

THE GLOBAL LAND PROJECT INTERNATIONAL PROJECT OFFICE

GLP REPORT

GLP – A JOINT RESEARCH AGENDA OF IGBP & IHDP

NO. 2, 2011



Toolbox options for conceptualizing change in human-environmental systems



Pathways, path dependency,
legacies, syndromes and scenarios

© GLP International Project Office and author 2011

GLP Reports publish land system relevant material from the GLP community

GLP – The Global Land Project - is a joint research project for land systems of the International Geosphere-Biosphere Programme (IGBP) and the International Human Dimensions Programme (IHDP).

Published by:

GLP International Project Office,
University of Copenhagen
Department of Geography and Geology
Oster Voldgade 10
DK-1350 Copenhagen K
Denmark
www.globallandproject.org

Refer to this publication as:

Reenberg, Anette (2011). Toolbox options for conceptualizing change in human-environmental systems - Pathways, path dependency, legacies, syndromes and scenarios. GLP Report No. 2. GLP-IPO, Copenhagen.

ISSN 1904-5069

Toolbox options for conceptualizing change in human-environmental systems

Pathways, path dependency, legacies, syndromes and
scenarios

Anette Reenberg

GLP Report No. 2



Contents

Preface	1
1. An introductory narrative: Understanding the complexities of change in the Sahel	2
2. Investigating trends and directions of change	4
3. Path dependency: inspiration from economic, complexity and political science	5
4. Pathways of change: a range of different meanings	7
5. The notion of legacies	11
6. Syndromes: a generic presentation of change processes	11
7. Scenarios – looking forward	14
8. Future challenges	15
References	18

Preface

This brief report has been inspired by two different spheres of research in which I have recently been involved.

One belongs to the land change community, which is still struggling with a number of 'grand challenges' related to an appropriate conceptualization of the change processes of land systems. This theme was apparent in, for example, many of the sessions of the recent Open Science Meeting for GLP at Arizona State University. It has emerged in various contexts that the history experienced by land systems may shape future pathways of change, causing a reconfiguration of land systems and adaptive capacities, a process that has been labelled 'historicity' or 'path dependency'.

The other source of inspiration is rooted in the interdisciplinary research activities conducted under the auspices of the EU/ERC funded WATERWORLDS project, which focuses on scrutinizing the risks related to climate change and how people deal with such uncertainty through change and adaptation processes.

In both these contexts, it has repeatedly become clear that the conceptualization of change processes remains a huge challenge for researchers who are dealing with global environmental change issues and human-environmental interaction.

Together, these experiences have convinced me that it is worthwhile to share the present, albeit preliminary, reflections on where the 'human-environmental' science community may seek inspiration from other disciplinary areas for analytical and conceptual approaches that may help us get to grips with the complicated issues of 'change processes' and 'change of change'.

1. An introductory narrative: Understanding the complexities of change in the Sahel

Although this report aims solely at providing some general reflections about possible theoretical mindsets that may provide useful inspiration for land systems science in order to improve the conceptualization of change, I will begin with a brief description of my empirical platform and the analytical challenges that inspired me to seek conceptual inspiration from other fields. The Sahelian livelihood systems serve well to illustrate the value and importance of employing a coupled human-environment system perspective and of focusing on change processes, with possible non-linear dynamics, feedback loops, time lags and legacy effects on present conditions and future possibilities (Liu et al. 2007). The African drylands are home to several hundred million people. The livelihood conditions of these regions are spatially heterogeneous, enabled and constrained not only by the scarce rainfall but also by, for example, a variety of soil types and huge differences in market accessibility. They share, however, a pronounced and unpredictable spatial and temporal variability in rainfall, which creates a risky decision environment for households' land use strategies. This is reflected in an impressive flexibility, adaptability and dynamism in the human-environmental systems that have constituted the foundation for the local livelihoods for centuries. Seen in a long-term historical perspective, significant climate variability is a key issue (Brooks 2004). If we look back to 10000 BP, the climatic situation in the Sahel was characterized by an intensified monsoon situation and the landscape was dominated by lakes and open woodland. By 5000 BP a final collapse of the monsoon was experienced after periods of abrupt arid crises and at this point in time, cattle herders migrated to the Sahel. Pastoral land use by nomadic cultures that were well suited to adapt to the spatially and temporally erratic resource base has played a prominent role in the drier parts of the Sahel. In 1950-60s, the Sahel experienced an unusually high rainfall, coincidentally with independence of the nation states in the region. This co-development of the societal and environmental events created a great incentive to expand cultivation into marginal land, and has, in turn, led to profound implications for the vulnerability of this land use system at the margin of the desert.

A general portrait of the contemporary agro-ecological systems in the region is provided in Figure 1. Generally speaking, population increase in the Sahel has led to the expansion, intensification, and often closer integration of crops and to strong linkages between the dryland communities and the more humid or urbanized regions. Innovation and experimentation characterize the economic activities of dryland people, both in the use of natural resources and in the exploitation of livelihood opportunities. Hence, local people's insight and past experience are significant resources when management strategies for the risky environments are determined.

Rainfall yearly	Agroecology Zone	Pastoral activities	Agriculture Main crops
<100 mm	Sahara	Nomadism	No cultivation
200-600 mm	Sahel	Transhumance	Sorghum Peanuts Millet Cowpeas
> 600 mm	Soudano-Sahel	Sedentary	

Figure 1. Rough schematic overview of the agro-ecological zones and land use activities in the West African Soudano-Sahelian region.

