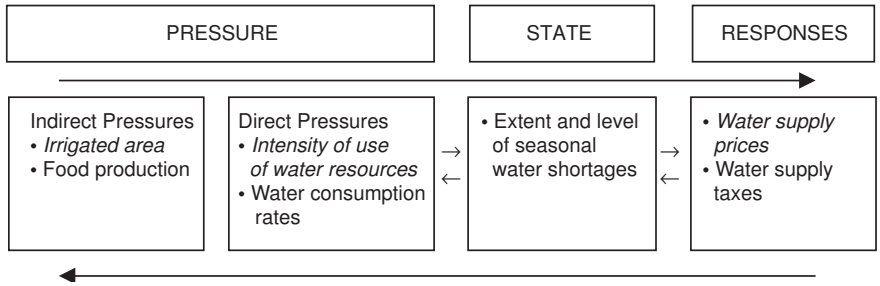

Figure 14.3 Water resources pressure-state-responses (P–S–R) model. Italics highlight indicators in the Core Set; others are presented as supplementary or are being further developed. Source: OECD (1998).

We provide more detail on the desertification syndromes below, following an overview of linkages between local and global scales. An APPENDIX provides details on methodologies.

Two recent efforts illustrate ways to compile indicators of vulnerability, pertaining to generic sustainability. The Organization for Economic Cooperation and Development (OECD 1998) sought to gauge how well-developed countries have met their domestic and international commitments on environment. Some 33 indicators were selected, covering climate change, ozone layer depletion, air quality, waster, water quality, water resources, forest resources, fish resources, biodiversity, GDP and population, consumption, energy, transport, agriculture, and expenditure. For each topic, a conceptual model of pressure, state, and response is included (see Figure 14.3 for the water sector). This provides a basis for choosing representative indicators, and includes other potential indicators for which additional data are available or still being collated. Criteria for selecting indicators include policy relevance, analytical soundness, and measurability. There is no attempt to create a composite index of overall environmental performance.

The report stresses three guiding principles: (a) indicators are only one tool for evaluation, and additional scientific and policy-oriented interpretation is necessary; (b) the relevance of indicators varies by country and the context must be taken into account — each country has different ecological, geographical, social, economic, and institutional features; and (c) there is no single method of standardization that leads to complete comparability across countries.

Recently, the Global Leaders for Tomorrow Environmental Task Force of the World Economic Forum presented a pilot environmental sustainability index, developed in collaboration with the Yale Center for Environmental Law and Policy and the Center for International Earth Science Information Network.[1] The index is "an exploratory effort to measure the ability of economies to achieve environmentally sustainable development" (p. 4). The hierarchical index covers 56 countries (Figure 14.4). The study concluded: (a) it is possible to construct a single index and the results are plausible and useful; (b) comparing the index with measures of economic performance sheds light on the conflicts between economic and environmental objectives. High levels of environmental protection appear to be compatible with, and may even be conducive to, high levels of economic growth; and (c) considerable work is required to refine the index, including developing better data sets.

[1] See www.weforum.org and www.ciesin.org/indicators/ESI).

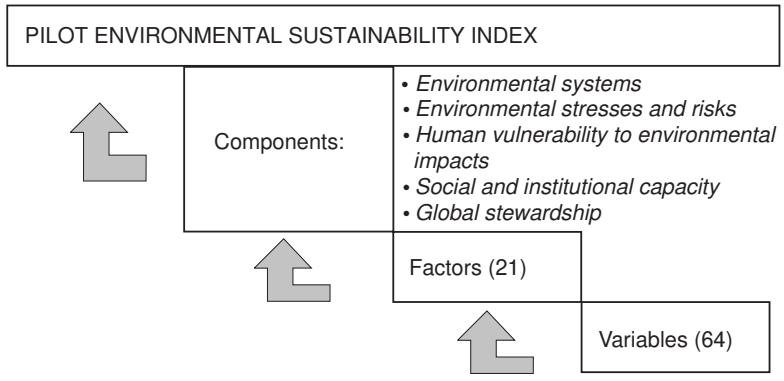

Figure 14.4 Hierarchical construction of the Pilot Environmental Sustainability Index. Source: World Economic Forum (2000).

INTERNATIONAL INSTITUTIONS AND REGIMES

We now turn to the question of how local vulnerability and land degradation are related to international processes. We begin with an overview of international institutions and then explore the nature of local–global linkages. Institutions and regimes in this chapter refer to the "new institutional analysis" where institutions are "norms, rules and shared strategies" (Ostrom 1986; Ostrom et al. 1994).

