

Chapter 9

Migration as Societal Response to Climate Change and Land Degradation in Mali and Senegal

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Abstract The majority of the rural population in the West African Sahel depends on subsistence and small-scale farming. Thus, climate change, with its increasing temperatures and rainfall variability, impacts the environment and poses considerable risks to livelihoods. Given these circumstances, migration can be an important strategy for coping with the changing environmental conditions. Focusing on two regions in the West African Sahel, Bandiagara in Mali and Linguère in Senegal, the paper addresses the issue of migration as a societal response to climate change. It draws on results from the interdisciplinary project *micle*. Within the project qualitative and quantitative socio-empirical surveys have been conducted and a number of geo-scientific data from remote sensing and field measurements have been collected in the two study regions. The empirical data have been integrated and analysed using the methods of Bayesian belief networks (BBN). A policy analysis of relevant environmental, development and migration policies, supplemented by scenario analysis, identified options for political action. The results of the interdisciplinary analysis show that changing and unsteady environmental conditions lead to changing patterns of migration regarding its duration and destination. Depending on the migration motives and social-ecological conditions, the migration patterns can be very specific. Although environmental conditions have a certain impact on these patterns, all in all socio-economic conditions show a greater impact on the people's migration decision. While socio-economic factors like higher education are important for long-term migrations to the capital, unfavourable environmental conditions play a decisive role when

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people migrate seasonally for economic reasons. One important leverage point for political action is therefore the promotion and facilitation of formal education.

Keywords Bayesian belief networks · Climate change · Interdisciplinary research · Migration · Policy analysis · Sahel · Scenario development

9.1 Introduction

For the last two decades, there has been an increasing interest in the relationship between climate change, environmental degradation and mobility of the population in the public and scientific debate (Wilkinson 2002; UNDP 2009; IPCC 2014a). The West African Sahel is expected to be the most affected by the effects of climate change and climate variability such as hotter and drier climates, oscillations in rainfall patterns, droughts, land degradation and desertification. For West Africa, predictions suggest an increase of between 3 and 4 °C, while rainfall predictions vary highly in time and space. An increased tendency for extreme events such as droughts and floods is estimated (IPCC 2014b). Against this background, negative impacts on food production, including crops as well as livestock farming, are expected for the region (IFPRI et al. 2014; Worldbank 2012). More than thirty years ago, during the 1970s and 1980s, the West African Sahel experienced a number of severe droughts and a considerable decrease in rainfall in the following years. Together with political conflicts, these droughts contributed to severe famines and the displacement of large parts of the population (Findley 1994; Morrissey 2014). Notwithstanding a recovery of rainfall over the last three decades that has been registered, many studies suggest that a growing population and climatic trends will result in increasing land degradation, combined with negative effects on natural resources, agricultural productivity, food security, and thus increasing outmigration of the affected population (Warner et al. 2010; UNEP 2011; Véron 2012). Yet, the West African Sahel region is well-known for its high population mobility as part of the history and culture, combined with a multitude of migration patterns and trajectories. Since pre-colonial times, mobility has been common in the region and has included both cyclical migrations linked to agricultural production styles, as well as movements resulting from the search for better economic opportunities and changes of the natural environment (Cordell et al. 1996; Castles 2009).

Today there is a broad consensus in the discourse on environmentally induced migration, at least in the academic debate, that migration is a complex phenomenon and is thus not determined by one single factor (Piguet et al. 2011; Black et al. 2011; Hummel 2015). Climate change as such usually does not directly cause people to move, but it produces specific environmental effects such as temperature increases, fluctuations in precipitation, and extreme events such as hurricanes or floods, which can impair the livelihoods and increase the vulnerability of parts of the population. Hence, it is a context-specific interplay of environmental, social, cultural, demographic, economic and political factors that must be considered (Black et al. 2011;

Piguet et al. 2011). This means that migration cannot be explained in a deterministic and linear way, since its causes, features and patterns are highly complex, dynamic and context-dependent. The challenge for empirical research is therefore to relate the multiple factors influencing migration in order to understand the specific weight of each and their interactions. Given this overall agreement in the scientific debate, most studies have moved from simple push-pull frameworks to more comprehensive research that considers the interplay of ecological and social factors, or a deeper view on scale-related interrelations of individuals or households with societal settings, for example, issues of social inequality or the role of social networks for migration decision-making (Hummel et al. 2012: 15f.).

Another shift in the debate can be observed: until a few years ago, the prevailing perspective is that environmentally-induced “migration is the worst scenario and the option to avoid, and policies should strive to enable people to stay” (Piguet et al. 2011: 15). In contrast, recent studies focus on the role of migration as an adaptation strategy of households and individuals to reduce vulnerabilities to environmental, social and economic risks, and to diversify their income (Tacoli 2009, 2011). Other authors emphasize the role of migration as one of alternative “livelihood strategies” of individuals or households (McDowell and de Haan 1997), or just as a “way of life” (Black 2006: 2). Given these recent discussions, we critically discuss the issue of migration as adaptation or coping strategy using the example of migration patterns in two selected regions in Mali and Senegal. We will argue that migration can be regarded as a societal response to climate change and land degradation.

Whether it constitutes an adaption strategy, a livelihood strategy or a way of life depends on the specific social-ecological conditions which influence the different actions and strategies taken by individuals, groups and societies to cope with changes of their natural environments. These actions and decisions are influenced by social, cultural, political and economic settings, and environmental changes in turn influence these settings. Causes and motives for migration overlap and thus cannot be strictly separated into single factors. Based on the results of the inter- and transdisciplinary research project *micle* “Climate Change, Changes to the Environment and Migration in Sahel”, in this paper we will focus on the social-empirical analysis, modelling, and policy analysis.

