



On scale and disciplinarity in the study of natural resource use in the Sahel - lessons from the SEREIN research program

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Abstract

This article presents some of the basic methodological reflections on which SEREIN's (The Sahel-Sudan Environmental Research Initiative) research activities are based. Environmental research that involves several scientific disciplines has in recent years been seen as the correct method to improve our insight into the man-nature relationship and the way in which this relationship influences the environment. Embarking upon multidisciplinary teamwork is, however, demanding and requires careful consideration concerning the common platform for the collaborative work. This paper describes how scientific and philosophical discussions have produced different meta-theoretical standpoints that have had a significant influence on how the environment and its dynamic change are perceived. Also presented is the fact that we need to develop approaches and tools, which may allow us to describe, analyse and predict land use patterns and changes including their environmental impact in a multi-faceted and hierarchical context. The concepts and analytical approaches chosen must, therefore, combine different time and spatial

levels in order to make the results from local studies meaningful in a broader strategical framework. The paper briefly touches upon how these challenges have been addressed within the SEREIN program.

Keywords

Environment, Sahel, degradation, hierarchical systems, combination of disciplines, land use.

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The increasing interest in analysing the man-environment relationship in a broader context, in the Sahel as elsewhere, has fostered a number of enlightening studies (e.g. Berry 1993; Mortimore 1993; Tiffin, Mortimore & Gichuki 1994; Fairhead & Leach 1996; Leach & Mearns 1996; Reij et al. 1996; Toulmin 1996). Such studies have presented new insight and approaches in the study of the nature of land use practices, which are often characterised by considerable complexity, diversity, and ambiguity. They have advanced our general understanding into the complex issues at hand; yet, a number of unresolved problems remain related to the methodic and analytical approach.

The discussion of how to recognise the complexity and diversity of man's land use strategies, while at the same time safeguarding against simplistic and linear conceptions of causal links, is not new. This discussion has been going on for years in the social sciences, whereas prominent

scholars such as Blaikie (1995) claim that it has only recently (and far too late) been introduced to the relevant schools of environmental studies, for example, geography. The discussion is fundamentally needed due to its wide implications but care needs to be taken to avoid over-reactions. This was illustrated when a rather innocent quotation by Walford & Haggett (1995) on the need to take a 'bird's eye view' of the world led to a ferocious attack by Edwards (1996), accusing them of disengaging 'from the world in order to understand it', e.g. maintaining a positivist standpoint and expressing views "predicated on a set of unquestioned modernist assumptions".

Although this criticism may seem unduly harsh, the problems are real. They are rooted in the fact that researchers, as well as those who are involved in the management of the natural resources in land use systems may find it useful to look for structures at a larger scale. These

can, however, be difficult to translate to reasonably precise predictions of biophysical and socio-economic processes and conditions on a local scale. On the one hand, there is a need to 'translate' experience and observations from individual cases to a larger global perspective. On the other hand, this is not an easy task because localised knowledge, diversity and heterogeneity may be difficult to incorporate into a more generalised perspective on land use and land management strategies and policies, without falling into the trap of offering universal solutions to complex problems, based only on scattered evidence from few selected villages or other place-bound locations. Some elements of this discussion relate to the structure-agency debate (see, for example, Long & Long, 1992; Booth, 1994; Long & van der Ploeg, 1994), but have also penetrated much of the work presented by the researchers dealing with the human dimension of global change (Turner et al., 1995).

Recognition of such difficulties had significant implications for the formulation of the SEREIN-research project, particularly when related to the perceived need to develop approaches and tools, which may allow us to describe, analyse and predict land use patterns and changes and their environmental impact in a hierarchical context.

This paper argues that in order to meet this analytical challenge, the researchers' perception of the issues, as well as the concepts and analytical approaches chosen, must combine different time and spatial levels. Only if this is done successfully, will it be possible to suggest theoretical and conceptual models to guide attempts at extrapolating findings from one scale to another, and thus to make results from local studies meaningful in a broader strategical framework.

Further, the article argues that in studying land use practices and land management strategies, a 'middle road' has to be explored, both in relation to the positivism-structuration (or, in Blaikie's phrasing (1995), 'interactionist') debate, and as related to the structure-agency discussion. The challenge is recognising diversity and ambiguity related to socio-economic and cultural factors that enable or constrain resource management options, while at the same time combining them with more unambiguously defined characterisations of bio-physical conditions and processes. Possible instruments to meet this challenge may be based on the principle of multidisciplinary and holism which offers ways in which to look at enabling and constraining factors for local land managers decisions (both structurally seen and locally perceived).