The principal international institutions that have a role in land degradation include:

- Climate change and drought, which may be significant forces of land degradation. Climate change can be considered an institution — the combination of actors who emit greenhouse gases and fail to adopt stabilization polices. As the climate changes, there is reason to believe that drought hazards will increase.
- Trade and economic growth. The extraction of resources from semi-arid areas drives many forms of land use. For example, demand for cotton, in place of synthetic fibers or wool, accelerates growth of a crop that requires high agrochemical inputs and often irrigation. Or, livestock exports sustain production in marginal regions that are then subject to rapid deterioration during a drought.
- Environmental concern and civil society are seen as forces promoting sustainable development and influencing decision making on economic development policy. This regime is largely sustained by international NGOs, with varying commitments from financial organizations and governments.
- Aid and humanitarian assistance — the regime that responds to disasters and promotes development in marginal areas, including setting development targets and conditionality of loans negotiated with host governments.

These institutions both promote and mitigate land degradation (also see Chasek and Corell 2002). For instance, trade and aid can create demand for goods and the socioeconomic infrastructure that support sustainable livelihoods. Climate change could reduce drought hazards in some regions, at least with increased transpiration efficiency.

LOCAL–INTERNATIONAL LINKS

What links the local experience of land degradation with the international regimes? We suggest there are three main linkages:

- National economies and business. The market shapes flows of goods and services, decides on investments, dictates terms of trade. Of course the market is only a framework (or institution) resulting from decisions of its agents (Harou 2002). Economic rationality prevails in this view of local–global linkages. Economic rationality is often seen as a driving force of land degradation, but less often viewed as a means to reduce vulnerability.
- Planning, administration, and law sit alongside the market, setting policy, agreeing objectives, translating policy into procedures, auditing compliance. Such linkages are shaped by organizational theory and decision making. This is a wider view of rationality, one that often dominates conceptions of land-use policy.
- Uneven development and elite hegemony, structural interpretations of a political ecology, focus on conflict, irrationality, and deviance. Processes of multi-stakeholder negotiation, compromise, or intentional marginalization — along a continuum of empowerment — imply that vulnerability is intentional and means to reduce vulnerability will be at the expense of existing systems of governance or at odds with market forces (e.g., through welfare and subsidies).

We should not assume that any of these sets of linkages is appropriate or sufficient to reduce the threats of land degradation. Consider an example from drought and food security. A planning model assumes that better information, advance predictions, and emergency preparedness would provide sufficient scope for action to mitigate the worst effects of a drought crisis. If national food supply is threatened, the major response needs to be large-scale imports. Imports are possible through market forces or under humanitarian regimes. Markets can prevent a crisis, as occurred throughout Africa in the 1990s, provided the country has good standing and credit (not guaranteed, witness Zimbabwe at present). Access to humanitarian aid is also related to the uneven development and political hegemony of aid, witness the withdrawal of most U.S. assistance from Niger in the mid-1990s.

International trends involved in syndromes related to desertification (Sahel, Overexploitation, Dust Bowl, Aral Sea) are either drivers of change or consequences of the syndrome. Entries in Table 14.2 denote the relevance of a trend for the respective syndrome. The international trends shown were identified in the Dahlem Workshop. Most of the syndromes suggest local processes as the dominant driving forces (e.g., Sahel, Rural Exodus, Aral Sea). The Development and Sink syndromes place degradation in a national and international context, as they concern processes of economic growth and industrialization.

DESERTIFICATION SYNDROMES

Overexploitation Syndrome

The Overexploitation Syndrome involves the conversion of natural ecosystems and the overexploitation of biological resources. Ecosystems (e.g., forests, savannas) are

overexploited without regard for their regenerative capacity, resulting in severe damage to the natural balance. Important effects of the Overexploitation Syndrome that have a global character are the enhanced greenhouse effect via net CO_2 emissions induced by land-cover changes (Houghton 1999), the loss of biodiversity (Fearnside 1999), and cross-border migration (Westing 1994). A further consequence of the Overexploitation Syndrome is the dampening effect it has on the economic growth in the country of origin. Essentially this interaction reflects the threat to a country's foundation of existence (increasing international economic disparities). The only feedback path of these globally relevant impacts on the syndrome dynamics is the increase of international agreements and institutions via increased environmental awareness. This negative feedback (in the sense of weakening the syndrome) competes with the core mechanism of the syndrome: provided the driving forces persist, the Overexploitation Syndrome "reproduces" itself in Region B when it has exhausted Region A through complete overuse ("sparkler effect"— for more details see Cassel-Gintz and Petschel-Held 2000).

