

CAUSES AND PATHWAYS OF LAND CHANGE  
IN SOUTHERN AFRICA DURING THE PAST 300 YEARS  
Moving from simplifications to generality and complexity

With 3 figures and 1 table

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*Zusammenfassung:* Ursachen- und Verlaufsanalyse von terrestrischem Wandel im südlichen Afrika (1700–1990). Generalisierung und Komplexität statt Vereinfachung

Die bahnbrechende Modellierung gekoppelter Mensch-Umwelt-Systeme leidet unter dem Mangel an einer systematisch erstellten und leicht verfügbaren Dokumentation von Trajektorien terrestrischen Wandels, die auch quantitative Informationen bereithält über das zugrundeliegende Verursachungsmuster. Für die Gesamtregion des südlichen Afrika werden, am Beispiel der Acker- und Weidelandausweitung, jüngste und weitgehend kompatible Ergebnisse zweier Schätzwertrechnungen vorgestellt (1700–1990). Es wird gezeigt, dass allzu vereinfachende, aber populäre Darstellungen der Verursachungsmusters von Landnutzungsveränderung („Mythen“) durch qualitative Trajektorien ersetzt werden können, die sich aus einer Vielzahl von empirischen Belegen speisen. An etlichen Fallbeispielen ausgewählter Veränderungsprozesse (Entwaldung, Wald- und Boden-degradierung, ‚Desertifikation‘) werden meta-analytisch (semi)quantitative Daten erzeugt. Es wird gezeigt, dass der Interpretationsrahmen von direkten Kausalfaktoren (z.B. Ausweitung des Tabakanbaus) *versus* zugrundeliegender Verursachung (z.B. Marktdynamik, Politikentscheidungen, Bevölkerungsdynamik) hilfreich und notwendig, aber nicht ausreichend ist. Eine systematische Bestandsaufnahme des robusten Ursache-Wirkungszusammenhangs von Landnutzungsveränderungen sollte darüber hinaus auch systemische Eigenheiten (z.B. Feedbacks) und Elemente der Vulnerabilitätsanalyse (z.B. Widerstands- oder Adaptionsfähigkeit) enthalten.

*Summary:* Progress in integrated land change science, especially the modelling of coupled human-environment conditions, suffers from the lack of a systematically generated and readily comparable documentation of trajectories of land use and land cover change. Taking the case of Southern Africa, two recent estimates of historical land change in the region are presented, together with indicative cause explorations inherent in them (cropland and pasture expansion). For selected classes of land change (deforestation, woodland degradation, ‘desertification’, rangeland modification), major simplifications or ‘myths’ are presented and held against qualitatively derived pathways of land change. It is further argued that a (semi)quantitative understanding of cause-connections is important, and that fast-track data can be generated from a meta-analysis of proximate causes (e.g., agricultural expansion) and underlying driving forces (e.g., market forces, policies, human population dynamics). However, the systematic exploration of case studies of land change is just a fast-track measure and first step towards the identification of robust cause-connections so as better to inform original case study research protocols (and the modelling community). Besides generalising from cases, a more complex framework for a causative factor and trajectory analysis is suggested, which extends beyond the proximate/underlying divide, including properties of systems dynamics (e.g., feedbacks) and vulnerability (e.g., resilience).

### 1 Introduction

Land use and cover change is an important forcing function of global environmental change, and also determines, in part, the vulnerability of places and people to climatic, economic or socio-political perturbations (GEIST 1999a, TURNER 2001). The 300 years of land change in Southern Africa<sup>1)</sup> considered here correspond, as in most regions of the world, to the start of the period of greatest and most rapid transformations of land cover with measurable impacts on today’s landscape configurations. Despite improvements in the documentation and monitoring of land change – i.e., software and hardware development, methodological and technological issues (e.g. CIHLAR a. JANSEN 2001) – “systematically generated and readily comparable

documentation of land use and land cover change has been woefully sparse” (TURNER 2001, 270). Better data alone would be insufficient, unless they are matched by an enhanced understanding of the causes of change. This is pivotal for the development of models to generate projections of future land use and local to global environmental change.<sup>2)</sup> Unfortunately, reliable information on human cause-connections and their effects

<sup>1)</sup> The regional breakdown used in this study is: Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe.

<sup>2)</sup> It also requires an understanding of how changes in climate and global biogeochemistry affect both land use and land cover, and vice versa, to integrate feedback loops (e.g. TYSON a. GATEBE 2001).

upon land surface processes is lacking, which is especially true for the semi-arid lands of Southern Africa (HULME 1996, MAGADZA 1996, DUBE a. PICKUP 2001, HULME et al. 2001). Much of the progress in integrated environmental modelling has hitherto been blocked (DESANKER et al. 2001).<sup>3</sup> Consequently, land use and cover change has been identified to be among the high priority research issues of social and environmental change in Africa (DESANKER a. JUSTICE 2001).

