CHAPTER 7

Embedded Flexibility in Coupled Human-Environmental Systems in the Sahel: Talking about Resilience

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Abstract

This chapter aims at demonstrating how the concept of resilience can serve to characterize the condition of a human-environmental system. It briefly presents different definitions and disciplinary uses of the term resilience and employs a case study from the Sahelian region of Burkina Faso as illustration. The case focuses on understanding the dynamics and pathways of change of the land use systems as a result of complex interactions and feedback mechanisms. It emphasizes aspects related to the rhetoric of climate change research, e.g. vulnerability, adaptive capacity and resilience. It demonstrates, for example, how the change of local livelihood and land use corresponds to the evolution of socio-economic and biophysical driving forces. The issue of field expansions and interrelation between pastoral and agricultural strategies is specifically explored.

The conclusion suggests how some of the different meanings of the 'resilience notion' may serve to characterize important features of the human-environmental system in Sahel.

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The present anthology aims at addressing the question of resilience on the basis of insight into the ways in which local communities meet new environmental challenges, for example rooted in global climate change. In this spirit, the following paper presents a case study from the Sahel[1] which specifically focuses on the living conditions on the margin of the desert.

The main concern is to illustrate how a selection of different meanings of the concept of resilience may serve to characterize the condition of a human-environmental system. The case study from northern Burkina Faso serves as point of departure for this illustration. It presents the land use and livelihood system in a village which has previously been studied in depth over decades, specifically with focus on understanding the dynamics of the land use systems as a result of complex interactions and feedbacks between social and environmental factors. The example illustrates the explanatory importance of incorporating the temporal dimension in the analysis of man's interaction with and responses to the environment, for example by demonstrating the co-evolution of driving forces by use of coupled human-environmental timelines. In more concrete terms, the example provides insight into recent land use dynamics that challenges commonly accepted narratives of land use and livelihood development pathways in response to the triple exposure of globalization, climatic variability and population pressure.

The presentation of the case rests on the rhetoric related to climate change research, e.g. vulnerability, adaptive capacity and resilience, recognizing the multiple sources of vulnerability of the Sahelian livelihood and land use systems. The notion of resilience, in some of its multiple meanings and definitions, is scrutinized in order to demonstrate the potential problems related to the lack of general consensus concerning the meaning of this term which has become popular across a wide range of different disciplines.

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1. Sahel refers to the agro-ecological zone bordering the Sahara desert. It is most frequently defined by an average annual precipitation of between 200 and 600 mm. It includes parts of Senegal, Mali, Burkina Faso, Niger and Chad.

Background – climate and human-environmental systems in the Sahel

In the Sahelian region, agricultural and pastoral production constitutes a very important sector that sustains the majority of people living here. Hence, the overall livelihood conditions are to a very large extent linked to the agricultural activities and the natural resource endowment. The significant attention given to agriculture in official national documents dealing with climate adaptation and sustainable development issues, such as the Burkinean national plan for climate adaptation, is therefore well justified. While many important traits are taken into account in such policy documents, it can also be noted that simplified notions of the state and dynamics of Sahelian land use systems have a prominent position. This concerns, for example, the pertinent issue of the development of the agricultural frontline across the drier part of the Sahel, which is presented in the well-established narrative of a simplistic notion of more people/less rain => more need for land => field expansion on marginal land => soil degradation => even more need for land etc. (PANA, 2007).[2]

Especially the desert fringe region of the Sahel is characterized by a fragile balance between limited natural resources and a rapidly growing population. Agriculture (including pastoral production) is the main source of sustenance for the predominantly rural population. To a large extent and in different ways, livestock interacts with the environment within a production system, such as grazing, mixed farming and industrial systems. While agriculture and pastoral production constitute the backbone of the livelihood portfolio in the Sahel, it should be noted that circular migration plays a significant role as well. Specifically, male migration to the coastal cities or the plantations during the dry season has been an important source of remittances to the villages in the Sahel.

2. On a more theoretical level of understanding, Reynolds et al. (2007:848) also mention the expansion of cropping into rangeland during wet periods as an inherent general feature in dry land systems, which leads to vulnerability and environmental collapse.

The very high variability in climate, specifically the spatial and temporal variability in precipitation both within and between years is well documented and known to be a major challenge for local livelihood conditions (Dietz et al. 2004).

Seen in a long-term historical perspective, significant climate variability is a key issue (Brooks 2004). If we look back 10,000 years, the climatic situation in the Sahel was characterized by an intensified monsoon situation, and the landscape was dominated by lakes and open woodland. By 5,000 BCE a final collapse of the monsoon was experienced after periods of abrupt arid crises. At this point in time, cattle herders migrated to the Sahel. Unlike in e.g. Asia, Sahel pastoralism was not from the outset linked with sedentary agriculture; lack of water in terms of rivers for irrigation was considered the main cause of the lacking development of urban civilizations in the region. Pastoral land use has played a prominent role in the drier parts of the Sahel, which are well known for its nomadic cultures that are well adapted to the spatially and temporally erratic resource base. In the 1950s and 1960s, the Sahel experienced unusually high rainfall, which coincided with the independence of the nation states in the region. This development of societal and environmental events created a powerful incentive to expand cultivation into marginal land, and has, in turn, had profound implications for the vulnerability of the land use system at the margin of the desert.