A major anthropogenic cause on the global scale may be seen in the use of forests by multinational players in the timber industry, use not designed for long-term management but for short-term profit maximization. The influence of a company in amplifying the syndrome is all the higher the more "complete" is its coverage (e.g., international) and the more inefficiently it operates. In Indonesia, for instance, in the mid-1990s just 43 per cent of the logged timber was processed into products, the rest was waste. In other developing and newly industrializing countries the ratio at 45 per cent waste is a little more favorable (Jepma 1995; Dudley et al. 1996).

The overexploitation of biological resources that is not prevented — or is even promoted — by national policy, is spurred on essentially by two factors: first, increasing use of energy (firewood) and raw materials (wood products), and second, a change in the demand structure (product spectrum). If one looks at the logic of the process of the Overexploitation Syndrome then its point of origin is a lucrative market, which is driven by increasing global demand (*globalization of markets*). In the last few years, in addition to the high demand coupled with strong purchasing power in the industrial countries, there has been an increasing domestic demand from newly industrializing and developing countries (e.g., Brazil, Malaysia) (*the spread of Western lifestyle and consumption patterns*). In some industrial countries in the recent past demand for tropical hardwoods has been falling or at least stagnating, in part as a consequence of changed parameters in world trade (*increase in international agreements and institutions*), partly as a result of changed consumer behavior and/or a growing sensitization to global problems in public opinion. The debate regarding the introduction of product classification (certification) is characteristic of that behavior.

The technology of resource harvesting and processing and the form of consumption play a crucial role in determining the amount in demand. On the one hand *automation and mechanization* of the syndrome, the wide availability of the chainsaw, or heavy timber processing equipment are examples of this phenomenon. On the other hand it has to be considered that the state's restricted room to maneuver may lead to a situation where the infrastructure that is conducive to the overexploitation is no longer affordable (for an example see Ecuador from 1974 to 1982).

Another much discussed driving force behind the Overexploitation Syndrome is the *international indebtedness* of many developing and take-off countries (Miller and Warrell 1990;

Kahn and McDonald 1995). It has more of an indirect impact and is only really brought to bear once the decisive political institutions that hold responsibility for the timber resources have failed. A waiver of debt in public budgets can only reach private-sector players via the contorted route of budgetary, fiscal, or economic policy measures. These can, but certainly do not have to, lead to the decision of servicing the debt with the logging and export of native timber resources.

With the pressure on wood as a resource, the habitat and cultural space of indigenous communities is also under threat. Often their traditional rights of use are annulled when the forest becomes government property, and not uncommonly the reserves conceded to them are not offered sufficient protection. Overuse and damage to ecosystems destroy their habitat and drive many of them away into urban or rural settlements (*migration*) where they are subject to social and economic marginalization.

Aral Sea Syndrome

The Aral Sea Syndrome refers to the ecological and social problems induced by the bad management or failure of centrally planned, large-scale projects involving deliberate reshaping of the natural environment. Large-scale projects create the impression that development goals, such as increasing energy production, can be achieved rapidly and at extremely low cost. Major projects are often central elements of economic strategies to promote specific sectors or regions (e.g., the Aral Sea irrigation scheme). However, at least in developing countries the financial scope of the projects usually precludes any self-financing. For this reason, dams have long numbered among the projects receiving the most assistance from international financing institutions (World Bank, IMF), whose growing significance has further boosted the implementation of large-scale projects. The World Bank alone, the most important public institution for financing dams, has provided $58 billion (1993 dollar value) for this purpose between 1944 and 1994 (*increasing international institutions*). This is closely linked to the interests of construction companies and consultants in industrialized countries, who similarly favor large-scale projects (*globalization of markets, knowledge and technology transfer*). This is certainly another reason why the development policies of industrialized nations provide special support for large-scale projects. The Swedish International Development Agency (SIDA), for example, estimates that up to three fourths of the money it lends for hydroelectric projects flows back to Swedish companies (Usher [1994] quoted from McCully [1996]).

The World Bank and other international organizations may have helped countries to realize water resource development projects, but by the same token have contributed to their *international debts*. The final cost of the Chixoy Dam in Guatemala ($944 million), for example, represented nearly 40% of the country's total external debt, while Brazil guaranteed loans of $16.6 billion (1990) for the Itaipú Dam, which made up nearly 14% of the total state debt (McCully 1996).