This paper argues that knowledge about causes of land change has so far been mostly gained from individual ('isolated'), local case studies rather than from a consistent case study network: "[a] few case studies at the local level exist ..., but there is a general lack of synthesis of land use going from the local/community levels to the regional level" (DESANKER a. JUSTICE 2001, 97, 101). To take the argument even further: among these 'isolated' causal explorations widespread myths or popular simplifications exist of what actually constitutes a human source of land change (LAMBIN et al. 2001, 262). Therefore, this paper, first identifies the most prevalent simplifications on causes of land change, and, secondly, moves beyond them in an attempt to synthesize preliminary results from several case studies (forest conversion and/or modification, cropland and pasture modification). Use is made of the conceptual framework of proximate causes and underlying driving forces of land change (TURNER et al. 1995). It is hypothesised that, against the background of historical estimates of land change over the past 300 years, economic opportunities shaped by policy factors – rather than population pressure – are at the heart of understanding the causes of land change in Southern Africa. Finally, a framework for a causative factor and trajectory analysis of land change, extending beyond the proximate/underlying divide, is suggested.

## 2 Historical land use and cover change (1700–1990)

Despite improvements in land cover characterization made possible, for example, by earth observing satellites (LOVELAND et al. 1999), land covers and uses in Southern Africa are poorly enumerated (DESANKER a.

JUSTICE 2001). There have been few comprehensive studies of long-term historical changes in the region, and if so, they cover only a few countries (e.g. FAIRBANKS et al. 2001). Therefore, data are drawn here from two recently developed historical databases of global land change (RAMANKUTTY a. FOLEY 1999, KLEIN GOLDEWIJK 2001). Based on historical statistical inventories (e.g. census data, tax records, land surveys, historical geography estimates, etc.) and applying different spatial analysis techniques, this has been an attempt to reconstruct land cover change due to land uses for the last 300 years.<sup>4</sup>

– One estimate (KLEIN GOLDEWIJK 2001) holds that croplands expanded from 8.4 million ha (Mha) in 1700 to 41.3 Mha in 1990, which implies increases by 0.4 Mha during the 18<sup>th</sup> century, by 3.7 Mha in the 19<sup>th</sup> century, and a veritable 28.8 Mha in the 20<sup>th</sup> century (1900–1990). In terms of relative annual change in these three periods, this meant increases from 0.05% to 0.35%, and to 1.34%, respectively. At more or less constant rates (0.51%, 0.68%, 0.58%), pasture land is estimated to have expanded from 60.0 Mha in 1700 to 332.1 Mha in 1990, i.e. by 40.3 Mha on average in the 18<sup>th</sup> century, by 96.5 Mha during the 19<sup>th</sup> century, and by 135.3 Mha in the 20<sup>th</sup> century – see Figure 1.

– Another estimate (RAMANKUTTY a. FOLEY 1999), covering all of Africa minus North Africa, holds that the change in croplands from 0.74 10<sup>6</sup> km<sup>2</sup> in 1700 to 1.52 10<sup>6</sup> km<sup>2</sup> in 1990 was gradual between 1700 and 1850, with growth rates having been exponential since then. Almost two thirds of this crop cover came from savannas, grasslands and steppes, while another third came from forests and woodlands. Both categories decreased from 5.39 10<sup>6</sup> km<sup>2</sup> and 10.85 10<sup>6</sup> km<sup>2</sup> to 5.15 10<sup>6</sup> km<sup>2</sup> and 10.38 10<sup>6</sup> km<sup>2</sup>, respectively.

Interestingly, the data sets of KLEIN GOLDEWIJK (2001) and RAMANKUTTY and FOLEY (1999) are consistent in a way that natural land cover in Southern Africa had been converted into other uses especially since about the turn of the 19<sup>th</sup> to the 20<sup>th</sup> century, and that this process, though mainly derived from population variables, could be linked to the expansion of human settlements and European colonization ('civilisation'). RICHARDS (1990, 163) characterizes such land transformation as "a spiralling arc that is determined, for the most part, by European political and economic control". Figures derived from these data

<sup>3</sup> Critical towards existing global integrated models, DESANKER and JUSTICE (2001, 100) suggest a comprehensive, spatial land use change model to be applied in Africa-wide modelling as well as in regional integrated studies, with important regional model components being droughts and floods, climate variability and agriculture, water quality, land use, livelihoods, shared resources, and hazards in the case of Southern Africa.

<sup>4</sup> The CD-ROM "Historical Land Use Changes over the past 300 years : New global Data Sets", July 2001, can be obtained at: <http://www.rivm.nl/env/int/hyde>. For other attempts, see also: <http://miombo.gecp.virginia.edu/cd/MiomboCd/Docs/Database.html#LandUse>.