It is a widely debated question whether a recent increase in rainfall can be interpreted as a return to earlier levels or whether it is simply an example of natural variability. Bolwig et al. (2007) summarize that from around 1986, rainfall generally increased compared to the 1970-1985 period and that in the 1998-2003 period, rainfall had recovered in the southern parts of the Sahel zone (12-16°N) compared to the 1968-1997 period, whereas drought has intensified in the northern part (16-20°N). In the southernmost Sahel (12-14°N) conditions in the 1998-2003 period seem to have been comparable to the very wet period in the 1950s and 1960s (Nicholson, 2005).

As regards future climate predictions, IPCC's' Fourth Assessment Report is inconclusive (Christensen et al., 2007). The West African region is one of the regions of the world where global climate models diverge in their predictions, yet variability is likely to increase, and

both prolonged droughts and extreme rainfall may become more frequent.

The scientific literature on land use systems in the Sahel provides a useful general portrait of contemporary agro-ecological systems in the region (e.g. Keulen & Schiere 2004), see figure 1. In farmlands, livestock and crop activities are often integrated, and for agriculture in general this integration has been a significant path to intensification. Generally speaking, population increase in the Sahel has led to the expansion, intensification, and often closer integration of crop and livestock production systems (Powell et al. 2004).

The principal linkages between crops and livestock are income, animal power, feed, and manure. Most livestock derive their feed almost exclusively from natural rangeland and crop residues, and live-

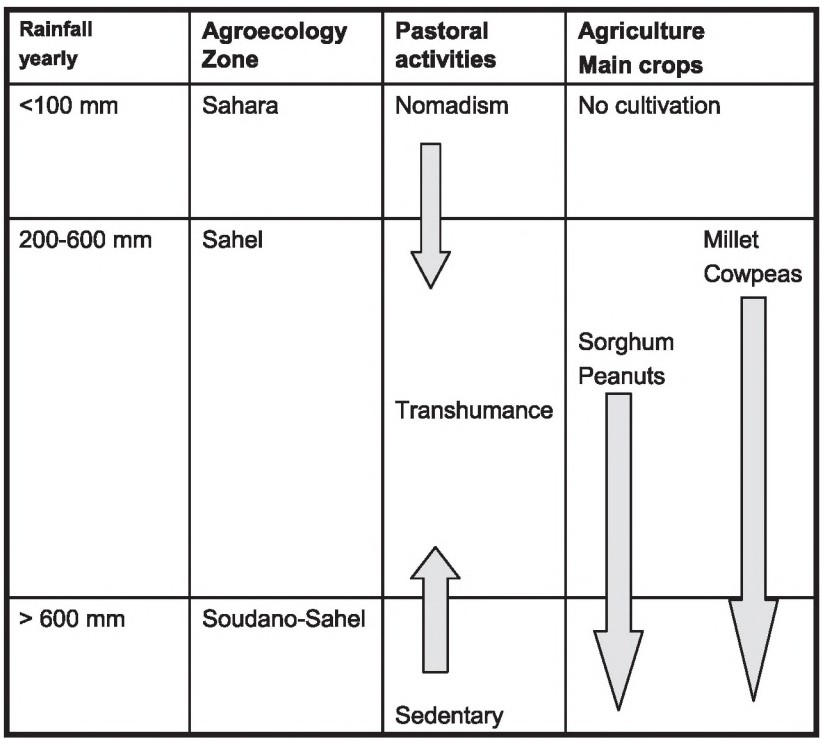


FIGURE 1. Rough, schematic overview of the agro-ecological zones and land use activities in the West African Soudano-Sahelian region.

stock manure is an important soil fertility amendment. Hence, the productivities of livestock, rangelands, and croplands are linked. Crop residues can be vital livestock feeds during the dry season, and manure enhances soil fertility for crop production. Forage from rangelands and fallow lands provides important livestock feed and, through manure, nutrients for cropland. A farmer obtains manure either from his own livestock or through exchange relationships with pastoralists.

Research concerning pastoral production systems and agricultural production systems as separate functional systems has been comprehensive and much detailed knowledge about productivity and sustainability aspects has been gained (Hesse & Cotula 2006). Crop-livestock interaction has also been carefully analysed in agro-ecological research on semi-arid land use systems, notably with empirical focus on the more humid part of e.g. the Sahelian region (Banzhof 2005; Brooks 2006; Nori & Davies 2007). Much less is known, however, about the complementarities of pastoral and agricultural components in local livelihood systems which take advantage of a dynamic and flexible prioritization of balance between livestock and crop production, adjusted in an optimal fashion to the temporal fluctuations in environmental or societal production conditions.

In recent history, the especially severe drought years which occurred in the 1970s and 1980s drew attention to the Sahel region and occasioned a significant amount of research activity aimed at assessing the sustainability of the natural resource management strategies. A large body of research results has been presented in the literature as discussions of the processes of land degradation or desertification (Bolwig et al. 2007; Raynaut 1997; Marcussen & Reenberg 1999; Ba et al. 2000; Barbier 2004) and a number of narratives have developed to become established truths with no need for further documentation. This includes, for example, the earlier mentioned notion of vicious circles of land degradation prompted by population pressure and low rainfall, leading to excessive expansion of fields onto marginal land, which in turn leads to irreversible degradation of the natural resource base, lower productivity and the need for larger areas to sustain the population. Recent literature, however, encour-

ages readers to look critically at received wisdom in order to avoid misinterpreting the processes of change and their likely future directions (Mortimore 2005).

Any future changes to the northern limit of agriculture may have crucial implications for the vulnerability of the land use system to possible changes in the monsoon regime. If the recent 'greening of the Sahel' (Olsson et al. 2005) leads to an expansion of cropland onto pastureland as was the case in the 1960s, this may again expose the region to acute food shortages caused by new drought situations.