Flexibility and mobility have been key to survival strategies, and wise coping and adaptation strategies will be crucial to ensure sustainable livelihoods for the future. On this background, it is of significant interest to describe and analyse the change processes over time in the dryland systems¹. Recognizing that most regional-scale human-environmental systems have a number of potential regime shifts, in different domains (ecological, social, and economic) and at different scales, it is specifically interesting to understand the temporal evolution of the resource management strategies. Furthermore, it is crucial to capture the fact that short-term coping mechanisms might be displayed at the household and individual scales, whereas long-term adaptive strategies, such as change in cultural values, may be expressed at broader scales.

Local and regional studies of human resource management strategies in the Sahel show considerable resourcefulness in the face of external change. Social and economic systems have been dynamic enough to allow farmers to adapt flexibly to climate variability change.

¹ Dryland systems are advantageously considered to be 'the co-evolved product of complex interactions between biophysical (e.g., climate, soil, biota) and human (e.g., demographic, economic, institutional) subsystems, complete with a history and geography, and are constantly changing in response to both external (e.g., climate, prices) and internal (e.g., feedbacks between soil nutrients and plant growth, a farmer's economic decisions regarding land use) drivers' (Reynolds et al. 2007:847-851).

The study of change directions in coupled human-environment systems can be viewed as a purely intellectual activity intended to cast light on the intricacies of nonlinear dynamics, cross-scale interactions, and complex adaptive systems (Redman and Kinzig 2003). It can, however, also have a more practical purpose by way of assessing the sustainability, adaptive capacity, and functioning of the prevailing human-environmental systems. One aspect of improving our ability to flexibly manage for desirable future development lies in understanding the long-term dynamics of the system. This includes insight into critical time lags in perception, decision and response as well as mismatches in monitoring scale and response scale. Insight into longer term dynamics of the human-environment system and human response to changing conditions can make it possible to identify the key signals humans choose to respond to and what determines the range of response options that actors have at their disposal.

2. Investigating trends and directions of change

There is no single optimal analytical approach readily available to scrutinize in an integrative fashion the causes and trajectories of change of resource management in land systems. As Dearing et al. (2010) have suggested, a long-term perspective diminishes the risk of imposing a priori limits on the total number of change steps that we consider analysing, and hence, avoids biasing the knowledge towards perturbations observed in the recent past. The epistemological basis for learning from the past, especially with regard to an 'analogue approach', deserves special attention. Analogues might prove problematic for systematic assessment of current conditions, not least because boundary conditions change especially with regard to the socio-economic-cultural conditions. On the other hand, heuristic analogues might offer useful insight into differences between cases, and in this respect be a useful means to sensitize communities and policymakers to possible future surprises and response options. In the context of global environmental change, recent literature has stressed the prominence of the acceleration of change processes as well as the presence of non-analogue situations. This raises pertinent questions as regards feedback mechanisms in human-environmental systems and their dynamics that must be addressed in order to guide future management. Long time scales are crucial to inform such answers. One important dimension to explore is change trends, including understanding the processes of change and taking into account how macro structural variables affect micro agency with respect to resource management strategies. In addition, the embedded implications of past decisions for current and future options are important to consider. This leads us to the general notions of pathways, path dependencies, legacies, syndromes and scenarios, which may serve as inspiration and a step in the direction of further conceptual development.

In the following, the mindsets related to these concepts that are emerging in various disciplines will be briefly presented. The ambition is to provide inspiration for how these different mindsets might contribute to a productive framework for human-environment systems that:

- Describes the development process
- Contains a suitable selection of temporal and spatial reach and analytical resolution
- Suggests a typology of causes of change
- Offers a platform for ways of predicting the expected futures

In other words, we will look for conceptual inspiration to cover the gaps identified in the GLP science plan (2005:6): *“...there are relatively few methods for learning from the past, and most of them depend on assuming that there will be no change in the underlying processes. If models are based on static assumptions about cause and effect, projections will be based on the risky assertion that explaining the present from our knowledge of the past is the same as projecting the future based on our knowledge of the present. In fact, many system dynamics that were not active or interacting previously now are, resulting in major changes in these second order dynamics – the ways in which the process of change itself is changing”*. And *“Decisions made in the past constitute the initial conditions for our present-day landscapes. That is, past land system practices may ‘lock out’ future options, constraining the pathways that can be taken.”* (ibid:39) .. *“including the chances for return to former structure and function.”* (ibid:39).

3. Path dependency: inspiration from economic, complexity and political science

Path dependence is one term among others that has been brought into common use in both economics and law in order to assert that ‘history matters’. The economic concept of path dependency looks in principle at how the set of decisions one currently faces is limited by decisions made in the past, even though the latter may no longer be relevant.

The idea of path dependence came to economics from chaos theory, which offered the idea of non-linear models sensitive to small events or perturbations, which tend to cause a system to evolve in very different ways. The system never settles down in any repeatable path and never finds equilibrium². Path dependence in economics has adopted the view that minor initial perturbations are important, but suggests a theory of a finite number of perfectly stable alternative states that arise from the particular initial conditions. The continuous state of ‘disequilibrium’ suggested by chaos theory is thus missing from the economic version of path dependence.

² These ideas resonate to some extent with the theoretical discussions on non-linearity and the dynamics and evolution of human-environmental systems introduced in the theoretical reflection in geography by Zimmerer, based in similar lines of thought carried over from systems ecology (Zimmerer 1994).