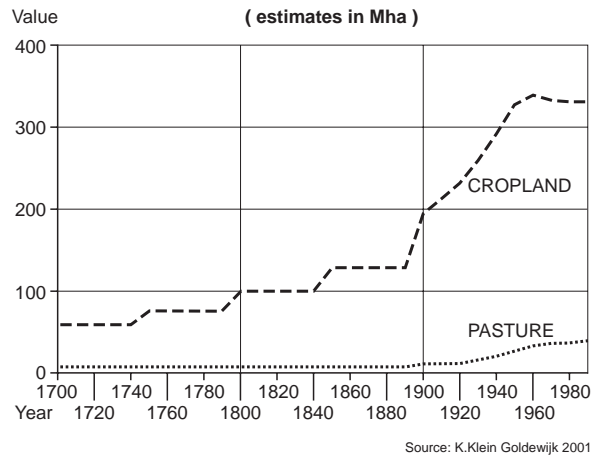


Fig. 1: Cropland and pasture expansion in Southern Africa, 1700–1990

Source: KLEIN GOLDEWIJK (2001)

Ausweitung von Acker- und Weideland im Südlichen Afrika, 1700–1990

bases mask, at least, one important historical pathway of land change in Southern Africa: accruing investments in land have raised the level of its exploitation and human domination to new heights since about late 19<sup>th</sup> century.

Indeed, the evolution of crop cover in Africa has been characterized as increasing intensification of croplands rather than large-scale extensification, while the situation in some countries of Southern Africa (Zambia and Zimbabwe, at least) seems different: large-scale cover conversion and land use extension prevail over intensification during the last 300 years (RAMANKUTTY a. FOLEY 1999, 1016). Previous studies also point out that numerous (semi)arid areas in the region have been brought under ambitious irrigation schemes and became suitable for growing crops – which seems especially true for South Africa (RICHARDS 1986). Land-related human dimensions of environmental change in Southern Africa are addressed for at least parts of the total region (e.g. GROSSMAN a. GANDAR 1989, DUBE 1992, WOODHOUSE 1992, MISANA et al. 1996, ODADA et al. 1996, SCOTT et al. 1997). MISANA et al. (1996), for example, claim that in the agriculturally productive zones of the miombo woodland zone all factors contributing to the conservation of the woodlands have drastically changed during the colonial and post-colonial past: a continuous contraction of woodlands and dry forests since early colonial periods in response to the ever-expanding subsistence and commercial activities. These activities were – and still are – rooted in outside interventions into the agricultural economies, based on highly erosive European settler

crops such as tobacco, tea, coffee and cotton. DUBE (1992) argues that past land use practices did not produce significant land degradation because population densities were low, settlements were often not permanent, and seasonal migration occurred. ODADA et al. (1996) suggest that only more recently population increases, together with political change and development pressure, have led to increased land changes, and DESANKER et al. (1997, 23) – claiming that human activities are central to the dynamics of environmental change – admit though that “details, however, have still to be fully revealed and understood”. Oddly, given the significance of human-driven land change, most of the works are ‘isolated’ case studies bearing mainly site-specific explanations (e.g. VEGTEN 1981, BOSCH 1989, HOFFMAN a. COWLING 1990, CAMPBELL a. DU TOIT 1994, LORUP et al. 1998). None of these – and other – causative explorations have ever been linked to broader and systematic historical land use and cover data sets as given above.

### 3 Generalising from case studies

In the study of land use change, case studies allow building a compendium of robust knowledge about local land use decisions and land cover dynamics (TURNER et al. 1995). Comparative studies are important to generalise understanding about relevant processes at work. Structured case study comparisons can either be achieved through common, standardised data protocols leading to original research or through a systematic literature review (meta-analysis) following high quality standards (the latter approach was chosen for the purpose of this paper).

On robust causes and pathways of land change, this paper draws from the outcomes of a global assessment of case studies, which was done qualitatively rather than in quantitative terms. The comparative assessment (LAMBIN et al. 2001) was carried out for classes of land change such as tropical deforestation, rangeland modification, agricultural intensification, and urbanisation. Simplifications were held against a body of empirical case study evidence, with the aim of arriving at common qualitative sets of cause-connections that typify these classes of land change.