9.2 Project Region

In order to assess the effects of climate change and land degradation on migration it is reasonable to consider a region that is subject to changing environmental conditions and has a mobile population which depends on these conditions in every day life.

Being located in the Sahel region, both study areas—Linguère in Senegal and Bandiagara in Mali (Fig. 9.1)—show the characteristics of semi-arid grass and shrubland (Herrmann et al. 2005). The unstable climatic and environmental conditions of the West African Sahel are reflected in the ongoing controversial debate about desertification and re-greening (Dardel et al. 2014). Even more crucial, they

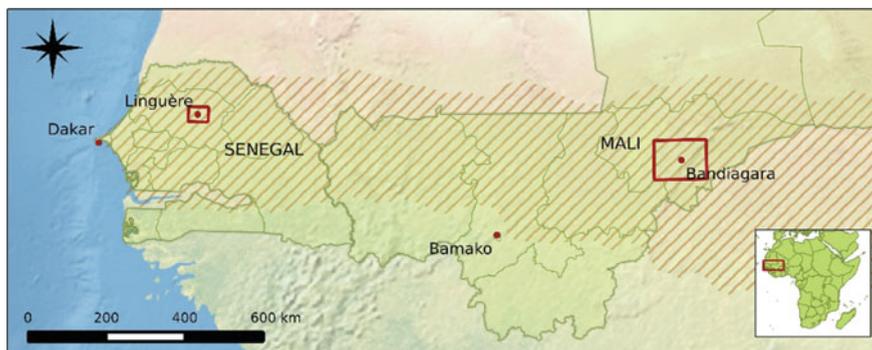


Fig. 9.1 Location of study areas at Linguère and Bandiagara (rectangles). The shaded area indicates the Sahel's extent, delimited by the 250 mm/a isohyet in the north and 900 mm/a in the south (based on the definition of the MEA 2005). (Data sources: DIVA-GIS, Natural Earth Data. Cartography: Lukas Drees)

affect the life of the inhabitants, especially because the project region is predominantly a rural area where agriculture and livestock farming play a dominant role regarding people's economic activities.

For both crop farmers and livestock farmers, the rainy season (between June and October) and the amounts and the distribution of rainfall in this period are decisive for their livelihood. This is especially true for farmers who usually do rainfed subsistence farming and hardly have the opportunity for irrigation. Still, people adapted to a certain degree to the unreliable conditions that can cause poor harvests in any year. This situation is aggravated by a rise in temperature since the 1960s and the ever-present risk of longer dry spells, as they occurred in the 1970s and 80s (Brandt et al. 2014a). At the same time, the area used for agriculture increased during the last decades, especially at the cost of open shrubland and grassland (Hummel et al. 2012). When all these factors are taken together, the increasing pressure on natural resources and soil become obvious.

According to national statistical data for the Mopti region in Mali that Bandiagara belongs to, the total enrolment rate in 2004 was only 50 % (IPE-Mali 2009), while it was slightly higher in Linguère with 55 % in 2006 (ANSD 2007). This is only one of the indicators which cause that both countries are ranked among the 25 least developed countries in the Human Development Index (Malik 2014).

Within the Malian project region the predominant ethnic group are the Dogon, followed by the Peulh (or Fulani/Fulbe). The latter, being also one of the two main ethnic groups around Linguère in Senegal, are traditionally half-nomadic livestock farmers, but are becoming more sedentary. In contrast, Dogon as well as Wolof, who account for the second of the larger ethnic groups in the Senegalese study area, usually cultivate fields. On these fields crops such as millet, sorghum and peanuts prevail, while the livestock is mainly made up of goats, sheep and cattle.

Further occupations of the population include trade, craft and forestry. Keeping in mind that firewood is the main source of energy, its importance and thus the

importance of maintaining these resources becomes apparent. In this context, climatic and anthropogenic influences are very decisive and a sustainable forestry management is likely to become crucial over the coming decades (Ndiaye 2007).

The West African Sahel has been and still is a region where migratory movements are part of everyday life. This applies especially to herders who seasonally move with their cattle to adapt to the environmental conditions. But also, many other social groups chose to migrate for various other reasons. In spite of many medial narratives of an ‘invasion’ of Europe and of human trafficking, research has shown that most migrants move within the country and West Africa and migrations to Europe play a minor role (Spaan and van Moppes 2006; de Haas 2007, 2008).

These characteristics of the study areas, namely the high dynamics in climatic and environmental conditions as well as in demography (with a negative net migration rate) and the population’s high dependency on activities that are strongly affected by land degradation, in particular livestock farming and small-scale agriculture, are the main reasons for selecting these areas (Hummel et al. 2012).

9.3 Research Approach

Forming the basis for the following analyses was a social empirical survey which consisted of two phases. An explorative phase between February and April 2011 with qualitative interviews preceded and prepared for the main phase which lasted from November 2011 until April 2012. Within the latter, 905 standardised interviews were conducted in the study areas Bandiagara and Linguère and with migrants originating from these regions in the capitals Bamako and Dakar. Both qualitative and quantitative data are used to answer questions concerning the perception of environmental changes, their influence on every day life and migration decisions, as well as further motives for migrating and the temporal and spatial patterns of migration.

Nonetheless, in order to gain an integrated view of migration in the project region, it is crucial to consider socio-economic and cultural factors together with environmental factors. While the social and natural sciences have proven methods to analyse the respective factors of their disciplines, the integration of this knowledge poses challenges that require case specific solutions. A productive conceptual framework to guide the identification of relevant factors as well as the development of a customised method is the concept of social-ecological systems (SES) (Hummel et al. 2011; Hummel 2015; Liehr et al. in preparation). By looking at human-nature interactions with special regards to ecosystem services and the security of supply of the population, a central link between both spheres that is very important for migration decisions is covered. Applying this concept allows us to look at migration as a practice adopted to respond to climate change and land degradation. This practice is framed by institutional settings like the respective traditions and cultural norms but also by knowledge on, e.g., migration destinations and social networks (Drees and Liehr 2015). In addition, the SES is able to depict further relevant influences on the environment/migration nexus (Hummel 2015).