It has been noted (Desanker et al. 2001, Dietz et al. 2004; Brooks 2006; Brooks et al. 2005) that knowledge of climate variability and adaptation in the Sahel can be improved, and that insight into some of the mechanisms that Sahelian communities have used to cope with current climate variability may be a useful complement to technological innovations (Kandij et al. 2006). Such full understanding of the climate-livelihood interaction is needed to assess the potentiality, vulnerability, and resilience of food production vis-à-vis perturbations related to climate changes.

New ways of formalizing thoughts about complex human-environment systems and their feedback mechanisms, such as resilience thinking (Walter & Salt 2006) are currently suggested as supplements to previous approaches such as livelihoods, sustainable development, etc. It will be worthwhile to investigate whether such lines of understanding could be valuable complements when examining development processes that support flexible and climate robust pathways. Thus, the following section will briefly present some of the key concepts and notions related to resilience thinking, with the aim of using the perspectives as a source of inspiration for the exploration of our case study.

The issue of resilience

While it is beyond the scope of this chapter to present a thorough scholarly discussion of the concept of resilience, I shall briefly explore some lines of thought related to the usage of this term, primarily with the aim of supporting the application of the term in the discussion of the dynamic traits of the land use system.

The term resilience is widely used in several scientific disciplines, underpinned by an equally wide range of definitions of the exact meaning of the term, complicating cross-disciplinary communication. Confusion arises because different groups adopt different meanings to fit their understanding and purpose.[3] In recent years, resilience has become a frequently used notion in different contexts related to sustainability issues and to broader reflections related to the precautionary principle and the future challenges for the planet under pressure from human growth and environmental changes. In simple terms, resilience can be viewed as the ability to 'bounce back' in a timely way from adverse impacts and shocks, i.e. the ability to withstand the consequences of an incident, the power to recover to the original situation or the capacity to adapt without harm.

The resilience perspective emerged from a branch of ecology that addressed ecosystem system dynamics. More recently, social scientists have contributed actively with perspectives on the dynamics of human-environment systems and challenged the concept of an equilibrium based system; among those were scholars dealing with natural resource management systems in anthropology and geography (e. g. Vayda & McCay 1975; Zimmerer 1994). The resilience perspective is increasingly used as an approach for understanding the dynamics of social ecological systems (Folke 2006).[4] Adger (2000: 347) defines 'social resilience' as the ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change. Scholars emphasizing this meaning of the notion stress the necessity to 'learn to manage by change rather than simply react to it and the key role that individuals and small groups of individuals play' (Folke 2006:255). In the social sciences concerned with crises and disasters, resilience has been under-

3. The original definition as presented by Holling (1973) is: 'the capacity of a system to absorb disturbances and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks'.

4. The terminology used in connection with systems that embrace human/societal as well as nature/environment/ecology components varies across research communities. In this context we use the term human-environment (Turner et al. 2007), unless we refer directly to wordings used in citations from papers by other scholars.

stood as comprising three aspects of people's response to disasters; resistance, recovery and creativity (Maguire & Hagan, 2007). In one of the most recent presentations (Walker et al. 2009) it is specifically stressed that the resilience approach treats biophysical, social, and economic elements of a region as components of a single social-ecological system, and that it emphasizes the capacity of the system to continue delivering goods and services to people. However, taking the concept of resilience from the ecological sciences and applying it to social systems is not straightforward because it assumes that there is no essential difference in behaviour between social systems and ecological systems.

The concept of resilience has been frequently employed together with the concepts of vulnerability, adaptation and transformation in recent research related to environmental change, thus reflecting the inextricable linkage between human and environmental systems (Berkes & Folke 1998). Resilience is a loose antonym for vulnerability as it increases the capacity to cope with stress. More broadly speaking, the vulnerability of human-environmental systems has been researched in three conceptual lineages: one that draws on risk-hazard or biophysical approaches, one that draws on political-ecology approaches and explores vulnerability with respect to broad processes of institutional and environmental change, and one that relates to the concept of ecological resilience and sees vulnerability as a dynamic property of a system in which humans constantly interact with the environment (Eakin & Luers 2006).

Adaptability is defined as the capacity of actors (humans) in a system to influence resilience (Walker & Salt 2006:163). Turner et al. (2003) employ the term resilience or 'adaptive capacity' to assess the ability of actors to shield themselves and to recover from adverse impacts. The concept of adaptive capacity (Yohe & Tol 2001) describes those characteristics of an individual, household or population group that enable it to alter and structurally reorganize its activities to diminish present threats to survival while enhancing its ability to address new risks.

Hence, resilience provides adaptive capacity (Smit & Wandel 2006) that allows for continuous development of the system, but it

does not imply that resilience is always an advantage; it may hamper transformation from the current stage or architecture of the system into a more desirable one (Folke 2006).

Social and physical approaches are both essential parts of a framework to understand the vulnerability and adaptability of coupled human-environment systems (Paavola 2008). It is, however, important to be cautious in using the term adaptation as well, as it has likewise a number of different meanings. Orlove (2005:590) points to a broad range of adaptations, where several axes can be recognized, such as anticipatory/reactive adaptation, private/public adaptation and autonomous/planned adaptation.