Secondly, quantitative results from some cases in Southern Africa were generated and added to – or, tested against – these common qualitative sets of cause-connections. They are derived from a structured case study comparison which aims to identify both proximate (direct, immediate) causes as well as underlying (ultimate, final) social driving forces of change.<sup>5)</sup> Case

Table 1: Case studies to typify classes of land change in Southern Africa

Fallstudien zur Charakterisierung von terrestrischem Wandel im Südlichen Afrika

	Deforestation and woodland degradation and rangeland modification	Land degradation, desertification,	No. of cases
Angola	–	–	n=0
Botswana	–	Ringrose et al. 1996: south-central region, 1994	n=1
Lesotho	–	Quinlan 1995: Highlands, Mokhotlong District, 1880–1991	n=1
Malawi	Kalipeni & Feder 1999: Blantyre area, 1948–1996	Barbier 2000: Agricultural zones, 1970–1990	n=2
Mozambique	–	–	n=0
Namibia	–	Ward et al. 2000: central Namibia, 1695–1998	n=1
South Africa	Higgins et al. 1999: central lowveld, ca. 1970–1990	Palmer & Rooyen 1998 : southern Kalahari, 1989–1994	n=2
Swaziland	–	–	n=0
Tanzania	Kaoneka & Solberg 1997: Lukozi village in Lushoto District, 1991	Mwalyosi 1992: SW-Masailand, Arusha Region, 1957–1987	n=2
Zambia	Petit et al. 2001: Lusitu region, 1956–1999	–	n=1
Zimbabwe	Chipika & Kowero 2000: communal areas, 1980–1995	Tafangenyasha & Campbell 1998: Hwange National Park, 1952–1983	n=2
No. of cases	N=5	N=7	N=12

studies were taken from journals included in the 1992–2001 citation index of the Institute for Scientific Information (ISI). It was assumed that, due to the strict peer review applied in these journals, each study revealed the actual causes of land change in the study area. Therefore, the comparative analysis of case studies evaluates which causal patterns leading to land change are most often found in different parts of Southern Africa – see Table 1.

#### 4 Deforestation and woodland degradation

##### 4.1 Simplification

The major simplification or misconception on forest and woodland cover losses is that high rates of deforestation or degradation are most commonly linked to population growth and poverty, and shifting cultivation in large tracts of forests (e.g. JANZEN 1988, LEWIS a. BERRY 1988). The ‘fuelwood crisis’ is a typically Southern African variant of this: burgeoning human populations cause fuelwood demand to exceed supplies (e.g. ECKHOLM et al. 1984, MILLINGTON et al. 1989, ABALU 1998, HUDAK a. WESSMAN 2000). However, while not denying a role of demography or poverty, the con-

ventional wisdom is increasingly being challenged (LEACH a. MEARNES 1996, LAMBIN et al. 2001), and most case studies fail to confirm this simplification in lieu of other, more important, if complex forces (e.g. HALL a. RODGERS 1986, GRUNDY et al. 1993, GRUNDY 1995, DEWEES 1995; 1996, ABBOT a. HOMEWOOD 1999). Also, results of careful surveys of economic models of tropical deforestation support the view that population growth is never the sole and often not the major underlying cause of forest cover change (ANGELSEN a. KAIMOWITZ 1999). Likewise, structured case study comparisons of proximate and underlying sources of change reveal that population impact (mainly in-migration) is just one of several underlying forces, working in a synergetic combination with a recurrent set of mainly economic and institutional or policy factors that produce typical patterns of proximate causation which vary by locations (GEIST a. LAMBIN 2002). Where deforestation is linked to the increased presence of shifting cultivators, triggering mechanisms invariably involve changes in frontier development and policies by national governments that pull and push migrants into sparsely occupied areas. In some cases, these ‘shifted’ agriculturalists (BRYANT a. BAILEY 1997) exacerbate deforestation because of unfamiliarity with their new environment; in other cases, they may bring new skills and understandings that have the opposite impact. The critical point, however, is that deforestation is driven largely by changing economic opportunities which are

<sup>5)</sup> For a more detailed conceptual framework, see GEIST and LAMBIN 2001 and 2002.