Besides the cooperative process of conceptualisation, several methods are used to integrate the social- and natural-scientific work and results of the project. First, we carried out collaborative field work and joint work on developing the questionnaire, then we built the hypotheses and developed scenarios in the interdisciplinary research team, while taking into account stakeholders' opinions. Finally, we incorporated the survey data and (remote-sensing) data on environmental conditions into an integrated model.

Considering the empirically diverse results, there is the need for a model that can handle data flexibly with regard to its origin, type and unit. Furthermore, we have to consider that no matter how well-founded the data appears, a considerable degree of uncertainty will always persist. With Bayesian belief networks (BBN) we chose a modelling method which meets these requirements, since it can incorporate any kind of data from expert assessments to quantitative data, while—due to its probability-based approach—it explicitly addresses uncertainty (Aguilera et al. 2011; Landuyt et al. 2012). Moreover, the graphical expression of the linkages between the crucial factors as a network can be used to communicate with stakeholders and decision makers.

Based on the policy analysis and supported by the modelled results of the scenarios, we made policy recommendations with regard to the major causes of land degradation, possible adaptation strategies—including migration—and the relevant and viable formal and informal institutions.

9.4 Social Empirical Findings

9.4.1 *Perceptions of Climatic and Environmental Change*

For many interviewees the droughts in the 1970s and 1980s are important events that shape their view on climatic and environmental changes. Since the occurrence of these extreme events, and in particular the drought in 1973, most interviewees (55 % of Senegalese and 71 % of Malian) are of the opinion that the rainfall amounts decreased within the last 20–30 years. While approximately one out of four respondents perceived an alternation of rainfall amounts, hardly anyone saw an increase or constancy.

Although the mean annual rainfall amounts are still lower compared to the pre-1970 conditions, recent analyses show that they have been increasing since the 1990s (Brandt et al. 2014a). Since farmers also report decreasing crop yields, these may explain the perceived lower rainfall amounts and thus affect the perception of climatic changes. Still rainfall distribution, degradation or a lack of appropriate fertilisers and seeds may also cause smaller harvests. In particular, irregularities of precipitation within the seasons are often referred to in the qualitative interviews. A further explanation for this contradiction between measurements and perception may be local narratives about decreasing rainfall, as assumed in other studies in the Sahel (Tschakert 2007; Mertz et al. 2009).

More in line are measurements and perception of vegetation trends and diversity. While trends of re-greening as well as of degradation partially occur due mainly to human activities and practices, the diversity of (tree) species has dramatically declined. Both of these developments are documented by interviewees and natural scientific data (Brandt et al. 2014b).

The environmental conditions are of particular importance, since 89 % of the respondents' families rely on agriculture as their main source of income and food supply. Also the main individual economic activity is agriculture—including farming and livestock breeding—and accounts for 67 % of those interviewed in rural areas. Based on the interviews conducted in the capitals, farming is still the most important activity, with 54 % in Mali and 33 % in Senegal. Of the latter, a further 17 % are engaged in livestock breeding.

With regard to the preceding year, the survey asked for negative factors that influenced the crop yields. Of major concern were the lack of rain (69 % in Senegal, 85 % in Mali) and the misdistribution of rain (66 and 36 %). For Senegalese farmers crop pests (50 %) and the lack of seeds (42 %) were also important, and the lack of fertilisers was mentioned by one out of four interviewees in both countries. Additionally, within the qualitative survey a decreasing soil fertility, overexploitation of the soil and, in Linguère, also the general growing scarcity of land due to population growth were named.

9.4.2 *Migration Patterns and Dynamics*

Since the scientific literature does not provide a consistent definition of migration, the project *micle* decided to define migration as 'being absent from the place of origin for more than three months'. This definition complies with the definitions used in the Human Development Report (UNDP 2009) and the Foresight project (Foresight 2011). Based on this definition the majority (87 %) of those interviewed in the study areas have migrated, which substantiates the assumption that migration is an inherent part of everyday life in the study area. Because factors like educational level and economic activity do not show a significant influence on the migration experience, it can be stated that migration is a phenomenon across all social strata. However, within the Malian study area the gender of a resident plays an important role regarding the migration experience. While 80 % of the Senegalese men and 78 % of the Senegalese women left their home villages for more than 3 months, only 70 % of the women but 94 % of the men from Bandiagara migrated. As many interviewees confirm, the main reason for this unequal distribution is the traditional way of life and associated restrictions that deny women the opportunity to migrate. This applies especially to the middle and the last decades of the last century, but gradually these restrictions are lifted.

The duration migrants stay at their destination before returning to their place of origin or moving to another destination is in many cases less than a year. People often (40 %) leave after the harvests as seasonal migrants and return before the next

harvest (3–9 months). Temporary migrations from 10 months up to 5 years occur more often in Mali (46 %) than in Senegal (28 %) where, on the other hand, permanent migrations (more than 5 years) are more common (33 vs. 14 %). Notable differences by gender can only be observed for Mali, where 49 % of men migrate seasonally (compared to 22 % of women) while only 9 % do so permanently (24 % of women). Strikingly, seasonal migration also accounts for nearly 50 % of the migrations during the droughts in the 1970s and 1980s.