Finally, it is worth noting that leading scholars in the 'resilience alliance' (Folke 2006) stress that resilience is 'a way of thinking' (an approach) that provides a context for the analysis of socio-ecological systems. It can be seen as an area of explorative research with implications for sustainable development policies; hence, it can be seen as one amongst several arenas for interdisciplinary scientific approaches to research concerning sustainable development pathways (others being vulnerability research, ecological economics, sustainability science, and land change science) (Lambin 2005; Turner et al. 2007).

A case from Northern Burkina Faso

Biidi 2, a village situated in the Oudalan province in Burkina Faso (cf. map in figure 2), serves well to illustrate a number of pertinent characteristics of the dynamics of change in a Sahelian land use system. The perspectives selected for presentation in this paper aim specifically at exploring the traditional coping mechanisms that have helped the local population deal with recurring droughts and rainfall variability and thereby create a relatively resilient livelihood system.

In more concrete terms I shall illustrate that changes to the agri - cultural frontline in the Sahel may not always conform with the simplistic notion of more people/less rain => more need for land => field expansion onto marginal land => soil degradation => even more need

for land => etc. In order to do this, a simple set of questions about field expansion and contraction in the northern Sahel (millet agriculture) is addressed:

- How has the limit of cultivation changed in recent years?
- How do human and biophysical factors drive land use change?
- How do local people perceive and explain directions of change?

The information needed to respond to these issues is extracted from a number of surveys and field visits that have been carried out in the course of the past fifteen years (partly reported in e.g. Reenberg 1994; Reenberg & Fog 1995: Reenberg & Paarup-Laursen 1997; Reenberg at al. 1998; Reenberg 2001).

The studies mentioned above have drawn from a wide range of theoretical lines of thought. It has proven useful employ a portfolio of complementary approaches and methods (Young et al. 2006) in order to provide a comprehensive analysis of event driven adaptation of human coping strategies in land use systems in Northern Burkina Faso. More precisely, they have striven to combine, for example, classical theoretical approaches to rural populations' adaptability to exo-

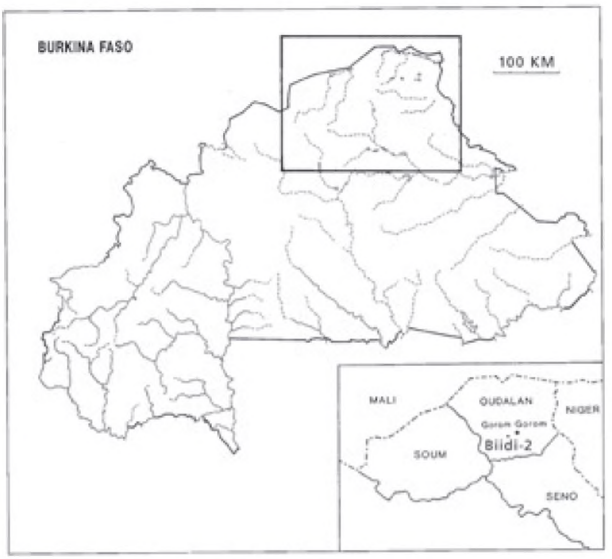


FIGURE 2. Location of the study site, Biidi 2.

genous and endogenous stressors in terms of shifts in the availability of natural resources, changes in population pressure or the introduction of new technologies (e.g. Boserup 1965; Bennett 1976; Netting 1993; Diamond 2005); livelihood analysis approaches to understanding how rural communities respond to environmental and social change (e.g. Chambers & Conway 1992; Scoones 1998); adaptation and vulnerability concepts (e.g. Adger et al. 2003; Yohe & Tol 2001); conceptual frameworks of coupled human-environmental systems and land systems that include environmental factors, social factors and feedbacks at various spatial and temporal scales and identify the driving forces of change (e.g. Fox et al. 2003; GLP 2005; Haberl et al. 2006; Lambin & Geist 2006; Marcussen & Reenberg 1999; Scoones 1999; Walker et al. 2006; Zimmerer & Bassett 2003); and more heuristic approaches such as 'ecological timelines' (Reid et al. 2000) or 'coupled human environmental timelines' (Reenberg et al. 2008) as a means to capture different causes and consequences of land use change over time. By doing so, we advocate a human-environment systems approach to the 'wicked problem' of managing a fragile environment under conditions of uncertainty caused by the triple exposure to globalization, climatic variability and population pressure.

Biidi 2 village is located on an East-West-oriented dune band, superimposed on a pediplain. In this respect it resembles a large number of villages in the Sahel region of northern Burkina Faso (figure 3).

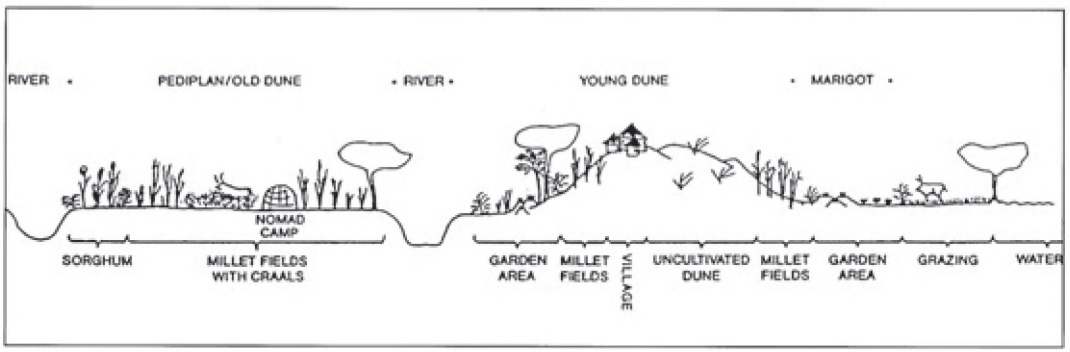


FIGURE 3. Landscape profile around Biidi 2. Source: Reenberg (2001).