The economic literature uses several very different notions of path dependence, which have vastly different implications. One, the *first degree path dependence* (Margolis and Liebowitz 2000), is a minimal form of path dependence, which is present if there is an element of persistence or durability in a decision, i.e. if the current situation critically depends on conditions that prevailed and decisions that were taken at some time in the past, but the decision taken can still be considered as rational. *Second degree path dependency* describes a situation where *ex ante* efficient decisions may not turn out to be efficient in retrospect. The inferiority of a chosen path is unknowable at the time a choice is made, but it is later apparent that some alternative path would have yielded greater wealth. In such a situation, the dependence on past conditions causes outcomes that are regrettable.

Hence, first-degree path dependence is a simple assertion of an inter-temporal relationship, with no implied error of prediction or claim of inefficiency, while second-degree path dependence stipulates that inter-temporal effects, together with imperfect prediction, result in actions that are regrettable. The notion of *third-degree path dependence* is used to describe the situation where the inter-temporal effects propagate error that was avoidable from the outset.

Page (2006), who in disciplinary terms belongs to the field of complex systems, political science, and economics, suggests in his essay on path dependence another set of basic definitions of various types of path dependence. He stresses that a formal model is more than a tool for empirical testing of a framework of causality; in fact, an important reason for constructing a framework for 'modelling' historical forces is that formal models can assist to discipline thicker, descriptive accounts (Gaddis 2002). Boiling down causal relations to spare fundamentals may 'assist us to identify conditions that are necessary and/or sufficient for past choices or outcomes to influence the present' (Page 2006:87).

Page (2006) notes that path dependence is almost a metaphorical concept. It is commonly used in the sense that current and future states, actions and decisions depend on the path of previous states, actions and decisions. But it has more recently also become a looser synonym for the idea of 'history matters'.

In identifying causes of path dependence, Page (2006) suggests four different, yet interrelated factors. The first is increasing returns, which implies that the more the action is taken, the larger the benefit will be. The second is self-reinforcement, which means that the action leads to a new set of forces that further encourage the sustaining of the action. The third is positive feedbacks, which means that the action creates positive externalities when the same choice is made by others. The fourth is lock-in; it describes the situation where a choice becomes better than any other because a sufficient number of people have already made this choice.

In order to create a logical structure of the possible sway of history, Page suggests a differentiation between several forms of history dependence:

- Path dependence – where the path of the previous outcome is important
- State dependence – where a finite number of states along the time path contain all relevant information
- Phat dependence – where events in the path are important, but their order is not

He also distinguishes between types of path dependences:

- Between early and recent path dependence
- Between processes in which outcomes are history dependent and processes in which equilibrium depends on history

He basically suggests a differentiation between two types of path dependence and two important ways that history can matter. History can have an influence by determining the outcome at a given point in time; this type of dependence is labelled outcome dependence. History can also matter by limiting the distribution of outcomes. This is called equilibrium-dependence³ and it implies that the long run distribution of outcomes depends on past outcomes. It is noted that equilibrium dependence implies outcome dependence. If history determines the equilibrium distribution of outcomes, then it must also determine the outcome in individual time periods.

In political science, models of path dependence based on increasing returns have played an important role in the analysis of institutional continuity and change (Boas 2007), but they have also been criticized for their inability to accommodate change. They acknowledge the important role of the concept of path dependency as a way of systemizing arguments about historical causation and moving the discussion beyond 'history matters'. More recent reflections, however, argue that the prevailing models of path dependence overstate the degree of stability in political institutions. They distance themselves from the path dependence notions of increasing returns and lock-in and focus on new mechanisms of institutional change, including layering and conversion, which they consider different from the increasing returns to scale that are included in traditional model of path dependence.

4. Pathways of change: a range of different meanings

The concept of pathways is used with very different meanings in different research disciplines. Scholars dealing with, for example, ethno botany and the ecology of indigenous knowledge (Cajate 1994; Fredericks 2007) use the concept of pathway as a structural metaphor to describe a transformation that

³ The notion of equilibrium is used by Page in the sense of convergence of the long run distribution of outcomes.

unfolds through time and space. It is considered useful to capture the fact that in travelling along a pathway, we make stops, encounter and overcome obstacles, recognize and interpret signs, and seek answers. Path denotes a structure; way implies a process (Cajate1994:55).

The anthropologists Bruijn et al. (2005) also deal extensively with the concept of 'pathways'. They see the concept as referring to the strategies arising out of the decisions taken by individual actors, households and groups of people, and they distinguish between a pathway and a strategy. While a strategy has the connotation of aiming at pre-set, rational goals, a pathway, by contrast, refers to an iterative process in which the goals, preferences, resources and means that the decision maker is facing are assessed in an iterative fashion (Figure 2 and Figure 3).