If we consider the destinations of migration it is apparent that international migrations account for a rather small number of migrations from Senegal, while many (25 %) Malian migrants cross the national border to the Ivory Coast. Figures 9.2 and 9.3 show the percentages of migrants in the national regions and in foreign countries

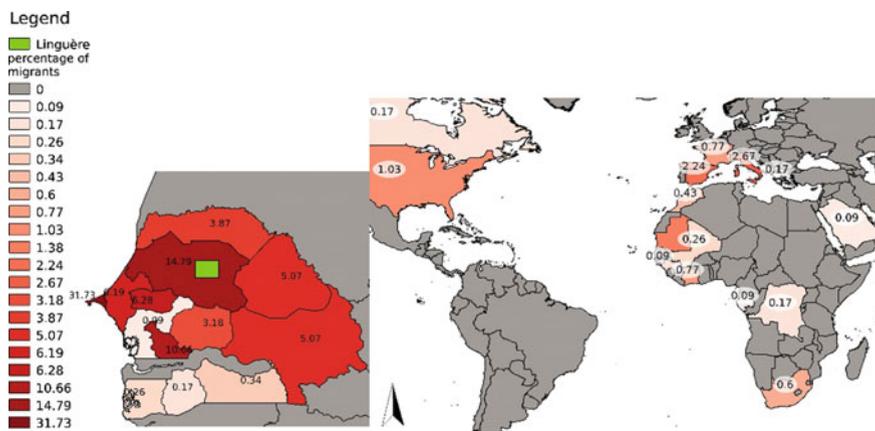


Fig. 9.2 Frequency of migrations from Linguère to Senegalese regions (*left*) and other countries (*right*)

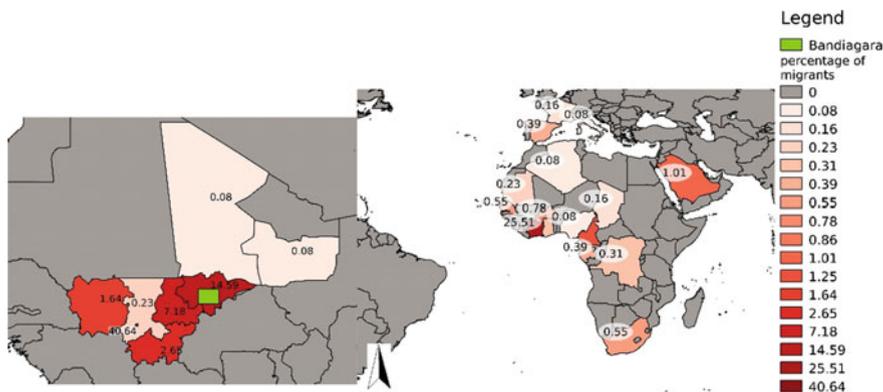


Fig. 9.3 Frequency of migrations from Bandiagara to Malian regions (*left*) and other countries (*right*)

(numbers represent migrations of the interviewees and their relatives). Both figures reveal that besides the region of origin, the capitals Dakar and Bamako in particular attract most of the migrants (categories up to 31.73 and 40.64 %). Furthermore, it is obvious that migrations to Europe are (especially for Malians) of minor importance. In contrast, when we summarise the data for the ten biggest cities of both countries, they account for nearly 60 % of the interviewees' destinations.

9.4.3 Migration Motives

Although migratory movements can hardly be explained by single causes, the vast majority of migrants (65 %) name the search for money and jobs as one of the main motives for migration. Only the few interviewees that have completed secondary school (about 10 % of all interviewees) name education as the most important motive for migration. Further differences exist between men and women. Although economic motives are dominant for both of them, they are noticeably less frequent for women who more often migrate for familial reasons or to visit someone. On the other hand, 15 % of the men, compared to 4 % of the women, name education as a migration motive. Moreover, the qualitative interviews revealed the importance of relatives and friends that live at the destination. These social networks help to reduce costs and risks of migration and thus foster chain migration.

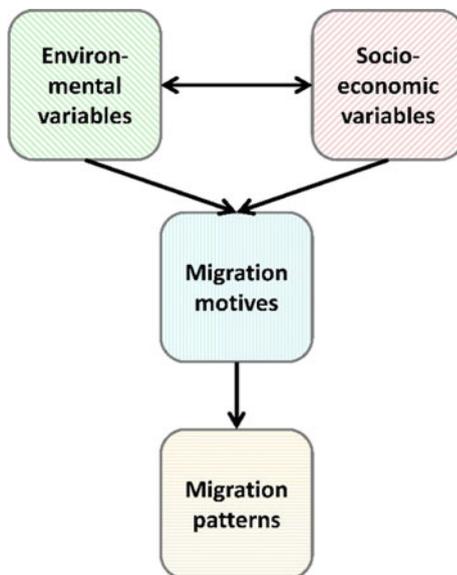
This view of the motives for migration shows the importance migrations have for a household's livelihood. Besides other strategies like selling animals or mutual help between neighbours, migration is an important measure to diversify the household's income in years with poor harvests. In this sense migration serves as a coping strategy or an immediate reaction to bad conditions and as an adaptation strategy for income diversification in the long run.

9.5 Modelling and Scenarios

9.5.1 Modelling Procedure

In order to get a better understanding of the complex interactions between socio-economic and environmental conditions, we adopted an integrative modelling approach using Bayesian belief networks (BBN), which complements and combines the natural and social scientific results. The conceptual framework on which the modelling process is based is shown in Fig. 9.4. The environmental and socio-economic variables interact and affect the motives for migration, which influence the decision to migrate and the spatial and temporal patterns of migration. While the environmental variables mainly encompass data on land cover and precipitation, the socio-economic variables are, on the one hand, biographical facts like age and

Fig. 9.4 Conceptual framework of the BBN



gender, and on the other hand, socio-economic aspects like occupation and education. The main migration motives, which were identified due to their correlation with characteristic patterns of migration, are *education*, *family*, *sustenance/employment* and *visit/curiosity*. Finally, the migration patterns are classified as follows: in accordance with the social empirical survey the duration of migration is classified into *seasonal*, *temporal* and *permanent*. The destinations comprise the categories *capital*, *within region of origin* and *distant destinations*.