Traditionally, these two different landscape types (i.e. dune vs. pediplain) have had alternating relative importance for cultivation, although there is a relative preference for fields in the dune landscape units in drier periods (Reenberg et al. 1998). In the contemporary situation, fields in Biidi 2 are primarily located on the pediplain. In addition, the local farmers cultivate gardens bordering the dune. The main crops are millet and sorghum, supplemented by a limited amount of cowpeas and groundnuts. However, the yield of these basic food crops far from suffices to meet the requirements of the village, even in good rainfall years (Nielsen & Reenberg in prep). The gardens have in recent years become a very important component in the land use system; the local wells provide water to sustain a reasonably stable production of vegetables (e.g. sweet potatoes, eggplants, tomatoes, various tree crops), which are mostly sold at the local market.

As an important supplement to the livelihood portfolio, the male population engages intensively in seasonal migration during the dry season, but normally comes back during the agricultural season, which is concentrated in the short rainy season (approximately June-October), and the harvest immediately thereafter.

Three main sources of data have been used for the study. The land use pattern and its spatial relation to the landscape units are explored by use of high resolution satellite images and aerial photography (in the early and mid-1990s) and field mapping by use of GPS (in 1995 and 2007). Two rounds of household surveys (total coverage of the entire village, 43 households in 1995 and 104 in 2007) have been conducted to provide information that goes far beyond the few issues addressed in this chapter, where I mainly rely on these surveys to provide information on population figures and insight into agricultural strategies and environmental events. Furthermore, in-depth group interviews and field walks were conducted, primarily to construct the coupled human-environmental timelines.

Figure 4 shows the land use history since the mid-1990s. Mapped on the aerial photography we see the entire extent of the village territory as well as the limits of the fields. The 1995-situation shows a detailed field outlay, which enables us to distinguish the single fields (a farmer has as a rule of thumb 1-2 fields, and most of them are,

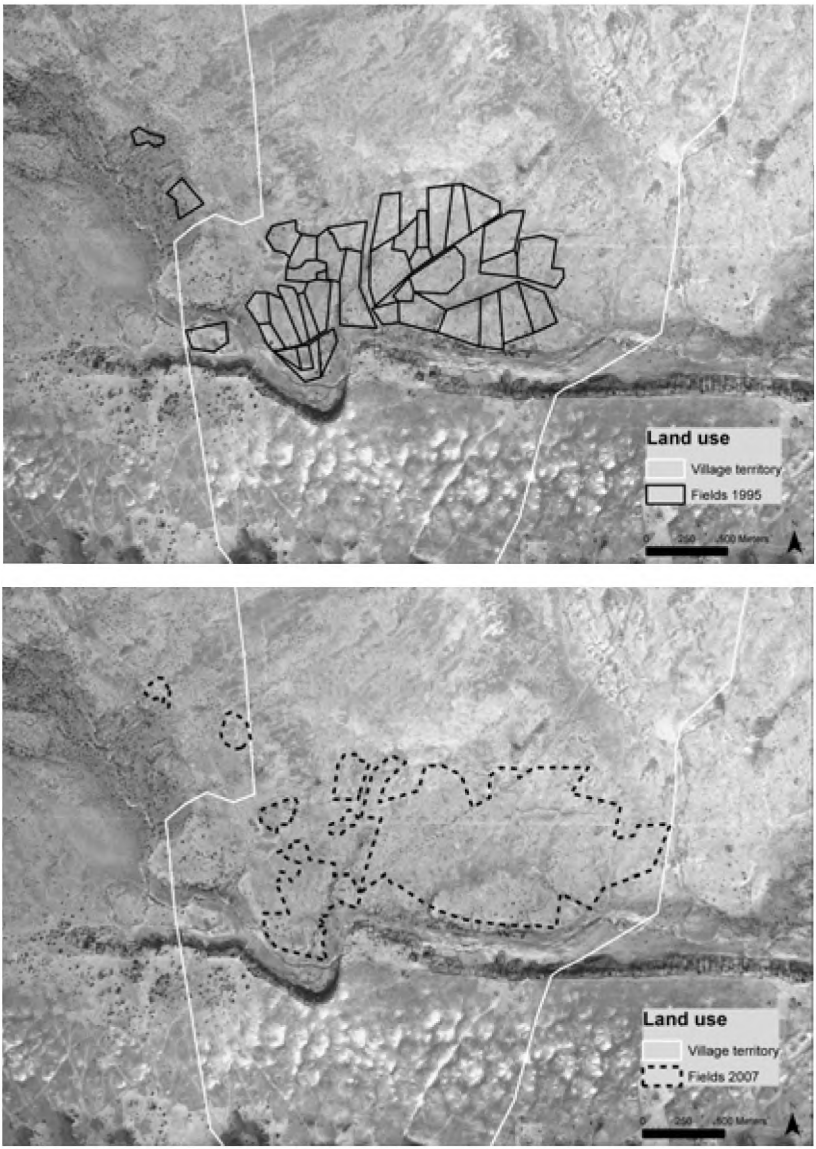


FIGURE 4. Field patterns in Biidi 2 in 1995 and 2007, respectively. The total acreage of the cropped land has only changed marginally. Source: GPS measurements.