Different actors might act differently when confronted with the same set of conditions because they have experienced different conditions over time, and their knowledge, experiences and understanding of their environment vary accordingly.⁴

Actors are seen as employing a range of 'rules of the game' to guide their decisions, and these rules are said to be part of the actors' habitus. By making

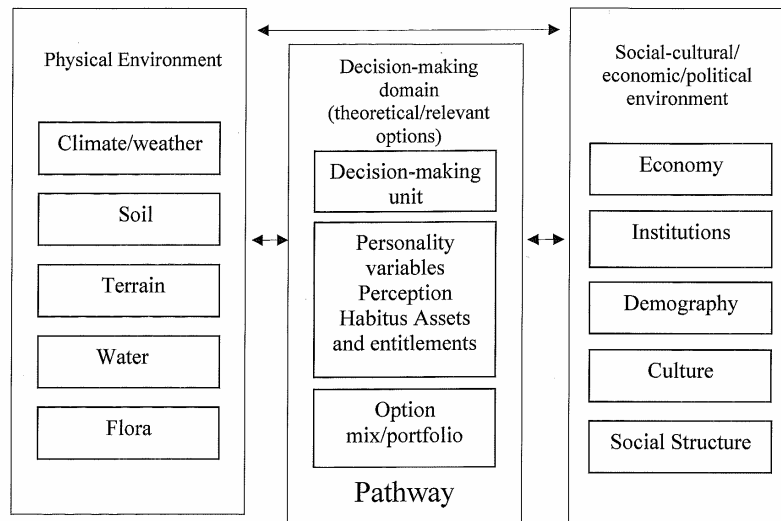


Figure 2. The decision-making unit in relation to the physical and institutional environment. Source: Bruijn et al. (2005:10)

⁴ In a Sahelian context, for example, people who have recently encountered a serious drought are likely to respond differently to a good year than people who have just experienced a number of good years. Likewise, there might be ethnic, gender or generation specific responses because of diverse experience or culturally embedded sensitivity to past events.

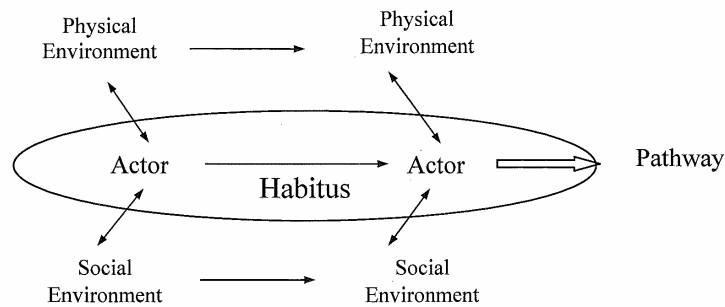


Figure 3. Evolution of the pathway through time. Source: Bruijn et al. (2005:10).

decisions, actors create certain pathways and close off others. Each decision, in turn, is seen to have implications for subsequent options⁵. Hence, the interaction between habitus and pathway can be described as a twin pair of form (pathway) and meaning (habitus).

Bruijn et al. (2005) commence the path analysis at the level of the individual, which, for example, allows a differentiation between male and female pathways and systematic differences across generations. They do, however, stress that some of the opportunities and constraints on decision makers are imposed by other actors as well as higher level institutions. Hence, the decision environment is pre-structured, for example, because land has already been allocated for specific purposes, rules have been formulated for the reallocation of assets, people have committed to collective arrangements, or because knowledge and cultural frames influence the understanding of the conditions and the assessment of the consequences of specific decisions.

In summary, Bruijn et al. (2005) see a number of underlying assumptions for the concept of pathways:

- the environment of decision-makers is inherently unstable;
- decision-makers proceed on a step-by-step basis in a high-risk environment and decision-making is an iterative process with the resulting pathway not necessarily having an intrinsically planned or rational character or following a logical order;
- past decisions have to be taken into account because they have constituted the pathways and the condition of the decision-maker and his/her mental attitude in the present;
- decisions are made within a specific context by decision-makers with a specific history, and variations in decisions need not be based on synchronic attributes (such as resource endowments) but can also arise from life history; and
- decision-makers coordinate their decisions explicitly and implicitly.

⁵ In this way the lines of thought presented share the mindset of the path dependency conceptualization presented earlier.

The recently emerged discipline of land change science (or land system science) (Turner et al. 2007) has likewise proposed a notion of pathways to characterize land change by identifying what they label *dominant pathways or trajectories* (Lambin and Geist 2006). One important aim is to illuminate associated risk factors for each trajectory of change processes in the coupled-human environmental system that constitutes the human management of terrestrial land resources. More specifically, they propose to scrutinize the array of causes of land changes (distinguished into fast and slow variables) and they postulate/hypothesize that there are ‘a number of generalizable patterns of change that result from recurrent interaction between driving forces, following specific sequences of events. Even though, at the detailed level, these sequences may play out differently in specific situations, their identification might confer some predictive power by analogy with similar pathways in comparable regional and historical contexts’ (Lambin and Geist 2006:67). It is noted (Lambin and Geist 2006:69) that the understanding of land change processes has evolved to include a more comprehensive understanding of situation specific interaction between a range of factors at different spatial and temporal levels of scale.

	Resource scarcity causing pressure of production on resources	Changing opportunities created by markets	Outside policy intervention	Loss of adaptive capacity and increased vulnerability	Changes in social organization, in resource access, and in attitudes
Slow	Population growth Domestic life cycles Land degradation Surplus extraction	Increase in commercialization Road construction Change in market prices Off-farm wages	Development projects Perverse subsidies Poor governance Insecure land tenure	Impoverishment Breakdown of informal networks Social discrimination	Land tenure changes Breakdown of extended families Poor information on environment issues
Fast	Spontaneous migration Encroachment by new land users (grab)	Capital investment Change in economic conditions Intensification by new technology	Rapid policy changes (e.g. devaluation) War	Internal conflicts Illness (HIV) Natural hazards	Loss of entitlement to natural resources (leads to marginalization of the poor)

Table 1. A suggested typology of causes of land change. Simplified after Lambin and Geist (2006:66).

