Managing social-ecological systems for resilience:Fisheries in the small reservoirs of northern Ghana

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To my wonderful family.

ABSTRACT

People in northern Ghana face an increasing number of challenges such as social change, political neglect, globalization and a lack of income generating alternatives. On top of this difficult situation they have to adapt to an increasing number of extreme climatic events that threaten the income from rainfed agriculture, their most important livelihood strategy.

Hundreds of small multi-purpose reservoirs were built during the past 60 years to help the rural population deal with the difficult environmental conditions by enhancing flexibility and diversifying income sources. Fisheries in these reservoirs were assumed to be a rather incidental benefit. Growing uncertainty and difficulty in organizing a livelihood make it necessary to consider all of the possible uses of small reservoirs, including the use of small reservoirs for fisheries. This study aims to contribute to the resilience of the rural poor in the Upper East Region of Ghana to environmental disturbances through improved understanding of the potentials of fisheries in small reservoirs. Resilience is thereby understood as the potential to create opportunities for doing new things, for innovation and development, even, or especially, during times of disturbance or crisis.

Results are based on empirical findings from three case studies. The first of three analytical steps focused on how fishing in small reservoirs and selling the catch influences the opportunities for doing new things, for innovation and for development. The second step analyzed the ecological potentials of the small reservoirs to provide aquatic resources. The third dimension of the analysis used the concepts provided by social network analysis to check the social potentialities for innovation and development necessary to realize the ecological potential of the reservoirs for improved human well-being.

Results show that for most of those involved in fisheries, the income from these activities is among the three most important livelihood strategies and the income from fishing is lifting about 15% of the economically active male population in the study communities out of absolute poverty. Furthermore, the income from fishing and selling fish can be used to invest in other livelihood strategies, such as farming and gardening.

The analysis of the fishermen's local ecological knowledge shows that the small reservoirs have a natural fish production. Considering that there are a vast number of reservoirs not yet used for fishing, this means that many communities have a source of income and protein at their feet. With some training and access to gear, the resilience of many thousands of families could be increased, simply by using the naturally occurring aquatic resources in the reservoirs. Technical solutions to enhance fish production further are available at low cost. Unfortunately, the data base did not, however, allow an exact prediction of the reservoirs' potential fish production.

This is exactly the starting point for an adaptive co-management approach, which is designed for the work under high uncertainty. Yet the approach has a number of pre-requisites that need to be fulfilled in order to manage reservoirs for increased production. Results of the social network analysis show, however, that the implementation of a new management approach would be challenged by a lack of political will and funding. The analysis further reveals clashing traditional, governmental, and participatory management strategies, as well as generational conflicts, bad leadership and distrust. These problems are fortified by strong competition for water amongst the various water users, and low capacity of the communities to organize water use and maintenance of the infrastructure.

Three development scenarios at the end of this study show that if no steps are taken to improve the situation, the scope of fisheries as a livelihood strategy to increase resilience remains limited. Yet if cooperation between science, politics and local stakeholders can be established to overcome problems of management, fisheries in small reservoirs have a great potential to strengthen the resilience of the local population.

KURZFASSUNG

Management sozial-ökologischer Systeme für mehr Resilienz: Fischerei in den kleinen Reservoiren Nordghanas

Die ländliche Bevölkerung in Nordghana muss sich einer Vielzahl von Herausforderungen, wie sozialen Veränderungen, politischer Vernachlässigung, Globalisierung, sowie einem Mangel an alternativen Einkommensquellen, stellen, um ihren täglichen Lebensunterhalt zu sichern. Zusätzlich zu diesen Problemen kommt eine steigende Anzahl klimatischer Extreme, wie Dürren und Überschwemmungen, die ihre Haupteinkommensquelle, den Regenfeldbau, bedrohen.

In den letzten 60 Jahren wurden hunderte kleine, vielfältig nutzbare Reservoire gebaut, um für die wachsende Bevölkerung Einkommensalternativen zu schaffen, vor allem im Bewässerungsfeldbau und durch größere Viehherden mittels zusätzlicher Tränkmöglichkeiten. Die Nutzung der Reservoire für die Fischereiwirtschaft hingegen rückte bisher kaum ins Blickfeld. Ständig zunehmende Unsicherheiten und Probleme bei der Sicherung des Lebensunterhaltes machen es jedoch notwendig, alle möglichen Nutzungen der Reservoire zu erwägen, einschließlich der Fischerei. Durch ein besseres Verständnis der Potentiale der Fischerei in kleinen Reservoiren, möchte die vorliegende Studie zur Stärkung der Resilienz der lokalen Bevölkerung gegenüber den immer extremer werdenden Umweltbedingungen beitragen. Angelehnt an Folke (2006) wird Resilienz als Potential verstanden sich, trotz umweltbedingter Störungen und Krisen, neue Möglichkeiten zu erschließen sowie als Potential für Innovation und Entwicklung.

Die Ergebnisse basieren auf empirischen Erkenntnissen aus drei Fallstudien an Reservoiren in der Upper East Region, Ghana, welche in unterschiedlicher Intensität fischereilich genutzt werden. Der erste von drei Untersuchungsschritten ist auf die Art und Weise fokussiert, wie sich das Fischen und der Handel mit Fisch auf die Potentiale neue Möglichkeiten zu erschließen auf Innovation und Entwicklung auswirkt. Der zweite Schritt analysiert das ökologische Potential der kleinen Reservoire hinsichtlich der Bereitstellung aquatischer Ressourcen. Mittels Konzepten der sozialen Netzwerkanalyse werden im dritten Untersuchungsschritt die sozialen Potentiale analysiert, die notwendig sind, um durch Innovationen bzw. verbessertes Management die ökologischen Potentiale der Reservoire zu realisieren.

Die Analyse des lokalen, ökologischen Wissens der Fischer zeigt, dass sich nach dem Bau der kleinen Reservoire eine natürliche Fischpopulation etabliert. Dennoch gibt es in Nordghana hunderte Reservoire, die fischereilich nicht genutzt werden, da den Menschen weder Know-how noch Fischereiausrüstung zur Verfügung stehen. Die drei Fallstudien zeigen aber, dass Fischerei sich, wenn Zugang zu Know-how und Fischereiausrüstung besteht, zu einer wichtigen Einkommensquelle entwickelt kann, die immerhin 15% der männlichen, ökonomisch aktiven Bevölkerung aus der absoluten Armut hilft. Darüber hinaus hat sich Fisch zu einer wichtigen Ergänzung im Speiseplan entwickelt. Zudem kann das Einkommen aus der Fischerei und aus dem Verkauf von Fisch in alternative Lebenssicherungsstrategien investiert bzw. extreme Hungerzeiten können abgefedert werden.

Kostengünstige, technische Lösungen zur Optimierung der natürlichen Fischpopulationen stehen ebenfalls zur Verfügung und könnten die Erträge steigern. Konkrete Vorraussagen zu potentiellen Steigerungsmöglichkeiten sind indes schwierig, da extrem variable Umweltbedingungen einer sehr schwachen Datenbasis bezüglich Fischproduktion in kleinen Reservoiren gegenüberstehen. Ein anpassungsfähiger Managementansatz, wie zum Beispiel vorgeschlagen von Berkes et al. 2001, berücksichtigt solche unsicheren Umstände, und empfiehlt auf unterschiedlichen Arten von Wissen aufzubauen und aus Fehlern und Erfolgen zu lernen. Eine erfolgreiche Umsetzung des Management-Konzeptes benötigt aber bestimmte Voraussetzungen, wie etwa good leadership, Vertrauen oder auch eine gemeinsame Vorstellung vom Ziel des Managements.

Die Ergebnisse der sozialen Netzwerkanalyse sowie die Auswertung historischer Daten deuten auf mangelnden politischen Willen sowie fehlenden Finanzierung als Hindernisse auf dem Weg zu einem verbesserten Fischereimanagement hin. Desweiteren zeigt die Analyse, dass sich traditionelles und staatliches Ressourcenmanagement nicht einfach mit neueren, demokratischen Managementansätzen vereinbaren lässt. Schlechte Führung der Fischereigemeinden sowie Konflikte zwischen jungen und alten Fischern resultieren in massivem Misstrauen, welches eine koordinierte fischereiliche Bewirtschaftung der Reservoire unmöglich macht. Auch die Dorfgemeinschaften sind mit der Organisation der verschiedenen Wassernutzungen und der Instandhaltung der Infrastruktur überfordert, und durch die Knappheit des Wassers entsteht eine starke Konkurrenz unter den verschiedenen Wassernutzern, welche die ohnehin schwierige Situation verschärft.

Drei deskriptive Entwicklungsszenarien am Ende der Studie zeigen, dass mit Zugang zu Know-how und Fischereiausrüstung die wirtschaftliche Nutzung der natürlichen Fischpopulation in den Reservoiren gesteigert und somit die Resilienz der lokalen Bevölkerung erhöht werden könnte. Die Möglichkeiten der Fischerei als eine Strategie zur Lebenssicherung bleiben allerdings beschränkt, sofern die problematische Situation im Fischereimanagement nicht verbessert wird. Eine gleichberechtigte Kooperation von Wissenschaft, Politik und lokalen Nutzern könnte helfen, die Managementverdrossenheit zu überwinden. Die Fischerei in kleinen Reservoiren könnte dann ihr Potenzial zur Stärkung der Resilienz der ländlichen Bevölkerung gegenüber den eingangs erwähnten Problemen entfalten.

LIST OF ACRONYMS

AES	Agricultural Extension Services
asl	above sea level
CIDA	Canadian International Development Agency
CP6	Challenge Program on Water and Food Project No. 6: Strategic Innovations in Dryland Farming
DA	District Assembly
DACF	District Assembly Common Fund
DANIDA	Danish International Development Agency
DDT	Dichlordiphenyltrichlorethan
DO	Dissolved Oxygen
EC	Electrical Conductivity
EU	European Union
FAO	Food and Agriculture Organization
F/C ratio	Forage / Carnivore ratio
FFHC	Freedom from Hunger Campaign
GHS	Ghanaian cedi
GIS	Geographic Information System
GLOWA	Global Change and the Hydrological Cycle
GLSS	Ghana Living Standard Survey
GPS	Global Positioning System
GSS	Ghana Statistical Service
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
GVP	GLOWA Volta Project
ICOUR	Irrigation Company of Upper Regions
IFAD	International Fund for Agricultural Development
IDA	Irrigation Development Authority
ISOE	Institute for Social-Ecological Research
ISSER	Institute of Statistical, Social and Economic Research

LACOSREP	Land Conservation and Smallholder Rehabilitation Project
LEK	Local Ecological Knowledge
MLFM	Ministry of Lands, Forestry and Mines
MODIS	Moderate Resolution Imaging Spectroradiometer
MoFI	Ministry of Fisheries
MoFA	Ministry of Food and Agriculture
NGO	Non-Governmental Organization
PEM	Protein Energy Malnutrition
PRA	Participatory rural appraisal
SAP	Structural Adjustment Program
SES	Social-Ecological Systems
SNA	Social Network Analysis
SRTM	Shuttle Radar Topography Mission
SSID	Small-Scale Irrigation Division
TDS	Total Dissolved Solids
UER	Upper East Region
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
URADEP	Upper Region Agricultural Development Project
WRI	Ghanaian Water Research Institute
WUA	Water User Associations
ZOVFA	Zuuri Organic Vegetable Farmers Association

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1 INTRODUCTION

1.1 Problem statement and aim of the study

Poverty in Ghana is declining at a rate that gives rise to hope that Ghana could be one of the few African countries to reach the first of the United Nation's Millennium Development Goals by halving the proportion of its population living in poverty. Spatial disaggregation of poverty figures, however, shows that while southern Ghana is flourishing, in northern Ghana poverty is stagnating or even increasing. This includes food insecurity and especially protein energy malnutrition, which causes growth retardation and underweight and even contributes to child mortality (Van de Poel et al. 2007).

The reasons explaining the situation are numerous and diverse. One popular explanation is the increase in extreme climatic events in the region. Disastrous events such as the floods of 2007 in northern Ghana seem to provide an informative basis for this explanation. Likewise alarming are the dwindling natural resources such as marine fish stocks (Atta-Mills et al. 2004), which are the most important source of protein in Ghana. Wild terrestrial mammal stocks, used as a secondary source of animal protein, are likewise on the decline. Brashares et al. (2004), for example, found in six forest reservoirs, three of them in northern Ghana, a decline in wildlife biomass from 110 kg per capita in 1970 to 12 kg per capita in 1999. In the densely populated non-reserve areas in the Upper East Region (UER) the biomass is probably much less.

Yet the impact of global climate change on Ghana and other phenomena of environmental change are discussed controversially. Furthermore, it is important to note that people in the area are used to a difficult and uncertain environment and have adapted to it over hundreds of years. Their adaptive capacity becomes, for example, evident in the ongoing diversification of livelihood strategies.

Unfortunately, the environment causes only some of the uncertainties and challenges which human communities face. Political neglect, globalization and other challenges seem to overtax their capacity to cope and adapt and also improve their living conditions in the process. In addition, the alternatives to the traditional livelihood strategies i.e. rainfed farming and animal husbandry are limited. This limitation is especially problematic in the UER. The high population and land-use density in the

region allows neither the expansion of farming, nor the increase in the number of animals.

To overcome water scarcity and at the same time create new income sources for a steadily growing population and release the pressure on natural resources hundreds of small, multi-purpose reservoirs were built. This process was started by the British colonial administration more than 60 years ago and continued by the Ghanaian government after independence in 1957 with support from various international donor organizations.

Fisheries were at best perceived to be an incidental benefit of the reservoirs, based on assessments like those of Dickson and Benneh (2004, p. 60-61) „*River fishing is taking place in northern Ghana where it is done mainly by the groups of Ewe fishermen who have migrated there from the Volta Region. The northern Ghanaians themselves are not particularly interested in fishing.*" Further, Essuman (1992) and Ackah and Appleton (2003), for example, explain that the fish supply to northern Ghana and the consumption of fish there are low, since people produce and prefer to consume meat. Statements like these contributed not only to the neglect of developing fisheries of naturally occurring aquatic resources, but also to the fact that the potential of the reservoirs in terms of enhanced fisheries management in the region is still considered to be untouched (Kapetsky et al. 1991; Prein et al. 1996; FAO 2004a).

Yet, an analysis of the Ghana Living Standard Surveys 3 and 4 (GSS 2000) shows increasing expenditure for fish. Furthermore, Armar-Klemesu et al. (1995) found that even though almost every household raises animals such as cows, goats, sheep and fowl, these are rarely eaten but instead sold in times of need. Finally, doubts concerning statements such as those of Dickson and Benneh were expressed by colleagues from the GLOWA Volta Project (GVP) and the Challenge Program on Water and Food Project No. 46: Small Multi-purpose Reservoir Ensemble Planning, who observed fisheries' activities while investigating other aspects of small reservoirs in the UER.

This study aims to contribute to the resilience of the rural poor in the Upper East Region of Ghana to environmental disturbances through improved understanding of the potentials of fisheries in small reservoirs. Following Folke (2006) resilience is understood as being the potential to create opportunities for doing new things, for innovation and development, even, or especially, during times of disturbances. When

framing the definition of resilience this way, social actors, their potentialities, their creativity and their capabilities are at the center of analysis (Bohle et al. 2009).

The understanding of the potentials of fisheries in small reservoirs has three dimensions in this study. The first dimension is closely linked to statements of Essuman (1992) and Ackah and Appleton (2003) that people prefer to consume meat and that of Dickson and Benneh (2004) that northern Ghanaians themselves are not particularly interested in fishing. The first step of this study is to check these arguments. If they are true, then fisheries in small reservoirs have no potential to contribute to the resilience of the local population as they have decided not to integrate these activities into their livelihood portfolios. If people have integrated the livelihood strategies into their livelihood portfolios, the question is how these new strategies influence the opportunities for doing new things, for innovation and for development.

The second dimension is determined by the potential of ecosystems to produce fish. Neither data about the current productivity of the reservoirs, nor about fish yields exist for any of the small reservoirs in the Upper East Region. The questions arising are: how productive are the reservoirs in terms of fish yields and how robust are fish yields against disturbance, including fishing pressure? Taking into consideration the statements from Kapetsky et al. (1991) Prein et al. (1996) or the FAO (2004a), a further question arises about the potential to enhance fish yields through increased fish production in harmony with other water uses.

The third dimension assumes that people have adopted fisheries and selling fish as livelihood strategies and that the aquatic ecosystems provide the potential for increased fish production. This would require a complex management approach, which is flexible enough to react to sudden, medium and long-term changes in ecological as well as social terms. Such a management approach makes demands on human capacity, including, for example, diverse types of knowledge, the capacity to learn, the ability and willingness to cooperate, trust, and commitment to adhere to rules. So the last question is whether people have the capacity to manage not only the ecosystems, but also the social systems in a way that the new livelihood strategies further increase the opportunities for doing new things, for innovation and development.

1.2 Study structure

This study is divided into five parts. The first part, following the introduction, consists of a review and discussion of the key research concepts that build the analytical framework. First, the Sustainable Livelihoods Framework developed by the British development agency DFID (DFID 1999) is introduced to provide a framework for the analysis of the impact of fisheries on livelihoods and resilience of the local population. Moreover, the analytical framework contains the research design for the assessment of the aquatic ecosystems of reservoirs, their current use and potentials. The third part of the analytical framework introduces the concept of the adaptive co-management approach and provides ideas from social network analysis to examine the pre-requisites of the social system needed in order to apply the adaptive co-management approach. The chapter concludes with the description of the analytical framework for the empirical study in the UER of Ghana.

The second part of this study contains information about the availability of secondary data and how the research area and reservoirs were selected. Furthermore, the methodologies of data collection are presented.

In order to judge the potential of fisheries to strengthen the resilience of the rural poor, it is necessary to know which contingencies and stress people face and the difficulties coping with them or, in short, the vulnerability context in which the people live. Thus, the third part of this study provides a literature review on the environmental as well the social, political, economic and cultural conditions which people face. Further, some recent measures to counteract poverty and the reasons for their relatively low success are discussed.

In the fourth part of this study, the primary data are analyzed. First, the current importance of fish for local livelihoods is assessed and the development of these activities is derived from an historical analysis. The analysis is followed by an assessment of the current fish yields of the reservoirs and ecological conditions for increased fish production. As mentioned above, the third part of the primary data analysis looks at the social structures, actors and their potential to manage the reservoirs for increased fish production.

The last part concludes the thesis and presents some development scenarios for fisheries in the Upper East Region.

Defining the research problem
Resilience of the rural poor to difficult and changing environmental conditions

Deciding on the research focus
Impact of fisheries in small, multi-purpose reservoirs on the resilience of the rural population whose livelihoods are dependent on natural resources and its management

Determining an area for empirical study
Upper East Region, one of the poorest Regions of Ghana

Developing an analytical framework

Research areas
- Vulnerability & livelihoods research
- Ecosystem research
- Study of resource management

Key concepts
- Sustainable Livelihoods Framework
- Aquatic ecosystems
- Adaptive co-management
- Social network analysis

Formulating research questions

- How did the local population integrate fishing and selling of fish into existing livelihood portfolios?
- How does fishing and selling of fish influence the resilience of the resource users?
- How are aquatic resources affected by the use?
- What potentials do the reservoirs provide for enhanced fish production?
- Which capacities are needed to manage the reservoirs for increased production?
- What implication do the needs for capacity have for rural development planning and livelihood development programs?

Case Study: Fisheries in the Upper East Region of Ghana
Empirical studies and assessments of three reservoirs and their user communities of different ethnicity and religion

Methods:

- Participatory rural appraisal tools;
- Questionnaire-based surveys;
- Aquatic ecosystem assessment.

Data analysis and presentation
- Past and present role of fisheries in local livelihoods
- Current fish yields and enhanced production potentials
- Analysis of actors and their social networks needed for adaptive co-management
- Scenarios describing different possible futures of fisheries development

Figure 1.1: Schematic overview of the research process

2 KEY RESEARCH CONCEPTS

2.1 Livelihood approach

In order to assess the impact of fisheries and the selling of fish on the opportunities for doing new things, for innovation and for development, this study uses the Sustainable Livelihoods Framework developed by the British development agency DFID (DFID 1999). The framework helps to understand and analyze the livelihoods of the poor. It views people as operating in a context of vulnerability. This context frames the external environment in which people exist. Drawing from Chambers' (1989:1) early work, vulnerability can be defined as:

> "*The exposure to contingencies and stress, and the difficulty coping with them. Vulnerability has thus two sides: an external side of risk, shocks and stress to which an individual or household is subject; and an internal side which is defencelessness, meaning a lack of means to cope without damaging loss."*

Within the vulnerability context, people have access to an asset portfolio owned, controlled, claimed, or accessed in some other way. The DFID framework deals with five different assets: Human capital represents the skills, knowledge, ability to labor and good health that together enable people to use the other four assets properly, pursue different livelihood strategies and achieve their livelihood objectives. Social capital is taken to mean the social resources upon which people draw in pursuit of their livelihood objectives. Like human capital, social capital is the crucial asset for management. Because of their importance, these two assets will be dealt with separately in chapter 2.3. Natural capital is the term used for the natural resource stock from which resources flow and services useful for livelihoods are derived. Reservoirs or irrigation plots belong to this asset group, as do public goods such as the atmosphere and biodiversity. Physical capital comprises the basic infrastructure and producer goods needed to support livelihoods. Essential infrastructure components are affordable transport, secure shelter and buildings, adequate water supply, affordable energy, access to information and communication or fishing gear. Financial capital is available cash or equivalent that enables people to adopt their livelihood strategies. This includes savings such as cash, bank deposits or liquid assets such as livestock and jewellery. Financial resources can also be obtained through credit-providing institutions. Another source of

financial capital is the regular reliable income of money such as earned income, pensions or transfers from the state and remittances.

The assets gain their meaning and value through the prevailing social, institutional and organizational environment that shape a livelihood. They effectively determine access to various types of capital, to livelihood strategies and to decision-making bodies and sources of influence. Furthermore, they determine terms of exchange between different types of capital and returns to any given livelihood strategy. One of the major critiques on the framework pointed out e.g. by de Haan and Zoomers (2005) or Bohle et al. (2009) is that the framework focuses very much on agency, meaning the capacity of individuals to act independently and to make their own free choices. Social relations are often downplayed structural features. To understand current power constellations, however, it is necessary to look at historical legacies of power and value conflicts, as they influence how actors actually interact today (Thelen 1999; Nadasdy 2003; Natcher et al. 2005). Lewis et al. (2003) add that despite the political economic and sociological contexts, it is the history that influences what is and can be done by organizations.