again as a rule, cultivated every year). The mapping conducted in 2007 is less detailed and concerns only the outer limit of the field

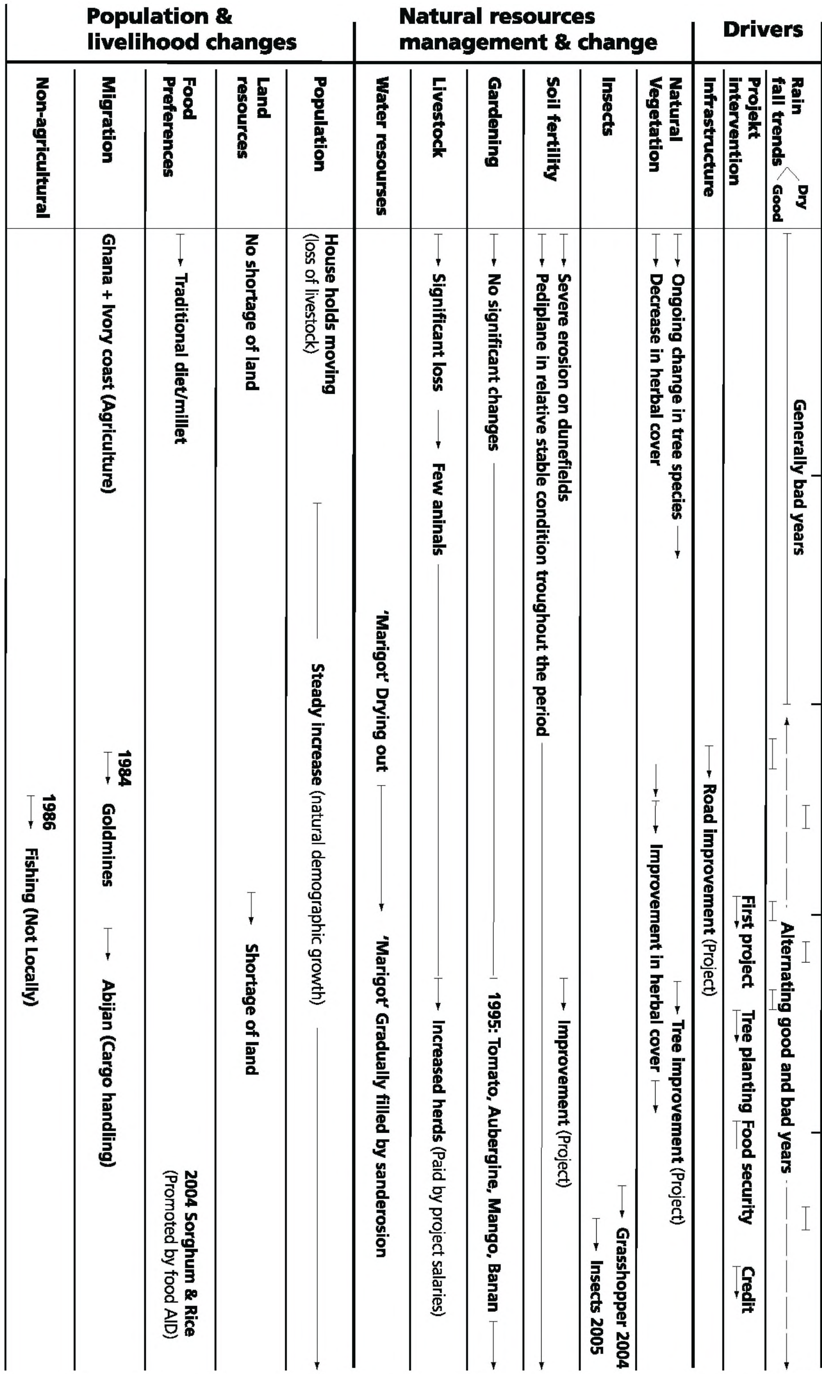
area. However, the area within this circumference is almost entirely occupied by fields, with the exception of a cattle corridor which has been permanent since the first recording year. Hence, there is a reasonable basis for overlaying the two maps to identify possible shifts in the location and size of fields between 1995 and 2007.

Two main observations are conspicuous; the total amount of land cultivated has only changed marginally but the location has shifted towards the east. The new locations are mainly a result of the long-term fallowing which is practiced in the sense that fields are cultivated continuously for many years, but if the yields become too low, new land is taken into use.

The co-evolution of field patterns and socio-economic and environmental conditions that constitute the local livelihood context are visualized in a coupled human-environmental timeline (figure 5). Whereas population growth is a significant 'slow' variable (i.e. a gradual change), three main sets of drivers are proposed in the dia - gram to catch the main events of importance to change: climate, development intervention and infrastructure. Perception of climate change amongst the villagers appeared to be rather fuzzy, yet recent years were seen to be a mixture of 'good' and 'bad' years. Climate variation has some impact on field expansion and contraction, but certainly not in a very systematic manner. While a tendency towards expansion, conforming with the commonly held notion described earlier, is reported by farmers to have occurred in the 'good years' before our study period, it is equally important to note that farmers actually report abandoning fields in recent years – explaining this too as a result of good rains (the reason being that the good rain provides good grazing in the bush, which enables them to increase their herds; with more animals to sell, they have less incentive to embark upon hard work in the fields and as a consequence diminish cultivation).

A number of income promoting factors have a much more prominent place when farmers are listing factors of significance for change

PAGE 147 · FIGURE 5. Time line of human-environmental interactions in Biidi 2 from 1960s to 2007. Information is based on group interviews and portrays farmers' perceptions and observations.