In the following chapters, we will look into some of the challenges to be faced by a heterogeneous group of researchers dealing with sustainable natural resource management and possible processes of environmental degradation. Initially, the basic dangers of adopting simplified notions and easy solutions when studying environmental degradation will be given some attention, with reference to recent studies which emphasize the equivalent ambitions as the SEREIN set-up. We will then focus on the epistemological reflections concerning the need for striking a balance between positivism and constructivism, between structure and agency, and between the localised (micro) and the scaled-up (macro) perspective, leading to a discussion of the virtues of a holistic and hierarchical perspective regarding the land managers' resource management strategies. Finally, we will turn to a more concrete discussion of the way in which the SEREIN activities have tried to address this array of challenges while at the same time maintaining the ambition to present concrete empirical results of strategic relevance.

Notions of environmental changes

Recent research has indicated that analysing environmental degradation is not an easy and straightforward task. Contemporary research increasingly questions 'received wisdom' (Leach and Mearns, 1996), 'conventional wisdom' (Fairhead & Leach, 1996), 'myths' (Thomson, 1997; Forsyth, 1998) or 'narratives' (Hoben, 1996 and 1998). These researchers challenge established truths or traditional orthodoxies about the environment and environmental degradation by claiming that the orthodoxies have been shown to be too simplistic and, in cases, demonstrably false.

Rasmussen (1998:50) discusses this issue with special reference to the situation in the Sahel-Sudan and summarises 'standard views' on the state and trends of the environment that have emerged within the overall land degradation theme. These include: that desertification is seen as an ongoing process affecting large parts of the semi-arid and sub-humid zones; that the fertility of agricultural soils is being reduced due to the pressure of growing populations; that erosion (by water and wind) becomes ever more important, due to the degradation of soils and the reduction in natural vegetation cover; that grazing resources are being over utilised, leading to reduction in the biological productivity of pastures and loss of diversity; and that the

woody vegetation cover is reduced, due to clearing for cultivation, overgrazing and collection of wood for fuel, construction, etc.

More recently, however, such 'standard views', or prominent environmental narratives, have generated criticism among both natural and social scientists. It is argued that the 'standard views' have been maintained over decades, in spite of growing evidence showing that the environmental changes are not (always) in accordance with the most widespread interpretations (Swift, 1996). A series of examples presented in Leach & Mearns (1996), provides empirical evidence to support this change. A change which has important implications for environmental and development policies, as well as for scientific studies of environmental change in the Sahel-Sudan. Regarding the latter, Rasmussen (1998) specifically recommends that great care should be taken not to base conclusions on a few local case-studies. Since generalisations are certainly required, much more emphasis should be placed on addressing the 'upscaling problem'. Much research on environmental change on a coarse scale is purely descriptive, and the link to the understanding of micro-scale processes, physical and biological as well as socio-economic, is often lost.

Much recent research made considerable effort to prove that the environment is in part socially constructed. The implication of this is, from a meta-scientific point of view, far reaching. While nature traditionally has been seen as separate from man, with man acting upon nature in trying to derive a benefit, this separation has simultaneously fostered the traditional positivist perception of nature, where the environment is seen and observed from a distance, with the scientist separated and disengaged from the object of study. In the constructivist perspective, however, scientists have as well 'become subjects in our landscape' (Blaikie, 1995:203).

The need for 'hybridity' in the study of environmental issues

Following such lines of thought that recommend that nature be considered as partly socially constructed, Latour (1997 (1991)) questioned the historic distinction between nature and society. Latour's point of departure is that the appearance of what he terms 'quasi-objects', such as global warming, deforestation, desertification, etc., are events which deem us to consider and analyse nature-society, in

a broader perspective, while adopting a new approach to environmental analysis and explanation.

While traditional analytical inquiries have been conducted under asymmetrical approaches, characterised by a clear distinction between the 'Nature Pole' and the 'Subject/Society Pole', with environmental changes automatically leading to societal changes and impacts, the symmetrical explanation of science advocated by Latour calls for a holistic, multi-faceted approach in which it is recognised that many "truths" exist and that the representations of nature and society must be dealt with simultaneously and in their totality.

Latour's work is sub-titled an "Essai d'anthropologie symétrique". He finds his inspiration in traditional ethnographic analysis in which it would be unthinkable not to analyse nature-culture relations in their totality: "Even the most rationalists among ethnographers, while doing field work, are fully capable of linking myths, ethnoscience, genealogies, political structures, technologies, religion, epic expressions as well as rites of the people studied and combine these elements within the very same monography" (p. 15, translation ours). The artificial separation between discourse, nature and society, which traditional (positivist) scientific approaches have forced upon us, is to be blamed in this regard.