This social, institutional and organizational environment does not only influence the access to assets, but also the livelihood strategies – ways of combining and using assets - that are open to people in pursuit of beneficial livelihood outcomes that meet their own livelihood objectives. In other words, livelihood strategies are composed of activities that generate the means of survival (Ellis 2000). Usually diverse activities are combined to meet their various needs at different times. In doing so, different strategies occasionally compete with each other. Because of limited resources households often have to decide for one strategy, which means they can not practice the other.

According to Bohle (2009) the most prominent field of applying the livelihood approach has been in vulnerability analysis. However, while this study also analyzes the vulnerability. it focuses much more on the livelihood outcomes. Livelihood outcomes are the achievements or outputs of livelihood strategies. Amongst other things, outcomes could be more income, increased wellbeing, reduced vulnerability, improved food security and more sustainable use of the natural resource base. The analysis of the

outputs will allow conclusions to be drawn about whether fisheries and selling fish increase people's opportunities and capacity to innovate and develop.

2.2 Ecosystem assessment

Since small reservoirs are built for human use they are usually looked upon as technical infrastructure that can either provide additional income or increase maintenance costs . When looking at the fish yields which reservoirs provide it is, however, essential to have a closer look at the ecosystem that provide this service. This part of the analytical framework introduces the research design used to answer the questions about the current fish yields of the reservoirs, its robustness against disturbance and the potential for enhanced fish yields.

In the absence of secondary data, one possibility to look at the fish yields of a reservoir is to record data about catches per unit of effort on a daily basis. This is, however, very time and cost intensive and thus it was decided to use another method based on fishermen's recalls of their catches. A method to validate the recall data from fishermen's area-catch studies can be conducted, which take stock samples at the beginning of the main fishing season and at the end of the fishing season, to check the reduction of stock.

However, fishing pressure is not the only factor influencing the fish stocks. The factors can be divided into two main categories. The first category contains the different kinds of human impact. In this category of human impact, it is mainly the presence or absence of management processes that affect fish yields. Intensive fishing does not only have decimating effects on the fish stock. When fish density is reduced, usually more food is available, which in turn leads to higher reproduction rates and overall faster growth of fish. This can lead to stable yields. However, if fishing pressure is pushed beyond this stability, the stock collapses because of overexploitation (Welcomme 2001).

The second category contains environmental factos. For example, fish species diversity can have an effect on productivity. Diverse systems are assumed to be more productive than simpler ones, and production is assumed to be more stable (Welcomme 2001) as available food is used more efficiently by multiple species with diverse feeding

habits. Lévêque (1995), however, found similar levels of productivity in three African lakes but differing levels of species diversity.

In order to obtain a complete picture of the productivity and ecological balance of reservoirs, it would be necessary to analyze the whole food web, including invertebrates and plants, especially algae. This would help to determine not only reservoir productivity, but also potential organic pollution of the waterbodies. Unfortunately, sampling of biological indicators such as the Saprobic index or algal pollution indices was technically unrealizable, given the lack of time. However, a number of simple indices which are available to describe biodiversity are used in this study to describe at least the biodiversity of the fish stock.

Table 2.1: Selected indices describing biodiversity

Margalef species richness index (Margalef 1968).	
$D = (S - n)/\ln(n)$	where D = species richness; S = number of species; (n) = number of individuals and $\ln$ = natural logarithm.
Shannon diversity index (Shannon and Wiener 1963).	
$H = \sum_{i=1}^{S} -(pi * \ln pi)$	where H = Shannon diversity index; *pi* = fraction of the entire population made up of species i, S = number of species and $\sum$ = sum from species 1 to species S

The balance of the fish stock can be estimated by the ratio of forage fishes to carnivore fishes (i.e., forage-carnivore or F/C ratio) with respect to weight.

However, it is not only the assemblage of species that is important but also the ability of the species to cope with a rapidly changing environment and withstand periods of stress caused, e.g., by low oxygen levels, high temperatures or limited food availability.

Catchments play various roles. After a rainfall event, parts of the catchment turn into floodplains, which serve as feeding and breeding habitats (Welcomme 2001; Moritz and Linsenmair 2004). During the flood period, fishes find large quantities of food (in the form of insects and other invertebrates, fruits, vegetation and other allochthonous materials), putting floodplains in the tropics among the most productive aquatic habitats (Welcomme 1985). This also applies to the fry of fish born in the floodplains (Moss 1992; Linsenmair 2003). It can be said that the larger the flood

plains, the larger the increase in fish stock, as the availability of food is positively related to reproductive behavior and growth. The onset of the rainy season, the amount of rainfall and other characteristics of precipitation events are very important in this context (Moritz and Linsenmair 2004). The characteristics of a rainfall event also influence run-off behavior. Short and/or heavy rainfall events cause high surface run-off, which accumulates in the reservoir and causes spill-over rather than the development of floodplains. These rather establish when rainfall is prolonged and moderate.

The characteristics of precipitation also influence the levels of erosion. Surface run-off becomes modified as substances dissolve from local geology, soils, litter, etc. The loaded water passes into the streams that drain the catchments into the reservoirs. The position of the reservoirs in the base of a drainage basin gives them the characteristic of a sediment trap, which is further increased by the absence of biologically active wetlands. These are usually found in natural lakes and serve as a filter, which usually do not exist around man-made reservoirs.

The size of the catchment area is as important for the amount of nutrients and sediment transported as the characteristics of soils and geology. Chemical characteristics of surface waters are closely related to the soil characteristics (Keup 1968; Vollenweider 1968, Lal 1998). In this context, pH and carbonate contents are important for fish production. Mosig and Fallu (2004) and Pillay and Kutty (2005) suggest an optimum range of pH for fish farming between 6.5 and 9. Carbonate is known to buffer pH swings that occur naturally as a result of the photosynthetic activity of plants (Wetzel 1983). Further, it fosters the photosynthetic process by making carbon dioxide available. Boyd (1990) showed that carbonate contents below 120 mg/l can reduce primary production in unfertilized ponds. Recommended values for carbonate contents range from 50 mg/l to 100 mg/l as a minimum and 150 mg/l to 200 mg/l as a maximum (Wurts 2002; Mosig and Fallu 2004). However, these values are for aquaculture ponds, since values for multi-purpose reservoirs were not available.

Phosphorus is one of the key nutrients contributed by the catchments to streams and lakes, and usually emanates from the surface drainage. The phosphorus demand of living organisms is high, and limited availability is generally the first factor to impose limitations on the system (Wetzel 2001). When too few nutrients are washed

into the reservoir, primary production is low and food availability for fish is limited. High nutrient loadings cause high production and organic loading, which in turn can induce eutrophication (Wetzel 2001). Land use in the catchment area influences the nutrient availability. While intensive agriculture that leaves bare soils increases erosion, dense vegetation can significantly reduce it.

Once sediments enter the reservoirs, they sink to the bottom of the reservoirs to form a layer of mud, and the water becomes quite clear some time after precipitation. The sediment layer provides a habitat for a micro-flora and –fauna, as well as shelter for some fish species which hide in the mud when the waterbodies dry out. The settling of sediment and stratification of the water column into several layers with differences in temperature, which can be observed in most standing waterbodies, is disturbed in small reservoirs in two ways. One is the depth of the small reservoirs, which is often so shallow that even light movements by wind mix the whole waterbody and not just the top layer. This is confirmed by Baijot et al. (1997) who found stratification only in deeper reservoirs with an average depth of at least 3-4 m. The wind does not only prevent the formation of the different water layers, but also swirls up the sediments from the ground and limits the transparency in the reservoirs. The Bontanga and Libga reservoirs in the Northern Region, for example, show low values with 60 cm and 54 cm, respectively (Quarcoopome et al. 2008). The average transparency of 7 reservoirs in Burkina Faso with 1.14 m is only slightly deeper (de Graaf 2003). In their investigation of 49 reservoirs, Arfi et al. (2007), however, found an even lower average of 32 cm. The second reason for the low transparency in small reservoirs is the water withdrawal from the bottom of the reservoir for irrigation purposes, which creates a pull that contributes to the circulation of the waterbody. Though high turbidity increases the availability of nutrients as they are no longer stored inaccessibly in the sediment layer, it limits available light, which is necessary for photosynthetic processes and primary production processes. Whether these facts balance each other or one dominates is dependent on a number of other factors, described in the following, which make the growth and interactive metabolic properties of shallow lakes most variable, and generalization is difficult (Wetzel 2001).

The temperature of the reservoir plays an important role. Water below 20°C can seriously hamper fish production (Baijot et al. 1997). Although a high water

temperature is usually associated with high production of fish as well as algae, there are optima, which if crossed can cause considerable stress to fish (Lampert and Sommer 1999). Temperature affects the solubility of oxygen, which decreases considerably with warm water (Wetzel 2001). Warm waters with high nutrient loads lead to high algal production, which in turn is fed on by many fish species. However, while algae produce large amounts of oxygen during the day, during the night these microorganisms consume much of the available oxygen, and if their numbers are too large, this can lead to a total exhaustion of oxygen, which is lethal to all higher organisms, including fish.

Algae are not the only plants that play a role in fish production. There are multiple interactions between fish and aquatic macrophytes. Freshwater fish use aquatic macrophytes for shelter and refuge, as a food source either directly or indirectly, and as spawning, nesting and nursery sites (Petr 2000). However, according to Petr (2000), reservoirs provide difficult growing conditions as the water level fluctuates considerably. Flooded terrestrial soils also may not be suitable for rooted aquatic plants, and wave action along the shoreline may soon wash out fine soil, leaving only pebbles or rocks.

In order to assess the factors mentioned above, data were collected which are supported by local and expert knowledge, as described in chapter 3.

2.3 Adaptive co-management

The third dimension of this study is looking at the potential within the communities to manage the reservoirs for an increased fish yield. A conventional management approach would use target reference points (increase catch by x tons/year) to measure the success of a management strategy to maximize outputs. The approach is suitable for an environment in which most production factors can be controlled (Berkes et al. 2001).

It is argued in this study that target reference points are unsuitable for areas such as the UER where uncertainty is the rule rather than the exception, and management must be flexible in order to be able to react to sudden, medium and long-term changes. This is especially true for cases in which the existence and impact of slowly changing variables, whose influence can only be detected when looking, e.g., at past centuries and a resolution of one year (Folke 2006) or on large spatial scales, are unknown. More generally, resilience literature suggests an approach which is called

adaptive governance to handle uncertainty (e.g., Dietz et al. 2003; Olsson et al. 2004a; Folke et al. 2005; Hahn et al. 2006). Lee (2003) defines adaptive governance as a polycentric form of social coordination in which actions are coordinated voluntarily by individuals and organizations with self-organizing and self-enforcing capabilities. Lebel et al. (2005) add the importance of shared power and decision making. In order to make governance adaptive, Boyle et al. (2001) suggest a triad of activities. First, governance would be the process of resolving trade-offs and of providing a vision and direction for sustainability. Second, this vision would need to be operationalized into management. As a third activity, monitoring would provide feedback about the success or failure of adaptation.

Adaptive co-management can be understood as a mode of adaptive governance, where the emphasis is on systematic experimentation with management strategies and the feedback of what is learned in order to shape subsequent policies (Boyle et al. 2001; Pomeroy and Rivery-Guieb 2005) or new, more suitable management strategies.

However, as argued in the introduction, the people in the Upper East Region do face an increasing number of challenges and experimental approaches seem like an extra burden that strains their capacities. Another disadvantage of an experimental approach is that every negative experience builds cynicism and distrust and increases the difficulty in encouraging people to try again (Beratan 2007). Scientists are therefore emphasizing the need for co-management approaches to share the burden of responsibilities, be they financial, organizational, or otherwise.

More recent literature on adaptation suggests going beyond adaptation as a process to adapt to current situations and emphasizes that transformability should be included (Folke 2006). Transformability is seen as the capacity of people to create a fundamentally new situation when ecological, political, social, or economic conditions make the existing system untenable (Walker et al. 2004; Folke 2006; Nelson et al. 2007). When working with this notion, however, it is necessary to accept that statements about the characteristics of a system can neither be naively accepted as objective reality, nor as a mere illusion produced through discourse (Neumann 2005). There is often a lack of understanding about the intentions for intervening transformations and - more importantly - who formulates them (Voß and Bauknecht

2004) or, as Bohle (2009) formulates it in a development context: *„the world in which the vulnerable seek to secure a living is a political arena with conflicting interests*" and contradicting objectives (Mollinga et al. 2007). Thus a particular focus of this work is, as suggested by Etzold et al. (2009), not only on formal and informal rules determining management or the potential for management, but also on the social agents and the agency allowing them to organize themselves into social networks and actively influence the rules of the game.

2.3.1 Pre-requisites for adaptive co-management

While adaptive co-management seems to be a suitable approach to the management of small reservoirs in the UER, a number of pre-requisites, which are introduced in the following, need to be fulfilled to make the approach work.

The key to the development of the experiments as a basis for learning is the access to and combination of various sources of knowledge, contributed by multiple actors (Folke et al. 2005; Olsson et al. 2006). Scientists such as Cohen and Levinthal (1990), Westley (1995) or Roux et al. (2006) point out that diverse knowledge can provide robustness when responding to new challenges.

These types of knowledge can contribute substantially to the solution of one of the most important problems of resource use: the lack of a common understanding of the problem (Bodin and Crona 2008) and common mental models or visions as a basis for establishing management rules and judging the direction and desirability of system change (Boyle et al. 2001; Walker et al. 2006; Hermans 2008). Learning, sharing of knowledge and the development of visions can only be accomplished through the free flow of information and unhindered communication (Crona and Bodin 2006). Yet actors and institutions often have heterogeneous and often contradicting objectives (Mollinga et al. 2007), and efforts to define mental models must be analyzed in the context of contested and evolving human interests (Dedeurwaerdere 2008). The same applies to learning processes, where Galaz (2005) points out that they are highly vulnerable to strategic behavior among natural resources, an aspect that will be taken into account during data analysis.

The lessons learned during experiments need to be integrated into historically grown knowledge systems, also called social or collective memory, which are essential

to avoid mistakes made in the past and provide the capacity to approach challenges of change and transformation actively (Lee 1993; Pretty 2003; Malayang et al. 2005; Bohle 2008). It is therefore important to realize that a social memory consists of a multitude of diverse individuals, institutions, organizations, and other actors with different roles overlapping within and between groups (Folke et al. 2003) or cliques, as they are called later.

An experimental learning approach is also based on learning from failure. Flexibility provided, for example, by the diversity of assets or alternative livelihood strategies to buffer loss is essential. This flexibility can be based on culture, such as the tradition to share food with each other in times of crisis or inter-community trade (Berkes and Jolly 2001). Another kind of flexibility is mobility and migration (Adger 2000). For example, Overå (2001) found that the institutionalization of migration has resulted in an extremely extensive and flexible utilization of resources in Ghanaian coastal fisheries. This flexibility has resulted in a fish-production and employment system that can be characterized by resilience in the face of processes such as population growth and environmentally or human-induced variations in fish stocks, political conflict and national economic decline.

Another important aspect is the collaboration of multiple actors defined as a process through which parties who see different aspects of a problem can constructively explore their differences and search for solutions that go beyond their own limited vision of what is possible (e.g., Gray 1989; Wondolleck and Yaffee 2000). Collaboration would also solve the problem of the legitimacy of a solution, which often arises when a single organization tries to solve a complex problem. Amongst other issues, solutions are usually controversial, create unwanted consequences for other parties, and are therefore often not accepted by the public.

The participation of a diverse set of stakeholders operating at different levels is of equal importance (Berkes and Seixas 2005; Folke et al. 2005; Johnson 2006; Lebel et al. 2006; Armitage et al. 2007; Bohle 2008). An organizational structure of management with multiple, relatively independent centers creates opportunities for locally appropriate institutions to evolve (Berkes and Folke 1998). Further, such a multi-layered, polycentric approach also provides flexibility to compensate for the malfunction of single centers, which in turn is considered important for dealing with

uncertainty and change (Danter et al. 2000; McCay 2002; Armitage 2005; Ostrom 2005).

Despite all collaboration and participation, Folke et al. (2005), Walker et al. (2006) and Gunderson et al. (2006) identify leadership as an elemental pre-condition for successful collaboration. The role of opinion leaders for the behavior of groups and their important influence on change is also discussed by Scheffer et al. (2003), who come to the conclusion that the absence of a decision-making authority can lead to slow negotiations over final regulation. In this capacity, leadership plays a key role in helping to create a system 'vision' as well as in making sense. (Olsson et al. 2004a; Brunner et al. 2005; Folke et al. 2005). While Pahl-Wostl (2007) adds that, for example, during social learning processes in multi-actor domains, some form of direction setting to facilitate joint responsibility for developing solutions requires leadership, she emphasizes that it should be shared or distributed. This emphasis is due to the fact that disproportionately powerful stakeholders who benefit from status quo can delay or block regulation (Scheffer et al. 2003), and Walker et al. (2006) suggests multiple leadership roles, vested in different individuals or groups also because they argue that there is no single style of leadership that guarantees adaptability and transformability.

Yet there are some indications for good or successful leadership. Emphasis must be given to leadership roles that encourage a move away from an authoritarian decision maker to a facilitator or catalyst that agrees and accepts any decision that is reached within the group (Gray 1989). In this context, transparency and accountability of leaders are named as important in order to generate trust as a precondition for co-operation (Ribot 2005; Harvey and Reed 2006; Lebel et al. 2006). Interpreters, sense-makers, visionaries or inspirers, who are able to provide incentives for renewal and reorganization, must not necessarily, however, be leaders, but can be normal members of the community who have good information processing and translation skills (Folke et al. 2003).

Trust is highlighted as a feature of social interaction required for true partnership and collaborative engagements (Berkes and Seixas 2005; Brunner et al. 2005; Folke et al. 2005; Beratan 2007; Lubell 2007). Burt and Knez (1996, p. 69) note that *„trust is committing to an exchange before you know how the other person will reciprocate.*" In natural resources management, this definition needs to be extended to

include the commitment to rules, even when not knowing whether others will commit to the same extent. In order to keep trust as part of the equation, modest sanctions can be imposed on first offenders, and the severity of sanctions gradually increased for those who do not learn from their first or second encounter (Ostrom et al. 1994; Weinstein 2000; Dietz et al. 2003).

Another form of trust is identified by Longstaff and Yang (2008), namely the trust in information flow. This can be rather difficult in times of uncertainty. A good example is the weather forecast. If it gives out storm warnings several times that do not materialize, people are less likely to listen to them and are surprised when the storm actually arrives. Forums for exchanging and critically discussing information such as citizens' committees and public hearings have the potential to create or increase accountability and hence trust (Moench et al. 1999; Bruns et al. 2005). The access to reliable information that is widely shared and debated not only creates trust among stakeholders, but also serves as a means of empowering them by increasing their knowledge (Mollinga et al. 2007).

Trust is an indicator for social capital (Bohle 2005), which is in turn considered to have a beneficial effect on the capacity of individuals to organize themselves effectively (Coleman 1990; Fukuyama 1995). Ronald Burt (1992) explains social capital as a metaphor in which people who are better connected are people who do better.

> *„Certain people or certain groups are connected to certain others, trusting certain others, obligated to support certain others, dependent on exchange with certain others. Holding a certain position in the structure of these exchanges can be an asset in its own right. That asset is social capital, in essence, a concept of location effects in differentiated markets.*" (Burt 2002, p. 150).

Putnam (2000) does not focus on individuals, but on groups and their social networks and the norms of reciprocity and trustworthiness that arise from them. Social capital, in this sense, is the connections that a group can use to achieve its objectives. The ability to turn social capital into action can be viewed as a group's agency and this agency will impact its ability to engage successfully with sustainable development issues (Dale and Newman 2006). Critical features of social capital and network formation include the ability of local groups to self-organize and to realize adaptive co-

management systems, mobilizing social networks to connect institutions and organizations across levels and scales (Olsson et al. 2004c).

Beyond the analysis of social capital, the tools and approaches developed to analyze a social network provide a number of options to check to what extent the pre-requisites for adaptive co-management are fulfilled. In the following, some network-theoretical considerations and basic concepts are introduced and subsequently linked with the pre-requisites for adaptive co-management.

2.3.2 Network-theoretical considerations and basic concepts

A network consists of nodes, which are connected by ties/linkages. Nodes represent, e.g., individual actors, organizations, groups, websites, computers or even animals in a food web. Nodes have attributes, such as age, education or ethical and religious affiliation, charisma or power, which can also play a role in analysis. The strength of the network approach lies in its ability to describe structures systematically as system properties, formed by ties between nodes, be it human relations, flows of resources or money, information, social security, etc. Network analysis and related concepts further allow the measurement and interpretation of patterns in structures. In the following, selected concepts are introduced.

It is important to mention that there is a growing recognition amongst network analysts as well as other scientists that structure alone cannot explain everything. Or as Lukes (2005, p. 68–69) puts it:

> *„(...) social life can only be properly understood as an interplay of power and structure, a web of possibilities for agents, whose nature is both active and structured, to make choices and pursue strategies within given limits, which in consequence expand and contract over time.*"

Long (1989) further emphasizes external, institutional and cultural factors that may shape an actor's behavior and reasoning. The intriguing thing about the network perspective is that it allows several combinations of micro-level actions and/or attributes of individuals and subordinate, macro-level structures and attributes (Jansen 2006).

Ties and their characteristics

One way of looking at linkages in networks is to look at their cohesiveness. This is expressed by the ratio of the number of actual reciprocal links between two nodes to the

number of possible reciprocal links in the network (Jansen 2006). This measure is also called degree of reciprocity and expresses how balanced the network is in terms of giving and taking.

Another way to describe linkages is to look at the frequency or intensity of contact between two nodes (Borgatti and Foster 2003). Frequent and intense contact is often associated with bonding ties, found in so-called cliques. These ties build the foundation for bonding social capital, as strong links are usually perceived to provide security of all kinds, only, however, to members of the clique. The term clique simply describes a sub-set of actors who are more closely related to each other than they are to actors who are not part of the group. Cliques are interesting units of investigation, since it is assumed that structurally similar units tend to share information, personnel, managerial procedures and resources. Their emergence is often ascribed to a phenomenon called homophily, which describes the behavior of humans to select others who are similar (Monge and Contractor 2003) and maintain a close association when they share the same attributes such as social class, kinship, education, and common norms.