1960
1970
1980
1990
2000
Drivers
Rain fall trends
Dry
Good
Generally bad years
Alternating good and bad years
Projekt intervention
First project
Tree planting
Food security
Credit
Infrastructure
Road improvement (Project)
Natural resources management & change
Natural Vegetation
Ongoing change in tree species
Decrease in herbal cover
Tree improvement (Project)
Improvement in herbal cover
Insects
Grasshopper 2004
Insects 2005
Soil fertility
Severe erosion on dunefields
Pediplane in relative stable condition troughout the period
Improvement (Project)
Gardening
No significant changes
1995: Tomato, Aubergine, Mango, Banan
Livestock
Significant loss
Few aninals
Increased herds (Paid by project salaries)
Water resourses
'Marigot' Drying out
'Marigot' Gradually filled by sanderosion
Population & livelihood changes
Population
House holds moving
(loss of livestock)
Steady increase (natural demographic growth)
Land resources
No shortage of land
Shortage of land
Food Preferences
Traditional diet/millet
2004 Sorghum & Rice
(Promoted by food AID)
Migration
Ghana + Ivory coast (Agriculture)
1984
Goldmines
Abijan (Cargo handling)
Non-agricultural
1986
Fishing (Not Locally)

in livelihood strategies. Project intervention was, for example, perceived as a major factor of change, as was establishment of infrastructure (road access). The latter greatly facilitates access to markets as well as the seasonal migration activities, and hence increases the ability to earn money and provide remittances to sustain the village.

Seen in a population pressure perspective, the lack of field expansion is interesting. The village surveys revealed that the population of the village has increased from 346 to 585 persons in the course of the twelve years (1995 to 2007). Hence, a suspected close correspondence between population size and the incentive to expand land cannot be observed.

To sum up, the land use change trends, traditional crop production on the pediplain fields has remained almost the same throughout the period. Land available for cultivation is perceived as having been sufficient until around 1987, but insufficient hereafter because of the growing population. Yet, in reality, expansion of cropland is not restrained by the lack of more idle land, but rather by the fact that farmers do not want to invest more labour in marginal lands.

Livestock has changed in importance in Biidi 2. The dry years in the 1970s led to large losses of animals. Consequently, livestock became insignificant in the daily livelihood of farmers, who expanded the fields to provide food. The herds remained small until the mid-1990s when new sources of income, created by e.g. project activities, were invested in animals with a significant increase in the village's livestock as a result. More rain in recent years has further supported this development.

Hence, the observed land use dynamic can be described as a result of two different feedback loops - both to some extent triggered by rainfall change (towards more rain). *One pathway* (a positive loop: more rain => more fields at the desert margin) is conforming to the classical notion. It certainly holds true that the establishment of millet cultivation in the region was supported by the unusually favourable rainfall conditions in the 1960s. Field expansions even continued to be an important response to food demand in the dry years that followed for some time, probably as a result of a certain inertia or adjustment time. *Another pathway* (a negative loop: more rain => less fields at the desert margin), describes well the contemporary

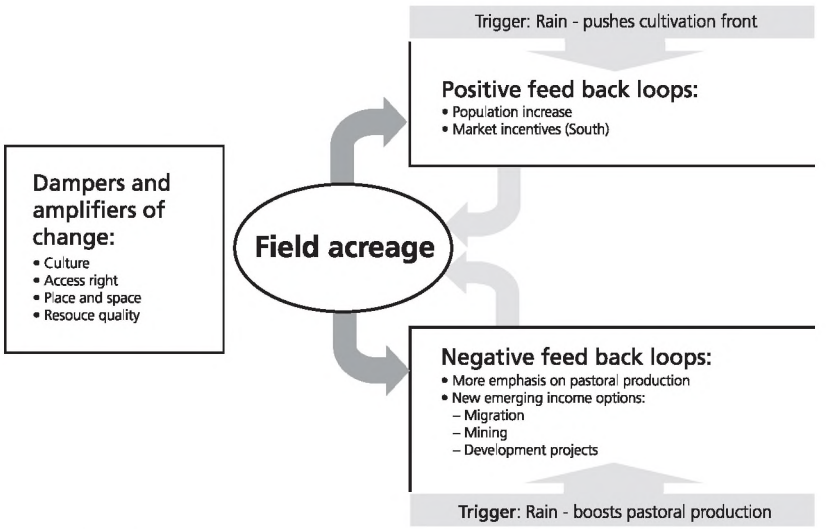


FIGURE 6. Rainfall impacts in bi-directional ways on field acreage. Increasing rain may explain expansion of fields at the desert fringe as well as reduction. No single, universal causal relation can be established.

situation in Biidi 2. Good rainy seasons in recent years have lead to increased pasture productivity, which, as described above, leads to more emphasis on livestock and less incentive to cultivate all available land. This loop is further strengthened by the emergence of a range of other, alternative income options that enable farmers to rely on other sources for food and even invest in livestock to build up the herds (figure 6).

Lifestyle in terms of food habits and people's perception of primary occupation has changed very little in Biidi 2. Millet or sorghum porridge is the main staple in the village and agricultural activities are considered the main occupation in spite of the fact that agri - cultural output rarely suffices to provide food for a major part of the year. Supplementary income from other activities is needed to survive. In fact, people explicitly explained that they perceived themselves as farmers and that these activities constituted their cultural identity. Migration has played a role throughout the period of investigation, and though the precise reasons for the migration have changed with available options (such as migration to the agricultural

plantations in Ghana in the 1960s, migration to the local goldmines from the late 1980s, and migration to work in the transport sector in Abidjan in recent years), it remains a permanent part of the livelihood portfolio. Variations in migration through time were not explained as responses to the climatic variability or to other of the proposed main driving forces of land use change.