The Euphrates, Indus, Ganges, and Jordan basins provide examples of the potential for conflict associated with large-scale dam projects, which may escalate into an increasing number of *international and national conflicts.* The conflict potential in semi-arid regions is most pronounced where such regions depend on only one river.

Construction of a dam, for example, may involve not only compulsory resettlement of local inhabitants (*migration*), but also a change in land-use rights, usually at the expense of population groups that are already marginalized (Sahel Syndrome). Providing resources promotes industrialization, which may itself have severe consequences for the environment (Asian Tigers Syndrome) or induce pull effects that favor urbanization (Favela Syndrome).

Furthermore, especially in developing countries, the prestige value of gigantic construction projects for domestic policy (visible evidence of progress and modernity, *spread of Western lifestyles*) and its stabilizing effect for the state or government are rated very highly, with the result that priority is frequently given to large-scale projects rather than to small-scale or decentralized alternatives (Schmidt-Kallert 1989).

Sahel Syndrome

The mechanism of the Sahel Syndrome consists of existential rural poverty which drives farmers to overuse their lands, leading to environmental degradation which reduces yields and thereby further exacerbates rural poverty. Both national and international economic trends or frameworks (e.g., the *globalization of markets*, *international indebtedness*, *the world trade regime*) may operate as major causes of marginalization within the Sahel Syndrome, triggering or accelerating its central mechanism (for more details see Lüdeke et al. 1999). The main features of nonadapted national economic policy within the Sahel Syndrome are that it is geared too much to securing an adequate livelihood for the urban population, and not enough to the problems faced by agricultural producers; relies too heavily on export-oriented monocultures while neglecting to ensure food security through the development of a local agricultural sector; and prevents sustainable forms of land management by creating the wrong incentives.

Many of these factors are reinforced by international influences: agricultural development is blocked because of imports from countries with highly subsidized agriculture, high indebtedness induces a short-term orientation, while credits are linked to certain development paradigms and the related criteria imposed by international institutions, e.g., structural adjustment programs. These usually rely on the devaluation of national currency to obtain greater competitiveness for local products (e.g., agricultural) on the world market. But this is often an incentive for resource mining of soils for agriculture and therefore increases the likelihood of desertification — in particular under abandonment of subsidies important for financing resource conservation measures.

With respect to *international indebtedness* a reduction of investments in social, natural, and human-made capital (health, education, resource management and protection, infrastructure) in favor of current expenditures (politically more important but not sustainable) for jobs can be observed. Here debt relief has a positive effect via reduction in budget deficit leading to a reduction of pressure on resources (for more details see Harou 2002).

Dust Bowl Syndrome

The Dust Bowl Syndrome refers to the natural physical-geographical consequences of the industrialized farming practices that have emerged in the context of the evolution of *national and international markets*. These nonsustainable farming practices can lead to substantial

environmental damage. Types of damage include changes in the hydrological regime, eutrophication and contamination of surface water and groundwater reservoirs, *the loss of biological diversity*, the accumulation of pesticides in the food chain with resultant health impacts, and the *emission of greenhouse gases*. The Dust Bowl Syndrome occurs not only in developing and newly industrializing countries, but also in industrialized nations, where the displacement of labor from agriculture through rising labor productivity plays a major role.

The central trend of the Dust Bowl Syndrome is the intensification of agriculture, which, via interactions with various spheres, leads to the degradation of the natural bases of production. Agricultural intensification is driven by economic developments in conjunction with technological advances. This is underlain by rising aspirations and the *spread of Western lifestyle and consumption patterns*. The use of high-yielding crop varieties instead of traditional and adapted species is typical of agricultural intensification in the Dust Bowl Syndrome (recently, these varieties have been developed by genetic modification as an expression of *knowledge and technology transfer*) — *loss of biodiversity* and *introduction of alien species* are related trends. *Mechanization* and the use of high-yielding varieties necessitate the application of large quantities of pesticides, which contribute substantially to the risk posed by persistent organic pollutants (POPs).

The syndrome contributes to the *enhanced greenhouse effect*, notably through methane emissions in animal husbandry and wet rice cultivation, and through N_2O emissions from the intensive application of mineral fertilizers and organic manure. In addition to intensification, expansion of agriculturally utilized areas, with the associated conversion of forest ecosystems to agricultural uses, plays an important role. Taken together, agriculturally related emissions presently account for about 30% of the total annual growth in human-induced radiative forcing. Of this, a considerable proportion is attributable to the Dust Bowl Syndrome.