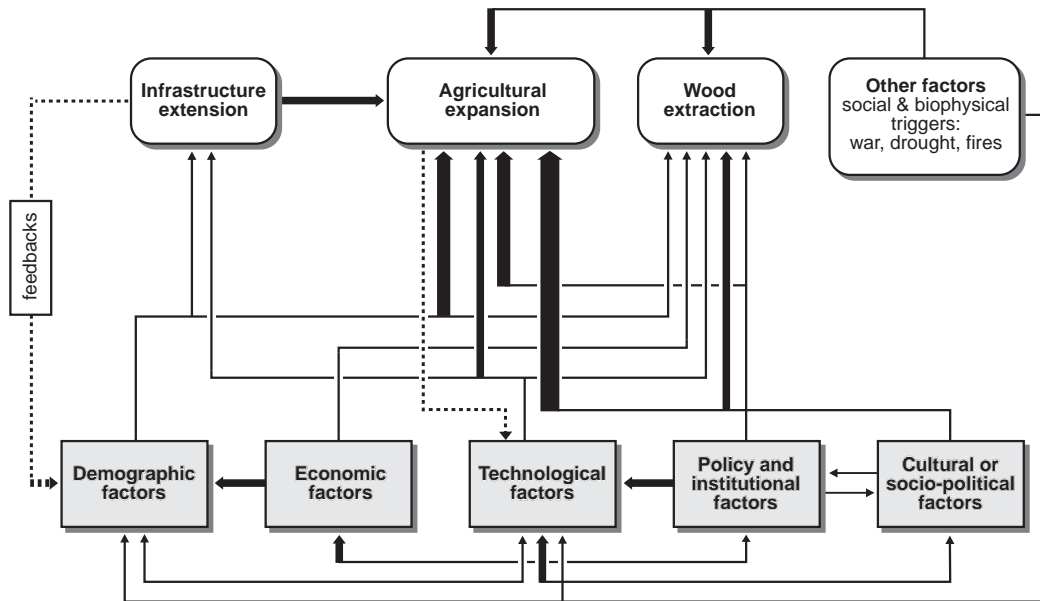


Fig. 2: A systemic view upon the causative pattern of deforestation and woodland degradation in Southern Africa (n = 5 case studies)

Source: Own data generation from KALIPENI a. FEDER (2001), HIGGINS et al. (1999), KAONEKA a. SOLBERG (1997), PETTIT et al. (2001), CHIPIKA a. KOWERO (2000)

Eine systemische Sicht des Verursachungsmusters von Entwaldung und Walddegradierung im Südlichen Afrika (n = 5 Fallstudien)

linked to yet other social, political, and infrastructural changes (LAMBIN et al. 2001, 263).

#### 4.2 The not-so-simple pathways

Large-scale deforestation in a region which is predominantly characterised by the world's largest dry forest and woodland zone (miombo ecosystem) is predicated on the existence of large, sparsely occupied forest regions in which the indigenous inhabitants have little or no power to influence the exogenous forces acting upon them and the land (LAMBIN et al. 2001, 262–263). In-migration is triggered by government decisions to open the frontier through settlement schemes, development projects, and plantations, or through extractive industries, basically timber, with the spin-off consequences of 'spontaneous' colonization. In either case, infrastructure development follows in the form of roads, electrification, health services and/or potable water, which attracts landless families, and consolidates occupation. The deeper reasons for the government decisions include the desire to secure territorial claims and national political support, to attract international capital, to facilitate market opportunities, or to advance

special, self-legitimizing interests through exploiting natural resources controlled by the state (or ruling party). These motivations, the relative role of settlement-project development and timber extraction, and the subsequent impacts on land use and cover vary (globally and) within the region (LAMBIN et al. 2001, 262–263).

A comparison of cases drawn from five countries in the region – see Table 1 – provides a systemic view upon the main proximate causes and underlying driving forces – see Figure 2. Clearly, the interplay of social forces, mainly socio-political or cultural, policy or institutional, and demographic factors driving agricultural expansion and wood extraction, dominate the process of deforestation and woodland degradation. The process, however, is not a simply straightforward one since other factors – mainly, social and biophysical triggers such as civil wars, droughts and forest fires – are involved, and (amplifying) feedbacks exist from the proximate upon the underlying level. The relatively low impact of the 'road-agriculture tandem' makes the Southern African cases different from other regional cases (e.g. Amazonia) where this two-factor chain-logical connection operates in a more distinct manner

(GEIST a. LAMBIN 2002). Among demographic factors, for example, population increases due to natural increment and in-migration are well balanced, and always interrelated with underlying and other factors. Feedbacks exist from the proximate level upon the underlying demographic dynamics (i.e. 'road-migration tandem'). Remarkably, social and biophysical triggers exert impact even upon (or shape) underlying driving forces.

## 5 Land degradation, 'desertification', and rangeland modification

### 5.1 Simplifications

There are two general major simplifications on land degradation, desertification and rangeland modification (LAMBIN et al. 2001, 263–4):

– The first myth is that rangelands are 'natural' 'climax' vegetation, with the misconception that they are natural entities which, in the absence of human impact, would persist unchanging within climate epochs. Indeed, some rangelands are largely edaphically or climatically determined, but, more generally, large areas have been created and are maintained by the interaction of human and biophysical drivers. Human activities are therefore a common and functional part of these 'semi-natural' ecosystems, and reducing or eliminating human use will trigger significant changes (e.g. THOMAS a. SPORTON 1997, BEHNKE 1999, SCOONES 1999). Southern African rangelands usually are both highly dynamic and also resilient (COWLING et al. 1997, DOUGILL et al. 1998, SNYMAN 1998) – even to high stocking densities (WARD et al. 1998) –, moving through multiple vegetation states, either as successional sequences or by shifting chaotically in response to random human and biophysical drivers (DAHLBERG 2000).