Granovetter (1973) describes another kind of ties, which he refers to as weak ties. He suggests that weak ties are those that bridge the gap between two densely knit cliques or networks which have no connection at all apart from these few weak ties. Nodes that have such ties bridge structural wholes (Burt 1982) between otherwise unlinked units. The ability to build bridges is often perceived to be an advantage and is called bridging social capital. As will be described later, these ties play an important role, e.g., in innovation or the learning processes.

Apart from the weak ties, which are often perceived as more horizontal ties between rather similar entities, many authors use a third category of ties, which they call linking ties. These go beyond bridging ties and engage cliques vertically with external agencies and formal institutions, e.g., to draw on useful resources or to influence policies (Woolcock and Sweetser 2002; Pretty 2003).

Nodes and their characteristics

In the following, some measures are described that allow the analysis of the position of individual actors within a network.

Actors with bridging and linking ties are often in central positions, which in turn are associated with a higher amount of power and leadership. Social network analysis developed measures that allow measurement of the centrality of actors. The three most common measures of centrality are the degree of centrality, closeness and betweenness (Freeman 1979) which are briefly described in the following (for details, see section 3.6). The degree of centrality is the number of direct links one node has with other nodes. Network analysts assume that actors who have more ties have greater opportunities because they have choices. This autonomy makes them less dependent on any other specific actor, and hence more powerful.

Another reason why an actor can be more powerful than other actors is that he or she is closer to more actors than any other actor. This measure called closeness expresses the extent to which an actor can easily reach all other nodes in the network.

The third aspect of a structurally advantaged position is being in between other actors. This so-called betweenness is expressed by the extent to which an actor sits between any other two nodes on the shortest path. Betweenness makes a statement about how much each node contributes to minimizing the distance between nodes in the network. Actors with a high betweenness centrality are able to control interactions between those network members that they connect and derive power through their position as the `necessary point of passage`. With a growing amount of empirical studies it became clear that many networks show similar structures and nodes with the same characteristics or roles. Nodes with a high level of betweenness are predestined for a role called broker (Burt 2002), which is discussed below.

Size, density, reachability and centrality of whole networks

In the following, measures are described that are not concerned with the individual, but with characteristics of the network structure as a whole.

The size of a network can be important, i.e., the number of nodes as well as the density of the network, which is the ratio of the number of actual links to the number of possible links in the network. For the distribution of, e.g., information or viruses, the reachability within a network is important. This accounts for the number of steps maximally needed to reach from one node to any other node in the network (Hanneman and Riddle 2005). Despite the centrality of single actors, centralization can be measured

for the whole network and indicates the degree to which an entire network is focused around a few central nodes (Scott 1991). The centralization of networks is a measure for the problem-solving capacity of a group (Jansen 2006).

2.3.3 Social network analysis and the pre-requisites for adaptive co-management

Some decades ago, management science already associated non-hierarchical organizations, which are highly connected and where resources are more uniformly distributed, with the ability to change continuously and adapt rapidly (Quinn 1985). The ability of networks to respond adaptively to environmental change and to initiate and sustain successful adaptive co-management of natural resources is often emphasized (Gunderson et al. 1999; Paton et al. 2001; Tompkins et al. 2002; Olsson et al. 2004b; Tompkins and Adger 2004; Folke et al. 2005). Hahn et al. (2006) state that social networks are instrumental for mobilizing social memory, generating social capital as well as legal, political, and financial support to ecosystem management initiatives. The existence of informal as well as formal relationships that form social networks are seen as the foundation of successful collaboration (Lubell and Fulton 2007; Lauber et al. 2008). Armitage (2008) emphasizes the role of networks, as they bridge actors across scales. Tompkins and Adger (2004) further emphasize that the expansion of local or community networks appears to be critical as more resources become available to them. Furthermore, through an increased number of connections to levels and scales other than the local, the chances of communities increase as their needs are taken into consideration, and the engagement in a network can foster representation, e.g., in a political arena (Cox 1998). In a nutshell social networks contain the social capital that can bring agency to bear on system-induced problems (Newman and Dale 2005a).

In the following, these measures and the concepts described above are linked to pre-requisites for adaptive co-management, to provide ideas for operationalization. Furthermore, the network concepts and terms are used to identify and describe the roles that are, for example, important in order to develop and retain a collective memory of resources and ecosystem management (Folke et al. 2003).

Looking at the whole network

A high degree of centralization, i.e. a network with only a few central nodes and where the rest of the nodes are rather unrelated, may in some respects be very good for facilitating the process of solving simple tasks. Relevant information can quickly be synthesized and relayed to a few actors who can make a decision and take action (Leavitt 1951). For the same reason, high centralization might also be good in times of change when effective coordination of actors and resources may be needed.

However, centralization reduces participation and the access of individual actors to multiple sources of information and thus hampers learning that draws on diverse information (Weimann 1982; Abrahamson and Rosenkopf 1997). Also, highly centralized networks can be vulnerable to shocks that remove the central node. If the central node is removed or does not do its work properly, the whole network disintegrates and what remains is a number of unrelated nodes.

A high level of reciprocity as well as a high density in networks can strengthen trust, which is part of the bonding social capital (Granovetter 1985; Coleman 1990; Pretty and Ward 2001; Woolcock and Sweetser 2002; Pretty 2003). In some cases, a large amount of this type of social capital provides some flexibility through providing, e.g., social, financial or other kinds of security when experimenting with new ideas. High density may also facilitate the spread of information through increased accessibility to information and exchange of ideas (Weimann 1982; Abrahamson and Rosenkopf 1997; Lauber et al. 2008). For example, Bohle et al. (2009: 56) found for informal wholesale markets for fish in Dhaka Bangladesh that "among the fish traders, strong social ties have evolved that enable the sharing of information with each other; create an atmosphere of mutual trust and reciprocity; and eventually lay the foundation for joint problem solving and cooperation in the risk-prone fish business. Taken together, such elements of social capital can enhance their business opportunities and also promote their adaptability towards the inherent risks and uncertainties that characterize the trade of fish as a highly perishable product."

Networks with bonding social capital can often be found within families, circles of friends, and neighborhoods, but unfortunately these structures are also associated with mafia-like organizations or terror networks. The interpretation of the consequences of strong bonding ties is, like most other network measures, case

dependent. For example, while in some cases bonding ties increase flexibility, as pointed out above, in other cases flexibility is decreased. For example, Bohle (2005) and Newman and Dale (2005a) point out that high density can impose constraining social norms and foster group homophily, which decreases flexibility towards innovation by discouraging experimentation and limiting accepted options. This is confirmed, e.g., by Oh et al. (2004), Reagans and McEvily (2003) and Bodin and Crona (2008), who agree that from a broader perspective, homogeneity among key persons is likely to reduce their collective ability to perceive and synthesize new information and knowledge of different kinds and reduce their ability to adapt to new circumstances. Another downside of networks with high density is pointed out by Granovetter (1973). He argues that high density leads to similarities in circulated information and attitudes, as everyone within the primary group communicates mainly with other group members. Thus, always the same information circulates.

Another concept that measures the connectivity of a network is the reachability. Density and reachability are connected and a high density normally implies high reachability (Janssen et al. 2006). A high reachability of a network, which is similar to a high closeness centrality of many actors, can facilitate communication and the access of information and knowledge from many sources (Borgatti and Foster 2003). It can, vice versa, also provide access to many and diverse storage possibilities of experiences and knowledge gained from experiments. Yet the reachability does not allow conclusions about whether the network is really participatory, e.g., open for local stakeholders, and whether their knowledge is included for better-informed decision making (Tompkins and Hurlston 2003). It could, for example, be possible that information is exchanged in written form and everybody has the right to contribute his or her statement. So while in principle this is meant to be inclusive, it would leave out stakeholders who cannot read and write or who use a language not understood by everybody. This notion reveals a weakness of network measures. Like most statistical concepts, they tend to generalize and are interpreted without taking the context into consideration.

If management is organized in a polycentric manner, then it is of utmost importance to have enough bridging ties or bridging social capital that facilitate the exchange knowledge generated within one center/clique to the other centers. In

addition, bridging ties appear to be central to the initial departure from convention during an innovation (Reuf 2002), as the ties allow the overcoming of social norms with support from outside the local network (Newman and Dale 2005b). Linking ties or linking social capital are important to facilitate entrances of entirely new information into the management network.

Since every type of tie (bonding, bridging, linking) might have some advantages and disadvantages, Newman and Dale (2005b) emphasize that only diversity and a mixture of different kinds of ties enable proactive maintenance.

Nodes and their roles within networks

The functioning of a network depends not only on its structure, but also on the nodes or actors that develop and use it. As described above, SNA provides tools especially for analyzing central nodes which often have some sort of leadership function. A high betweenness, i.e., connecting people in the shortest way with bridging or linking ties, is often part of a role that is called the `broker` (Jansen 2006). Similar to the broker are the roles of boundary spanners or networkers and facilitators (Folke et al. 2003). All the roles are to some extent associated with leadership which derives influence from good connections (Milgram 1967), but often also from their innovative nature (Rogers 1983), and/or charisma (Hatfield et al. 1994).

These roles become relevant when a network is dispersed with relatively dense but isolated cliques. By knowing several groups, a broker gains access to various sources of information as well access to the memory captured inside the different groups. This allows the broker to synthesize a large knowledge pool. Access to financial and other material resources and political influence are just as important (Lauber et al. 2008). Unfortunately, network analysis alone does not tell us whether the broker in question is an altruistic individual with social skills who serves as information distributer (Gladwell 2000) or somebody who uses his position to manipulate the behavior of social groups by selective dissemination. It thus becomes necessary to look at the actors themselves and how they operate as active agents, rather than simply to follow normative scripts (Bierschenk et al. 2002).

Burt (2002) points out that brokers, with early access to critical information, often create new understandings, and Long (2001) adds that central nodes can open up

new sources of economic activity and investment. Further, the position enables deviant behavior of actors based on loosened peer pressure and thus opens windows for learning, innovation, modernization and change of norms (Jansen 2006). Cash et al. (2006) and Hahn et al. (2006) emphasize the establishment of new or the extension of existing organizations that take over the role of intermediaries. Such organizations would further have the task to moderate a social discourse and integrate diverse stakeholder interests (such as property rights) into collective decisions (Davos 1998). Such mediating or scale-matching institutions (Lee 1993) or people (Olsson et al. 2004b) could guarantee institutional fit (Folke et al. 1998; Brown 2003) and even bridge spatially heterogeneous contexts (Imperial 1999; McGinnis 1999; Cash et al. 2006).

Bierschenk et al. (2002) is more critical towards intermediaries as he found brokers to have influenced power structures in pre-colonial West Africa; they still influence current development practice by acquiring, controlling and redistributing development revenues. Brokerage is also often associated with patronage. Steiner (2008) describes brokers in the context of patronage and clientelism, where local politicians distribute politically motivated favors to their local electorate.

Again the context becomes important, and research has to fall back on additional information in order to look at legitimacy, accountability, transparency, fairness and justice of the person or institution in question (Pero and Smith 2008), and to study discourses (Beratan 2007) and social conflicts and their solutions (Thelen 2000).

Networks of knowledge

The combinations of SNA and the concept of social capital or brokerage are very prominent. Another combination, not as prominent but nevertheless very interesting for this study with respect to adaptive capacity, is the notion of knowledge networks as complex self-organizing systems. Monge and Contractor (2003) identified four features ascribed to the ability to self-organize. The first feature is autocatalysis, which captures the capabilities of the parts of the system to self-create and self-renew. In the case of knowledge networks, humans are able to create new knowledge, and the network is self-generative as it allows access to its knowledgeable parts and thus attracts more participants itself. Mutual causality is another key feature of self-organization. On the

one hand, once people decide to share their knowledge with others, the knowledge becomes independent of the provider, and becomes information circulated in the network that can be used as raw material to generate new knowledge. On the other hand, as people are the actual inventors of new ideas, pooling together the intelligence of better-informed and motivated people can spin off much more new knowledge. The third feature of the network is that it is open to the environment with respect to the exchange of knowledge. Each time a new person is recruited into the network, it gains new resources for self-organization. A fourth feature of self-organization is that it operates far from the equilibrium state, since it is the state where self-organizing adaptive activities are most likely to happen. By far not all networks of knowledge work like this. Looking at a practical example, Bodin et al. (2006) assumed that the distribution of Local Ecological Knowledge (LEK) in a Kenyan fishing community also depends on the network structure. They could show that knowledge about the state of fishing resources got stuck in different sub-groups due to missing communicative bridges. This hampered the development of a common understanding of resource-related problems, in their case the over-exploitation of fish stocks. The failure to understand a common problem in turn affected the ability of the fishing community to self-organize itself around regulations of resource extraction, leading to continued depletion of resources.

2.4 Analytical framework

In order to assess the potentials of fisheries to contribute to the resilience of the rural poor in the Upper East Region of Ghana, the vulnerability context will be assessed using existing literature. The external side of risk, shocks and stress will be analyzed by looking at the physical geography of the UER. Information about the internal side of vulnerability will be provided by a critical look at the human-geographical characteristics of the Upper East Region. Therefore, not only are existing social structures important, but also trends such as changing political and social structures will receive special attention. These trends are believed to be of special importance, not only for the development of new livelihood strategies, but also for the establishment of new management regimes.

While the analysis of the vulnerability context will be very broad, the subsequent steps of the analysis will focus on three study reservoirs and attached communities and the connection between the aquatic resources of the reservoirs and the local livelihoods. The number of fishermen and people selling fish will be assessed as well as the meaning of the new strategies and the assets needed to incorporate them into the existing livelihood portfolio. While assuming that new livelihood strategies are generally positive, this study will also check whether new vulnerabilities could arise from them. As mentioned above, this work will not only focus on people's agency to make use of new opportunities, but will also focus on the structural context in which they are embedded. Therefore, the review of the historical developments or fisheries' activities and also traditional and other natural resources governance regimes receives special attention. The goal of this first cluster of analyses is to draw conclusions about if and how these new strategies influence the resilience of the local population. Thus the last step evaluates whether the people in the UER have the assets and the structural requirements to adopt the new strategies, which not only decrease vulnerabilities, but also provide outcomes for doing new things, for innovation and for development.

The second cluster of analyses revolves around ecological pre-conditions and potentials. First, current fish yields will be assessed using data about catch recalls from fishermen. In order to validate the catch figures derived from interviews with fishermen, area-catch studies were conducted in early February, as intensive fishing usually starts around that time, and at the end of May, when fishing activities are reduced drastically as the onset of the rainy season requires full labor force on farms. To assess the robustness of yields against disturbances as well as ecological potentials to increase fish production in the reservoirs and thus potentials fish yields, human as well as environmental factors will be analyzed. Other water uses will also be included into the analysis as the harmony amongst all water users is seen as a critical pre-requisite for a sustainable increase in fish yields.

As pointed out above, the third dimension of this study assumes that fisheries and selling fish already contribute to the resilience of the local population and further assumes that enhanced fish production is ecologically possible and economically plausible. The question then becomes, which capacities are needed or asking the other way around, which pre-requisites are fulfilled in order to manage the reservoirs for

increased fish yields and strengthened resilience. As described in the previous section of this chapter, a number of pre-requisites need to be fulfilled to manage reservoirs and the user community for resilience. These are (social) learning, access to knowledge and a storage facility in form of a social or collective memory. Participation, collaboration and communication were also perceived to be important, as were common mental models or visions, flexibility, leadership, trust and social capital. As described above, the tools and concepts provided by SNA are used to analyze to what extent the pre-requisites are fulfilled and capacities, also in form of human actors, exist. Special attention is thereby paid to the roles that actors play and social structures and processes that influence the management of reservoirs. Further, the scales and levels and accompanying goals and interests the actors represent are investigated in order to increase the understanding of power and control, the social construction of problems and knowledge valuation.

Based on the conclusions from the social and the ecological analysis, three descriptive scenarios are presented which show alternative developments for fisheries in the UER to strengthen the resilience of the local population and their livelihoods.

3 MATERIAL AND METHODS

3.1 Secondary information

A comprehensive investigation limits the number of cases that can be studied here to three. This renders statistical methods to identify explanatory power of independent variables, for example via regression analysis, impossible. It was therefore decided to adopt a comparative perspective and to identify causal mechanisms by looking for distinct patterns that are common to the cases investigated and by applying tools that focus on conjunctures or combinations of factors that explain the state of resilience (Young et al. 2006). This is not seen as a constraint. Causal explanations and theories often play a role in a social inquiry, where they are used to identify problems, future impacts of new regulations or to evaluate the effectiveness of, and assign responsibility for, past interventions (Lin 1998; Young 1999). To cover data gaps and support research findings, causal explanations based on secondary data, literature, local or expert knowledge, are used.

3.1.1 Secondary data

The GLOWA Volta Project (GVP) operated in the Volta Basin from 2000 to 2009, and a considerable amount of data was collected and assembled during that time, including GIS and remote sensing data, information about climate, soils and other physical conditions available at the GLOWA Volta Geoportal (http://131.220.109.6/Geoportal/index.jsp). Social, anthropological, political and economic information was also collected and used in this study where indicated. Especially helpful was the work of Jens Liebe (2002) and Liebe et al. (2005). Several doctoral theses, e.g., Osman Gyasi (2005), Wolfram Laube (2007), Irit Eguavoen (2008) and Makarius Mdemu (2008) provided very valuable insights into the region.

Further, data such as on soils in catchments and reservoir grounds were taken from the Food and Agriculture Organization of the United Nations (FAO) digital soil map of the world. Other data, such as stream courses and neighboring reservoirs were taken from digital maps collected from the Ghana Statistical Service (GSS). The GSS also provided the Ghana Living Standard Survey data, which were used to support

research results throughout this study. GIS data were processed using the ESRI software ArcGIS 9.

Data on fisheries and management of the reservoirs from the Ministry of Fisheries (MoFI) in the Upper East Region are scarcely available. Nevertheless, where available they were also taken into consideration.

3.1.2 Local knowledge

Local knowledge is used in this study in a two-fold way. First, it assists in triangulating scientifically generated knowledge. Second, the inclusion of local knowledge and perceptions significantly influence the design of management scenarios.

Local knowledge is defined, following Antweiler (1994, p. 19) who states: *„Local knowledge consists of factual knowledge as well as capabilities and skills, most of which have some empirical grounding.*" Those with this kind of knowledge can be called experts. The term expert implies that the knowledge of locals is not based on beliefs or unquestioned traditions, but on empirical observations often resulting from trial and error experiences or the observation of `natural experiments` (Gadgil et al. 2003). This kind of knowledge often has the advantage that it is based on a lengthy series of local observations. It is thus very suitable for social-ecological research that tries to identify long-term changes in slowly changing variables which are not easily detected in short-term research such as this study.

Furthermore, the inclusion of local knowledge is important because local and global perceptions are not necessarily coherent. For example, while the *„water scarcity narrative is omnipresent in drinking water policies concerned with Sub-Saharan Africa.*" (Eguavoen 2008, p. 99), the local water users find themselves nowadays less prone to seasonal variations in drinking water availability.

> *„As local knowledge and values still form the main driving force for rural people's decisions on land use, food production, community management, health practices, religious practices, teaching, learning and experimenting, these should be seen as the main point of articulation for development activities.*" (Haverkort et al. 2002, p. 151).

This is especially true of the development of extension services. Lightfoot et al. (1994) could already show that the integration of farmers' knowledge into bioresource flow modeling not only resulted in farmers learning new ways to recycle

materials, but also informed the extension services. Despite this awareness, local knowledge is still neglected in Ghanaian extension services, and the over-reliance on scientific knowledge results in a lower interest or ability of farmers to accept new technologies or practices (Boateng 2006).

3.1.3 Preliminary survey

Prior to the field research for this study, a preliminary survey was conducted in the UER in August and September 2006 in the context of the GVP. This first field trip was based on the encouragement of colleagues from the GVP and the Challenge Program on Water and Food Project No. 46: Small Multi-purpose Reservoir Ensemble Planning, who observed fishing activities during their own field research in the UER. Driving questions for this first trip were: Do people use small reservoirs for fisheries and, if yes, how is the resource managed?

Based on the secondary data described above, maps were developed which built the starting point for the site selection of the survey. Information considered were administrative boundaries, distribution of the population and ethnical groups, occurrence of ethnical conflicts, land use and land cover, size of the reservoirs and their distance to larger waterbodies such as the medium-size reservoirs Tono and Vea, but also larger rivers such as the Red and White Volta. Further, the distance to urban areas and border towns was considered. As conflicts amongst different water users are also an issue, reservoirs were selected with the infrastructure suitable for irrigation.

In the field information was collected on the seasonal or perennial water availability of reservoirs, management and interactions with the Ministry of Fisheries, density of fishermen, as well as on the existence and functioning of fishermen or fishmonger (small-scale fish trader) groups. This information was partly derived from observation, but mainly from 20 interviews with scientists, and technical and extension staff of the Ministry of Fisheries as well as with other key informants. Based on this information, 70 reservoirs were selected for a visit. As a result of the combination of the information from maps, interviews and site visits, 33 reservoirs (Figure 3.1) were selected for further investigation. 40 individual or group interviews were conducted with fishermen, fish mongers, dam caretakers and local authorities.

The interview partners were selected via purposive sampling. Besides the interest in the study of existing management structures, the following criteria were of interest: the number of fishermen and fisheries activities or water-use conflicts, the size of the reservoirs, condition of the dam, the location of the community and access to roads and markets. Seasonal waterbodies were excluded from the survey. Further excluded were communities that did not use the reservoirs for fishing and reservoirs that had exceptional dominant use (e.g., ecotourism).

Based on the information and local knowledge gathered during this survey, the research questions were further defined and three reservoirs were selected accordingly as explained in the following.

3.2 Selection of research area and sites

Research area

As will be explained in detail later, the UER is one, if not the poorest, region in Ghana, despite a vast number of small- and several large-scale development programs. Large sums were invested in the establishment of small reservoirs and related infrastructure, yet water productivity is still low (Liebe et al. 2005). This also applies to the other northern Regions. However, the high population density in the UER means that many more people are affected and questions about development strategies are even more pressing.

The availability of data, project contacts with government officials, NGOs and other authorities and advisors and infrastructure also led to the selection of the UER as the research area.

Selection of reservoirs

From the 33 reservoirs, three (Figure 3.1) were selected based on criteria described in the following.