The first and vital step for the following modelling procedure is the integration of social empirical and environmental data. The basis for this lies in the social empirical survey that provides the data for the socio-economic variables, the migration motives and patterns. It must be stated that the data refers only to the first migration experiences, since the points of departure for following migrations are not necessarily within the study area. In order not to distort the migration rates, the interviews conducted within the capitals (with people originating from the study areas) were excluded, since these interviewees had necessarily already migrated. Subsequently, the environmental conditions at the interviewees' place of origin are defined by calculating the average value of the mapped data on land cover and precipitation within a radius of 3 km around the respective village (spatial intersection). Variables that can be assigned to a specific year are furthermore aligned with the year of migration (temporal intersection).

Based on the identified motives for migration, four submodels are constructed. For the migration motives *education*, *family* and *visit/curiosity*, only socio-economic variables were chosen as potential influencing variables or parent nodes, as the term used for BBN. On the other hand, the motive/child node *sustenance/employment* is also influenced by environmental variables. By using an iterative process of

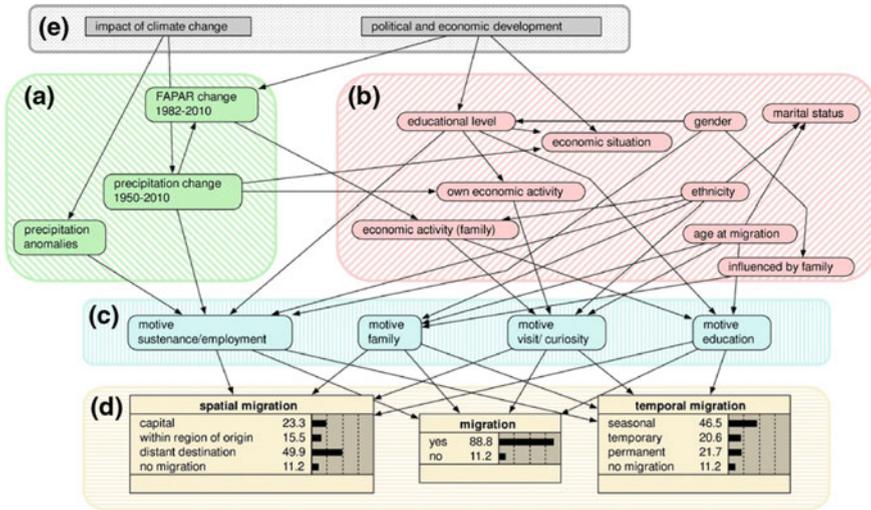


Fig. 9.5 Trained BBN for Linguère with interacting environmental (*rectangle a*) and socio-economic factors (*b*) affecting the migration motives (*c*) that influence the migration patterns (*d*). For the latter probability distributions are included, which exist—except for the scenario nodes—also for the other nodes. The nodes in *rectangle e* represent the scenario axes and they, as well as their linkages, are not part of the basic model (*source*: Drees and Liehr 2015)

sensitivity analyses and train-and-test method, the parent nodes were gradually reduced from all potential variables to those variables that are most sensitive to changes of the migration motive and possess the highest predictive accuracy. Finally, all submodels are combined in one main model on the basis of the interrelations between the influencing variables that are also linked to result in the final network structure. These steps were conducted for each study area in order to construct individual models for both areas (for a detailed description of the modelling procedure see Drees and Liehr 2015).

The final structures of the BBNs for Linguère and Bandiagara, shown in Figs. 9.5 and 9.6, are trained with the complete dataset. By applying the EM (expectation maximisation) algorithm, which is incorporated into the software Netica™, Version 5.12 (Norsys 2014) which was used, we take account of gaps in the dataset.

9.5.2 Analytic and Diagnostic Reasoning/Findings

Once the networks are trained, they can be used to perform manifold analyses (estimating the probable consequences of certain conditions) and diagnoses (estimating the probable conditions for certain consequences).

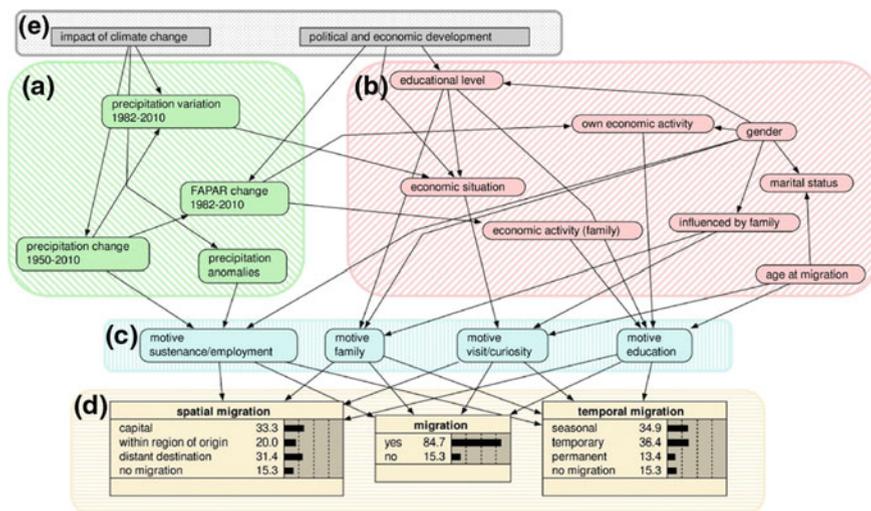


Fig. 9.6 Trained BBN for Bandiagara with interacting environmental (*rectangle a*) and socio-economic factors (*b*) affecting the migration motives (*c*) that influence the migration patterns (*d*). For the latter probability distributions are included, which exist—except for the scenario nodes—also for the other nodes. The nodes in *rectangle e* represent the scenario axes and they, as well as their linkages, are not part of the basic model (*source*: Drees and Liehr 2015)

With regard to the structure of BBNs, it can be stated that the most important influencing nodes in both models for Linguère and Bandiagara are similar. The major difference is caused by the absence of the node *ethnicity* within the network for Bandiagara, due to the fact that 98 % of the interviewees belonged to one ethnic group (Dogon). The presence/absence of *ethnicity* in the networks can be further seen as a major cause for differing linkages among the social-ecological variables, as well as between them and the migration motives (see Table 9.1; Figs. 9.5 and 9.6). Moreover, important differences arise for the probabilities of the *motive family* and *distant destinations*, both being more likely within Linguère, and the duration of migration. For the latter, temporal migrations in Bandiagara are more likely compared to Linguère at the expense of the probabilities for seasonal and permanent migration patterns (Table 9.1).