– The second, widespread and related simplification is that rangelands have relatively constant carrying capacities derived from their natural agro-ecological potential and that stocking strategies exceeding these capacities will cause land 'degradation' and, even 'desertification'. Numerous studies aim at describing and measuring that the expansion of pastoral agriculture with livestock on these 'native' lands has had deleterious impacts (e.g. SKARPE 1990, LE HOUÉROU 1994, HUDAK 1999), that increases in human and domestic livestock populations are the main human causes driving land towards desertification (e.g. DEAN a. MACDONALD 1994, DEAN et al. 1995), reducing wildlife

habitats and increasing grazing pressure (e.g. VERLINDEN 1997), and that, in more general terms, land cover conversion is straightforwardly related to land degradation (e.g. BARBIER 1999, DUBE a. PICKUP 2001).

However, the point has to be made that the intrinsic variability of rangeland ecology makes it difficult to distinguish (uni)directional change – such as losses of biological diversity and soil degradation – from readily reversible fluctuations. Rangelands are increasingly seen as non-equilibrium ecosystems. On the one hand, in arid or semi-arid zones the modification in the biological productivity of rangelands at the annual to decadal time scales is mainly governed by biophysical drivers such as interannual rainfall variability and ENSO (El Niño Southern Oscillation) events, with stocking rates having less long-term effect on productive potential. While, on the other hand, less arid systems are increasingly seen as governed by a combination of human and biophysical drivers, and may be more prone to being developed through cover conversion and agricultural intensification (e.g. TAPSON 1993, BEHNKE a. SCOONES 1993, SCOONES 1995, KIPURI 1995, SULLIVAN 1996; 1999, ROHDE 1997, BEHNKE 1999, DOUGILL et al. 1999, SCOONES 1999).

### 5.2 Multiple pathways

Throughout Southern Africa, state policies are framed under the assumption that pastoralists overstock rangelands, leading to degradation and 'desertification' (e.g. ELLIS a. SWIFT 1988, ARCHER et al. 1989, SHACKLETON 1993, WERNER 1994, SCOONES 1995). The resulting management strategies aim to control, modify, and even obliterate traditional patterns of pastoralism, including the development of watering points or long-term exclusion of grazing (and cultivation) – see, for example, TAFANGENYASHA a. CAMPBELL (1995), HOMEWOOD a. BROCKINGTON (1999), WARD et al. (2000). Two common pathways follow:

– Weakened indigenous pastoral systems undermine local economies and resource institutions or precipitate urban migration with rural remittances, either of which may lead to land alienation and conversion, with concentration in the remaining areas, local overstocking and degradation (e.g. QUINLAN 1995, WARD et al. 2000).

– Alternatively, exclusion and reduced grazing lead to a 'loss' of species diversity, a change in vegetation cover, and 'reduced' plant production (e.g. TAFANGENYASHA a. CAMPBELL 1998).

In wetter rangelands, reduced burning leads to increasing woodlands. Evidence indicates that grazing, rather than being inherently destructive, is necessary

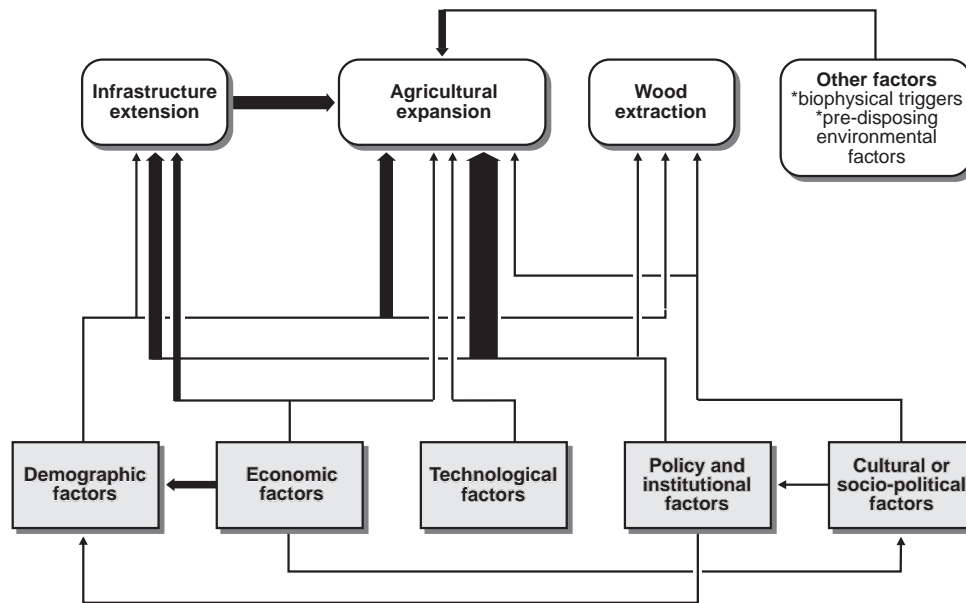


Fig. 3: A systemic view upon the causative pattern of land degradation, desertification and rangeland modification in Southern Africa (n = 7 case studies)