Reservoirs were selected which had communities attached that used these reservoirs frequently and actively for fishing, and also for other purposes such as irrigation and livestock watering. As none of the communities actively managed their fisheries resources, communities were chosen where at least rudiments of past management approaches were observed. While all of the 33 reservoirs were used for

fisheries, the existence of management structures narrowed down the number of potential cases to seven.

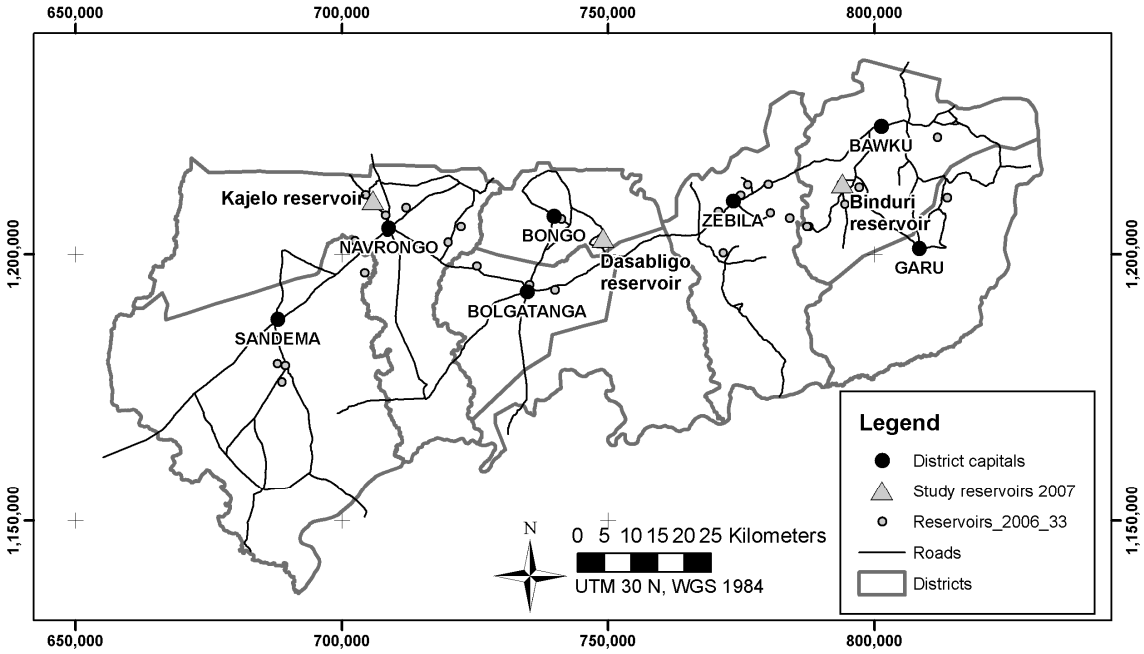


Figure 3.1: Reservoirs visited during a preliminary survey in 2006 and study reservoirs

The next selection criterion was the spatial distribution of reservoirs, based on the assumption that fisheries activities, management as well as fish production may vary geographically. Decisive were differences in ethnicities, different tribes are assumed to have different natural resources governance systems, traditionally grown and even applied to the comparatively new resources provided by the reservoirs. Further, the studies conducted in the context of the GVP and other authors (e.g., Bacho and Bonye 2006) suggest that conflicts amongst ethnic groups may also considerably hamper management. It was further assumed that remoteness of the communities and related access to extension services and markets and other fishing facilities such as larger reservoirs or rivers would influence fisheries activities and management.

Five of out of seven cases were selected and visited again at the beginning of the field trip in 2007. Since it was planned to stay in the communities for several weeks, the final selection criteria were proper housing and access to safe drinking water and food as well as cell-phone coverage in case of emergency, which were provided in three communities, Kajelo, Dasabligo and Binduri.

Kajelo has several reservoirs and an active fishing community, which was in the past repeatedly organized by the extension officers of the MoFI. The largest reservoir was chosen, as it is perennial and has an irrigation structure. The community population consists of one main tribe (Kassenas), which leads to the exclusion of ethnic rivalries. Furthermore, the community has good access to two larger markets as well as to the Tono reservoir. An assessment accomplished by Hesselberg and Yaro (2006) reflecting on the extent and causes of food insecurity in Kajelo using a livelihood vulnerability framework provided valuable additional information.

The second reservoir that was chosen is the Dasabligo reservoir close to the border of Ghana and Burkina Faso. It is shared by two communities with two different ethnic groups, Dasabligo in the Talensi-Nabdam district and the sub-community Atonbogoro of Beo community in the Bongo district. As in the other communities, there is a number of other small reservoirs but none of them has a proper irrigation infrastructure and they are all much smaller. In contrast to the other two reservoirs, the Department of Fisheries and later the MoFI never became involved here. Nevertheless, the communities have very active fishermen, who tried to form a group without encouragement from outside and subsequently made the community very interesting for further studies.

Binduri in the Bawku municipality district was also selected. The community is home to a number of ethnic groups, and the area is known to suffer from ethnic rivalries. Although it does not have the market access like Kajelo, Binduri has its own small market. Out of a number of small reservoirs within the community, the Binduri reservoir was the largest and had a well working irrigation infrastructure.

3.3 Timeline and basic research principles

Timeline

Fisheries in the UER have a clear seasonal pattern. During the preliminary field trip, fishermen explained that the fishing season starts when the water starts to become warmer at the end of January / beginning of February, as the higher temperature means that the fishermen can stay in the water longer. Following this pattern, field work in the UER started in February 2007. The research process started with an introductory meeting in each community, open for everybody, where activities and goals of the

research were explained to the villagers, and permission was sought to work on community grounds.

In order to gain an overview of the fish stocks before the main harvesting began area catch studies were conducted in the three reservoirs. At the same time, the first water samples were taken; this is hereafter referred to as the first measurement campaign. Dates for the measurement campaigns were set according to seasons with February representing the dry season.

Then each community was visited for two weeks between March and May 2007. The elders of all sub-communities were visited, market surveys were conducted, and lists of all fishermen and mongers in the communities were established. Group discussions with fishermen and mongers were organized for participatory appraisals and several key informant interviews were conducted.

A second measurement campaign for water quality was conducted in the May. This is usually the beginning of the rainy season, and the time was selected in order to capture the changes in water chemistry induced by the rains. Unfortunately, the year 2007 was far from being a typical year with respect to climatic patterns. The dry season prolonged into June, and water levels were exceptionally low in the study reservoirs, so that results from these water samples do not reflect the onset of the rainy season but an extremely dry season.

To get an estimate of how much fish was caught in the fishing season, a second area catch study was conducted at the end of May as well.

Another two weeks were spent in each community between June and August 2007, when the social network data were collected. Market surveys were conducted again to detect seasonal changes in products and prices. Several group discussions with fishermen and fishmongers were organized for participatory appraisal and also to discuss preliminary research results.

In between the measurement campaigns and community stays, many days were spent with the extension staff of the MoFI, actors from NGOs and other researchers to obtain their views in open interviews. Furthermore, time was spent searching in Ghanaian libraries and talking to people from the FAO, IFAD and especially staff from the fisheries section of the Ghanaian Water Research Institute (WRI).

After the end of the field trip in August 2007, data were entered and analyzed. In this process, data gaps were identified that made a second 2-month field trip necessary from mid March to mid May 2008. During this trip water quality was again measured, this time including oxygen measurements and alkalinity tests. The survey to recall catch data from fishermen was accomplished and influence factors maps were drawn. Apart from filling the data gaps, this second field trip provided an excellent opportunity to present preliminary results to the communities, the Ministry of Fisheries and other stakeholders for discussion.

Basic research principles

Apart from the questionnaire-based surveys and the ecological assessments the major part of this research is based on the principles of qualitative social research seeking to understand the reality of the local communities from the inside (Flick 2000). Qualitative research does not seek to establish absolute values for the topics which are investigated. The intention is rather to recognize all important aspects and detect as many causal mechanisms as possible. Therefore, the selection of the interview partners was based on the reflection of who has additional new information about the topic. The number of interviews was not known before the field trip. The process was stopped as soon as theoretical saturation was reached, which means there was no additional information (Flick 2000).

Interviews with individuals as well as with groups had the objective to involve them in an open discussion, where dialog or discussion were preferred to the exact execution of question-answer-constellation. New topics were dealt with if they arose, and the interview partner(s) were encouraged to raise his or her own questions and issues (Mayring 1990).

In four communities selected for the case study, different languages were spoken, which made it necessary to work with local translators who were familiar with the local dialect. Young people were chosen when possible in order to avoid as far as possible involvement in community political issues.

Interviews were documented by writing down all comments and observations made during the interview, as detailed as possible. After the fieldwork, the translator and the author met to exchange field notes and if missing data or uncertainties were

detected interviewees were asked again the next day. This was very time consuming, but ensured quality data.

Unless described otherwise, qualitative interviews and participatory appraisals were analyzed using Mayrings (2003) guide for qualitative content analysis. Relevant comments were extracted from the interviews and language was harmonized, without changing the content. The relevant comments were grouped into pre-categories which were further differentiated into subcategories following the outcomes of the discussions and interviews. Within each category different schemes of answers were extracted.

3.4 Livelihoods and history

3.4.1 Participatory appraisal

At the beginning of the 2-week community stay, the elders of all sub-communities were visited to greet them and introduce the research work. These visits were also used to talk about the elder's perception of poverty and wealth. Further, first observations of the community infrastructure such as markets, schools, religious facilities, etc., were discussed. Insights and information gained during these visits were handled in the same way as information derived from the key informant interviews.

Several group discussions with fishmongers and fishermen in each community provided information about the livelihood strategies preferred according to season, the assets needed for fisheries activities and the problems faced with fishing and selling fish. At the end of the field research in 2007 and 2008, group discussions were organized with both fishmongers and fishermen to present preliminary research findings and subject them to criticism and discussion. Moreover, ideas and strategies for the future were discussed.

Apart from the group discussions, resources maps were developed with fishermen following Kumar (2002), to establish the radius in which fishermen go fishing in different waterbodies. Based on this map, all waterbodies were visited and GPS points were taken with a GPS unit (Garmin eTrex Summit) and combined with other GIS layers to produce comparable maps.

The seasonal figuring (Kumar 2002) was conducted with several fishermen in each community to get an idea about the details of seasonal variation in income, workload, expenditure, food availability, credit requirement, availability of wage

employment, etc. The interviews also provided scope for discussion on coping strategies during periods of crisis.

3.4.2 Questionnaires

Complete lists of fishermen and fishmongers were established or, where already existing, updated, and short baseline questionnaires were filled in for all members of the list who were available. These surveys were conducted by the translators after the author left the community after the first community stay.

The questionnaires cover the name, age, education, ethnicity, religion, residence according to sub-community, main occupation(s), and household size. Further, the fishermen were asked how often and where they went fishing, what gear they used and when they started fishing. All the information was collected for the dry and rainy season. Based on this first survey, a second survey was conducted in April 2008 (see Appendix 1). The second survey was mainly conducted to support the ecological assessments (see section 3.5.1) but also to provide additional information about income from fishing, and advantages and disadvantages of the livelihood strategy. As the field trip in 2008 was short, only a limited number of questionnaires could be filled in. Interview partners were randomly sampled from the established lists. Confidence interval of the sample is 85% and margin of error 15%. Sample size, confidence interval and margin of error were calculated using the sample size calculator available under: http://www.raosoft.com/samplesize.html.

Information collected from all the fishmongers in 2007 was the same as for the fishermen. Further, the fishmongers were asked from where they obtained their fish and from whom, where and how they sold it, how much they earned in the dry and the rainy season, how much the earned money contributed to the household income, and when they started selling fish and why.

3.4.3 Market assessment

Each market was visited once a week when staying in the respective community and once during 2008. During these visits, the number of women selling fish was counted, including information about their commodities and the source of supply. In addition, the quantity and price of produce available were assessed. The women were asked about

their observations of trends in demand and supply and possible reasons for changes. Further information about investment costs, profits or losses was acquired.

3.4.4 Historic assessment

Accounts of historical developments of the meaning of fish for livelihoods and fisheries management were established using an approach called path dependencies described by Bennett and Elman (2006). The analysis starts with an open period during which there are a number of plausible alternatives. Then a critical juncture appears where contingent events result in one of these alternatives being selected, and then feedback that constrains actors to keep to that particular path.

Following these suggestions, a chronicle for each of the selected communities is presented to throw light on how the current situation of fisheries and fisheries management came about. Thereby, the four time categories pre-colonial, colonial, and post-colonial and contemporary were used. The categories are compared in order to filter the causes for current situations. Although there will be a focus on the local developments, international influences, e.g., by the colonial administration or development policies to the national level of general fisheries policies or their regional implementation, will be taken into consideration.

Information for the chronicles has to rely on few literature sources for the use of aquatic resources in pre-colonial times. For the colonial section, the analysis has to rely mainly on literature. However, some elderly fishermen were found with memories dating back to colonial time and they shared their memories in open interviews. For the post-colonial and contemporary time categories, the most detailed information could be found. Apart from the current MoFI staff, retired extension officers were ready to talk about the time when the first fisheries offices were opened in the UER and what happened until the date they retired. In group discussions, experienced and partly retired fishermen willingly shared information about the last 50 years of the reservoirs. In open interviews they described how the fisheries activities developed.

3.5 Ecological data collection and processing

Data to assess the ecological system of the reservoirs were mainly collected from February 2007 to August 2007. Another short field campaign was possible in April

2008. Due to time limitations, most data were either collected once or sampled seasonally (every three months).

3.5.1 Fishing pressure and catch data from fishermen

In a first round of questionnaires in 2007, all fishermen of a community using the particular reservoirs under investigation were surveyed individually to determine their total number, amount and type of fishing gear (see section 3.4.2). Based on this survey, the second survey (Appendix 1) was conducted in April 2008 to obtain estimates from the fishermen about the recalls of their catches and about the fishing days per week in the rainy as well as in the dry season.

Although the local fishermen reported that fishermen from outside the community sometimes fish in the respective reservoirs, none was met during the investigations, and hence information about their numbers and catches was not available.

Figure 3.2 and 3.3: Cast nets

Figure 3.4 and 3.5: Cross/Gil nets

Figure 3.6: Line and hooks

The estimates of the fishermen are based on their visual memory. Prices for fish are negotiated based on a visual assessment when the fish is laid out by the fishermen in front of the fishmongers. In order to create such a picture, paper fishes were presented to the fishermen who were asked to assemble a catch from a normal fishing day for each gear type they used. This was repeated for rainy and for dry seasons. For simplification reasons only, the main species caught in the area catch studies in 2007 were presented.

Figure 3.7: Oreochromis niloticus (Linnaeus, 1758)

Figure 3.8: Tilapia zillii (Gervais, 1848)

Figure 3.9: Hemichromis bimaculatus Gill, 1862

Figure 3.10: Sarotherodon galilaeus (Linnaeus, 1758)

Figure 3.11: Hemichromis fasciatus Peters, 1857

Figure 3.12: Clarias gariepinus (Burchell, 1822)

Cichlidae were grouped together as Tilapia, as nobody was familiar with the term Cichlidae. The local names for the fishes were different for all four communities, and not even all the fishermen were familiar with them. In order to avoid confusion and clarify the questions, pictures of the fish were shown.

For each of the main fish types, the fishermen could choose between three size categories which were pre-selected based on the area catch studies and which provided size categories with associated average weight (see Table 3.3).

Table 3.3: Average size categories and associated weights of Tilapia and Clarias gariepinus stocks in Kajelo, Dasabligo and Binduri reservoir

	Kajelo	**Dasabligo**	**Binduri**
		Tilapia	
small			
weight [g]	3	3	3.5
length [cm]	5	5	5.5
medium			
weight [g]	8	7	8
length [cm]	8	7.5	8
large			
weight [g]	17.5	25	25
length [cm]	10	11.5	11.5
		Clarias gariepinus	
small			
weight [g]	15	37	44
length [cm]	15	16	15
medium			
weight [g]	70	118	150
length [cm]	20	26	25
large			
weight [g]	450	400	400
length [cm]	40	38	38

The estimates from the fishermen were processed separately for Cichlidae and for *Clarias gariepinus* as well as for each season as described step-by-step in the following:

1. The average number of fish of each size category and gear was calculated and then multiplied by the associated average weight for the size category.
2. The weight was summed up to obtain the estimated total weight of fish per catch day per gear.
3. A weighted average was calculated from the values of the different gears, based on the % to which each gear is used in the community to obtain an average catch/day.
4. The average catch/day was multiplied by the number of fishermen and then the amount caught by all fishermen per day was multiplied by the average number of fishing days per week and multiplied by 24 weeks (average season). This figure provides the total fish catch per fish species per season.
5. The total catch was divided by the reservoir surface area (ha) and both seasons were summed up to obtain the amount of fish in kg/ha/year, comparable to the area catch studies.

The results from this survey are probably subject to a number of biases. First, the margin of error of the interviews has to be considered. Furthermore the possibility of "strategic answering" must be taken into consideration, which may be caused by the expectation that indicating small catches increases the chances to obtain assistance from a development project. Another possibility is that fishermen report large catches to show their good fishing skills to increase their prestige. Another source of error could be that fishermen were not able to explain what they catch normally. According to Welcomme (2001), fish populations in reservoirs vary widely in abundance from year to year. So what is normal for the year 2007 might not be normal for 2008. The year 2008 was, according to all fishermen, a very good year, since the floods in 2007 brought many fish. The stock assessments were done in 2007, a bad fishing year according to the fishermen. This might explain some of the bias between the high catch figures from the fishermen, especially in Dasabligo and the low catch figures from 2007. Another reason for bias is that fishermen access a number of reservoirs and other fishing grounds close to or even within the communities aside from the respective reservoirs investigated in this study. Although it was emphasized the catch figures from either

Kajelo, Dasabligo or Binduri were of interest, it is well possible that they confused yield from other sources with those from the reservoir under review.

3.5.2 Area catch study

The fish populations of the reservoirs were assessed twice (see section 3.3). The catch per area sampled can be assumed to be proportional to the abundance (Sparre and Venema 1998). On advice of local fisheries experts and fishermen, no area catch study was conducted after the onset of the rainy season. The MoFI provided the net for the assessment and invaluable expertise for selecting samplings sites, organizing local fishermen who helped to drag the net and identify and measure the various fish species. The fish were identified using the key provided by Lévêque et al. (1992) and Dankwa et al. (1999).

Since the stock assessment procedure was lethal for the fish, the sampling was mostly limited to two sampling sites per reservoir and one haul per site. The two sampling sites were selected to cover the deeper part of the reservoirs along the dam wall and the shallow partly overgrown shore areas close to the estuary of the seasonal rivers, which were long dried up at the times of assessment. Apart from these characteristics, sites were selected where the catch could be landed without too much loss and no big rocks could tear the net.

The hand-drawn drag net had wings of 21.5 m, and 16.5 m, and a bag of 25.5 m. It reached a depth of 4 m between the head and foot ropes. Mesh sizes were 5 cm at the wings and 2.5 cm at the bag (see Figure 3.16).

Figure 3.13: Areas of area catch studies in February and May 2007 in Kajelo reservoir

Figure 3.14: Areas of area catch studies in February and May 2007 in Dasabligo reservoir

Figure 3.15: Areas of area catch studies in February and May 2007 in Binduri reservoir

Assessments were made from the shore and the vertical extent of 4 m made it possible to cover the ground of the reservoirs. A boat dragged one end of the net into the reservoir, dragged the net in a curve and landed some distance from the starting point when the net was fully unfolded. With this procedure fish was encircled and then hauled towards the shore where it was collected and stored in big containers until further processing.

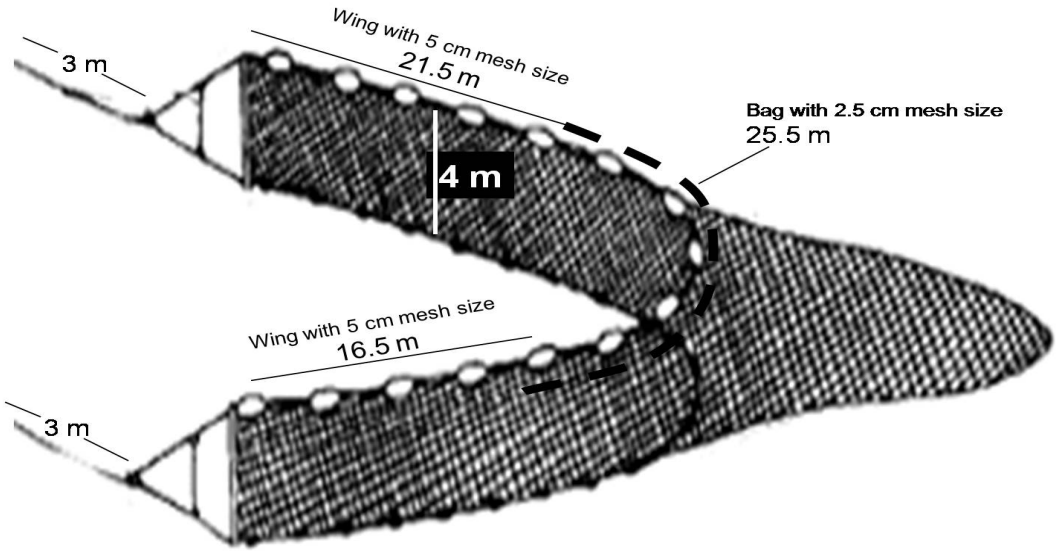


Figure 3.16: Drag net used for area catch studies

The total weight of each sample was measured and the sample sorted according to species. All fish were counted, and total length and weight was recorded following Sparre and Venema (1998). Fish species with high abundance were sorted into three size categories (see Table 3.3). The number of fish in each group was counted, each group weighed separately, and the size range of the fish recorded.

The average of the two hauls was calculated and extrapolated to the whole reservoir using the percentage of area covered by the drag net in proportion to the total surface area at the point of assessment. The area of a net was calculated as a semi circle with a 21.5 m + 25.5 m + 16.5 m as half of the circumference of a full circle, i.e., approximately 642 m^2. Total areas of the reservoirs at the time of the area catch studies were calculated with GPS data and the *ESRI* software ArcGIS 9.

Here again there are some possible errors that have to be taken into consideration. The method used for the area catch study is probably only suitable for catching certain species while others can more easily escape. This was observed for *Clarias gariepinus*, a fish that can easily hide in the muddy layers of the reservoirs and avoid the net.

3.5.3 Water quality

Collection of the different parameters took place at four to five different positions on the reservoirs from the boat.