International indebtedness may trigger the syndrome by the need for foreign exchange, which may lead via national policies to the promotion of commercial cash crop farming, more oriented toward international market prices than on appropriateness of soil and climate conditions. A process that usually results in *increasing international disparities* as the natural production basis is exploited without substitution by capital. Influence of *increasing international agreements and institutions* (e.g., structural adjustment programs) is comparable to the effects on the smallholder agriculture as already discussed in the previous section.

As desertification is a part of global environmental change, it is already (at least conceptually) represented to some extent by the concept. In particular, the syndromes that include soil degradation as a relevant trend are candidates for functional patterns leading to desertification. Depending on the definition of desertification — irreversibility as related to the managed natural system or to the coupled system, (semi-) arid regions or marginal regions in general, etc. — further refinement could be accomplished.

Syndromes and Soil Degradation

A preliminary example of how syndrome diagnosis can be used to explain a global core problem (here soil degradation, which is not desertification but certainly includes it) is given in Figure 14.5. As only two (instead of all 16) syndromes are considered, many regions with high human-induced rates of soil degradation are unexplained, but the map illustrates the basic principle.

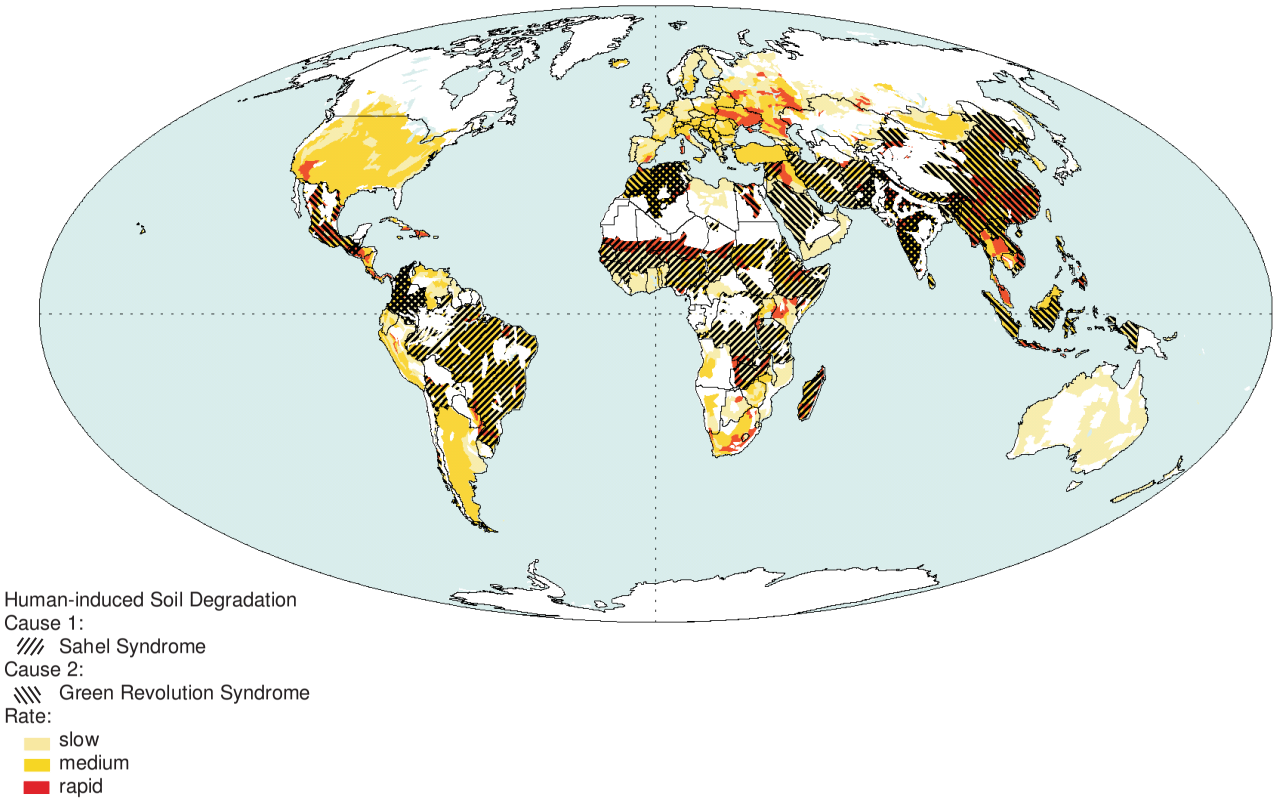

Figure 14.5 Example of a syndrome-specific explanation of a global core problem. The rate of anthropogenic soil degradation (Oldeman et al. 1990) is superimposed with the presence of the Sahel Syndrome (left to right hatching) and the Green Revolution Syndrome (right to left hatching) as two important explanatory mechanisms. Areas with both syndromes present are denoted by the cross-hatching. Areas with anthropogenic soil degradation and no hatching are infected by other syndromes (after Schellnhuber et al. 1997).

In summary, a theory of international vulnerability must embrace the diversity of forces that shape local vulnerability, at both local and international scales. While syndromes are analytically tractable, the local–global linkages in vulnerability are also related to the political economy of global development (Swyngedouw 1999), which may well be beyond the means of social science to capture in formal assessments.

ANALOGUES?

In addition to the characterization and modeling of syndromes, can analogues of local–international vulnerability provide some insight? Three that are well documented, and ongoing, are the Green Revolution, adaptation to climate change in the United Nations Framework Convention on Climate Change, and the case of intellectual property rights regarding indigenous knowledge and biodiversity. It is beyond our scope here to review these cases in detail. We simply highlight examples of lessons and issues that are relevant to land degradation.