Latour introduces the alternative notion of 'hybrid networks' and 'hybrid combinations of social and physical research', where he suggests a reworking of our mental landscape, by the introduction of hybrids that recognises the connection between nature and culture. The hypothesis is that the following two sets of entirely different practices must remain distinct if they are to remain effective, but that they have recently begun to overlap. The first set of practices, by translation, creates mixtures between entirely new types of beings, hybrids of nature and culture. The second, by purification, creates two entirely distinct ontological zones: that of human beings on the one hand and that of non-humans on the other. The first set corresponds to what Latour calls, 'networks', the second to what he calls the 'modern critical stance'. Latour argues that the two processes mutually support each other in the analytical process. Hybrid knowledge sources may allow researchers to use multifaceted information to review environmental reality from a number of viewpoints, across time and space scales. Reflexivity and integrative approaches are other expressions used to combine, to grasp subtleties and to rely on a broader spectre of methods and data gathering.

For Thompson (1997:143), the main problem is rooted in the fact that humans are both a part of nature and apart from nature, and that both human and natural systems are not "simple (that is, linear, predictable, deterministic, equilibrium-seeking, insensitive to initial conditions and so on)", quite the contrary. This calls for an analytical response which seeks to "harness this plurality", rather than to reduce it. Therefore, as an approach, he recommends Cultural Theory which recognises complexity and plural responsiveness, and he further suggests a focus of study that concerns solidarities expressed by individuals or groups of people, and mediated by institutions from the local (micro, or village) to the national (macro) level.

Also Forsyth (1998:107-108) adheres to the "growing trend towards accepting Cultural Theory and critical realism in environmental research, which provide(s) alternatives to positivism or post-modern deconstruction of environmental discourse". Forsyth reiterates that environmental change means different things to different people, and he outlines the two divergent conceptions: The "study and measurement of bio-physical processes" which is increasingly being replaced by the studies of "local adaptations to change and social movements". The latter is, however, seen as overwhelmingly post-modern and is characterised by qualitative analysis "which stresses the uniqueness of environmental perception and response".

While the questioning of myths has led to increasing interest in studies of the post-modern kind, the need (and interest) for assessing whether 'myths' are true or false, one of the main methodological virtues of positivism, has apparently faltered. Considering this, Forsyth (1998:108) asks: "Does this mean that it is now no longer possible to combine this acknowledgement of social constructions of environment with some learning of how biophysical processes operate?" His response is negative. He states that on the one hand, bio-physical processes cannot be overlooked as they do exist, and do affect and are affected by the way in which humans interact with nature. On the other hand, the constructivist, post-modern approaches to the study of environmental degradation have attempted to apply research results to wider time and space scales. Both elements are necessary to take into consideration when analysing land use and land use changes. A more holistic or hybrid approach (using the Latour notion), should be investigated where the two meta-scientific standpoints are integrated. Batterbury et al. (1997), for example, support the idea of adopting a hybrid research approach, in which

they suggest that long-term environmental histories may play an important role.

Theoretically, hybridity seeks to combine various disciplines and meta-scientific standpoints. The goal is to show methodological flexibility, reflexivity and understanding, realising "that ecological processes are real and external to human experience, but that all knowledge claims about processes are socially constructed" (Forsyth, 1998:112). What this may mean in practice is, however, less well developed. The closest to a demarcation is the one offered by Forsyth: "Hybrid knowledge, in simple terms, is the combination of information from both social and natural sciences in order to provide alternative glimpses of 'externally-real' environmental processes. But in addition, it allows researchers to test and expand new research agendas identified by local inhabitants or those not previously represented in the research process" (p.113).

It is easy to subscribe to these principles in general; yet it can be difficult to provide practical guidelines for their actual implementation. In particular, it is unclear whether these methodological requirements should be fulfilled within a single research component, or whether hybridity may be seen as a general platform for larger research programs, such as the SEREIN project. In the latter case, individual projects address various issues and use different methodological entry points, but have been formulated within a common analytical framework, which takes its point of departure in hybrid combinations of the social and physical sciences.

Although not explicitly explained in the form of a dual set of practices, the various pluri-disciplinary analytical approaches to land use and natural resource management strategies, which have appeared in recent decades, build on similar lines of thought. As discussed in Reenberg (1998), the tradition for multidisciplinary approaches to land use and resource management analysis is well established (see e.g. Messerli & Messerli, 1978; Reenberg, 1991; Young & Solbrig, 1993; Palm et al., 1995; Turner II et al., 1995; Uitto & Ono, 1996). Thus, while adopting the notion of 'hybrid combinations of social and physical research' as presented by Latour and others, which can be seen as relevant for land use systems analyses, one may on the other hand claim that the basic ideas do not differ significantly from those implicitly assumed by, for example, prominent research groups dealing with the global land use and land cover research programs (Turner II, various references).