Conductivity and Total dissolved solids (TDS) were measured with a *Combo pH/EC/TDS Tester* from *Hanna* with ±0.5°C accuracy in February/March, April/May and June 2007 as well as April 2008. The probe measured electrical conductivity (EC) in (mS/cm) with an accuracy of ±2% F.S. The tester was calibrated with the recommended buffer and calibration solutions before each measurement campaign.

Water temperature was measured just beneath the surface with the *Combo pH/EC/TDS Tester* from *Hanna*. The tester was likewise used to measure the pH values. The turbidity of the water was measured with a Secchi disk, following the *Secchi Disk Transparency Protocol* provided by the GLOBE Program (www.globe.gov/r).

To assess the phosphorus content, three rounds of water samples were taken (February/March, April/May and June 2007) and brought to the WRI laboratories in Accra and in Tamale, and the Soil Research Institute laboratory in Kumasi for analysis and validation. However, the results from the phosphorus measurements of the same water samples varied extremely from laboratory to laboratory. As it was impossible to detect the source of error in order to be able to correct it, the figures are not taken into consideration.

Two parameters only measured during the field trip in 2008 were the carbonate content of the water and dissolved oxygen. Carbonate was assessed with a test set (*JBL CH Test Set* from *JBL GmbH Co KG*). Dissolved oxygen (DO) was measured with the *Water Quality Checker U-10* from *Horiba*, with a resolution of 0.1 (mg l^{-1}). Calibrations were made in the air and corrected for altitude before each sampling period as well as a Zero calibration using a solution of sodium sulfite. The measurements were taken over a 24 hour measurement cycle and included dissolved oxygen, ph and temperature. Data collection took place from a small platform about 1.5 to 2 m from the shoreline. The DO was recorded before the bucket was sunk under water in the reservoir to keep the temperature in the bucket at the same level as it would be in the reservoir. During the 24-hour cycle, the DO was recorded every 4 hours.

The reservoir catchment areas were calculated from digital elevation data. These data were taken from the Shuttle Radar Topography Mission (SRTM) with a spatial resolution of 90m and used to delineate the catchment area based on flow direction (Eastman 2003).

The land use and vegetation cover of the catchment areas surrounding the reservoirs were observed and documented with photos to supplement observations from Moderate Resolution Imaging Spectroradiometer (MODIS*)* satellite images. The images were obtained from the GLOWA Volta Geoportal.

Furthermore, the composition of reservoir sediment, reservoir vegetation and the utilization of the reservoir other than fishing were documented based on observation.

3.5.4 Influence factor maps

In order to visualize local ecological knowledge, the Net-Map tool (see section 3.6 below) was modified to collect data on social-ecological networks. The question was transformed into: What factors influenced fish production in your reservoir in the last five years and how? For experts other than fishermen, the question was: What factors influence the fish production in small reservoirs and how?

Factors and related processes were written on adhesive paper together with descriptions of how they influence fish production and pasted around a reservoir drawn on a white sheet of paper. For example, the factor rainfall was divided into low and high. A green arrow was then drawn from high rainfall pointing to the reservoir, indicating that high rainfall results in increased fish production, whereas the red arrow pointing to the reservoirs from low rainfall indicated that low rainfall results in low fish production. This was done for all factors and processes mentioned. Finally, the interview groups had to rank the influence of the factors and processes with towers consisting of an optional number of ball bearings, where a high tower represents high influence.

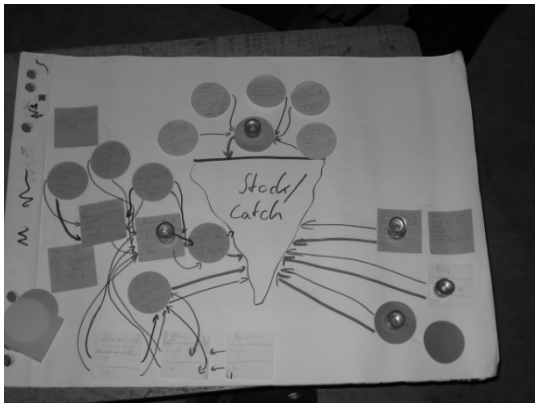


Figure 3.17: Factor influence map

Information on how the relations influenced each other could only partly be collected, as the interview took considerable time and attention was paid to the patience and time schedule of the interview partners. All factors were transferred to a spread sheet where the height of the influence towers was normalized to allow the aggregation of relative influence from all interviews. The information is supported by additional information collected together with the catch estimates from the fishermen. Fishermen were asked to mention the three most important factors or processes that influence the fish stock in the reservoir. Information on data collection concerning processes of reservoir management can be derived from section 3.1.2 on local knowledge.

3.6 Social influence network mapping

The concept of adaptive co-management as natural resources paradigm entails certain pre-requisites (for details, see section 2.3.1). The resulting research question is: Who are the actors and what are the social structures and processes that do or could influence the management of reservoirs for fisheries.

In order to answer this question, social network analysis was used. Social network data were collected using a research tool called Net-Map. An extensive description of the interviewing process as well as an elaborate discussion of the pros and cons of the method can be found in Schiffer and Hauck (accepted) or under *www.netmap.wordpress.com*.

3.6.1 Pre-testing

The Net-Map tool was a rather new tool and had not been tested at local level as it was developed by Schiffer (2007) to understand the complex governance situation of a regional, multi-stakeholder water governance body in northern Ghana.

Before the tool could be applied on a local level, extensive pre-testing in all the four communities was arranged to explore and discuss terms and definitions of the different kinds of influence, find the corresponding terms in the three languages and find common denominators for all four communities to make the networks comparable. In this phase it became already apparent that each interview would take at least 1.5 hours.

3.6.2 Preparation and selection of interview partners

Social network analysts usually seek to examine all members of a network in a census style in order to acquire a complete picture of the network.

However, for time reasons, it was decided to follow a purposive sampling approach, where key informants were selected representing every potentially influential group (Table 3.4), which could be identified based on the experience and observations gathered during the previous community stays. For pre-testing several preparatory maps were developed with individuals who knew the villagers very well, but were not involved in fishing activities. These maps were not included in the analysis.

Table 3.4: Groups, sub-groups and individuals influencing fisheries activities

Group	**Subgroup or individual**
Fishermen	Chief fisherman(men)
	Normal fishermen
Fishmongers	Normal fish mongers
	Lead fish monger(s)
Traditional authorities	Chief
	Tindana
	Elder(s)
Elected authorities	Assembly woman/man
Government	Extension staff
Non-governmental Organizations	NGOs
	Development programs
Other water users	Cattle owners
	Gardeners

It was, however, assumed that when relying solely on purposive sampling, a bias would occur. People who are very suitable as key informants are usually those who are very knowledgeable and, based on knowledge sometimes combined with other power attributes, very influential. The risk was perceived to be very high to capture only a few very limited views on the influence networks when talking only to the people who exert influence.

In order to address this problem, a second strategy was followed to complement the key informant views. A list of fishermen and fishmongers in the community was produced based on the baseline questionnaires (see section 3.4.2). This list was compared with the peviously conducted interviews to see which of the fishermen and mongers had not been mentioned and consequently to determine the

persons not considered to be influential. It was found that some were not influential. From the list of non-influential individuals, some were selected at random and also interviewed in order to include the views of people who are probably on the periphery of networks.

Interviews were conducted either with one individual or in small groups of two to three individuals with equal attributes. The small groups proved to be very helpful, since the interview partners could discuss their views and feel less intimidated by the external visitors, as people felt much more confident in the company of equals.

Based on the time limit, the interviewing was stopped when a point was reached where not much more new information could be extracted. The perceptions of the diverse interview partners about the structures of the networks were rather similar. The core influence networks of the communities soon became apparent, and interviewing was closed after 7-9 interviews per community. Since the exchange of information about power and influence is highly sensitive, interviews were conducted at the homes of the interview partners to avoid onlookers likely to observe, comment and spread information (Hübner-Schmid et al. 2003).

The equipment used was bought in the region and included large sheets of paper for drawing the influence network maps, small multi-colored actor cards to note down the actor names and tape to fix the cards on the map. Further, different-colored pens to draw different links were used as well as bicycle bearings as flat round disks that could be stacked to build influence towers.

3.6.3 Interviewing process

In order to allow the inclusion of the interview partner's definition of influence, the guiding research question for the actual interviews was kept rather open: *„Who influenced the fisheries activities in X reservoir in the last 5 years and how*?" Discussion was sought at the beginning of every interview about the different ways in which individuals could influence each other in terms of fisheries activities. The answers defined the links drawn in the ensuing Net-Mapping. In order to cross-check whether both parties were clear about the definition of the links, the interview partners were asked to give examples on how the actual process of influence would look. Apart from ensuring that both interviewer and interview partners had the same understanding

of the different kinds of influence mentioned, the introductory discussions served as an introduction to the principles behind social network analysis and to explain the purpose of the interview. In the second community, a link came up that was overlooked in the first community, and all interview partners in the first community were visited again.

After the first discussion, the interview partners were asked to think of all individuals, groups or organizations that influenced fisheries activities. These were then each written on the actor cards and fixed to the large sheet of paper in front of the interview partner. The cards had different colors according the group the actor belonged to, and each color was grouped. If one or more groups were not mentioned during this process, interview partners were asked whether they had just forgotten them or whether they had no influence. If the interview partners mentioned new groups or sub-groups these were included in the analysis.

In the next step, data were collected on how the groups and sub-groups or individuals are linked, i.e., how influence is exerted. This was done by drawing arrows of different colors between the actor card groupings. The colors represented different kinds of links or types of influence. The arrows indicated that "something" (such as advice, funds, etc.) flowed from one actor (group) to the other. If there was a mutual exchange, the arrow had two heads.

After establishing the links, the interviewees were asked to assess who or which sub-group had how much influence on fisheries activities. According to the answers, influence towers were placed next to the actor card groups in accordance with the following rules: (a) the towers can be as high as the interviewees want, (b) two actors can have towers of the same size, and (c) if a group has no influence at all, no tower needs to be added.

Finally, it was asked how the different actor groups or individuals influenced the fishing activities, based on the assumption that some actors would encourage fisheries activities, while others, e.g., other water users, would rather try to stop them.

3.6.4 Data processing

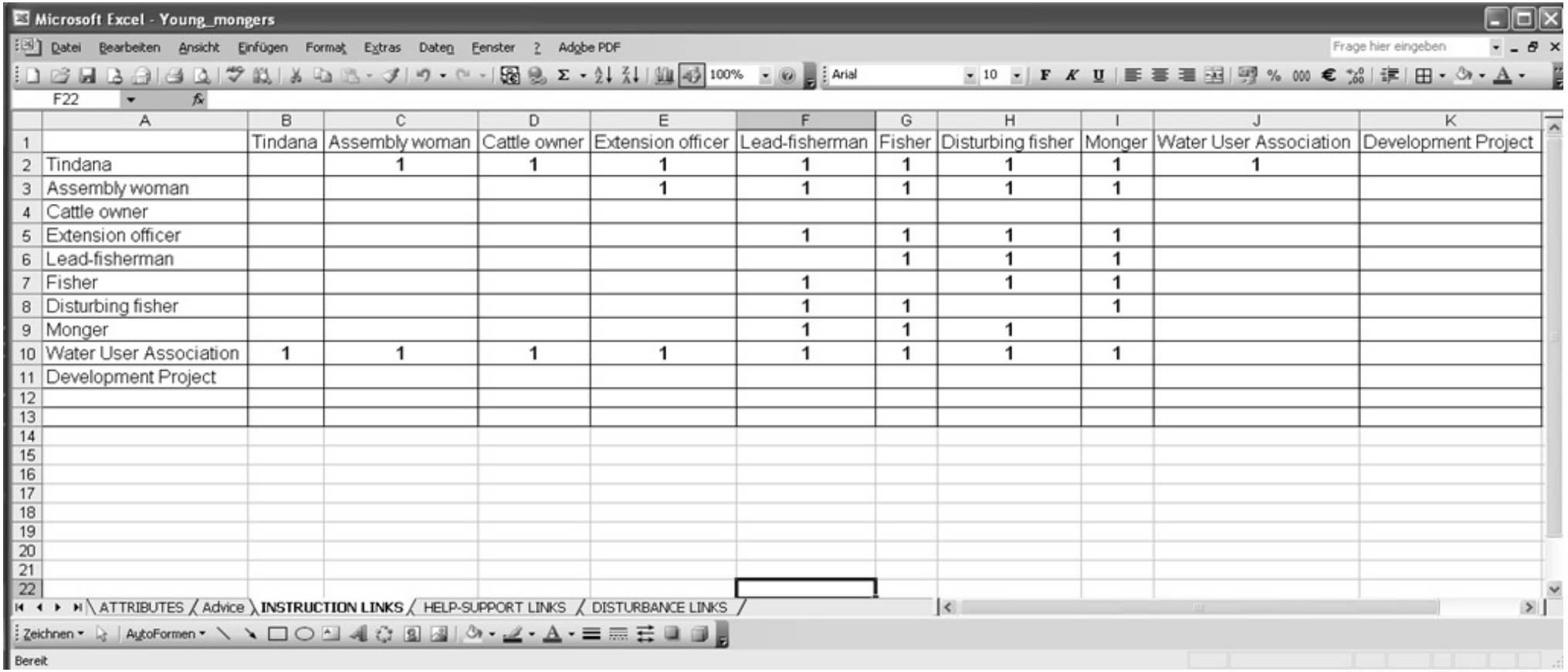
In order to be able compare the maps from within a community but also between communities, the language and actor names were harmonized. Categories of links were developed based on their functions of interactions between actors. The functions of

links were derived from notes taken during the interviews in which the interview partner described the functions of the links and gave concrete examples. The link/influence categories were a) advice and teaching, b) instructions, c) helps and support, and d) disturbance and conflict.

In a few cases, actors and linkages were mentioned that do not have a direct influence on fishing activities or where the ability to influence was no longer relevant. These names and linkages were removed from the maps before starting the analysis.

The answers to the question about how the people influenced the fisheries activities were also categorized according to the nature of the influence, e.g. whether people would encourage restricted or unrestricted fishing activities or try to stop or limit fishing activities. This was noted down together with the height of the influence tower.

Each type of influence was treated as a separate network, and every map had up to four networks. In order to analyze these multiplex network data, each network and sub-group was entered into a spread sheet as described in the following. First of all a list of sub-groups was established for each interview and entered into the column of an excel sheet (Figure 3.18).



	A	B	C	D	E	F	G	H	I	J	K
1		Tindana	Assembly woman	Cattle owner	Extension officer	Lead-fisherman	Fisher	Disturbing fisher	Monger	Water User Association	Development Project
2	Tindana		1	1	1	1	1	1	1	1	
3	Assembly woman				1	1	1	1	1		
4	Cattle owner										
5	Extension officer					1	1	1	1		
6	Lead-fisherman						1	1	1		
7	Fisher					1		1	1		
8	Disturbing fisher					1	1		1		
9	Monger					1	1	1			
10	Water User Association	1	1	1	1	1	1	1	1		
11	Development Project										
12											
13											

Figure 3.18: Network matrix (1 indicates link)

The approach is solely based on people's experiences and observations. If an actor was not mentioned or if the interview partner answered that he or she did not know whether the actor was influential or whether a link existed or not, this was counted as having no influence, since influence was neither experienced, nor observed. Of course, one could further argue that even a fisherman with no noted influence has probably still much more influence than an ordinary farmer in the community. These considerations, the limited number of interviews and other details require a careful interpretation of results with logic reasoning playing an important role.

The following data analysis procedures were developed:

- A pie chart was established reflecting how often each actor group was mentioned.
- The heights of the influence towers of each interview were normalized to obtain a scale of influence between 0 and 1. From these relative influence towers, average and standard deviation was calculated to determine which actor group had the greatest influence.
- The directions and levels of encouragement of influence were categorized.
- In order to compare and analyze the positions of the actors in the network, the degree centrality, closeness centrality and betweenness centrality were calculated using the *VisuaLyzer*™ software, following equations (Table 3.5) provided by Wasserman and Faust (1994).
- Networks of each category from each community were added up to a single network. When combining the networks, the links were transformed into weighted links according to how often they were mentioned in different interviews. Assuming 8 interviews, links that were mentioned 8-6 times were drawn in a thick line, links mentioned 4-5 times in a medium line, and links mentioned only 1-3 times in a thin line.
- The structures evolving from this visualization were then described and interpreted with the help of the detailed field notes taken during the interviews.

As pointed out above, the statistical analysis, such as averaging influence, has its flaws. In order to increase validity of the network data, group discussions were organized and

preliminary results and open questions were put up for discussion in focus groups with disguised data.

Table 3.5: Actor centrality measures provided by Wasserman and Faust (1994)

Indegree of an actor	
$l_k =< n_i, n_j >$, for all $l_k \in$ L and all $n_j \in$ N	where $l_k =< n_i, n_j >$ is the link from actor i to actor j, N = the set of actors in a network and L = the set of links in a network.
Outdegree of an actor	
$l_k =< n_i, n_j >$, for all $l_k \in$ L and all $n_j \in$ N	where $l_k =< n_i, n_j >$ is the link from actor i to actor j, N = the set of actors in a network and L = the set of links in a network.
Actor-level closeness centrality	
$C_C(n_i) = \left[\sum_{j=1}^{g} d(n_i, n_j) \right]^{-1}$	where $C_C(n_i)$ is the closeness centrality of an actor, g = the number of actors in a network in the respective network and $\sum_{j=1}^{g} d(n_i, n_j) =$ the total distance i from all other actors (where the sum is taken over all $j \neq i$).
Actor-level betweenness centrality	
$C_B(n_i) = \sum_{j<k} g_{jk}(n_i) / g_{jk}$	where $C_B(n_i) =$ actor-level betweenness centrality index and $g_{jk} =$ the number of geodesics linking actors j and k.

4 RESEARCH AREA

4.1 Physical geography of the Upper East Region in Ghana

Prior to analysis, the broader context in which the social and ecological systems are embedded and the vulnerability context of the local communities need to be determined. The following paragraph provides an overview of the physical geography of the UER, which determines the external side of vulnerability to a large extent.

4.1.1 Location

The UER is located between latitudes 10°30' to 11°15' north and longitudes 0° to 1°30' west and covers a land surface area of 8689.03 km^2 (Liebe 2002). The region borders on Burkina Faso to the north and Togo to the east and regionally with the Upper West Region in the west and the Northern Region in the south. At the beginning of the research the UER was divided into eight districts: Bawku Municipality and West, Bolgatanga Municipality, Bongo, Kassena-Nankana, Builsa, Talensi-Nabdam and Garu-Tempane (see Figure 4.1).

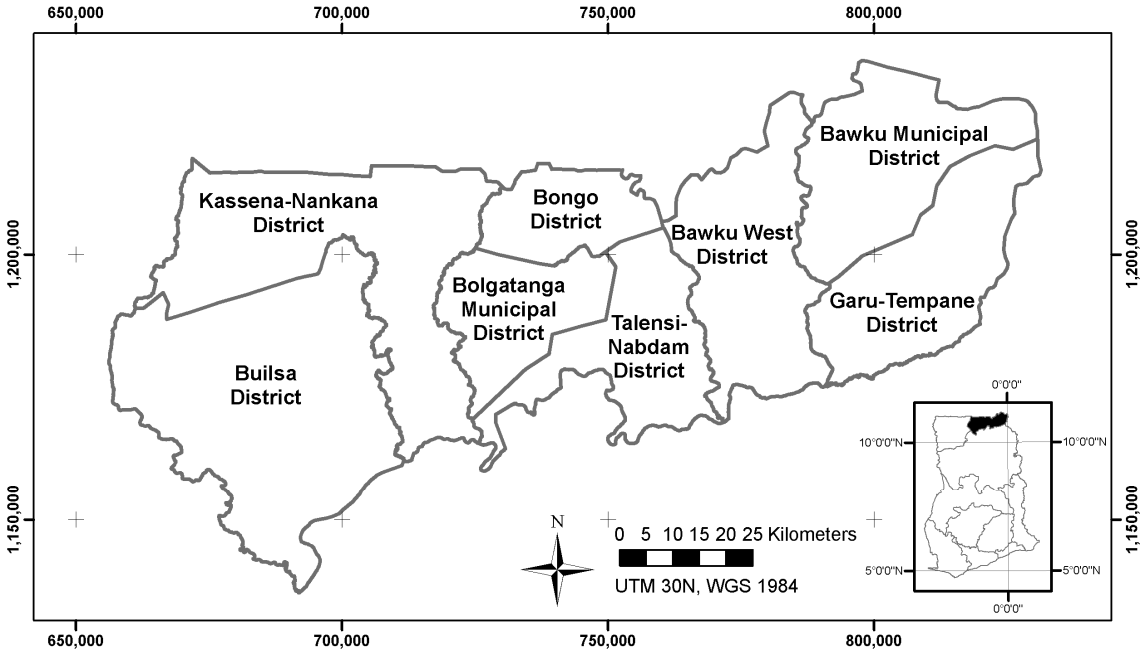


Figure 4.1: Districts of the Upper East Region

In the processes of decentralization (see section 4.3.2), in 2008 the Kassena-Nankana district was again divided into Kassena-Nankana and Kassena-Nankana West, i.e., nine districts. Maps that include the new district are not yet available.

4.1.2 Physical geography and agro-ecological conditions

Climate and rainfall characteristics

The UER belongs to the semi-arid tropics. Depending on author, the mean annual rainfall, which falls in a single rainy season, ranges between 700-1200 mm (Dickson and Benneh 2004), 682-1310 mm (Webber 1996) and 1000–1300 mm (Kranjac-Berisavljevic et al. 1999). A typical rainy season starts in April (Blench 2006) or May (Kranjac-Berisavljevic et al. 1999; Dickson and Benneh 2004) and ends in September or October, respectively. These variations can be ascribed to the fact that the start of the season varies considerably from year to year, and a high inter- and intra-annual variability make predictions difficult, if not impossible (Dickson and Benneh 2004; Van der Geest and Dietz 2004). The length of the rainy season varies between 140 and 190 days (Kranjac-Berisavljevic et al. 1999).

A very good example for the high variations in rainfall is the year 2007. During the field research, a 2-month delay in rainfall was observed. Hardly any rain events occurred until July. After the onset of the rainy season, however, heavy torrential rainfall flooded the whole region in August and September 2007. In view of the magnitude of the floods, the Government of Ghana declared the three northern regions as a disaster zone on 12 September 2007 (UNICEF 2007).