Lambin and Geist (2006) point to the fact that a theory that integrates insight into the causes of pathways of land change with a process oriented understanding of how macro-structural variables affect micro-agency with respect to land is still lacking. The concept of land use transitions is suggested to provide a first step in this direction, yet the issue of spatial scale remains a huge challenge. Explanations of processes vary importantly by the spatial scale at which they are studied, and the spatial reach of land transformation driven by human action has accelerated with the contemporary globalization (Reenberg et al. 2010).

5. The notion of legacies

The term 'legacy' has increasingly been employed to characterize human-environment systems in various contexts, providing another notion of 'history matters'. A *legacy* is what someone or something is remembered for or what they have left behind that is remembered or has influenced the current situation. For example, it is widely acknowledged in bio-geographical research that the land use history of an ecosystem influences the current structure and resilience to modern disturbances and stresses (Elmore et al. 2006). In that respect, land use history may be a key to understanding patterns of contemporary vegetation cover and response to precipitation, and insight into land use history may be crucial to the formulation of contemporary land management – not least if the current landscape is in some state of succession following agricultural abandonment.

In drylands, which is our empirical reference in this context, the dominant human land uses both in the past and the present are grazing, agriculture and extraction of forest resources. The legacies of past disturbances are apparent for centuries after the event of disturbance and can dramatically influence the ecosystem processes, with wider implications, for example, in terms of soil-atmosphere interaction (and hence climate), water balance and surface run off. These changes can include loss of biodiversity in riparian habitats (Reenberg et al. 2009), encroachment of new land uses, or alteration of species composition.

Such changes resulting from past land use impacts may have wider implications for the resilience of the present land use systems to current perturbations. Human impact on ecological systems may be deep and indeed raise the important question of what is the natural or baseline situation (Willis and Birks 2006).

6. Syndromes: a generic presentation of change processes

The notion of 'socio-environmental syndromes' has been proposed as a recent attempt to generalize contemporary environmental trajectories (Lüdeke et al. 1999). Syndromes have been primarily developed to design a research structure that can help identify the interdependencies between generic (syndrome specific) problems and subsequently elaborate appropriate response

strategies. It shares the same emphasis on 'strategies' as other conceptual approaches presented in this short report. Briefly summarized, the syndromes approach proposes as a first step, to identify the *network of interrelations* of the specific syndrome, displaying its critical trends, driving forces, impacts and mechanisms. It then focuses on the *disposition space* in order to identify the regions concerned and their vulnerability. The second step addresses the identification of ecological and socioeconomic *disposition factors*. Together, these two steps form the core of a qualitative systems analysis of the syndrome. The typology of syndromes reflects expert opinions based on local case examples, and the overall approach aims at a high level of generality in the description of mechanisms of environmental degradation.

The syndromes approach has been developed as an approach of its own to enable an integrated description of global environment and development problems and their specific dynamics. The term 'syndrome' was borrowed from the medical field (where it relates to complex clinical profiles) and subsequently suggested for the analysis of the Earth System. It proposes to start with a description of the health problem, then make a diagnosis based on the examination of symptoms, and finally conclude with recommendations for therapy. In other words, syndromes are 'seen as typical cause-effect patterns of global change, with impacts on both the environment and human development'. Syndrome analyses are meant to assess which regions of the world are particularly susceptible to specific syndromes in the present or future (Schellhuber et al. 1997).

The of the WBGU (1996) describes the 16 most important global change syndromes⁶. Three groups of syndromes are distinguished: a) the 'utilization'

⁶ **Utilization syndromes**

Overcultivation of marginal land, combined with rural poverty: *Sahel Syndrome*

Overexploitation of natural ecosystems: *Overexploitation Syndrome*

Environmental and developmental problems through abandonment of traditional agricultural practices: *Rural Exodus Syndrome*

Environmental degradation through agro-industry: *Dust Bowl Syndrome*

Environmental degradation through depletion of non-renewable resources: *Katanga Syndrome*

Destruction of nature by tourism: *Mass Tourism Syndrome*

Environmental destruction through military impacts: *Scorched Earth Syndrome*

Development syndromes

Environmental and developmental problems caused by large-scale, centrally planned projects: *Aral Sea Syndrome*

Disruption caused to the environment and society as a consequence of inappropriate rural development policies: *Green Revolution Syndrome*

Disregard for environmental standards in the course of rapid economic growth: *Asian Tigers Syndrome*

Environmental degradation and urban poverty through uncontrolled urbanization: *Favela Syndrome*

Destruction of landscapes through planned expansion of cities and infrastructures: *Urban Sprawl Syndrome*

Environmental disasters as a result of technical failures and industrial accidents: *Major Accident Syndrome*

Sink syndromes

Environmental degradation through large-scale diffusion of long-lived substances: *Smokestack Syndrome*

Threats to the environment through the disposal of waste: *Waste Dumping Syndrome*

Long-term pollution at or near industrial locations: *Contaminated Land Syndrome*

syndromes, resulting from the excessive or uncontrolled exploitation of natural resources, b) 'development' syndromes, arising from non-sustainable development processes, and c) 'sink' syndromes, resulting from maladapted disposal of materials in soil, water or air.

One of the proposed utilization syndromes is meant to characterize the prevalence of over-cultivation of marginal land, combined with rural poverty: it is labelled the *Sahel Syndrome* and has been selected for specifically detailed treatment in order to serve as a description of the analytical work process. The central mechanism of the *Sahel Syndrome* is perceived to be the mutual reinforcement of environmental degradation, social and economic marginalization and overexploitation, which form a vicious circle. The critical aspect, however, is that this vicious circle is not an isolated structure but is interrelated to numerous other trends of global change.