Meshing and interplay

In the area of environmental change and the man-environment interaction, a central issue is how to ensure an interplay between a micro and a macro scale focus. It should be noted that global processes have an impact on local places, but also that local actions are the foundations for global trends (Kates, 1995). Tracing these connections is an important concern for a number of scholars, particularly within 'political ecology' (Blaikie & Brookfield, 1987; Roberts & Emel, 1992; Meyer & Turner, 1994). The debate has also been at the fore among social scientists within the broader 'development impasse' debate (Booth, 1995), where the structure-agency problematic and its general shift away from structure towards localised and contextual actor-oriented studies is emphasised. The discussion which took place at the same time within the geographical sphere was more directed towards research and perceptions of nature and the environment.

From a general viewpoint, this gradual shift away from structure towards agency has been well justified, as most structuralist (including positivist) meta-scientific standpoints and studies until then had a basic perspective, which was rather deterministic, functionalistic, and, in the case of Marxist and neo-Marxists analyses, often economic. Within this perspective, "Reality was presumed to have an inner logic, ordered according to universal laws" (Edwards, 1996:218), which could be studied and determined through scientific inquiry.

This shift, however, has probably gone too far, as many 'post-modernist', localised micro-studies show. Numerous studies explore the particularities of the local and contextual issues, rather than seek to meet an ambition of generalising such knowledge and relate it to conditions at larger scales. When looking at environmental issues, it is, however, clear that some driving forces operate at larger scales (examples could be greenhouse gas compositions, global financial systems, etc.), while many other individual decisions that underlie human resource management decisions operate at local scales. The fact that there are methodological and meta-scientific limits to extrapolations and generalisations following from the diverse local social construction of reality, does not mean that such ambitions should be given up, rather to the contrary. Actually, this is a major challenge which will have to be dealt with, if research results should be meaningful in a broader strategic framework.

Studying the environment involves a combination of biophysical processes and human action, which cannot possibly be pursued without a certain amount of strict scientific inquiry, e.g. relying on methods and approaches which are stringent, systematic - and, therefore, representative. In other words, from a methodological point of view, rather than the meta-scientific one described above, a compromise has to be found between the recognition of reality, including the environment, as been socially constructed - and as been naturally given.

Kull (1998:164), for example, supports similar conclusions. He suggests that the application of the 'range of choice' concept is a means to grasp the critical factors that determine land-use changes, including factors as diverse as; population pressure, state policies, market incentives, climate variations and rights regulating access to land and water resources. The 'range of choice' approach is heuristic. It links part-explanations into an overall understanding of the process, and helps to organise and conceptualise the variety. Multiple explanations are seen as a means to get to grips with the way in which the land manager's historical account of constraints and opportunities influences decisions concerning land use.

The hierarchical attributes of sustainability

The issue of different scales does not, however, only concern striking the analytical balance between a micro-scale and a macro-scale focus as discussed above. How phenomena at different temporal and spatial scales interact in unpredictable and unexpected ways has rightly attracted increasing interest across the spectrum of sciences. Scale relationships must be acknowledged as important for the scientific understanding of important aspects of the man-environment interaction as, for example, the population-environment-nexus (Brookfield 1995) or global environmental change (Turner et al. 1995). The drought prone Sahel region can be seen as such an example. Climate change and markets operate globally through hierarchical systems over which farmers, herders or others that manage resources at local level have little influence. On the other hand, their resource management strategies at the local level may have environmental ramifications at higher levels in the hierarchy.

The notion of hierarchy and scale is, therefore, of importance when discussing the analytical approaches to re-

source management in land use systems. Hierarchical thinking, in its more pragmatic form, may serve as a useful guiding principle when setting up analytical frameworks for multidisciplinary research programmes.

As an example of this, the hierarchy of scales has been linked to the discussion of sustainability and to characterisation of various systems, with respect to their sustainability (Fresco & Kroonenberg, 1992; Wilbanks, 1994; Burrough, 1997; Bouma, 1997; Hurni, 1997). The important here is that the scale domain of environmental and economic systems is system specific, and that the appropriate delimitation of the system prior to the analysis of their resilience, must take this into account. Fresco et al. (1992) makes some rather basic, but very important reflections about the use and definition of the term sustainability: "The concept of sustainability is applied to land use systems of divergent geographical scales, from individual fields or farms to regions, countries or even the World as a whole" ... "Ecological sustainability can be adequately defined only with reference to specific spatial and time scales". Thus, in general, sustainability must always be considered with reference to the processes at a higher hierarchical level rather than just the system under consideration.

Time-scale selection and combinations of scales are, therefore, crucial when studying the sustainability of agricultural strategies, not least in a fluctuating environment, such as the Sahelian. The choice of scales influences the perception of the empirical reality which forms the platform of the analysis. Resource management scenarios, which will likewise be influenced by temporal and spatial scales under consideration. An example of this is, subsistence farmers with limited resources and who have a very short-term planning horizon. In some cases, sustainable practices, because of their higher production efficiency, pay for themselves in the short term. In other cases, an increased short-term exploitation of the resources may possibly be justified, if it increases income to such an extent that the farmer will be able to improve resource management in the long-term.