Examples of analyses performed with the BBNs are estimations of the consequences of varying environmental and economic conditions that can be modelled by selecting certain states of the corresponding variables. For unfavourable conditions these could be poor economic situation, negative precipitation anomalies and decreasing long-term changes of land cover and precipitation. More favourable conditions, accordingly, are modelled by selecting contrasting states. These analyses show that no change in the intensity of migration can be observed for deteriorating conditions, although an increase in migration rates is often assumed within assessments on a broader spatial and temporal scale (WBGU 2007; UNEP 2011) or are a

Table 9.1 Major differences between the models for Linguère and Bandiagara

	Linguère	Bandiagara
Unique nodes	Ethnicity	Precipitation variation 1982–2010
Major differences in the important linkages (<i>parent node/s</i> → <i>child node/s</i>)	Gender → educational level/familial influence	Gender → educational level/familial influence/own economic activity/marital status
	FAPAR change/ethnicity → economic activity (of the family)	FAPAR change → economic activity (of the family)
	Ethnicity/age at migration → motive family	Gender/educational level → motive family
	Gender/ethnicity/educational level → motive sustenance/employment	Gender → motive sustenance/employment
Major differences in the migration motives (<i>prior probabilities</i>) (%)	Motive family: 53 %	Motive family: 22 %
Major differences in the migration patterns (<i>prior probabilities</i>) (%)	Distant destinations: 48 %	Distant destinations: 32 %
	Seasonal migration: 45 %	Seasonal migration: 35 %
	Temporal migration: 23 %	Temporal migration: 36 %
	Permanent migration: 20 %	Permanent migration: 13 %

main hypothesis in local or national studies (in the Sahel), albeit rarely confirmed (Findley 1994; Henry et al. 2004). Nonetheless, our analyses reveal that the migration motives and patterns change in cases of less favourable environmental conditions. While the motive sustenance/employment, non-permanent migrations and distant destinations become more likely in this case, on the other hand, improved conditions increase the probabilities for the motive education, permanent migrations and migrations within the region. These changes in migration patterns are also stated in various other studies (Black et al. 2011). Interestingly, Afifi (2011) finds an opposing effect to our results—as well as to other studies (e.g., Findley 1994)—with an increase in long-term and permanent migration in Niger in case of deteriorating environmental conditions. However, in the latter case the deterioration of environmental conditions seems to be of a higher magnitude than in our study.

Similarly, diagnoses can be performed by selecting certain patterns of migration which result in changing probabilities within the influencing variables. Thus, an inverted approach of selecting *seasonal migrations* to *distant destinations* yields corresponding results for the conditions and moreover shows that men are more likely to have these migration patterns than women.

9.5.3 Scenario Analysis

In a further step we developed scenarios with a time horizon of about 50 years to use the knowledge gained in the models about dependencies and characteristics of migration, in order to assess the effect of alternating future conditions on migration. We identified two axes with two states each that frame the different scenarios. The first axis represents the *regional impact of climate change* and the second axis the *political and economic development* (grey nodes in Figs. 9.5 and 9.6). The four combinations of the states of the scenario axes form the four scenarios that were described in consistent storylines in view of the probable changes in fields like agriculture, politics, economy, demography and environment (for a detailed description of the scenarios see Drees and Liehr 2015).

Beginning with economic growth and institutional stability, the two scenarios *Limitation* and *Prosperity* are characterised. While in the *Limitation* scenario the good progress in most sectors is limited by the severe impacts of climate change, the relatively stable climatic conditions in the *Prosperity* scenario foster unconstrained favourable developments. If economic stagnation and institutional instability and severe regional impacts of climate change coincide in the scenario *Crisis*, a stagnating development and threats due to climate change lead to a partial worsening of the people's situation. The final scenario *Stagnation* is characterised by a stagnating political and economic development that prevents gains from relatively favourable climatic conditions (low regional impacts of climate change).

To implement the scenarios in the existing models, both scenario axes are included as decision nodes in the networks. By manually choosing between the two states of each decision node the four scenarios can be implemented. The interfaces to the influencing variables in the BBN were identified as follows: *political and economic development* is linked to *economic situation*, *educational level* and *FAPAR change* (representing land cover); *impact of climate change* is linked to nodes that relate to rainfall. While *Stagnation* serves as a baseline scenario that represents the status quo in the BBN, the other scenarios are expressed by adjustments of the conditional probabilities of the linked variables. These adjustments are implemented according to the briefly outlined storylines.

The modelled results for the scenarios demonstrate that changes in the economic and political situation are likely to have a greater impact on migratory movements in both study areas. Again, no considerable changes in the overall migration rates can be observed for any scenario. If, compared to the baseline scenario, only the pressure due to climatic conditions intensifies (*Crisis*), merely minor changes can be observed for the BBN for Bandiagara, while there are small increases in the probabilities for the motive *sustenance/employment* and *distant destinations* in Linguère. In contrast, the scenarios *Limitation* and *Prosperity* yield noticeably increasing probabilities for permanent migrations to destinations *within the region of origin* and for the migration motive *education*. In the case of Bandiagara the motives *family* and *visit/curiosity* also become more likely, whereas in the case of Linguère, notably the probability of the motive *sustenance/employment* decreases.