Source: Own data generation from RINGROSE et al. (1996), QUINLAN (1995), BARBIER (2000), WARD et al. (2000), PALMER a. ROOYEN (1998), MWALYOSI (1992), TAFANGENYASHA a. CAMPBELL (1998)

Eine systemische Sicht des Verursachungsmusters von Landdegradierung, Desertifikation und Weidelandwandel im Südlichen Afrika (n = 7 Fallstudien)

for the maintenance of tropical rangelands in arid zones of sub-Saharan Africa (OBA; STENSETH a. LUSIGI 2000).

A comparison of cases drawn from seven countries in the region – see Table 1 – reveals that the most important indicators of land degradation, both perceived by local managers and measured empirically, are sheet and/or gully erosion, increased bare ground (eroded, sand) cover, encroachment of woody (weed) species and/or short-grass vegetation, declining water quantity, and – translated into economic terms – reduced livestock or human carrying capacity. Figure 3 provides a systemic view upon the main proximate causes and underlying driving forces. Clearly, social forces dominate the process of degradation, whereas biophysical forces such as climatic events or pre-disposing environmental factors are mentioned significantly less. The interplay between social and biophysical forces is characterised, for example, by hill-side location and erosive rock sediments shaping a fast process of degradation, while droughts, occurring within natural oscillations, constitute a limiting factor for agricultural expansion (but do not actually drive the process). At the proximate level, infrastructure extension (cattle posts, boreholes, etc.) and agricultural expansion (livestock, croplands),

and their interplay, are more important than wood extraction. At the underlying level, policy and institutional factors (mainly land redistribution or zoning policies leading to land pressure, scarcity and, consequently, to overstocking) are associated with all degradation cases, while demographic factors (mainly in-migration) drive considerably fewer cases and are interlinked with other underlying (economic, political) factors.

### 6 Moving towards complexity

There is a high variability in biophysical environments, socio-economic activities and cultural contexts which are associated with land change. Identifying the causes of land use change requires an understanding of how these different factors interact in specific environmental, historical and social contexts to produce different uses of the land (LAMBIN a. GEIST 2002).

One should first distinguish between proximate causes and underlying driving forces of land use change. Proximate causes constitute (near-)final human activities or immediate actions that originate from intended land use and directly impact upon land cover. Differing

from structural, systemic or initial conditions, they are the more immediate, direct factors which originate from land use and directly impact upon land cover. Ultimate, underlying driving forces are fundamental forces that underpin the more proximate causes of land cover change. They are formed by a complex of social, political, economic, demographic, technological, and cultural variables that constitute initial conditions in the human-environmental relations that are structural (or systemic) in nature. The interplay between underlying and proximate causes may be shaped or modified by a number of mediating factors (e.g. gender, access to resources, wealth status or ethnical affiliation). Actually, the risk of specific adverse outcomes for a household, a community or an ecosystem in the face of a variety of stresses varies according to its vulnerability. This depends on the exposure of the unit of concern – the degree to which a human group comes into contact with particular stresses; its sensitivity – the degree to which an exposure unit is affected by exposure to any set of stresses; and its resilience – the ability of the exposure unit to resist or recover from the damage associated with the convergence of multiple stresses.

The nature of driving forces of land use change may be biophysical, socio-economic or cultural. These can be slow variables, with long turnover times, which determine the boundaries of sustainability and collectively govern the land use trajectory – such as the spread of salinity in irrigation schemes, or declining infant mortality, or fast variables, with short turnover times – such as food aid, climatic variability associated with El Niño oscillation. Disparities in turnover times make ecological legacies possible, and the effects of human land use persisting long after the activity has ceased is just one example. Land use change is also controlled by pre-disposing environmental factors or initial conditions (land characteristics or features of the biophysical environment which are difficult to manipulate), and biophysical or social trigger events (e.g. a drought, war or sudden policy change). The latter are fast variables which work as catalytic forces leading to sudden and abrupt changes in the human-environment condition. They have properties of switch and choke points in the system dynamics, i.e. points at which sudden, abrupt and irreversible shifts from one land use into another occur. Driving forces may also push the system beyond thresholds, which results in fundamental changes in system behaviour. Another important system property associated with changes in land use are feedbacks which can either accentuate or amplify speed, intensity or mode of land change, or constitute human mitigating forces, e.g. via institutional actions that dampen, impede or counteract factors or their im-

pacts. Examples are the direct regulation of access to land resources, market adjustments or informal social regulations (e.g. shared norms and values that give rise to shared land management practices).