Such recognitions of the need of taking into consideration how analytical scales can be combined in an appropriate way raises additional challenges to those who embark upon multidisciplinary research on the environment.

Making multidisciplinary work

In spite of the inherent difficulties and large challenges to be addressed, research programs have increasingly been specifically targeted to support efforts that combine different disciplines. It is acknowledged that social and natural scientists have considerable expertise that could be incorporated when addressing the environmental research agenda.

Taking the example of natural resource management issues and sustainable production strategies in the Sahel, the relevance of combining disciplines can be considered in a more concrete way. The need to include other aspects rather than just biophysical conditions, in order to understand what determines natural resource management strategies, is generally acknowledged. Mortimore (1993), for example, stressed that income diversification may relieve the farming system of the necessity to feed all its population, at all times, especially during food emergencies, and provides a potential source of investment funds for technical change, land conservation and yield improvement, benefitting the local environment. Economic issues, thus become important, be it in the form of changing market prices, access to markets, wage income from migrant workers, introduction of new products, etc. Labour bottlenecks are another serious issue (Nébié, 1992), especially related to the strong regional traditions for long- and short-distance migrations for work. Availability and strength of the labour force, especially for weeding, is a crucial determinant for land use strategies under the conditions of relative abundance of land that prevail in the Sahel. Finally, political, institutional and cultural issues play significant roles in shaping land use strategies.

Whereas funding problems were formerly seen as a major obstacle to embarking upon broader minded activities (Price, 1990), they can now be seen as a diminishing problem in many cases. This trend was also materialised in the Danish SMP-program (The Danish Strategic Environmental Research Programme), which provided financial and administrative support for SEREIN.

SEREIN's search for broader perspectives in the 'sustainable use of natural resources'-discourse, conforms to the international trends within the scientific community that address the man-environment interactions. It may, therefore, be appropriate to dwell briefly on the labels that are suggested when naming collaboration between the different scientific disciplines.

McNeill (1995:1) discussed the pressure for inter-disciplinary research, which he sees as a natural result of the public debate (for example the Brundtland Commission Report), that asserts that the problems of the environment and development are multi-faceted and require expertise from a number of disciplines, working in concert, to resolve them. In a review (Booth, 1988, cited in Price, 1990) found that "almost all researchers who undertake inter-disciplinary research (IDR) or who attempt to study the process of IDR, seem to have their own definition of IDR, including its requirements and final outcome". McNeill suggests a distinction between *multi-disciplinary research* "which involves researchers working together on a given theme, where each contributes information and/or analytical insight, but the disciplines work in concert, and even in parallel, so that the basic differences in approach or perspective are either not evident or are minimized" (p. 4) and *inter-disciplinary research* (also called cross-disciplinary) "which involves researchers identifying and confronting differences in perspectives and approach, not in order for one discipline to emerge as better according to some criterion, but for each to learn from, and contribute to, others; and hence also become more aware of the merits and limitations of their own".

As mentioned above, a central issue in many discussions highlighting the obstacles regarding research, which involves several disciplines, is the epistemological difference between the 'cultures' of the natural and social sciences (Herberlein, 1988). Almost forty years ago, Snow (1960)

spoke of 'two cultures', and cautioned against the gap between the natural sciences and the humanities - a gap which does not seem to have narrowed since that time; indeed, it may have widened (McNeill, 1995).

The challenge remains to overcome this gap, while at the same time realising that the network of factors driving resource management changes is very complex. An analytical framework that can facilitate the difficult task of getting to grips with the dynamics of the multiple forces that drive land use changes must be not only holistic or multidisciplinary in scope, it must also be able to capture the dynamic and modifying interaction between the different factors that constitute the system. It is in this perspective that SEREIN's joint analytical framework (Figure 1) should be seen.

The overall aim of SEREIN's research effort was initially defined as: to address 'sustainable use of natural resources in semi-arid regions in tropical Africa', giving specific attention to physio-biological processes in agro-ecosystems as well as to the socio-economic, cultural and institutional factors' influence on human management of natural resources. When the multidisciplinary group of researchers joined forces to address this fixed mandate, human land use patterns and strategies were chosen as a relevant and fruitful focal point for the joint research.