Differences between these two scenarios are small and thus substantiate the comparably low impacts of climatic changes.

In conclusion, the complex social-ecological interdependencies affecting migration in the study area become apparent in the modelling. Even though socio-economic conditions are most relevant, climatic changes are likely to affect people's livelihood and thereby their migration decisions and resulting migration patterns, not least because of the great importance of agriculture. Above all, this becomes apparent in the effect the social-ecological conditions have on the migration motives and the possibilities for households to react to bad conditions (i.e., short-term migrations) or to develop lasting adaptive measures (i.e., through education). This crucial distinction between "ex ante risk-management" and "ex post coping strategy" (Rademacher-Schulz et al. 2014: 51) is further discussed below.

9.6 Role of Policies

People's mobility in Mali and Senegal in the context of climate and environmental change depends on different international, regional and national policies in the fields of migration, development and environment. Thus, in order to identify possible starting points for political strategies and regulation, a perspective that considers the different political scales and sectors is needed.

Different sub-regional initiatives, treaties and regulations are significant for the regulation of migration in the West African Region, such as the ECOWAS (Economic Community of West African States) Common Approach on Migration. Formally, ECOWAS citizens have the entitlement to enter freely, reside and settle in member states. Notwithstanding that the implementation of this policy remains difficult (Awumbila et al. 2014), migrants from the Malian *micle* study area of Bandiagara, for example, can legally move to Ivory Coast for labour purposes.

Senegal and Mali seek to embed migration management in development strategies and have multiplied their efforts to cooperate internationally, mainly with the European Union and several other European countries (Sieveking and Fauser 2009; Trauner and Deimel 2013). 'Mobility partnerships', for example, offer temporary access to the EU labour market in exchange for cooperation on irregular migration (Some 2009). Overall, the EU migration policy is ambivalent: on the one hand, and above all, it is restrictive and control-oriented, and on the other hand, it is preventive and seeks to combat the root causes of migration such as poverty through policies of 'co-development' in bi-lateral programmes between Mali and Senegal and France, Spain and Italy. Hein de Haas (2007) described co-development programmes as "de facto 'return and stay at home' policies" (de Haas 2007: 289), since their primary goal was the circumvention of immigration. But there are also examples from Malian and Senegalese diaspora organisations whose members maintain strong relationships with their villages of origin and contribute significantly to the latter's development in the form of remittances as well as investments in water and energy supply systems, health care and school facilities (Scheffran et al. 2012).

Yet, the findings of our social-empirical study revealed that migration to Europe is rare (see Figs. 9.3 and 9.4) and that the majority of movements take place within the countries or the West African region. Therefore, the governments of Senegal and Mali face the challenge to develop adequate policies for sustainable regional development that consider the role of migration. In this regard, the set of Poverty Reduction Strategy Papers (PRSP) are important policy instruments. PRSP have been introduced in Mali and in Senegal and represent mid-term political strategies affecting education policy, the health sector, rural development policies, and environmental policies (for a detailed description see Hummel 2015). While the role of international and internal migration for development and poverty reduction is differently treated in the PRSPs in Mali and Senegal, the PRSPs of both countries suggest that rural development initiatives constitute important means to address internal migration. These initiatives should particularly focus on the improvement of living conditions and professional skills of the youth (Black and Sward 2009). The governments of Mali and Senegal have introduced several programmes for regional rural development, of which some explicitly seek to repel rural out-migration. One example is the Return to Agriculture Programme (Retour vers l'agriculture', REVA) in Senegal, which was established in 2006 in response to an increase in rural outmigration. It aims at a modernisation of agriculture and the creation of attractive job opportunities for young people which allow them to stay in their villages or to return home. So far, the impacts of such programmes are ambiguous. It must be considered that rural development measures can also lead to increased migration because they provide people with the incomes and monetary means that are necessary to migrate. As de Haas (2007: 833) has argued, "Poverty reduction is not in itself a migration-reducing strategy (...); alleviating absolute poverty and achieving some degree of 'development' in the form of increasing income, education and access to information not only enable but also motivate more people to go abroad. As long as aspirations increase faster than the livelihood opportunities in sending regions and countries, social and economic development will tend to coincide with sustained or increased out-migration".

Thus, some young people might decide to stay in their villages if they can benefit from an occupation in agriculture that generates adequate incomes. Our social-empirical analysis however revealed that particularly for young and better educated people farming is not very attractive; instead, they aspire to an occupation outside the agricultural sector (van der Land and Hummel 2013). Given these findings, programmes for rural development that focus only on improvements in the agricultural sector seem to fall short of people's demands, particularly those of the younger generation. Equally important for rural development strategies are non-farming employment opportunities, notably to provide incentives for people with higher education and formation. As our findings reveal, the social-ecological transformations in the study areas are associated with new patterns of relationships between rural and urban developments. Therefore, 'rural-urban linkages' (Bah et al. 2003; Tacoli 2003), including not only the improvement of employment opportunities, but also the enhancement of basic social services and infrastructure, should be taken into account by developing policy measures and regional planning.

9.7 Critical Discussion of Migration as an Adaptation Strategy

9.7.1 Migration as an Adaptation Strategy

Within the nexus of climate change, environmental changes and migration, the latter is often regarded as an adaptation strategy to the former, and in this sense as a response to occurred or expected climatic and environmental changes (Rademacher-Schultz et al. 2014). This view is substantiated by a number of studies (McLeman and Smit 2006; Banerjee et al. 2012; IPCC 2014a), some of which explicitly refer to the Sahel (Findley 1994; Niang et al. 2014), and it can also be derived from the results of the *micle* project. Despite this evidence, our findings further show that this view has to be critically discussed, because it bears the risk that historical and cultural characteristics of migration may be overlooked.