Early studies of the Green Revolution pointed to the discrepancy between the intervention package (high input, advanced agrotechnology, simple strategies) and household coping strategies among vulnerable farmers (constrained by lack of credit, simple technology but complex strategies of diversification and mixed production systems). Later, the trickle-down effect was documented — increasing commodification and wealth in the community seemed to increase welfare for most farmers (and farm labor). Most recently concerns have focused on the levels of indebtedness among the most vulnerable farmers, exposure to agrochemical hazards, and long-term sustainability of high-input farming. Some suggest that income distributions have worsened; while India produces enough rice to feed itself, many millions are too poor to purchase their minimum food requirements. While vulnerability is still seen as local, the global food system is acknowledged, often in conflicting ways. The new Green Revolution and biotechnology use the old Green Revolution arguments about the world feeding itself (but less often specifically how the vulnerable might feed themselves). Technological optimists see the continuing decline in food prices as signs of hope, but this adversely affects some farmers and pushes many farming systems into exploitative practices. The experience of the Green Revolution highlights the conflicting construction of vulnerability: the tension between global systems mediated by a few countries and local livelihoods.

The climate change convention includes considerable rhetoric about adaptation and general agreements to reduce vulnerability. Only recently has adaptation been taken up as a legitimate policy objective (in early debates, promoting adaptation was seen as a sign of weakness on reducing greenhouse gas emissions). The Conference of Parties in The Hague (COP6, Nov., 2000) spent some effort debating funding sources for adaptation, terms for deciding projects, and means for monitoring effective adaptation. The follow-on session (COP6.bis, the Marrakesh Accord) agreed on four international funds that include various aspects of adaptation in developing countries. Two key issues have been (a) whether, and if so, how, to differentiate vulnerability between countries or regions and (b) how to ensure funds are spent on adaptation to climate change (i.e., the additional costs of adaptation to the enhanced greenhouse effect) and not for generic development or disaster prevention.

The processes of negotiating climate change adaptation highlight the difficulty of surmounting international regimes. The rhetoric of bottom-up capacity building does not sit well

with the terms of bilateral and multilateral funding. A bias toward demonstration projects and large-scale development emerges, rather than empowerment and effective policy–economic frameworks for the vulnerable. Most of the effort so far has been spent on action plans and training of science elites rather than integration with development planning (e.g., Poverty Reduction Strategy Plans) and environmental action plans. Even the new national Action Plans for Adaptation adopted in the Marrakesh Accord are unlikely to trigger significant funding relative to the long-term threats. The experience of the Convention on Drought and Desertification appears to be similar.

The international protection of intellectual property rights versus local biodiversity and traditional knowledge has raised key issues regarding globalization and trade[2]. The Intellectual Property Rights (IPR) regime, designed to protect material inventions, is increasingly used to protect trade and knowledge. Few rights in traditional knowledge of plants and animals appear to reside irrevocably in developing countries, and there are relatively few options for developing countries if they wish to maintain favorable status as trading partners with major industrial markets. Those most vulnerable, who may hold privileged knowledge of local resources, may be poorly represented by international negotiations.