The basic assumption is that land use is an appropriate indicator of change or modification to the man-environment relationship, possibly the best available to monitor significant shifts in resource management strategies with

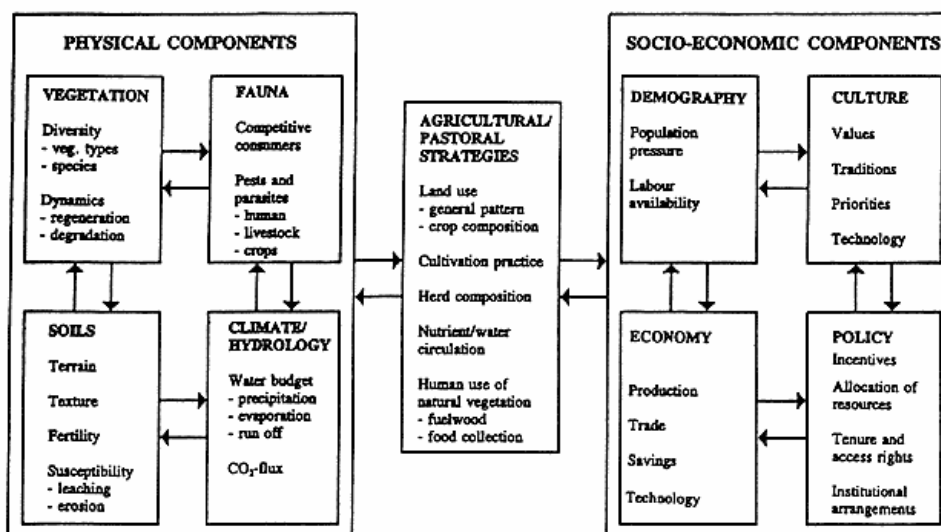


Figure 1: SEREIN analytical framework.

major ecological bearing such as cultivation encroachment, introduction of cash crops, changing balances between pastoral and agricultural production, etc. (Copan, 1974; Scott, 1979; Reenberg, 1982). At the conceptual level it was, therefore, found relevant to select land use as a joint pivot which binds together a series of different disciplines with the aim of answering some of the key questions related to the sustainability and resilience of prevailing and future resource management practices: How are strategies actually formed through the influence and constraints of a number of factors of an biophysical, environmental, socio-economic, political or cultural nature?

The land use focus allows each of the disciplines involved to contribute their specific expertise concerning factors that enable or constrain the resource management strategies in the land use system. It was acknowledged, however, that at the end of the day a much more detailed comprehension of the complex cause-effect relationship is probably needed, but it was believed that the implicit assumptions embedded in this common framework could initially guide and help to maintain a common direction of the research.

The analytical framework only hints at that land use systems are dynamic, and that in principle most changes in the man-land relation caused by people are reversible. In reality it is, however, crucial to embody these dynamic characteristics if the model should capture real-world processes. If land use strategies do not suffice to maintain a certain level of output, people often modify their strategies or techniques. For this to happen, the society has to have the institutional set-up, the knowledge, the resources and the organisation to deal with the issues in question. The constraints on land use are not only climate and soils but also the lack of human investment (in capital, labour, and knowledge) and tradition which are equally important.

In summing up, SEREIN has chosen a pragmatic policy, somewhat in-between 'multidisciplinarity' and 'interdisciplinarity', to bring different scientific disciplines together. While we have not strived to arrive at a common theoretical and epistemological platform, we have nonetheless deliberately made serious efforts to bring together different fields of expertise and different ways of analysing the environmental issues at hand. Furthermore, although not explicitly pinpointed in the diagrammatic sketch of SEREIN's analytical framework, dynamic thinking does constitute an important platform in many of the research

components. This pragmatic approach has proven useful (e.g. creating insight that may otherwise have been overlooked by the individual researcher), not least in the sense that it has led to new insight in several cases (e.g. Krogh & Paarup-Laursen, 1997; Reenberg & Paarup-Laursen, 1997; Reenberg & Lund, 1998).

Idealistically, the framework will enable us to analyse and understand the relative importance of the forces that drive resource management decisions, and thereby provide a background for anticipating development scenarios under various preconditions and suggesting culturally, economically and environmentally resilient improvements to the system.

Working with different scales in land use analysis

It has been discussed at length in a wide range of literature within the last decade (Conway, 1987; Fresco & Westphal, 1988; Marten, 1988; Spedding, 1988; Tivy, 1990; Altieri & Francis, 1992; Barrett, 1992; Fresco & Kroonenberg, 1992; Stromph et al., 1994; Altieri, 1995; Glaeser, 1995; van Duivenbooden, 1995; Odum, 1997) that natural resource management in land use systems is best examined on different spatial scales in combination, ranging from and matching the local plant-soil level to the global level.

It has been repeatedly noted, as previously mentioned, that analysis on one scale may lead to a significantly different set of outcomes or perceptions of reality than an analysis using another spatial scale (Fresco & Kroonenberg, 1992; Meyer et al., 1992). This problem is often referred to as the 'micro-macro' problem and has to be taken seriously. Especially within social sciences, the kinds of compatible data across time and space from which robust generalisations can be made are largely lacking (Arizpe et al., 1994).