First of all, it has to be clarified for whom migration can serve as an adaptation strategy. This can be regarded in at least two respects: First, the question arises whether migratory movements are an individual or a collective adaptation strategy. On the basis of the qualitative and quantitative surveys we conducted, migration can primarily be considered as a strategy for families or households to diversify their income. The reported cooperation between households as well as further studies indicates that to a certain extent this can also be conferred on the community level (Gioli et al. 2014). Second, it is questionable who is able to take advantage of this strategy. As Adger et al. (2009) and Gioli et al. (2014) note, there are social and economic restrictions to adaptive behaviours. In this context, it is also important to point out the difference between adaptive and coping measures. While the former is a long-term strategy to place the household's income on a broader basis and to fall back on remittances in case of unfavourable conditions like crop failures, a coping measure can be seen as an immediate response to bad conditions (Rademacher-Schulz et al. 2014). Our findings (see Sect. 9.5.2: Analytic and diagnostic reasoning) show that this distinction leads to differing patterns of migration regarding its duration and destination. An effective strategy for a long-lasting adaptation to climate change is education, which increases the possibilities for diversifying the household's income. It is clear from our results that those households with a higher educational level and in a better economic situation (can) support migration of family members to acquire education (van der Land and Hummel 2013).

Moreover, the conditions that cause families to think about adaptation strategies should not be reduced to environmental and climatic influences, but especially political and economic conditions affecting the families' livelihood have to be considered, in order not to depoliticise the discourse. Also the further diverse strategies to compensate for bad harvests should be regarded. Within the study area these are especially selling of animals, fruits, herbs and wood, gardening (especially in Bandiagara), taking up a loan and mutual aid between neighbours (Hummel 2015).

Finally, coming back to historical and cultural characteristics, familial concerns are not unilaterally restricted to sustenance, nor are individual prospects and wishes

irrelevant for migration decisions (Findley 1994). Further, migratory movements have always been and are likely to remain a normal phenomenon in everyday life in the study area. The academic challenge is to disclose these different factors that often come together and mutually overlap (Black et al. 2011).

9.7.2 Overlap of Social and Environmental Factors

The results of the analysis show that both social and environmental factors have a significant effect on the migration pattern for the interviewed persons at the project regions of Linguère and Bandiagara. Although these dependencies of migration patterns have been reported in other studies as well (e.g., Findley 1994; Afifi 2011; Black et al. 2011), our modelling approach is one of the few attempts to integrate social and natural scientific data for analysis and provides results that go beyond the mere stating of changing patterns. As argued on the basis of the results of our analysis, changes in the social-ecological conditions are linked to changes in migration pattern and thus to the responses of the people. Here, social factors dominate the environmental factors as they apparently exhibit a higher degree of relevance for migration decisions in the given setting. This would not hold true for environmental extremes which are not considered here. Two reasons for the dominance of social factors have been identified: first, migration decisions only partly depend on motives like sustenance and employment which clearly relate to environmental conditions for rural societies. The majority of motives for migration like education, family (familial reasons), curiosity and tradition are strongly shaped by socio-cultural aspirations. Here, social dynamics with communication, institutions, norms and rules, but also the effects of urbanisation and modernity play decisive roles in the decision processes. Second, social factors can mask environmental factors behind them. This is the case if motives for migration are seen in the background of their obvious social influences, but without reflecting, differentiating or explicating the environmental factors behind them (cf. Afifi 2011). The effect is that environmental factors are in the second or third order, meaning that they are overstamped in their importance and relevance by social factors. In effect, environmental factors are part of a complex chain of interactions (Veronis and McLeman 2014)—which can also be seen within the network structure of the BBNs. The analysis of systematic structural dependencies is difficult for such factors of higher order because data and information are subject to a high degree of uncertainty but also ignorance due to their inherent complexity.

Although social factors seem to outbalance the environmental ones, the latter should not be underestimated in their importance for migration decisions. Situations of climatically and environmentally induced stress can lead to conflicts and affect norms and rules, but may also change the attractiveness of alternative livelihoods. Those interrelations need to be considered in the discussion and development of future policies.

9.7.3 Policy Considerations and Outlook

The findings of our study confirm that climatic and environmental changes can indeed have effects on the mobility of the people (see Sect. 9.5.2: Analytic and diagnostic reasoning). However, the relationship between climate, environment and migration is complex, and environmental stress is usually not the most important factor causing people to migrate.

Mobility is traditionally a part of the culture and every day life in West Africa, and thus the suppression of migration does not represent an adequate political option. Instead, policies should make use of the positive potential of migration for sustainable regional development. Such policies could build upon already existing “co-development” approaches which support the transfer of remittances, knowledge, as well as investments of migrants in the areas of origin. In the rural areas, investments in sustainable agriculture are necessary, which should be accompanied by measures that create income and employment opportunities, not just within agriculture, but also in other economic sectors. Therefore, integrated regional development strategies which focus on linkages between urban and rural areas are required. For example, they should consider infrastructure development and the promotion of integrated land and water resources management for the prevention of land degradation. Furthermore, chances in life, particularly for the young generation, need to be increased, including better education opportunities. Against this background, there is the need for cross-sectoral strategies which integrate issues of migration, socio-economic development and environment, and which consider the participation of relevant societal actors and stakeholders.

In summary, the positive effect of migration on the adaptive capacities of households could be further supported by governments and administration in order to build up infrastructure for transport, public health, IT, etc. This could be a key to making communities less dependent on agriculture, which means that migration serves as a long-term strategy for securing wellbeing instead of a short-term response. In this case, migration also develops into a persistent societal response regarding the effects of climate change and land degradation.

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