The total evaporation of 2050 mm exceeds the annual rainfall often more than twofold. While rainfall amounts in the rainy season exceed evaporation, there is a great seasonal deficit in the dry season, which usually peaks in May (Kranjac-Berisavljevic et al.1999; Liebe 2002). With an average of 28.6°C, temperatures are consistently high. Monthly averages range from 26.4°C at the peak of the rainy season in August to a maximum of 32.1°C in April (Liebe 2002) (see Figure 4.2).

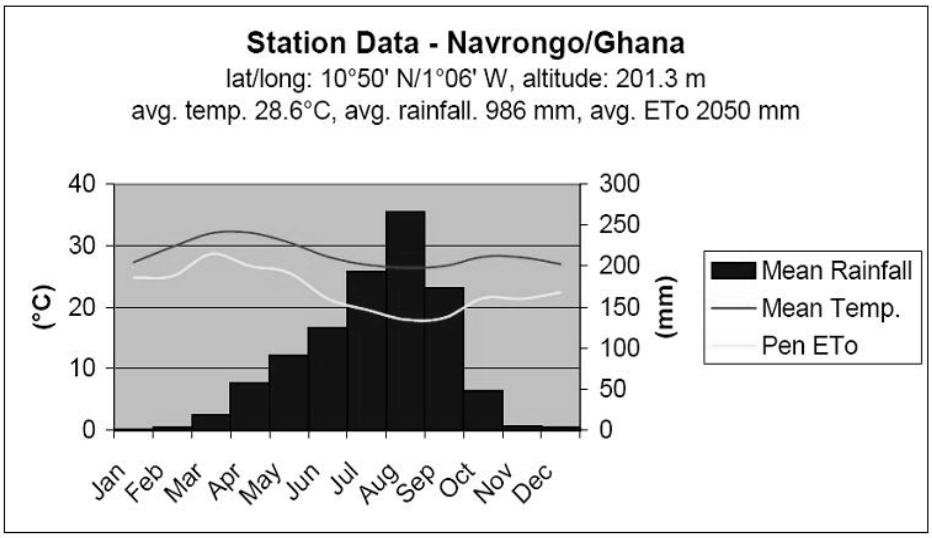


Figure 4.2: Climatic Data for Navrongo (Liebe 2002)

The consequences of climate change for the region are discussed controversially. Blench (2006), for example, could neither find inter-annual, nor intra-annual changes in rainfall patterns or temperatures.

Yet administrators and farmers claim that the overall quantity of rain falling is declining and that the distribution is more unfavorable and more unreliable than before (e.g., Laube 2007). Detailed analyses of climatic patterns in the context of the GLOWA Volta Project confirm change. Kunstmann and Jung (2005, p. 85), for example, state.

> *„Historical temperature time series showed clear positive trends at high levels of statistical significance. Among precipitation time series, most significant trends were negative. Results […] show that in April, which is the usual transition from the dry to the rainy season, precipitation will decrease by up to 70% and the duration of the rainy season will narrow, which may have extensive implications for agriculture. While the predicted total annual precipitation increases only slightly (5%), the increase in surface runoff is 18%. Predicted temperature increase in the rainy season is up to 2°C.*“

However, independent of whether there are climate changes or not, people are vulnerable to the erratic climate, since rainfed farming is still the most important livelihood in the UER (Blench 2006).

Geology, relief and drainage

The geology of the UER is dominated by crystalline rocks comprising the Birimian system and its associated granitic intrusives, as well as isolated patches of the

Tarkwaian formation. The Birimian system is made up of phyllite, schist, slate and some metmorphosed lava. The Tarkwaian rocks include quartzite, shale, phyllite and sandstone (WRC 2003; Dickson and Benneh 2004).

From a topographic point of view, the UER is part of the Savanna High Plains (Dickson and Benneh 2004), which are gently undulating with broad valleys and extensive flood plains adjacent to the Volta rivers (Kranjac-Berisavljevic et al. 1999). Minimum elevation is 122 m in the southern part of the region, while the maximum elevation of 455 m is directly on the border to Burkina Faso. Mean elevation is 197 m, and most of the relief can be described as flat and uniform (Liebe 2002).

The drainage system, which is part of the White Volta sub-basin (see Figure 4.3), runs mainly from north-east to south-west (Kranjac-Berisavljevic et al. 1999). The outlet from the Bagré dam in Burkina Faso mainly regulates the flow level of the White Volta, but other rivers in the region are intermittent, i.e., they flood in the rainy season and dry up in the dry season (Dickson and Benneh 2004). Major tributaries to the White Volta River all flow into Ghana from Burkina Faso. Apart from three major tributaries to the White and Red Volta, and the Sisili and the Tono River, there are many small seasonal rivers that have developed inland valleys of different sizes and shapes. Many of these valleys are suitable for the construction of small reservoirs (Liebe 2002).

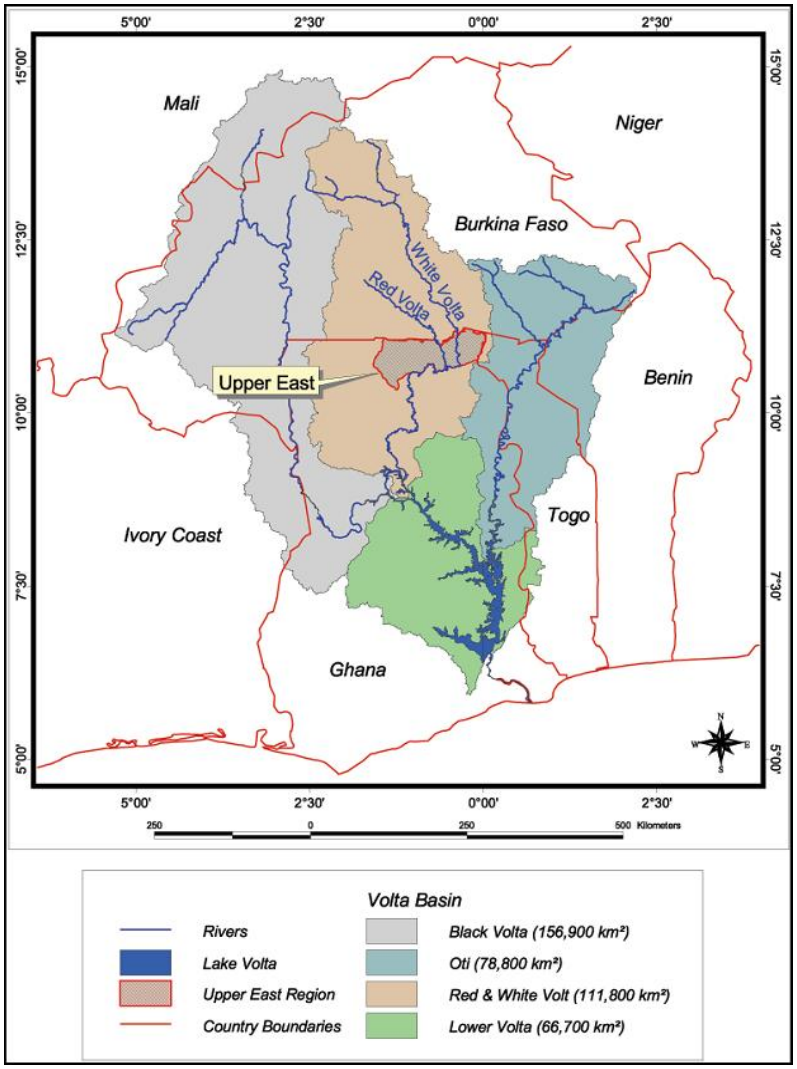


Figure 4.3: Upper East Region of Ghana within the Volta Basin (Liebe 2002)

Soils

According to the FAO classification system, the dominant soils of the region are lixisols. Lixisols develop on old landscapes in a tropical climate with a pronounced dry season and are strongly weathered. The clay is washed out down to a B-horizon. Their age and mineralogy have led to low levels of plant nutrients and a low absorptive capacity that causes high erodibility and flooding.

In addition to these natural processes, soil degradation is often accelerated by intense human use. Over 60 million people in sub-Saharan Africa live on land that is losing its ability to produce green biomass due to land degradation, which is mainly agriculture related (Vlek et al. 2008). Increasing population pressure and low investments in land conservation worsen the situation (Vlek 2005). This ‘creeping

disaster' as it is called by Vlek et al. (2008) was already observed in 1964 by Rose-Innes, who found that anthropogenic processes increase ecological degradation due to land clearing, grazing and bush burning. In addition, the high demand for firewood and wood as building material leads to a decreasing forest cover that lowers infiltration rates and thus increases run-off (Blench 2006; Laube 2007). Increasing livestock density resulting in an intensification of grazing pressure contributes likewise to the problem.

Vegetation and agro-ecological zones

The UER is situated in the transitional area of the northern Guinea and the Sudan savanna zone (see Figure 4.4). While in the Guinea savanna the growing period ranges from 165 to 210 days, the growing period in the Sudan savanna is significantly shorter with 90 to 165 days (Windmeijer and Andriesse 1993).

The vegetation can be characterized as open woodland savannas with few trees and perennial grasses in the Guinea savanna and increasingly annual tussock grasses in the Sudan savanna (Windmeijer and Andriesse 1993; Dickson and Benneh 2004; Blench 2006). The dominant tree species are locust ('dawadawa') (*Parkia biglobosa*), shea (*Vitellaria paradoxa*) and kapok (*Ceiba pentandra*) with a ground cover of perennial grasses such as *Andropogon gayanus*. Further north, baobab (*Adansonia digitata*) and whitethorn (*Faidherbia albida*) predominate. Introduced mango trees are common in bush areas, as is the Neem, which has assumed weed-species status (Blench 2006). Deforestation has led to the spread of Sudano-Sahelian conditions as the first phase in the desertification process (Songsore 2003).

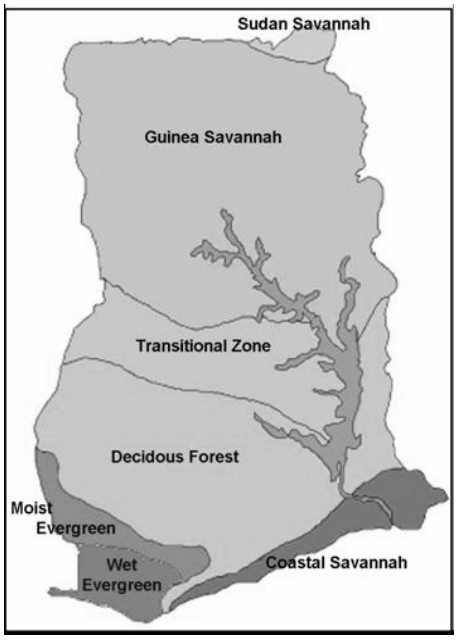


Figure 4.4: Agro-ecological zones in Ghana (https://www.uni-hohenheim.de/respta/pics/agriczones.jpg, accessed: 17.04.2009)

4.2 Human-geographical profile of the Upper East Region

Following the overview of environmental preconditions, the socio-economic, cultural, and political setting is portrayed, which relates to what Chambers calls the internal side of vulnerability, as a lack of means to cope, and the vicious circle of poverty.

4.2.1 Historic causes and current levels of poverty and vulnerability

Poverty levels in UER are comparable to those of some of the poorest countries in the world, notably Burkina Faso and Mali (Blench 2006). Laube (2007, p. 42) states: *„The part of the population that is classified as poor according to Ghanaian standards is as high as 73% and has been increasing since 1990. It might be as high as 90% in the rural areas."* According to the newer living standard survey (GLSSV 2005/2006 cited in Biederlack and Rivers 2009), this means that the vast majority of the people living in the UER are living below the national poverty threshold of 1.47 GHS per capita per day. Many of these people live even below the lower poverty line, where extreme poverty starts, with an income of less than 288 GHS per adult per year or 0.78 GHS per capita day (GLSSV 2005/2006 cited in Biederlack and Rivers 2009) (average Euro/Cedi exchange in 2008 was 1/1.6). Furthermore, there is a virtual absence of people from the

north in the middle and upper level job market due to a lack of qualified and skilled manpower (Nukunya 2003).

The reasons for poverty and its persistence are usually answered following two different lines of argumentation (Eguavoen 2008). Eguavoen (2008, p. 46) states: *„The first and naturalistic fraction merely holds the short supply of natural resources, shifts in hydrological conditions and climate change in the region responsible for the poverty.*" The seasonal recurring hunger gap at the end of the dry season or extreme climatic events such as the floods of 2007 reveal the vulnerability of people to seasonality and shocks and boost the logic of environmental determinism. However, this logic often pushes aside the critical question about the capacity of the people themselves to cope with stress.

The second line of argumentation tries to explain poverty and the lack of capacity to cope by pointing at historical circumstances. These have led to economic exploitation and delayed political integration of the north with the rest of the country (Eguavoen 2008).

Major contributions to the persistent poverty stem from the British colonial system. The colonial rulers actively promoted slave raiding, followed by initially forced labor migration from the north to the south (Shepherd and Gyimah-Boadi 2005). In addition, the lack of manpower resulting from slavery and out-migration, the region was deprived of investments in infrastructural development (education, health, roads and railways) and exportable cash crops (Songsore 2003). Laube (2007, p. 61) even argues that *„regional disparities between the north and the south were deliberately promoted to ensure a constant flow of cheap labor to the southern areas where the colonial profits were to be reaped.*"

Ghana became independent in 1957, and Kwame Nkrumah won the first national elections. In the first years of his rule, the country underwent an economic boom. However, Nkrumah's politics of integration of the economically lesser developed north failed, in part due to the concept of top-down modernization, and the attitude established that 'everything comes from Accra'. This led to a highly centralized government in Accra (Holtkamp 1994). Bureaucrats throughout the north were recruited from the south (Blench 2006), who considered a posting to the underdeveloped north as some form of punishment (Shepherd and Gyimah-Boadi 2005). The political control

over the northern regions decreased, and regional conflicts between ethnic groups intensified (Lentz 1993; Massing 1994; Laube 2007).

The Acheampong regime (1972-78) also had a positive vision for the development of the north and promoted the development of state-subsidized large-scale agriculture and irrigation. With a World Bank loan for the Upper Region Agricultural Development Project (URADEP), the development of the agricultural sector was boosted, e.g., with the establishment of a cotton industry. Other structures resulting from the regime are the medium-scale reservoirs Tono and Vea (see Figure 5.2 and 5.3 in Chapter 5) with a large irrigation infrastructure of 2.490 and 850 ha, respectively (ICOUR 1995). The structures were managed by a core group of agricultural experts and bureaucrats and used modern farm machinery, improved seeds, fertilizers and herbicides (Tonah 1994). Although these investments slightly improved the situation in the north, the repayments of the loan and the subsidies consumed a high proportion of the national agricultural budget (Aryeetey and Cox 1998). This and many other factors led to the collapse of the national formal economy in the late 1970s, and the agricultural sector with its subsidies could not be sustained.

Along with economic chaos, political instability increased until the military regime under Rawlings took over power in late 1982 (Massing 1994). The only alternative for the regime was to turn to the Bretton Woods institutions for help (Songsore 2003). A Structural Adjustment Program (SAP) was agreed on, based on a risky export-growth model (Holtkamp 1994), including liberalization of the economy, reduction of the civil service by 15%, the elimination of subsidies (Massing 1994) and a general drastic shift from the dirigisme of the earlier period to a private-sector-based development strategy (Songsore 2003). One of the consequences of these developments was the concentration of national resources in the export-oriented cocoa, timber and mining sectors (Tonah 1994), which are all located in the southern regions of Ghana.

The losses of the structural adjustment for the north were recognized to some degree by the various governments from the late 1980s through the 1990s, and several steps were taken to improve the situation. The electricity grid was extended to the north, the University for Development Studies (with campuses spread throughout the three northern regions) was established, and physical infrastructure was rehabilitated and developed. However, the impacts of these efforts are limited because there has not been

a concerted strategy (Shepherd and Gyimah-Boadi 2005). Further, the main livelihood basis of the north, the local-supply oriented agricultural sector, was further neglected in favor of the export-oriented agricultural sector and industry in the south.

The liberalization policies and austerity measures in the context of the SAP had also considerable impacts on the prices for agricultural produce, and Ghanaian farmers now have to accept not only seasonal fluctuations, but also the dictated prices of the world market.

4.2.2 Demography and settlement pattern

The Upper East region had a population of 920,089 in 2002 with an average population density of 105.89 persons per km^2. About half of the people are economically active adults. Comparing population figures of the whole region of 2002 with the previous censuses in 1970 and 1984 results in an annual population growth rate of 1.1%. Due to the constantly high permanent and seasonal out-migration, the population growth is significantly slower than the total fertility rate of 6.44 suggests (GSS 2002; Laube 2007).

The population density in the UER is very high compared to the two neighboring districts, the Upper West Region with 35.5 persons per km^2 and the Northern Region with 26 persons per km^2 (GSS 2002). Some authors suggest that the soils derived from crystalline or granite rock in the UER are slightly better and less prone to erosion and could therefore be a reason (e.g., Blench et al. 1999). Dickson and Benneh (2004, p. 47) give another explanation: *„These areas were strongly military and relatively stable. They could generally resist invasions and many refugees from the neighboring weaker tribes came to live there.*" Laube (2007) further explains that the military strength, widespread resistance and alliance building of the ethnic groups in the UER (see section 4.2.4) were the answer to the continuous slave raids by warriors of the kingdoms surrounding the region. Others argue that some of the ethnic groups of the UER participated in slave raiding in areas further away (Howell 1994; Lentz 1998).

Typical construction materials are mixtures of earth, sticks and straw and increasingly corrugated iron sheet roofs whenever a family can afford it. A typical rural settlement in northern Ghana consisted of compounds, which were scattered over a large area. Compounds traditionally consist of families (man, his wives, married sons

and their wives and his grandchildren) living in the middle of their land and widely separated from neighboring compounds. Individual members have their own huts, which are arranged in a circle within an enclosing wall to form the compound (Gyasi 2005). Some of these residential units start to break up and smaller compounds are built up only containing two generations, namely parents and their young children (Nukunya 2003). This trend is probably connected to the trend to move compounds closer together to build actual communities, in order to counteract splinter development. Overall urbanization levels are still very low (Blench 2006).

4.2.3 Public and private services

Education

Formal education in the UER is low, as indicated by the high levels of illiteracy of 69.4% for females to 57.4% for males (GSS 1999). However, the government and NGOs, working at grassroots levels, invest in basic education (Shepherd and Gyimah-Boadi 2005), and an extension of primary education (Blench 2006). Yet, increased school enrollment does not necessarily mean better education. At least in the 1990s the percentage of pupils passing mathematics and English tests was very low, and most children leave school as virtual illiterates given the poor quality of instruction (Songsore 2003). However, Osei et al. (2007) states that only the primary school enrollment improved while higher education remains low. Despite support in form of feeding programs and recent cancellation of school fees in public institutions, the cost of education is still high considering rising prices of uniforms, textbooks and exercise books (Hesselberg and Yaro 2006).

Health

The UER faces high levels of malnutrition especially during the regular hunger season (Alderman 1990; Heinbuch 1994; World Bank 2003). The hunger season is usually the end of the dry season in April and May, when all the harvest products are consumed or saved as input for the farming season that starts in April and May (Norton 1995; Hesselberg and Yaro 2006).

Malnutrition in Ghana is most prevalent in the form of Protein Energy Malnutrition (PEM), which causes growth retardation and underweight (Van de Poel et

al. 2007). About 54% of all deaths beyond early infancy are associated with PEM (GHS 2005).

The low bodyweights make the population susceptible to epidemics of all kinds (Dickson and Benneh 2004; Hesselberg and Yaro 2006). Cerebro-spinal meningitis, Guinea-worm, schistosomiasis, malaria and soil-transmitted helminths such as hookworm are common (e.g., Amankwa et al. 2003; Blench 2006). Many of the diseases are related to infected water sources and reservoirs (Blench 2006).

Another problem is the growing alcohol consumption. The abuse of alcohol in the form of strong, cheap, locally produced gin called *akpeteshie* was frequently observed in the field and indicated as being problematic during many interviews. Apart from the consequences for health, the alcohol abuse has also been recognized as a catalyzing factor for clan violence, fighting and violence against women and children (Luginaah and Dakubo 2003).

While the treatment with traditional medicine is decreasing (Norton 1995), the treatment with modern medicine has improved slightly due to NGOs and donor projects. However, these improvements do not apply to public health services. Since the introduction of payments for health services by the Ministry of Health as a measure to meet dwindling government subsidies, costs for medical treatment increased dramatically. Services, which were poor in terms of spatial access and quality, are now unaffordable for most people (Shepherd and Gyimah-Boadi 2005; Hesselberg and Yaro 2006).

Roads

Apart from the main Tamale-Bolgatanga-Paga trunk road and the sealed road from Bolgatanga to Bawku, the area is generally served by poor roads, which are difficult to travel on in general and often become impassable during the rainy season. This makes it more difficult for most villagers not only to access education and health facilities, but also to bring their cash crops to the markets in time (Gyasi 2005; Shepherd and Gyimah-Boadi 2005; Blench 2006).

Agricultural extension service

Agricultural extension service is often considered of key importance when bringing new technology for enhanced food production into the rural areas and contributing to food security and poverty reduction. In Ghana, the Agricultural Extension Services (AES), which until recently also included fisheries extension services, are provided by the Ministry of Food and Agriculture. As described by Tonah (1994, p. 201) AES seek to:

> *„a. improve on the traditional farming system. This involves stressing the importance of good land preparation, planting according to AES-recommended spacing, proper fertilizer application with regard to their rates and timing, timely harvesting, processing and proper storage of harvest to reduce post-harvest losses and non-burning of crop residues. b. inculcate the appreciation and adoption of soil conservation methods among small-holders."*

This is achieved through demonstration, training, group formation, provision of agricultural credits and other services that demand a wide range of skills from the extension staff.