The conceptual and practical issues which are related to integrating spatial scales and disaggregating resource management sectors is claimed to be the most important challenge confronting those dealing with man-environment interaction; yet these are still difficult to resolve. For example, Poncet & Quensière (1996) and Lambin (1993) discuss how the spatio-temporal thresholds and characteristics related to social organisation as well as physical conditions must lay the foundation for data collection. To achieve the optimal data base it must be acknowledged that the relevant level for biophysical characterisation may de-

part significantly from the level at which the social organisation can be described.

In the process of shaping a research program such as SEREIN, there are consequently good reasons for looking at natural resource management systems as a series of levels in a hierarchy, with temporal and spatial scales increasing at each level (e.g. field, village, landscape, national level). Several suggestions for such a conceptual model have been formulated (e.g. Fresco, 1986; Turner et al., 1995; Skole et al., 1994; Riebsame et al., 1994). In spite of an immediate resemblance in terms of the notions of hierarchy and multidisciplinary, they give quite different recommendations as to the way in which research is formulated (as further discussed in Reenberg, 1998). Reenberg (1996) suggests that it may be useful to direct the multidisciplinary research in such a way that different disciplines accentuate different spatial scales, and only link up on the scales of mutual interest. In this way it can be taken into account that the array of constraining and enabling conditions shaping the structure and development of the system will vary from one level to another. In the SEREIN program such a division of tasks between scales and disciplines was exercised in a preliminary plan outlying the research focus and elaborated in a set of maps that outlined the corresponding nested hierarchy levels of specific interest (see Reenberg, 1998:98 and 165-166).

As mentioned earlier, time-scale selection may also be crucial when studying the sustainability of resource management strategies, especially in a fluctuating environment such as the Sahelian one. In order to capture this, land use system characteristics must be seen in different time perspectives. The long term trends are best captured on the regional level looking at large time intervals. Key factors of major importance are biophysical (precipitation trends, soil depletion, biodiversity changes, etc.) as well as socio-economic (tenure, population pressure, etc.). They may be mirrored in the land use and land cover changes, characteristics that can be monitored at a coarse resolution. Yearly fluctuations (meso-temporal scale) are determined by a different set of key factors which are, however, also biophysical as well as socio-economical. The parameters suitable for monitoring changes (for example cultivation intensity) are best recorded on a spatial scale equivalent to that of the village level. Finally, on the farm and field level, soil fertility, yield variation and crop composition are decisive when evaluating actual food sufficiency in the short term (growing season).

Data for such a multi-temporal/multi-scale approach to the land use system must be composed from a range of sources, of which some are geocoded, others related to functional management units (households), and others can be obtained from statistical records. Whereas data on land use has been historically difficult to obtain in a predefined spatial and temporal resolution suitable for use in a well defined context, much has changed in the last decenniums with the appearance of satellite imagery. We are no longer confined to what scarce possibilities that may be available, more or less by coincidence. Different products, each with their specific qualities in terms of extent and resolution, are readily available to researchers and other users. Being digital, satellite images offer easy possibilities for geometric corrections, for handling in a GIS and for comparisons with other land use information sources that are transformed into a digital format (for example scanned aerial photos, digitised maps, etc).

Although 'hard' data is becoming more easily accessible, all problems related to the data gap and data combination are far from resolved. Not only do we have to struggle with the problem of co-handling qualitative information of a socio-cultural nature, derived from narratives and similar sources of information, with quantitative data of a biophysical or economical character which normally permits easy modelling. Another, and maybe more difficult challenge, is to deal with the issue of combining land use decision units, with their spatial equivalents, an issue which has been of prime concern in many of the case studies within SEREIN.

Although a coherent solution is far from being developed, important elements of the analyses base themselves on a linkage of information concerning the functional farm and the land use system, specifically those part of the activities that address the local/village scale. A wide range of information sources such as biophysical measurements, spatial data obtained from remote sensing or measurements in the field as well as quantitative and qualitative socio-economic information from interviews have, been combined in a way which facilitates maximum cross correlation of information (Reenberg, 1998). Remotely sensed data (satellite images, aerial photos) are stored in a digital form, and field measurements of land use variables are georelated in order to facilitate the immediate co-ordination of information. Socio-economic information derived from different household surveys are stored in a database which enables references to spatial locations as well as to functional units