Negotiations over the international IPR regime indicate that vulnerability will be strongly shaped by international processes that are outside the purview of the vulnerable themselves and may be indirectly related to the apparent manifestation of vulnerability. Negotiations on trade and IPR will likely have stronger real impacts on vulnerability than the volumes of specific discussions on desertification and land degradation.

LESSONS AND ISSUES

What are the lessons learned in local–global studies of sociogeographic vulnerability? Here we posit propositions that emerge from this review of local–global vulnerability. They are in the nature of assertions, for which the supporting evidence may be lacking or contested. They are intended to stimulate discussion!

Vulnerability cannot be differentiated into different causes. For instance, the threats to livelihood security in semi-arid areas cannot be differentiated between climate change (or increased variability) and land degradation related to land use (even ignoring economic and scale connections). Even if relative weights can be assigned in models or statistical relationships, the vulnerable themselves are indivisible.

Similar constellations of institutions and regimes will have diverse effects at the local level. This might reflect the patchiness of driving forces, using an ecosystem metaphor. But this is also a property of multilevel interactions. Only in rare cases (and perhaps not so interesting ones) will a single level of complexity be of such importance as to dominate the search for explanation and solution. In few cases will international regimes be the dominant force either in causing degradation or its amelioration.

Existing vulnerability assessments are inadequate to deal with multi-scale, long-term processes of vulnerability (or adaptation and resilience). Emergence, complexity, multilevel modeling, agent-based social simulation — the language and tools are being formulated but

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[2] These conclusions are based on conversations with Graham Dutfield, see Dutfield (1999, 2001).

are still quite distant from practical, robust applications. Expertise, and experts focusing on the right issues, is not soon to be supplanted by decision support systems or integrated assessment models.

Integrated assessment and policy are nonetheless essential. Vulnerability is the (integral) outcome of exposure at the level of agents, threats across the economy and environment, and sociopolitical processes across scales. An integrating framework is required, raising the ghosts of past efforts in development studies and regional science.

In conclusion, it is clear that land degradation is not the main attribute of vulnerability, although situations of land degradation are likely to exacerbate present vulnerability and could pose serious threats in the future. However, it may be that a concerted effort to address vulnerability — and the panoply of syndromes of environmental threats — should be higher on the sustainable development agenda than land degradation per se.

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APPENDIX: NOTES ON METHODOLOGY

In this section we present a cursory note on methodologies behind the assessment of vulnerability (see Stephen and Downing 2001) and syndromes.

The dominant methodology in vulnerability assessment is to compile a list of indicators and combine them in a profile and ranking. For example, a food poverty index might begin with indices of national food self-sufficiency, food poverty, and nutritional deprivation. The indices could then be standardized, added together and ranked. The most widespread such index is the Human Development

Index (UNDP 1998), while the Economic Vulnerability Index and the above examples from the OECD and World Economic Forum are being promoted as measures of vulnerability to global change.

Such indices are useful ways to focus on who and where — locating vulnerability relative to other social groups and regions. They have been termed the vacuum cleaner approach to vulnerability assessment — hoover up as many indices as available, then weigh the collected results to determine vulnerability. They are notably deficient regarding processes of vulnerability — the how is only indirectly related to an underlying conceptual model, if any.

A closer link between conceptualizations of vulnerability, the processes underlying exposure, risk and deprivation, and sociogeographic expressions of vulnerability is maintained in the syndromes promoted by the Potsdam Institute for Climate Impact Research (Petschel-Held, Block et al. 1999).[3] Syndromes are collections of processes and social geographies that lead to environmental destruction.

Syndrome identification starts from the limited but presently available knowledge of quantitative or qualitative functional relationships with respect to global change, the conditions of the validity of these interactions, and knowledge of problematic environmental and socioeconomic developments. This knowledge can be exemplified by, e.g., the Bretherton diagram for the natural science part of Global Change research (CIESIN 1992) or the diagram for socioeconomic drivers and consequences of land-use changes (Turner et al. 1995, p. 43). Beside this (often large-scale) complex functional knowledge, detailed, small-scale knowledge from case studies (e.g., Kasperson et al. 1995) is available. The functional resolution of the syndromes lies in between these two extreme scales — called the intermediate functional scale. Thus one avoids the details of an immense amount of different case studies or being too general to meet the necessary minimal differentiation (e.g., for at least weak forms of prognosis), especially at the civilization–nature interface.