The vicious circle presents a dilemma for human-environmental interaction: on the one hand, there is the need to ensure food security for the local population, which due to the lack of economic alternatives can only be achieved through intensification or expansion of agriculture or overexploitation of vegetation in both the short and medium term. On the other hand, overexploitation may lead to human induced degradation of the environment, further aggravating the situation. In addition, the Sahel Syndrome is impacted by a number of structural elements. Firstly, the response options of the affected people are severely restricted because population pressure and poverty mutually reinforce each other. Secondly, climate change may be a complex interaction in which conversion of natural ecosystems may bring about changes in climate. Thirdly, both national and international economic conditions play a critical role, triggering or accelerating the change processes.

Lambin and Geist (2006) propose to apply the notion of syndromes to the more specific field of land use trajectories. They suggest that the apparent complexity in land use change processes can be summarized in a limited number of ways in which these causes interact. Hence, they suggest that a limited number of syndromes of land use change processes are observed repeatedly around the world (Lambin et al. 2003:222):

- Loss of land productivity on sensitive areas following inappropriate use.
- Deforestation on forest frontiers by weak state economies, for geopolitical reasons or to promote interest groups.
- The transition from communal to private land ownership in developing regions.
- Ecological marginalization of the poor by land expropriation for large-scale agriculture, dams, forestry projects, tourism, and wildlife conservation.
- The 'tragedy of enclosure': decreased land availability through land zoning for forest reserves, wilderness areas or agro-industrial plantations.

- Land use intensification in peri-urban and market-accessible areas of developing regions.
- Urbanization-driven changes in regional consumption patterns and income distribution with impacts on rural land use.
- New economic opportunities linked to new market outlets, changes in economic policies, or capital investments.
- Policy interventions that drive modifications of landscapes and ecosystems.
- The breakdown of traditional extended families and its impacts on resource use efficiency.
- Macroeconomic shocks and structural adjustment policies with undesirable consequences on natural resources.
- Delayed and ineffective social responses to deteriorating environmental situations, combined with absence of political will to mitigate damage and to alter the trajectory of change.

The syndrome concept has recently been proposed as a conceptual frame for spatial analyses of recent land use transitions and causal links between drivers of change and spatial patterns in a major EU project. It is believed to be a valuable heuristic to help identify the occurrence of important trends in land use transition across Europe (Reenberg et al. 2011).

7. Scenarios – looking forward

Recently, research into global change has been increasingly concerned with plausible future development trends. Whereas the various conceptualizations of processes and trajectories of change presented so far have examined changes in the past, the notion of scenarios emphasizes the forward-looking perspective.

In business, scenarios have been employed to present detailed and plausible views of how the business environment of an organization might develop in the future based on a grouping of important environmental influences and drivers of change characterized by a high level of uncertainty Lynch (2003:93-94). Scenarios are, in other words, plausible and often simplified descriptions of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships (Martens and Rotmans, 2002). Scenarios are neither predictions nor projections. They are based on narrative story lines to describe consistently the relationships between driving forces of environmental changes and their evolution. Scenarios provide alternative images of how the future might unfold. They provide insights into the present by drawing analogies between historical and current situations. Scenarios may be derived from projections, but are often based on additional information from other sources, sometimes combined with a narrative storyline.

An important source of inspiration was provided by the Global Scenario Group, which was formed in 1995. The group was an independent, international body

that explored ways of fostering a sustainable future. They presented their suggested approach in the essay 'Great transitions: The promise and lure of the times ahead' (Raskin et al. 2002), which put forth the basic notion that we have entered a *planetary phase* of civilization and that a global panorama is necessary to understand the contemporary human condition or possible future paths of development. A scenario can, if constructed with rigor and imagination, help us to explore where we might be headed or provide guidance on how to act now to direct the sequence of events toward a desirable future.

The suggested themes of importance include analysis of the driving forces, critical uncertainties and stresses of each scenario. The scenarios are seen as helpful instruments to identify the policies, values, institutions, technologies, and lifestyles required for a sustainable future. The scenario approach has found its way into a number of global assessment exercises, e.g. UNEP's Global Environmental Outlook series, the US National Academy of Science Board on Sustainable Development, the OECD Environmental Outlook, the Intergovernmental Panel on Climate Change and the Millennium Ecosystem Assessment. The latter presents the ambition of the scenario tool in the following way:

"The scenarios are not predictions; instead, they were developed to explore the unpredictable and uncontrollable features of change in ecosystem services and a number of socioeconomic factors. No scenario represents business as usual, although all begin from current conditions and trends. The future will represent a mix of approaches and consequences described in the scenarios, as well as events and innovations that have not yet been imagined. No scenario is likely to match the future as it actually occurs. These four scenarios were not designed to explore the entire range of possible futures for ecosystem services—other scenarios could be developed with either more optimistic or more pessimistic outcomes for ecosystems, their services, and human well-being."

8. Future challenges

As indicated in the introduction of this report, there is no single, optimal analytical approach readily available to scrutinize in an integrative fashion the causes and trajectories of change of the resource management of land systems. The increasing concern about the pressure on the planetary resources, created by imminent, accelerating exposures to climatic change, population pressure and economic globalization, makes the need for appropriate characterizations of change in coupled human-environmental systems apparent. This, in turn, points to the importance of developing suitable conceptualizations and heuristics and of getting the rhetoric right in interdisciplinary teams to avoid misunderstanding.