Proximate causes generally operate at the local level (individual farms, households or communities). By contrast, underlying drivers may also originate from the regional (districts, provinces or country) or even global levels. In the latter case, they are uncontrollable by local communities and thus can be considered to be exogenous to these communities. Different factors driving land use change can intervene in concomitant occurrence – i.e. independent, separate operation of individual factors leading to land change, – or can be connected as causal chains – i.e. interconnected in a way that one, or several, variables (underlying factors, mainly) drive one, or several other variables (proximate factors, mainly). They also often intervene in synergetic factor combinations – i.e. several mutually interacting variables driving land use change.

## 7 Conclusions

The selective comparison of cases of land change in Southern Africa confirms that there is a recurrent set of underlying demographic, economic, technological, institutional, policy, and cultural or socio-political driving forces. These forces produce, at the proximate level, a limited set of direct outcomes such as cropland and livestock expansion, infrastructure extension and wood extraction which bear immediate consequences for land cover conversion and modification. Most strikingly, these causative variables operate in a synergetic manner, and the patterns of land change are found to bear striking similarities, with the deforestation pattern being more complex though, i.e. including feedbacks and more triggers than the degradation pattern. It could be argued that available case study evidence highlights a complex, but easily to be generalised relationship between human population dynamics and land change:

– On the one hand, evidence supports the conclusion that, at the time scales of a few decades, simple answers found in population growth and poverty rarely provide an adequate understanding of land change. Rather, individual and societal responses follow from changing economic conditions, mediated by institutional and policy factors. Opportunities and market constraints for new land use are created by markets and policies, increasingly influenced by global factors and producing specific global/local interplays (LAMBIN a. GEIST 2002). Extreme biophysical events occasionally



trigger – but do not drive – further changes. Various human-environment conditions react to and reshape the impacts of drivers differently, leading to specific pathways of land change. By large, results confirm the qualitative assessment of general pathways and cause-connections of land change (LAMBIN et al. 2001).

– On the other hand, insights from studies at longer time scales show both increases and decreases of a given population always had and still have tremendous impacts upon land cover changes. Therefore, a more nuanced population analysis is required, by less consideration of, for example, sheer increases in population size or related growth rates, but more so specific, especially migration-related demographic variables and life cycle features. It is obvious that human population dynamics prevails in the form of in-migration (rather than natural increment) and has to be seen as interlinked with next to all other underlying forces – driven, too, by feedbacks from the proximate level (i.e. infrastructure or road extension triggering increased in-migration).

Though the proximate/ultimate divide proves to be a useful tool to better conceptualize the understanding of causes and driving forces in Southern Africa, the impact of other factors such as triggers and feedbacks deserves to be better considered in more detail. There seems indication that these factors impact more in forest-related conversion and modification processes than in the degradation or modification of agricultural land. Concerning shifts between savanna ecosystems and human land-uses, thresholds and resilience limits to what ecologists like to call ‘disturbance’ will have to be considered, too. Indicative evidence exists that Southern African ecosystems can be pushed beyond some limits into new states by intense or novel uses (e.g. TAFANGENYASHA a. CAMPBELL 1998, HIGGINS et al. 1999), and that wildlife constitutes a potential factor of land change there (GROSSMAN a. GANDER 1989).

With respect to time scales, varying turnover rates of causative variables should be better taken into account. There is indicative empirical evidence that a discrepancy exists between slow variables (e.g. land zoning originating from the colonial past) and fast variables (such as development projects or resettlements). This should probably be best dealt with as ‘colonial legacy’ explaining a considerable part of land uses, cover conversions and related land change problematics in the region (DEININGER a. BINSWANGER 1995).

The impact of highly erosive European settler crops upon deforestation and land degradation – such as tobacco<sup>6)</sup> – is found to be considerable (e.g. KALIPENI a. FEDER 1999, BARBIER 2000, HUDAK a. WESSMAN 2000). As HEILIG (1994) pointed out, Western life-style crops have gained an increasingly global demand, and

actually constitute what he called the neglected human dimensions of land use change.

Finally, to move from a small exercise like this to a broader comparative effort, one has to deal with the lack of empirically investigated cases in countries such as Angola and Mozambique.

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<sup>6)</sup> For the tobacco economy as an important driver of land change in Southern Africa, see – besides the cases cited here – BOESEN a. MOHELE (1979), FRENCH (1986), FRASER (1986), MISANA (1988), BOOTH a. CLARKE (1994), TOBIN a. KNAUSENBERGER (1998), GEIST (1998a-c, 1999b-c, 2000), and SAMIMI (2000).

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