Problems with public services

Booth et al. (2005) describe the modern state of Ghana as neopatrimonial with a formal administrative structure governed by rules and underpinned by law on the one hand. On the other hand, much of the actual operation of public affairs is dictated by a different set of principles. State resources, bureaucratic positions, and the power to allocate rents, provide services, and determine policies and their beneficiaries are captured by personal or private networks in the hands of dominant patrons (Booth et al. 2005; Laube 2007). Booth et al. (2005) conclude that the state in such a situation typically has little policy autonomy. The ability of public officials to formulate and carry out policies in accordance with the public interest is constrained by the requirement to service patronage networks. On the national level this means, for example, that the focus of development efforts is in the south with the economic and political powerful, while the north is almost completely neglected. But even regional and local governments in the north try to satisfy local elites rather than work for the un-influential poor. This situation in maintained by the problem that is described by Ayariga (1992, adapted from Gyasi 2005) for the agricultural sector. The extension staff lacked the motivation to organize farmer participation as many perceived farmer participation in management to be an

impediment to rent-seeking opportunities. Farmers were made to play passive roles in management and therefore lacked a sense of belonging and ownership.

One of the processes which contributed to this passive behavior is a binary opposition between the enlightened and unenlightened through bureaucratic routines of interaction with clients (Antwi et al. 2009). Civil servants are categorized as being enlightened based on higher education levels, training or religion. The service recipients are categorized as unenlightened when they have low or no education and still follow traditional belief systems. This categorization creates the legitimization for paternalism. When accepting the role of the ignoramus, the recipients expect in return that they will be enlightened based on improved services. The acceptance of the role of the recipient can be shown by giving small gifts, bribes and other forms of entertainment perceived to be payments of recognition, respect and prestige of the enlightened (Nukunya 2003).

This behavior has far-reaching consequences and leads to the general perception that the government or district administrations are benefactors who should deliver development and infrastructure (Laube 2007). By accepting the role of recipient, the communities lose their self-determination and ability to stress their needs. The definition of poverty and the formulation of poverty reduction strategies frequently fall into the hands of elites living in urban areas and do not necessarily correspond with the needs of the rural population (Kyei 2000).

Despite the problems resulting from patronage systems public services suffer from a range of other problems. These include understaffing and poor training of service providers, excessive regulation and bureaucratic delays or problems of contract enforcement (Tonah 1994; Nukunya 2003; Booth et al. 2005; Laube 2007).

Private services

The UER has little financial service infrastructure (Shepherd and Gyimah-Boadi 2005). Seven of the 18 districts in northern Ghana have no banks, and the ratio of clients to banks is 100,000 to 1. This leaves the population with no choice but to keep their traditional saving strategy, i.e., invest in cows and informal money lending systems (Shepherd and Gyimah-Boadi 2005). The poor banking system also makes the transfer of remittances extremely difficult.

In terms of communication as a means to access information, e.g., about prices for cash crops, the picture is mixed. While fixed telephone lines are almost absent (ISSER 2004), the number of cellular phones is continuously rising, and services can be received even in some very remote areas.

Although literacy materials have been prepared in some of the languages in the UER, reading is not yet widespread enough for these to be major vehicles of agricultural extension or information dissemination.

The print, radio and electronic communication media can also play an important role in disseminating information, e.g., about improved agricultural technologies. Although the Mole-Dagbani, together with other ethnic groups in the north, constitute more than 24% of the Ghanaian population, they are often passed over in information distribution, for example, on the national radio and TV. The majority of broadcasts is in the Akan language, the mother tongue of about 50% of the Ghanaian population. It is assumed that everybody understands it, ignoring the fact that many northern Ghanaians do not speak the language of the south (Nukunya 2003).

However, a very active FM radio service has been established in the UER, broadcasting in six local languages (Laube 2007). While this service is only sporadically used for agricultural extension (Chapman et al. 2003), it provides potential for systematic information distribution (Blench 2006).

4.2.4 Ethnic groups and religion

Due to historical patterns of in-migration in pre-colonial times, the UER is home to a multitude of ethnic groups and different languages (Crook 2005; Laube 2007). No real lingua Franca exists in the region, although Twi, Hausa, and English are widely spoken (Asante and Gyimah-Boadi 2004; Laube 2007). In the following only those ethnic groups present around the study reservoirs are covered.

The northern part of Ghana was already, though sparsely, populated by small communities in the late Holocene sometime in the 3rd century B.C. (Eguavoen 2008). People referred to as Kassenas, speaking Kassem moved from the north to the UER about 300 years ago (Laube 2007). They mixed with the older settlers or started new settlements (see Figure 4.5). The most western of the study communities lies in this area and is mainly populated by this group. Kassenas refer to the neighboring ethnic group as

Nankanse. Smith (1978) refers to them as Nankane, however, according to Rattray (1932) they themselves prefer to be known as Gurensi/Gurense/Gurunsi. Under the colonial rule, they were also called Frafra, but Frafra is a term that summarizes several ethnic groups and is therefore rather confusing.

The Dasabligo reservoir lies on the traditional border of two ethnic groups. The community on the western side of the reservoir is mainly inhabited by Gurensi. The eastern side is home to a part of a small ethnic group called the Nabdams, who speak Nabt (see Figure 4.5).

The third and eastern-most reservoir of Binduri lies in an area mainly inhabited by Kusasi, speaking Kusal, and Mamprusi speaking Mamprule. While the other ethnic groups in the UER manage to live together quite peacefully, the Kusasi in Mamprusi fight frequently over the sovereignty of the area.

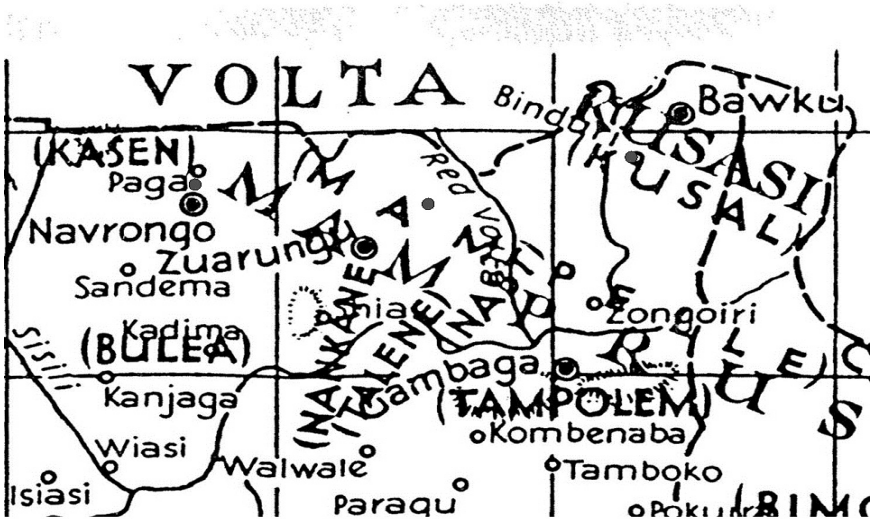


Figure 4.5: Ethnic groups in the Upper East Region (Rattray 1932)

The Kusasi claim to be the first settlers around the Bawku area. The Mamprusi in turn claim that they were there even before the Kusasi. Lund (2003, p. 298) states: *„The Mamprusi brought forth the myth of Na Gbewa, the founding father of the Mamprusi, and his settlement in Pusiga, close to what later became Bawku, long before the any Kusasi settlement.*" However, through the centuries, both ethnic groups established themselves in the area and the languages Mamprule and Kusal became mutuality intelligible (Rattray 1932). Intermarriage is common, although Mamprusi continue to regard themselves as somewhat separate and superior (Roncoli 1994). Other tribes in

that area are the minorities Busansi, Moshi or Mossi and Yarsi, who moved in much later than the Kusasi and Mamprusi, some of them even only in the last 100 years.

Apart from the Mamprusi, the ethnic groups in the UER are usually characterized as minor, stateless or sometimes acephalous. They were surrounded by larger kingdoms of the Dagomba, Nanumba, Moshi and Mamprusi. According to Eguavoen (2008), these kingdoms were founded by warriors from the Lake Chad region and Hausaland (today Nigeria), who first came there between the 11th and the 13th century, and by the 15th century had developed the kingdoms into centralized states.

Warriors from these kingdoms frequently raided the UER for slaves, one of the main income-generating activities of the surrounding kingdoms. Due to the slave raids but also war and the presence of marauding troops, the local population developed a profound distrust towards intruders from the outside (Laube 2007). The Mamprusi, for example, are reported to have invaded the region with horses and weapons in order to secure their trade routes from the coast of Ghana to the heart of the Sahara (Roncoli 1994).

However, not all of the invasions were hostile, and transit was often peaceful and provided the autonomous and scattered communities in the UER with trading opportunities. Quite a number of the invaders stayed and with time shaped many elements of social organization within communities.

The religious composition of the UER is as diverse as the ethnic. Traditional religious believers dominate with 46.4% (GSS 2002). In most of the traditional rites, the sacrifices are addressed to the ancestors and spirits, although in some ethnic groups, for example the Kassenas, God also plays a role (Der 1980; Laube 2007). Ancestors and spirits can reside in rivers, grooves in trees, in animals and other objects and places. Features of the religious beliefs and practices are closely related with agriculture and ancestors, and spirits and gods are usually held responsible for climatic events, success or failure of harvest, but also other areas such as health or fertility (Adongo et al. 1998).

The majority of the 28.3% Christians is Catholic, the rest are members of local or international protestant or charismatic churches (GSS 2002). The Kassena were the first people to come under Christian influence in northern Ghana when catholic missionaries began their work in Navrongo (Der 1980). Since the churches usually were heavily involved in education and health care, their influence spread quickly. Mission

practices were rather dismissive towards traditional belief systems and Pobee (2001, p. 409) states: *„Christianity in Ghana has sometimes been seen as yet another aspect of the colonial invasion of Africa.*"

Muslims make up 22.5% of the population of the UER (GSS 2002). Muslim traders, often from the surrounding kingdoms, have been present in the northern Ghana since the 16th century (Kusimi et al. 2006). While they partly allowed Islam to be adapted to a considerable extent to the local culture, the religion has remained mostly a religion of the alien groups who migrated into northern Ghana over the centuries (Kusimi et al. 2006). Due to the settlement of the Muslim Mamprusi in the Bawku area, this area is still home to a substantial number of Muslims (Samwini 2006).

The different religions do not exist as water-tight compartments, and most people still adhere to certain traditional beliefs, such as the traditional funeral customs (Tonah 1993). And yet while religion only plays a subordinate role in the conflicts between ethnic groups, the different churches accuse each other of taking sides (Lund 2003), and the association of religion and ethnic group is not likely to bridge the ethnic divide.

4.2.5 Political and social structures

The non-centralized ethnic groups such as the Kassenas, Gurensi, Nabdams or Kusasi, consist of several clans. The head of each clan is the highest authority (Kusimi et al. 2006).

Power also resides in the earth priests or *tindanas*, who are usually the patrilineal descendant of the first family that settled at the place. The priest is seen not as the owner but rather as a spiritual caretaker of the land appointed by the ancestors (Bakang and Garforth 1998; Gyasi 2005). The faith in the powers of ancestors is the source of social control the *tindana* has over the people, since they believe that the ancestors would sanction rule-breaking and disrespect. Amongst others, the *tindana* is responsible for enforcing social norms and taboos governing the use and protection of the community's natural resources (Gyasi 2005).

Beyond the *tindana* no social stratification or political elite was formed in pre-colonial times to unite the clans that belong to one ethnic group. Fights amongst clans even of the same ethnic group were common (Nukunya 2003).

The kingdoms are organized quite differently with

> *„systems of traditional administration under the tutelage of chieftaincy institution. Under this political organisation, there was a hierarchical structure, akin to the modern chieftaincy institutional structure. At the highest point is the paramount chief, assisted in administrative duties by a number of divisional chiefs, and then the village chiefs/clan headsmen at the bottom.*" (Kusimi et al. 2006, p. 213).

All of the above mentioned authorities are held by men. The *magazia* system provides some women leadership. Usually the chief's senior wife is responsible for appointing *magazias* to oversee women's affairs in the community. However, it seems the *magazias* have no say in decision making but do partake in implementing decisions regarding labor mobilization and contributions in cash and in kind (Mackain and Bumbie 2005).

As mentioned above, over the centuries small groups of people from the surrounding kingdoms migrated to the UER, either peacefully or with superior war technology. In many places, these groups gained control over the stateless groups. They formed the chiefdoms that included a number of or even all clans belonging to one of the autochthon ethnic groups and made themselves the chiefs. This was, however, not always an adverse process. The settling warriors were also seen to provide protection from other warriors, clans or chiefdoms. So in many cases, the clan heads and *tindanas* preferred handing out some land or paying some regular tribute to a chief in return for peace and protection (Massing 1994), and since the chiefs did not affect the responsibilities of the *tindanas,* some kind of dual leadership became established (Rattray 1932; Gyasi 2005). Yet many of today's ethnic conflicts or rivalries over land have their origin here, as many land disputes arise between indigenous people and settlers along agricultural frontiers and between their different authorities (chief and *tindana*) (Gyasi 2005).

The colonial administration of the Gold Coast, as Ghana was called then, extended and strengthened the chieftaincy rule over the *tindanas* and encouraged them to centralize further in order to enable the establishment of efficient and effective forms of local government (Laube 2007).

The advent of Christianity and Islam further devalued and eroded the authority of *tindanas*, who were also called fetish priests and pagan worshipers of the devil by the missionaries (Akrong 2006). However, since traditional forms of landholding were not

necessarily linked to political jurisdiction, the earth priests could in part sustain traditional land and water management practices under colonial rule (Lund 2006).

Apart from political changes, the colonials also established or enforced the money-using economy, triggering or at least increasing social stratification based on wealth and the establishment of the first local elites (Nukunya 2003).

Political leaders and government officials of post-colonial administrations recognized paramount chiefs as legitimate representatives and they were invited to cooperate with the ruling parties (Laube 2007).

This empowerment of the chiefs in the post-colonial era contributed further to the marginalization and the fading roles of the *tindanas* and closely connected traditional customs, religions, norms and taboos (Roncoli 1994; Nukunya 2003; Akrong 2006). With the devaluation of these traditional belief systems went a part of social control, and as not only Christianity and Islam, but also formal classroom education intensifies this is an ongoing process. The process is further catalyzed by the inability of the traditional systems to adjust and evolve practices that suit the emerging patterns of today's lifestyle (Gyasi 2005), resulting from democracy, availability of new goods, services and knowledge, etc. Nukunya (2003, p. 148) summarizes the effects of the process:

> *„strengthening of marital bonds at the expense of that of kinship; failure of kinship relations to be determined by traditional rules; non-adherence to traditional kinship practices; gradual departure from traditional rules and practices relating to inheritance; gradual breakdown of sanctions sustaining kinship behavior."*

Nukunya attributes these changes to the fact that traditional sanctions have 'lost their teeth'.

Despite all these influences, in many communities rudiments of councils of elders and *tindanas* still persist (Gyasi 2005), and since 1990 have gained power again. This sharpens the grown rivalry between ethnic groups and contributes to regular outbreaks of inter-communal violence around scarce natural resources and political dominance (Massing 1994; Lund 2003; Bacho and Bonye 2006; Kusimi et al. 2006; Laube 2007).

The situation is further complicated by the establishment of an elected political representative of the communities, the assembly woman/man, who represents the

community in the District Assemblies (DA). The assembly man usually has higher education, speaks English and creates links with the larger national infrastructure as well as NGOs. Often he or she stems from the chief's house or other local elites that can afford education and entertainment to convince voters. Their linking position provides the assembly men with power, and often they become a third pole of power in many communities (Blench et al. 1999).

In contrast to the ethnic groups, the households or compounds are organized in strict hierarchies. Compounds are headed by the oldest male member, and the underlying social structure is the extended patrilineal family. Tonah (1994) points out that the household head usually makes the land-use decisions regarding the land that belongs to the compound and is also responsible for the provision of the basic food needs of all members of the household. In turn, he can call upon all members of the household to provide labor for farming. Gyasi (2005) found strict norms, networks of associations and trust around this system, and hardly anybody can withdraw when called for labor. These patriarchal household arrangements make social mobilization for this kind of collective action easy.

Women also substantially contribute to labor on farms. Apart from this, they have many additional responsibilities such as bringing up children, managing the household, healthcare and nutrition, yet they have little say in household decision making (Songsore 2003; Hesselberg and Yaro 2006).

Like farming, social gatherings, especially funerals, are vital in all ethnical groups of the UER. Social gatherings are very important to tighten bonds and build up social capital, crucial for the provision of food and also money in times of need (Hesselberg and Yaro 2006).

Social structures are continuously subject to the process of change. One of the drivers of change is migration. In 1971 Hart described that with growing migration it is no longer possible to dichotomize the traditional and the modern or even the rural or urban life. Younger or middle-aged males play an important economic role especially because of the considerable income they earn with migration, and decisions concerning the compound and family lands made in their absence are often not considered binding (Blench 2006). The growing exposure to urban life during migration further erodes traditions and established social norms (Adongo et al. 1997). For example, children of

the household head increasingly refuse to work on family land and rather prefer to sell their labor. Hesselberg and Yaro (2006) observed that labor has been commoditized to the extent that sons even charge their fathers for their labor. The authors also describe the decline of the social capital or horizontal networks of reciprocal help. Vertical networks, referring to relationships between rich and poor, increasingly replace horizontal networks. Richer compounds give out credits in the form of seeds or food and increasingly even money and develop dependencies of which the rich dictate the conditions.

Another change is induced by the increasing levels of poverty in the UER. With the growing difficulty to organize the livelihood of a household, the importance of women, who increasingly engage in cash-income earning activities, is growing. The consequence is a slight change in power relations within the household in favor of women, although with strong resistance from men (Hesselberg and Yaro 2006). In a few communities, women are even elected to represent the community in district assemblies. However, Apusigah (2004) still finds women by and large excluded from decision-making structures regarding household, community and at district/regional level.

4.2.6 Livelihood strategies

Incomes from agriculture still represent over 71% of all rural household incomes in northern Ghana. Non-farm activities account for about 16% of household incomes whilst wages and remittances constitute only a small part (GSS 2002). Like the social structures, income structures are also subject to change, mainly diversification, described in the following.

Rainfed farming

In large parts of the UER people still rely on rainfed farming as their most important livelihood strategy, and every household tries to produce at least enough to sustain the household with food crops until the next production cycle. The basis of the cropping system throughout UER is pearl millet. There are two groups of millet cultivars. The short-season millet harvested in June/July is of special importance, as its harvest in June ends the hunger season. The long-season millet is harvested in October or later together

with other crops, such as sorghum, maize and rice along with legumes, especially peanut, cowpea, soybean, and pigeon pea (Gyasi 2005).

A delay in the onset of the rainy season extends the hunger season, but maybe worse than a delay is the uncertainty about the onset of the rainy season as was observed during the field research in 2007. Especially the first rains in April and May are often interrupted by long dry spells. When seeds are planted too early and the rains fail to continue, the seedlings wither and farmers often do not have the means to buy seeds for a second round. Yet if farms are not cultivated after these first rains, they become overgrown with weeds, which are difficult to remove later on. The situation in 2007 worsened when the torrential rainfall in August in September washed away the few crops that had survived.

Uncertain climate is, however, not the only challenge for the livelihood strategy. Agricultural land is, due to inheritance patterns, subject to fragmentation and has reduced the average size of a compound farm to less than an acre (2500 m^2) (Hardiman 2003; Gyasi 2005). Due to unequal distribution, many compounds have not enough land to keep a family, and paid labor usually on the farms belonging to wealthier compounds is playing an increasingly important role.

Despite sporadic efforts to fertilize the soils with dung of all sorts, the intensive use of the land is leading to impoverished soils (e.g., Songsore 2003; Dickson and Benneh 2004). The continuously declining soil fertility is difficult to buffer for local farmers, as chemical fertilizer is expensive and often not available in the rural areas (Blench 2006; Al-Hassan and Diao 2007). Mechanization is generally low, and farm operations are mainly done manually, but increasingly also with bullock traction (Hesse 1998).

Furthermore, the fluctuating prices of agricultural produce make it difficult to build savings. Prices peak usually in the hunger season when food is short and are very low after harvesting (Gyasi 2005). Irrigated crops such as tomatoes or leafy vegetables are even more affected by the seasonal variability in price due to their short shelf life (Gyasi 2005). These fluctuations are fortified by the dictated prices of the world market. For example, rice is produced in many countries with high subsidies. Their vast surpluses are sold on the world market at dumping prices, and it is difficult for local rice farmers in northern Ghana to compete (Laube 2007). The import of rice from Asia and

the USA has led to the abandonment of many rice farms in northern Ghana (Yaro 2007).

Livestock

Keeping livestock, especially small ruminants (sheep, goats, pigs) as well as poultry (chickens, guinea fowl, and pigeons), also represents a major coping strategy in times of need, for example after a crop failure (Blench 2006) as the animals can be sold. Other livestock species found in the UER are horses, donkeys and pigs. There are virtually no intensive production systems in the region, and animals are allowed to forage freely in the dry season and are confined in the wet. The topmost priority is to invest in herds, and there is greater emphasis on the size of the herd rather than on the quality of the stock, which leads in many cases to overstocking (Dickson and Benneh 2004).

Cattle are regarded as an outward sign of wealth and social standing and are produced principally for marriage payments and sacrifices at funerals and are rarely for sale. However, poorer households cannot afford to keep cattle and have mainly small ruminants and poultry. Having no sheep or goats is a sign of desperate poverty (Gyasi 2005).

Price fluctuations in this sector are overlaid by a continuous increase in prices. In the 1990s, the price of meat increased by 134% (Ackah and Appleton 2003), a trend that is continuing up to the present (Gyasi 2005). While this is generally very good for livestock owners, protein in the form of meat becomes unattainable for the rural poor.

Dry-season gardening

Blench (2006) assumes that Muslim migrants such as the Hausa introduced horticulture practices in shallow rivers and seasonally flooded land, where farmers irrigated by fetching water from wells and streams using buckets and hollow gourds. Today, traditional leafy vegetables are supplemented with high value crops such as rice, onions, tomatoes, pepper, cabbages and lettuce (Gyasi 2005). Dry-season gardening is recognized as having the potential to contribute to poverty eradication by implementing water harvesting strategies, such as reservoirs (for details, see section 4.3.3).

Migration

Migration from the north to the south started as forced labor migration under the colonial rule. Soon, the relative wealth of the southern forest zone in terms of gold mining, timber and cocoa has created an important magnet for surplus labor from the savannas, especially in the dry season (Blench 2006). Most of the migrants return at the beginning of the rainy season to their farms in the north where they invest their wages. Especially younger men often save the cash money to pay the bride price and, later in the life cycle, for a sacrifice at funerals or for food and other resources during the hunger season (Hart 1971).