Various notions have found their way into the literature dealing with change in human-environment systems. Most of them have been inspired or adopted from disciplinary arenas like economics, anthropology, and physics. They may

provide useful starting points for developing a set of common notions that can constitute the basis of a conceptual toolbox for researchers dealing with change processes in human-environmental systems.

The notion of *path dependence* is based on a detailed set of definitions and reflections that may offer constructive inspiration. It has the weakness that the continuous state of 'disequilibrium' suggested by chaos theory is missing from the economic version of path dependence. Hence, in this version, path dependence loses a potential chance to offer a way to capture the theoretical suggestion proposed by political ecology (Zimmerer 1994), i.e. to consider disequilibrium as a possible state of human-environment systems. On the other hand, boiling down causal relations to spare fundamentals is a useful ambition of the path dependence notion, inasmuch as it 'assists us to identify conditions that are necessary and/or sufficient for past choices or outcomes to influence the present' (Page 2006:87). The proposed notions of 'outcome dependence' (i.e. history can have an influence by determining the outcome at a given point in time) and 'equilibrium dependence' (history matters by limiting the distribution of outcomes so the long run distribution of outcomes depends on past outcomes) are likewise examples of useful conceptualizations that could be adapted from the path dependence school of thought and constructively developed further and employed to characterize change in human-environment systems.

The notion of *pathways* is often presented as if it was well defined and beyond need of further clarification, but it is used with significantly different meanings by different scholars. The common denominator is that the concept of pathway is normally understood as a structural metaphor to describe a transformation that unfolds through time and space. Yet, as described above, some scholars (in anthropology) see the concept as very actor-decision maker oriented, referring to the decisions taken by individual actors, households and groups of people, and they distinguish between a pathway and a strategy. Others (e.g. in land change science) use the label in the sense of generalizable patterns of change that result from recurrent interaction between driving forces. By way of improving the theoretical backbone of land change science, they seek a theory that integrates insight into the causes of pathways of land change with a process oriented understanding of how macro-structural variables affect micro-agency. Hence, they share some of the interest in the agent with the anthropologists' notion, but have a more explicit focus on various driving forces. Thus, the notion of pathways should be used with care in interdisciplinary settings to avoid misunderstandings created by the fact that different scholars have a firm, predetermined understanding of the notion, which at a second glance appears to cover widely different conceptualizations depending on the users' disciplinary background.

The term *legacy* does not offer much in terms of providing a theoretical view of change processes. It has increasingly been employed to characterize human-environment systems in various contexts, but it is merely used as another notion of 'history matters', in the sense of what someone or something is

remembered for. In other words, it is a wording that can signal the importance of the temporal dimension, but it does not add much in terms of proposing analytical perspectives on the change process.

The *syndrome approach* postulates the existence of archetypical, dynamic, co-evolutionary patterns of human-environment interactions (Petschel-Held et al. 1999). Hence, it is suggested that the interactions between humans and nature can be clustered into typical patterns, and that case studies can be grouped into ensembles of similar processes, embedded into similar constraints on a larger scale. The big question - and the methodological Achilles heel - is how such patterns can be discovered in a diversity of real world situations, and how unsubstantiated generalizations of causalities can be avoided. The notion may, however, prove helpful to assist researchers in the analytical process by drawing their attention to causalities and feedback mechanisms of a more general nature in the change processes.

In hindsight, the development of human-environment interaction has proven to be more complicated and more surprising than was often anticipated. *Scenario approaches* have recently become a popular tool to frame a primarily qualitative analysis of development and change. Scenario analyses try to capture essential dynamics by looking at the past, examining current driving forces and anticipating future development. They strongly emphasize important uncertainties in the framework conditions, acknowledging the crucial importance of political, environmental and cultural norms, which enable and constrain change process. Thus, scenarios do not provide precise answers as to what the direction of change in human-environment systems will be, but they may be helpful to guide the explorative reflections of the possible outcomes if certain assumptions are changed.

To sum up, a number of more or less rigorous conceptual lenses have been offered as a platform for the analysis of change processes and directions of change. They emerge from various disciplinary settings and each has its own advantages and weaknesses. Although they may be seen as presenting different and complementary perspectives, they do not readily add up to a fully fledged portfolio of complementary analytical perspectives. One obvious challenge is to harness the proposed concepts and their implicit meanings to a commonly understood and acknowledged set of notions and lenses for the analysis and characterization of human-environmental systems. It is, for example, crucial for a productive interdisciplinary approach to the dynamics of human-environmental systems to get the rhetoric right. The different notions, conceptualizations and descriptive frameworks of change deserve to be explored in concert, with the aim of creating a consistent platform (or toolbox) of complementary approaches that effectively enhances insight into the change processes (and change of change). This is essential for a broader discussion of dynamic properties such as adaptation, resilience, vulnerability or sustainability.

Acknowledgement

This report is written as a contribution to the research efforts supported by a ERC/EU research grant, WATERWORLDS (lead by professor Kirsten Hastrup) and the LaSyRe/FFU project funded by DANIDA (09-001KU). The author highly appreciates the inspiration from the Global Land Project community.

References

Brooks, N. (2004). Drought in the African Sahel: Long-term perspectives and future prospects. Tyndall Centre Working Paper No. 61.

Cajete, G. (1994). Look To The Mountain. An Ecology of Indigenous Education. Kivaki Press: Durango, Colorado.