Given our functional knowledge, the first step is to define variables describing global change (symptoms) according to the following criteria: they must help to decompose the complex global system in almost independent subsystems while the important interactions between the original variables must remain discernible. This implies choices about aggregation and functional resolution. A first list of about 80 of these variables or symptoms was suggested by the German Advisory Council on Global Change (WBGU 1997) and developed further by the QUESTIONS project (Petschel-Held, Lüdeke et al. 1999).

The second step is to group the huge number of interactions between the symptoms in functional patterns producing syndromatic behaviors (and possibly others). Here, the spatial and functional conditions of the validity of interactions play an important role: a necessary condition that two particular interactions which have one symptom in common (e.g., globalization of markets causing agricultural intensification and agricultural intensification leading to loss of biodiversity) belong to one submodel (syndrome) is spatial coincidence. But this is not sufficient because further functional conditions may assign the interactions/symptoms to, e.g., different economic sectors or groups of actors which may coexist at one location assuming a realistic spatial resolution (e.g., poverty of different social groups in a city will have different effects on migration).

Due to the limited knowledge base used for the identification of the syndromes they must be interpreted as educated first guesses that have to be corroborated in the usual process of verification/ falsification/ modification. Because syndromes are abstract concepts, they cannot be checked directly. Instead, results deduced from them have to be compared with observed phenomena.

One approach to validation is the data-based syndrome diagnosis.[4] The disposition is calculated from the structure of a syndrome, which describes the possibility that the most important syndrome-specific mechanisms and interactions may become active in a specific region. One important

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[3] See www.pik-potsdam.de/cp/quest/ for details of the Questions theme.

[4] A more formal iterative method based on qualitative differential equations is introduced in Petschel-Held and Lüdeke (2001).

aspect in the definition of this concept is time-scale. Disposition usually depends on natural and socioeconomic characteristics which are assumed to change slowly in time compared with the typical time scales of the syndrome. In general, it is necessary to describe the complex conditions for the potential validity of the main interactions by a relatively large set of hierarchically ordered indicators, which can be illustrated by a decision tree, showing the different hierarchical levels together with the logical relations between the basic indicators. An appropriate way to formalize this decision tree has to reflect the mostly qualitative nature of the syndrome mechanism's description which implies the use of qualitative knowledge in the identification of syndrome-prone regions too. So far, fuzzy logic (Zimmermann 1991) has been fruitful in this context (Cassel-Gintz et al. 1997).

The next step in syndrome diagnosis is the determination of the so-called intensity. Whereas disposition determines whether a syndrome might become active, intensity measures whether it actually is active in a certain region. Therefore it has to be examined whether the contributing symptoms show up because of the proposed mechanisms. It is most direct to formalize the mechanism in terms of a simple mathematical model and to obtain conditions for the temporal behavior of the symptoms from this model (see, e.g., the intensity measurement of the Sahel Syndrome in Petschel-Held, Block et al. [1999] — for a measurement mainly based on indicators for relevant symptoms, see, e.g., Kropp et al. 2001). The comparison of the global, data-based maps for syndrome occurrence and independent local and regional case studies provides a means for validation.

The syndrome methodology employs innovative combinations of dynamic simulation, qualitative differential equations, fuzzy sets, and geographic information systems. While insightful, the approach tends to focus on conditions of deteriorating environment rather than the balance between degradation leading to vulnerability and sustainable livelihoods leading to development.

The greatest methodological challenge is to combine the sociogeographic and dynamical methods (indices and syndromes) with an understanding of the processes of decision making and institutional structures that influence the evolution of vulnerability over time periods of interest (say the decades of policy making to the century of global change). Kohler and Gumerman (2000) review the prospects of an agent-based social science in a volume from the Sante Fe Institute. Agent-based social simulation holds great promise in handling various levels of complexity, each with its own causal explanations and emergent properties: individual behavior, interactions, relationships, and social structure. To which some would add genotype and culture at either end of the sociogeographic scale.

Although in their early stages, techniques of agent-based social simulation hold some promise (see Moss et al. [2001] for relevance to integrated assessment, Downing, Moss et al. [2001] for a pilot application to water, Rouchier [2000] for applications to land use, and Kohler and Gumerman [2000] for a collection of promising applications). Despite encouraging beginnings, much remains to be proven, especially in representing the meta-level linkages between the agency of individuals and the economies and cultures in which they operate.

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