The coupled human-environmental timeline in figure 5 serves to give a glimpse of the many factors which interact in enabling and constraining the ways in which local people manage the natural resources and modify their livelihood strategies.

Conclusion

Looking through the lens of resilience terminology, how can the land use and livelihood system that have been briefly described above be characterized? Some of the important notions mentioned earlier in this chapter can be captured under a number of perspectives, some of which are to a certain extent contradictory:

Resilience in the sense of the ability of the system to bounce back: The land use strategies in Biidi 2 have revealed flexible traits that enable alternating emphasis on pastoral and agricultural components in the land use system. The trends in recent years towards less cultivation can be interpreted as an ability to shift back when pasture productivity increases and hence opens the opportunity for a re-focusing of the natural resource management strategies.

Social resilience as the ability to cope with external stresses and disturbances as a result of social, political and environmental change: Biidi 2 has been exposed to stressors from population growth, political instability in neighbouring countries (target regions for the seasonal migration), and climatic variability. The timeline studies have documented that farmers have been able to compose a flexible livelihood portfolio, picking up new opportunities within the agricultural domain as well as in new areas of income generation. Hence, the village has, on the one hand, managed to remain 'the same' to a remarkable extent, containing the same families, and maintaining its cultural identity as a peasant society. On the other hand, this has only been possible because of the continuously increasing reliance on external generation

of income to support the population, which has increased by almost 70% in the course of 12 years.

Social resilience as capturing aspects of people's response to disasters; resistance, recovery, and creativity: The pronounced local and temporal variability in the rainfall conditions is an inherent trait in the Sahel region to which land use has had to be adapted for centuries. The above-mentioned flexible combination of and alteration between pastoral and agricultural land use has been a central feature of the traditional land use systems. It has, in turn, enabled the local population to cope to a reasonable extent with extreme events by moving in the landscape, or by putting more or less emphasis on the different types of production in the land use system.

Resilience as a measure of the capacity of the system to continue delivering goods and services to people: By relying on relatively flexible livelihood strategies that include an increasing range of activities that are not directly related to farming, the human-environmental system has been able to deliver food (or at least part of the food requirement) to the local population, and maybe more notably to deliver the appreciated service of enabling people to maintain their cultural identity as farmers.

Resilience as a loose antonym of vulnerability: By relying on a flexible combination of pastoral and agricultural production, the land use system can counteract vulnerability to some extent by choosing the most advantageous strategy in times of e.g. climate events. The development of a broader livelihood portfolio, with income generated from many different sources, has also implied that people are much less dependent on the local food production in a specific year. Hence, the contemporary system is much less vulnerable to climatic variations.

Resilience or 'adaptive capacity' characterizing the ability of actors to shield themselves and to recover from adverse impacts: Mobility and migration are a further set of important indicators of resilience. Where migration is circular in nature and stimulated by the demand for labour elsewhere outside the region, as is the case in Biidi 2, the resource flows associated with remittances can help enhance resilience.

Resilience as hampering transformation from the current architecture of the system into a more desirable one: Resilience is related to stability, but it is not clear whether this characteristic is always desirable, for example, in

development terms. Stafford Smith et al. (in press) note that for some dry land regions, the main issue is not to increase resilience. They portray a development of the human-environmental system which is undesirable, but resilient, and which is the outcome of cross-scale effects coupled with inherently low adaptive capacity. For these regions, they suggest, the problem is not to increase resilience, but to increase transformability in order to enable a transformation from the current type of system to some other kind of system. This may entail changing the ways people make a living, developing new 'goods and services' and operating at different scales. Hence, transformation and transformability are emerging as critical areas of concern and discussion for areas like Biidi 2 that have a very low level of material living standards under current conditions.

Perspectives

The study of resilience in coupled human-environment systems can be viewed as a purely intellectual activity intended to shed light on the intricacies of nonlinear dynamics, cross-scale interactions, and complex adaptive systems (Redman & Kinzig 2003). Describing a specific system by use of resilience rhetoric as exemplified above can, however, also have a more practical purpose by way of characterizing aspects of sustainability, adaptive capacity, and functioning of the prevailing human-environmental systems. One aspect of improving our ability to flexibly manage for resilience (in its different meanings of the term) 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 in mismatches in monitoring scale and response scale. Insight into longer term dynamics of the human-environment system and human response to changing conditions may make it possible to identify the key signals humans choose to respond to and what determines the range of response options which actors have at their disposal.

The accelerating complexity of changing environmental and societal conditions that local people are confronted with has been coined by (Liechenko & O'Brian, 2008) in the phrase 'double exposure', pointing to the fact the societal transformations are altering

the context for adaptation to climate change. This captures well the serious problems that Sahel villages face. Local and regional studies of human resource management strategies in Sahel show, however, that local people have considerable resourcefulness in the face of external change. Social and economic systems have been dynamic enough to allow farmers to adapt flexibly to climate change. Livelihood diversification is the key; it can occur *within* agriculture and natural resource use as well as *beyond* activities reliant on the environment. Diversification is indicative of a level of responsiveness to external forcing factors that may be significant in terms of the capability to adapt.

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