Boas, T.C. (2007). Conceptualizing continuity and change. The Composite-standard model of path dependence. *Journal of Theoretical Politics* 19(1):33-54.

de Bruijn, M., van Dijk, H., Kaag, M. and van Til, K. (2005). Sahelian pathways. Climate and society in Central and South Mali. African Studies Centre, Research report 78: Leiden.

Dearing, J.A., Braimoh, A.K., Reenberg, A., Turner, B.L. II. and van der Leeuw, S.E. (2010). Complex land systems: the need for long time perspectives in order to assess their future. *Ecology & Society* 15(4):21.

Elmore, A.J., Mustard, J.F., Hamburg, S.P. and Manning, S.J. (2006). Agricultural legacies in the Great Basin alter vegetation cover, composition and response to precipitation. *Ecosystems* 9:1231-1241.

Fredericks, B.L. (2007). Utilising the Concept of Pathway as a Framework for Indigenous Research. *Australian Journal of Indigenous Education* 36(S):15-22.

Gaddis, J.L. (2002). *The Landscape of History: How historians map the past*. Oxford University Press.

Lambin, E.F., Geist, H. and Lepers, E. (2003). Dynamics of land use and landcover change in tropical and subtropical regions. *Annual Review of Environment and Resources* 28:205-241.

Lambin, E. & Geist, H. (eds) (2006). *Land Use and Land Cover Change: Local Processes, Global Impacts*. Springer Verlag: New York.

Lüdeke, M.K.B., Moldenhauer, O. and Petschel-Held, G. (1999). Rural poverty driven soil degradation under climate change: the sensitivity of the disposition towards the Sahel Syndrome with respect to climate. *Environmental Modeling and Assessment* 4:315-326.

Liu, J., Dietz, T., Carpenter, S.R., et al. (2007). Complexities of coupled human and natural systems. *Science* 317:1513-1516.

Lynch, R. (2003). *Corporate Strategy*. Prentice Hall: London.

Margolis, S.E. and Liebowitz, S.J. (2000). Path dependence, Lock-in and History.

Martens, P. and Rotmans, J. (2002). *Transitions in a globalizing world*. Swets & Zeitlinger Publishers: Lisse.

Page, S.E. (2006). Path Dependence. *Quarterly Journal of Political Science* 1(1):87-115.

Petschel-Held, G., Block, A., Cassel-Gintz, M., Lüdeke, M.K.B., Kropp, J., Moldenhauer, O., Reusswig, F. and Schellnhuber, H.J. (1999). Syndromes of Global Change: a qualitative modelling approach to assist global environmental management. *Environmental Modelling and Assessment* 4:295-314.

Raskin, P., Banuri, T., Gallopín, G., Gutman, P., Hammond, A., Kates, R. and Swart, R. (2002). *Great Transition: the Promise and Lure of the Times Ahead*. Stockholm Environmental Institute.

Redman, C.L. and Kinzig, A.P. (2003). Resilience of past landscapes: Resilience theory, society, and the Longue Durée. *Conservation Ecology* 7(1):14.

Reenberg, A., Langanke, T., Kristensen, S.B.P. and Colding, T.S. (2010). Globalization of agricultural landscapes: a land systems approach. Pp. 31-56 in: Primdahl, J. and Swaffield, S. (eds). *Globalisation and agricultural landscapes. Change patterns and policy trends in developed countries*. Cambridge University Press.

Reenberg, A., Mbow, C., Diallo, B., Ba, M., Touré, A. and Noergaard, A. (2009). Conceptualizing the change process in Sudano-Sahelian landscapes: Land use and land cover dynamics in forest reserves and their margins. *West African Journal of Applied Ecology* 15:105-125.

Reenberg, A., Pedrolí, B. and Rounsevell, M. (2011). GLP mindset in action: New EU-FP7 project VOLANTE develops visions for future land use transitions in Europe. *GLP NEWS* 7:17-20.

Reynolds J.F., Mark Stafford Smith, D., Lambin E.F., Turner II, B.L., Mortimore M., Batterbury, S.P.J., Downing, T.E., Dowlatabadi, H., Fernandez, R.J., Herrick J.E., Huber-Sannwald, E., Jiang, H., Leemans, R., Lynam, T., Maestre, F., Walker, B. and Ayarza, M. (2007). Global Desertification: Building a Science for Dryland Development. *Science* 316:847-851.

Schellnhuber, H.-J., Block, A., Cassel-Gintz, M., Kropp, J., Lamm, G., Lass, W., Lienkamp, R., Loose, C., Lüdeke, M.K.B., Moldenhauer, O., Petschel-Held, G., Plöchl, M. and Reussig, F. (1997). Syndromes of Global Change. *GAIA* 6(1):1-17.

Turner II, B.L., Lambin, E.F. and Reenberg, A., (2007). The Emergence of Land Change Science for Global Environmental Change and Sustainability. *PNAS* 104(52):20666-20671.

WBGU (1996). *World in Transition: The Research Challenge*. German Advisory Council on Global Change, Annual report of the WBGU: Bremerhaven.

Willis, K.-J. and Birks, H.J.B. (2006). What is natural? The need for a long term perspective in biodiversity conservation. *Science* 314:1261-1265.

Zimmerer, K. (1994). Integrating the new ecology in human geography, *Annals of the Association of American Geographers* 84:108-25

GLP International Project Office
University of Copenhagen
Department of Geography and Geology
Oster Voldgade 10
DK-1350 Copenhagen K.
Denmark
Internet: www.globallandproject.org