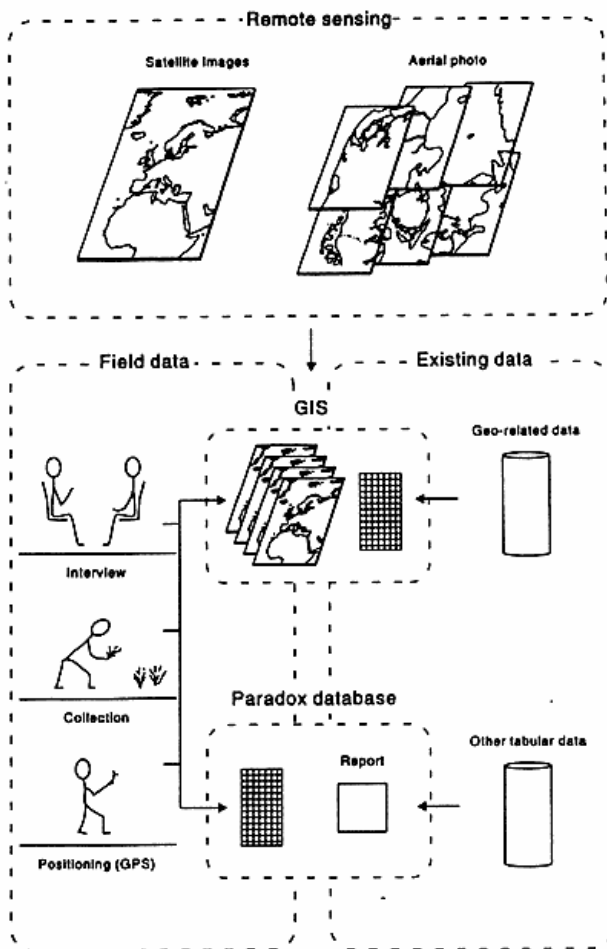


Figure 2: The case studies in SEREIN aim at using a common format for data storage. Georelated information is stored in a GIS. Other data are stored in a database that contains also spatial characterization whenever possible. This allows for direct reference between the different sets of information.

(Figure 2). Some of the SEREIN research efforts have taken explicit advantage of combining spatial and functional characteristics with the aim of decoding agricultural strategies (see e.g. Reenberg & Paarup-Laursen, 1997; Reenberg & Lund, 1998; Reenberg et al., 1998).

Spatial heterogeneity and diversity, however, appears to constrain our ability to translate information from one scale to another, at least in the form of generally applicable mathematical models. Thus, a coherent, multidisciplinary model that enables a quantitative description of land use dynamics and its appearance at various spatial scales can hardly be developed. The possibilities for acquiring pertinent data on land use relevant issues has, nevertheless,

improved significantly - in terms of, for example, land use data with high temporal and spatial resolution. Such improvements make it possible to document and analyse the extrapolation regime for land use trends at different levels in the land use hierarchy. Such efforts can provide a useful insight into parts of the overall picture, yet they cannot claim to fully meet the demand for a comprehensive, hierarchical land use model, a 'mental model' which also incorporates the socially constructed environment.

Lessons learned and future challenges

The preceding presentation has tried to address some of the theoretical and practical challenges to be faced by those analysing complex man-environment interactions in Sahelian land use systems. The need to bring different scientific disciplines together, and thereby maybe also conflicting philosophies, has been stressed, as were issues such as the dynamic aspect of land use systems, and the hierarchical nature of factors that enable and constrain land use.

In this context, case studies on a smaller scale may play a significant role as pivots. They represent the level in the hierarchy of space and resolution at which it is most simple to get to grasp of various ways in which environmental research can use 'hybrid' combinations of social and physical research, challenging orthodox resource management and environmental explanations. The village level provides a scale of observation which most readily offers a manageable framework for the holistic studies of man-environment interactions. It is, therefore, obvious to select this scale as the analytical point of departure and subsequently to develop methods that enable integration or extrapolation of information from or to other levels in the hierarchy of land use systems.

Locally based studies could possibly lead to the identification of forces which drive or constrain resource management strategies, policies and options, whether such constraining and enabling forces may be situated in the localised, contextual place-bound settings, or derived from more structurally determining external factors, such as prices, incentives or tenure rights. In the SEREIN research efforts, this has in many cases been the approach taken, as described in publications from the program as well as contributions to the present volume. In actual research situations, a non-dogmatic view has been taken, allowing for attempts at understanding local complexity and recognis-

ing diversity, without giving up the ambition of searching for more generalised, system-wide conclusions. Such an undogmatic view has included efforts in navigating between structure and agency, between the localised and generalised, between the perception of the environment as socially constructed and physically given, between the micro and macro-levels of research, etc.

While this navigation has been far from unproblematic, particularly when researchers from different natural and social science disciplines meet, the mutual interest in exploring the potential of inter-disciplinarity, coupled with a systematic effort in conducting field work together, has in a constructive way assisted in breaking down certain disciplinary boundaries and, in our humble opinion, improved the quality of research. However, solving a great number of meta-scientific issues and controversies and succeeding in cross-fertilising disciplines across boundaries and approaches is, of course, not done with one stroke. It requires a long-term investment, reaching far beyond the time-limit of the present SEREIN research programme.

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