However, based mainly on land pressure, but also on other reasons such as intergenerational conflicts, migration increasingly takes on aspects of permanence (Grindal 2003; Meier 2003). Contributing to this development is probably also the growing problems with respect to seasonal migration. Hesselberg and Yaro (2006), for example, found that migrants often have trouble in finding a job or are underpaid and sometimes cheated out of their money.

Markets and trading

Diversification is not new to the people in the UER, although there is a growing commercialization of livelihood strategies. Yaro (2007) found that in the 1970s, most households only engaged in natural resource gathering activities for noncommercial purposes. In more recent years, more and more women engage in trading, and as a result markets are growing.

There are hundreds of small community markets which serve as assembling points for surrounding communities or, in larger communities, the surrounding sub-communities (Gyasi 2001; Dickson and Benneh 2004). Due to poor infrastructure and a lack of transportation, local producers have to offer their produce on these community markets. Main buyers are intermediaries from regional or district capitals, who can afford to hire private transportation to transfer the produce to the urban markets (Mackain and Bumbie 2005). Each district has at least one major market in the district capital. Besides supplying the urban population, these markets also function as relay markets and attract regional traders. The largest of them, e.g., in Bolgatanga or Bawku,

even attract traders from southern Ghana who buy the local produce and bring it to urban markets in the south (Gyasi 2005).

Independent of size, markets are usually held twice a week in a three-day cycle (Gyasi 2005; Millar and Yeboah 2006). While larger markets often have some kind of permanent sheds and stalls, which are built or rented by the traders (Dickson and Benneh 2004), community markets often take place on the bare ground, with a plastic tarpaulin as underlay.

The vast majority of the traders are women, whilst men only have a few businesses such as livestock trading, repairing bicycles or selling spare parts. Younger men are often not in trading but provide so-called greasing services such as driving transport vehicles, or if unmotorized, pushing the vehicle. When the commodities are transported by lorry or bus, young men make sure that the goods get a place on the usually heavily packed trucks and load them. Their considerable earnings show the importance of these services (Millar and Yeboah 2006).

The commodities and activities are related to the wealth rank. At the top of the hierarchy there are the so-called "Market Queens". They are responsible for order in the trade and settle disputes among traders, based in part on their experience (Millar and Yeboah 2006). Further, they usually come from rich households and are able to buy large quantities of a certain product, which can then be sold wholesale. This allows them to fix prices and manipulate the supply.

Women who call themselves not "rich" but at least "better-off" are involved in businesses that require certain investments and also labor. They are often involved in processing and selling cooked food, groundnut oil or paste, *pito* (local beer) or shea-butter. They are also involved in petty trading. The main goods are agricultural produce, and in communities with reservoirs, onions, tomatoes, pepper and other vegetables. In addition, basic consumer products, ranging from tooth brushes and soap to engineering articles are sold in small quantities. A number of women sell liquor in and also outside the markets.

Poorer women who have no capital for initial investments often collect and sell firewood, herbs and wild fruits or seeds such as the locust beans (*Parkia biglobosa*), which they process to obtain Dawadawa, a spice used to prepare soups and stews.

Poorer women are also often found helping in better-off or rich households or providing minor services in the markets such as fetching drinking water or washing dishes.

Other minor activities

Galamsey is a Ghanaian expression for unorganized small-scale mining, which uses crude methods. Alluvial mud is washed and the sand is sieved, e.g., in the dry season in the tributaries of the Red Volta, which yields traces of gold (Bacho 2004). In some areas there is weaving, basketry and pottery, as well as stone quarrying (Bacho 2004; Gyasi 2005; Sundong 2005).

Hunting, done by men, is another supplemental activity (Dickson and Benneh 2004). The terrestrial wildlife buffers the impact of environmental or other shocks by providing bushmeat for animal protein and income in times of economic hardship or food scarcity (Barrett and Arcese 1998; Milner-Gulland et al. 2003). However, due to the massive decline in wildlife biomass (see Figure 4.6) this livelihood strategy is seriously at risk.

Besides hunting, the gathering of wild herbs, roots and fruits contributes to the livelihoods of especially poor people, but in times of crisis, e.g., after an extreme climatic event, most households supplement their diets with wild plants.

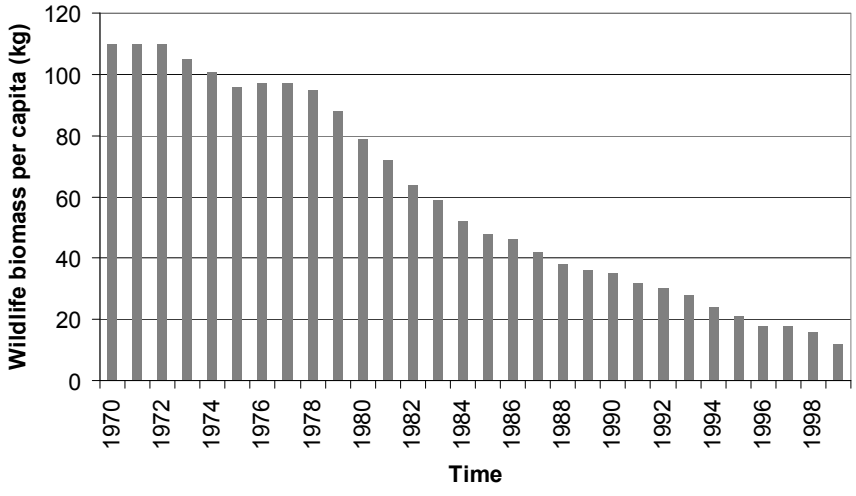


Figure 4.6: Per capita wildlife biomass (kg) in Ghana (Data source: Brashares et al. 2004)

4.3 Actors and measures adopted in the fight against poverty

The last part of this chapter critically discusses selected actors, policies and measures to counteract vulnerability and poverty.

4.3.1 Multilateral and bilateral aid agencies, NGOs and their programs

A large share of Ghana's overall economic success in the last years is based on foreign aid and loans given by a large number of donors who want to reward the country and its politicians for persisting with reforms and because they want to be associated with Ghana's success story (Younger 1992; Songsore 2003; Schmitt 2008). A multitude of aid agencies dedicate their work to alleviate poverty in the north, and the Ghanaian government relies substantially on aid to bridge the gap between north and south. Shepherd and Gyimah-Boadi (2005) even argue that the massive support led to a state abdication of responsibility.

One of the first actors to appear on the aid platform was the World Bank under the Acheampong regime. Other important actor that became involved in the early 1980s in northern Ghana were the FAO and the International Fund for Agricultural Development (IFAD). Other bilateral donors that are active directly in the region are, for example, the Canadian International Development Agency (CIDA), the Danish International Development Agency (DANIDA) and the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ).

The NGOs present include large well-funded international organizations such as OXFAM and Save the Children Fund, Actionaid and Technoserve, to name just a few. Church-based NGOs are important, and all the major denominations have some type of operation. Apart from these international players, a multitude of local NGOs have evolved, mostly financed by bilateral donors preferring to finance NGOs or to work through budget support to the Accra government (Shepherd and Gyimah-Boadi 2005; Blench 2006). DAs also received a share of support from international donors. This parallel system led to considerable rivalry between NGOs and government (Shepherd and Gyimah-Boadi 2005).

The scope of development projects is huge, intransparent and associated with a lack of coordination amongst donors, but criticism about development aid goes further. Blench (2006, p. 23), for example, claims that despite the efforts of a multiplicity of

organizations, food shortages, migration and malnutrition remain at high levels and asks very critically: *„Is it possible that they simply create aid dependency rather than providing sustainable solutions?*"

As the existence of most NGOs is dependent on the existence of problems that cannot be dealt with in a local context alone, this question seems to be legitimate. Shepherd and Gyimah-Boadi (2005), for example, claim that while NGOs like to present themselves as advocates for the poor, hardly any attention is paid to the structural causes of poverty, and the challenge to move from charity to sustainable development is rarely addressed. Mohan (2002) goes even further and implies that NGO work supports local elites and the middle class and provides platforms for aspiring politicians (Mohan 2002). Large parts of the critique of public services discussed in section 4.2.3 also apply to many NGOs (e.g., Mackain and Bumbie 2005; Blench et al. 1999).

4.3.2 Decentralization

Political decentralization

The process of decentralization in Ghana, which has been ongoing since the 1990s, has arisen out of a general paradigmatic shift in the debate on development theories as well as on the renewed political instability in the 1980s (Blench 2006). The process includes the transfer of power, authority and responsibility as well as development planning, budgeting and implementation to the regions and districts (Holtkamp 1994). The geographical coverage of districts has been restructured and local level political institutions, such as the District Assemblies, established. The objectives include popular participation and empowerment, equity, transparency, responsiveness, accountability, stability, efficiency, effectiveness, and a counterbalance to the rural-urban drift and north-south divide (Ayee 1999; Songsore 2003).

The strength of the DAs lies in the fact that some of the members are elected by the local communities that they serve, and their membership can be terminated only by that electorate. The assemblies also have a District Assembly Common Fund (DACF) into which 5% of total government revenues are paid and other sources of revenues and funds that allow the DAs to invest in local development according to their planning (Al-Hassan and Diao 2007).

A number of authors, however, also point out some critical points in the development. Laube (2007) states that the DAs are compromised by the system of presidential appointment of the District Chief Executive and of 33% of the assembly members. Laube further notes that government resources are allocated and distributed by the local elites among their social and political networks, and funds are used to create political support.

With the more than limited budgets, the assemblies themselves are forced to invent new taxes and levy special development rates, thus bringing themselves into disrepute (Holtkamp 1994). While there is political commitment to real decentralization, the bureaucrats that should implement and facilitate the process are actually opposed to it in fear of losing their privileges, and they develop a "we have to educate the people" attitude described in section 4.2.3. In addition to financial short-comings, the human capacity to plan, initiate, implement, and monitor local development remains weak. Weak regional administrative capacity is also reflected in the reluctance and / or failure of key social sector ministries such as health and education to submit to constitutional and statutory obligations for decentralization (Shepherd and Gyimah-Boadi 2005).

Holtkamp (1994, p. 290) concludes that *„Without a sincere commitment from the administrative level and without a massive transfer of both financial and personnel resources the Assembly concept threatens to fail.*"

Decentralization of natural resources management

Starting in the late 1990s, international donor directives, based on the same decentralization paradigm as described above, suggested increased community participation in decision-making processes about natural resources. It is assumed that participation results in a sense of ownership of the community towards the resources, which in turn triggers a more reliable, responsible and sustainable handling of the same (Hauck and Youkhana 2008). In resonance to these directives, decentralization took place in Ghanaian natural resources management (Gyasi 2005) and especially in rural water management (Eguavoen 2008) and will be explained in more detail with the example of small, multipurpose reservoirs in the following section.

4.3.3 Small multipurpose reservoirs

General features of small reservoirs

In their analysis of satellite images Liebe et al. (2005) found a total of 504 reservoirs in the UER. However, the images reflect the situation of a very wet rainy season in 1999 and together with the coarse resolution perhaps not all of the 504 identified waterbodies count as reservoirs. Especially the 348 reservoirs with an acreage of less than 1 ha could be flat seasonal waterbodies that formed in water-logged depressions. This leaves more than 150 reservoirs, ranging from 1 to 35 ha, with a total surface area of 999.54 ha (Liebe et al. 2005) and the number is growing as dam construction is ongoing. Figure 4.7 shows the reservoirs divided into three size categories: category 1 has 51 reservoirs of 1 - 2.79 ha, category 2 has 53 reservoirs of 2.88 - 6.93 ha, and category 3 has 50 reservoirs of 7.02 - 35 ha (Liebe 2002).

Reservoirs are mostly established in order to harvest the water along water courses from a defined area referred to as a catchment area. The reservoirs have one or two inflows which are retained by earthen dams. Most dams have a clay core and ideally a rock riprap for the prevention of dam erosion. A spillway allows surplus water to drain out in a controlled way (Liebe 2002).

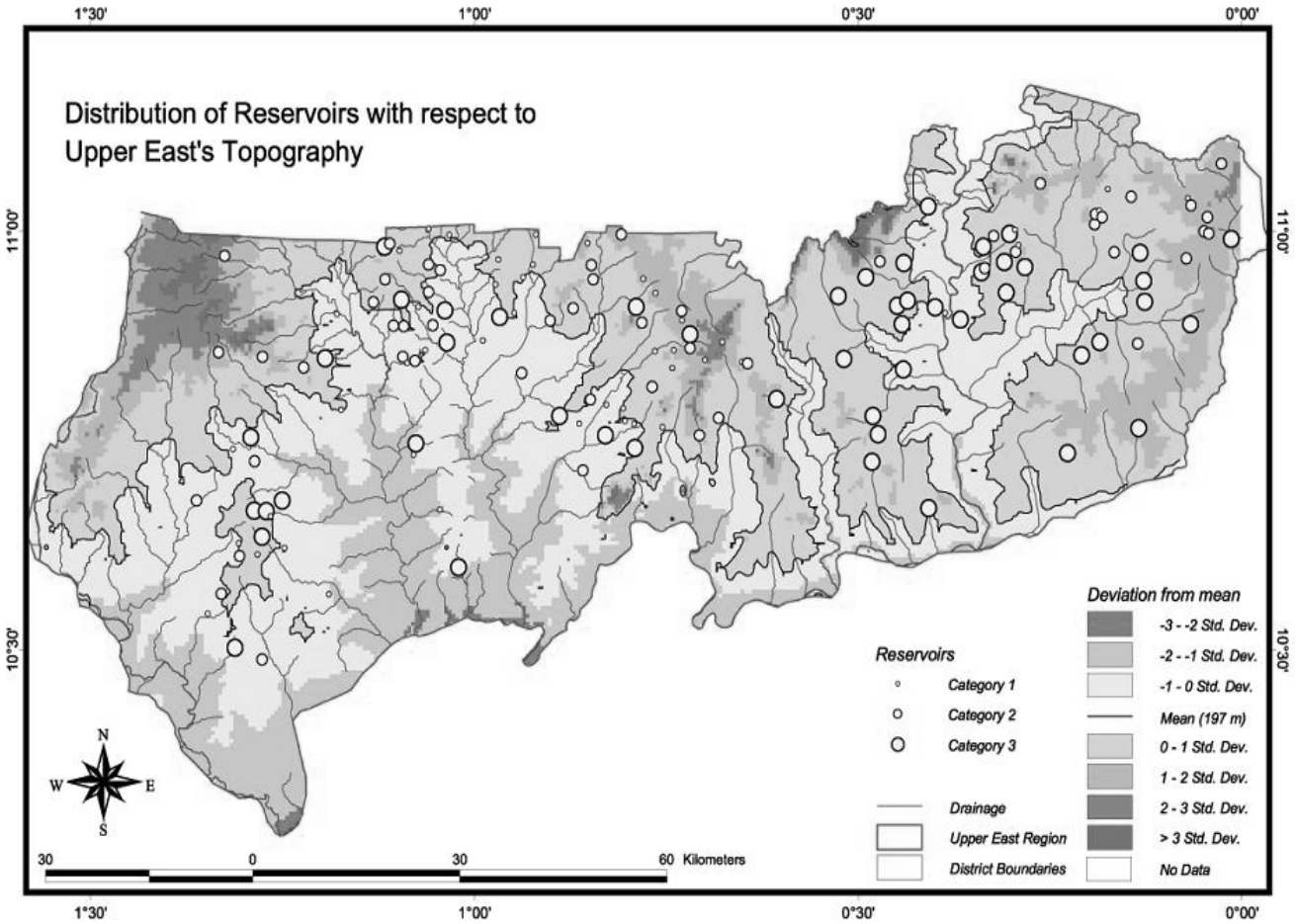


Figure 4.7: Distribution of Reservoirs with respect to Upper East Region's Topography (Liebe 2002)

Early developments

Based on the assumption that poverty is also caused by harsh environmental conditions, and especially water shortage, the colonial administration initiated water conservation programs in the 1940s. In the context of these programs, several small dams were constructed to conserve runoff in the rainy season. The primary goal was to provide drinking water for people and livestock. The ownership of these reservoirs remained unclear, but tasks such as water and land distribution, dam maintenance or measures to prevent soil erosion were originally retained by the local communities. They were put into effect through traditional local authorities, either the earth priests or the chiefs (MacPherson and Agyenim-Boateng 1991).

Formal irrigation systems in combination with small reservoirs were first introduced in the UER in the early 1950s under the former Land Planning Unit (Gyasi 2005). Since independence, irrigation has always been seen as an important way to achieve food self-sufficiency and development. Despite considerable efforts to increase irrigation, however, the development was rather slow.

The government hoped to increase the pace of development by establishing the Irrigation Development Authority (IDA) in 1977 with the task of developing irrigation for farming, livestock improvement, and fish culture (van Edig et al. 2002; Opoku-Ankomah et al. 2006; Lautze et al. 2008). More irrigation schemes of varying sizes were developed mainly for vegetable gardening in the dry season (Gyasi 2005).

At the same time, the Ghanaian government launched the Upper Region Agricultural Development Programme (URADEP) to boost development via small and medium-size reservoirs together with the World Bank, FAO, IFAD and various other funding agencies. The project became an important policy instrument for channeling subsidies on inputs, credits and mechanization to particular groups of farmers. However, the project was less than successful and a World Bank review came to the conclusion that production of some crops was substantially lower than before the program (Aryeetey and Goldstein 2000).

One of the reasons for the failure was the poor maintenance of the irrigation schemes, which quickly led to malfunctions. Gyasi (2005, p. 33) states:

> *„Under the URADEP, the Small-Scale Irrigation Division (SSID) was set up to take over the responsibility for operation, maintenance, rehabilitation and construction of small dams. (...) Rights and responsibilities were not clearly*

defined and technical officers were largely in charge of the operation and maintenance of the schemes. This did not only promote dependency but farmers also felt alienated and apathetic towards maintenance of the schemes. The irrigation schemes were seen as government property and their maintenance as the government's responsibility. Lack of state funding and poor maintenance (in many cases complete lack of it) resulted in deterioration and in a state of disrepair of many of the schemes."

Recent developments

Based on the lessons learned and on international discourses on the decentralization of natural resources management, the subsequent projects in the form of the Land Conservation and Smallholder Rehabilitation Projects (LACOSREP) I (1994–1998) and II (2000–2006) introduced participatory management strategies (Abukari et al. 2007). Management responsibilities were transferred to so-called Water User Associations (WUAs) in order to strengthen the sense of responsibility of the beneficiary communities to carry out better quality operation and maintenance (IFAD 2001).

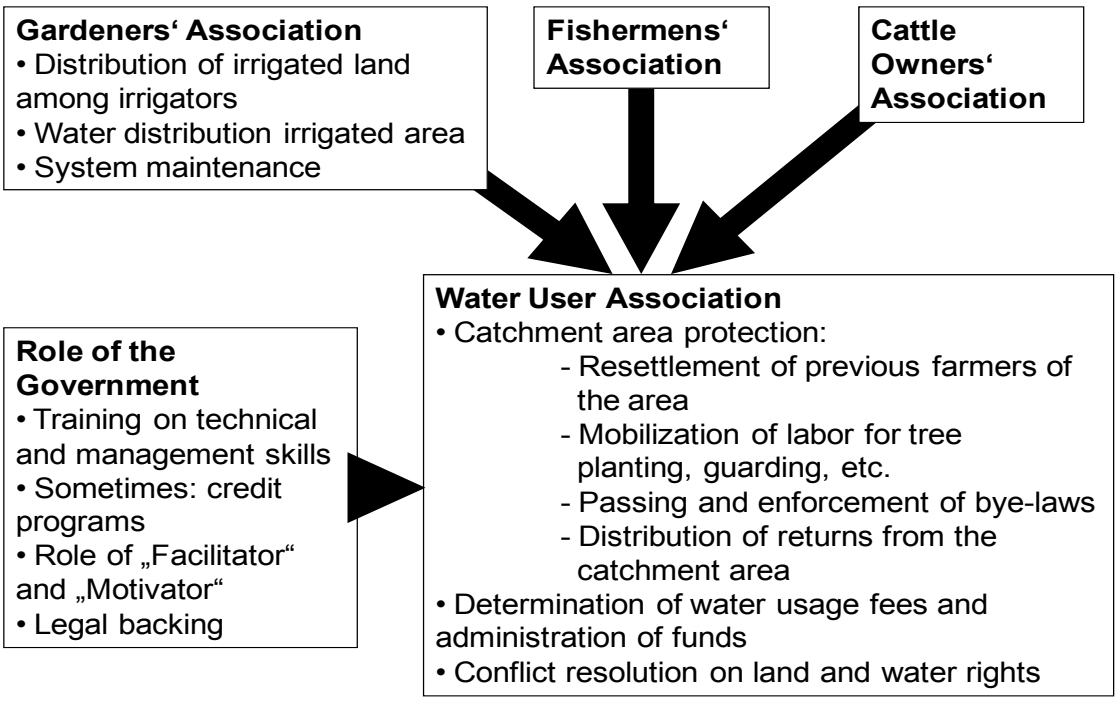


Figure 4.8: Structure and functions of water users' associations in northern Ghana (van Edig et al. 2002)

The WUAs were envisaged as umbrella organizations encompassing groups that have stakes in the dam infrastructure (see Figure 4.8). Elected representatives of the interest

groups constitute the executive committee of the WUA, also referred to as the Damsite Management Committee. The dominant economic groups include gardeners, livestock owners, and fishermen (Gyasi 2005). Members of the executive committee, consisting of the chairperson, secretary, treasurer, and other members, are elected by all members, and their services are strictly voluntary (Gyasi 2005).

Extension staff of the Ministry of Food and Agriculture (MoFA), IDA, and the Department of Cooperatives and Community Development provide supervision, assist the farmers in the maintenance and train WUA executives. Operational tasks of WUAs include, for example, fair (seasonal) distribution, and allocation of land and water, conflict mitigation between different user groups and the collection of water user fees.

Despite all the efforts, water productivity is still rather low (Mdemu et al. 2009). Due to the limited size of the irrigation schemes, the plots are hard fought over, and considerable conflicts about land distribution are widespread, often catalyzed by ethnical or political rivalries. The land owners who contributed the land on which reservoirs and irrigation schemes are built ask for compensation and often resist land redistribution. Many farmers do not, or cannot, pay water levies or help with maintenance tasks. The quality of the construction and the rehabilitation work is frequently poor, and this has a significantly negative effect on household maintenance morale and participation. Water distribution is at least as problematic as land allocation, especially in water-scarce years when reservoirs run the risk of drying out (van Edig et al. 2002; Gyasi 2005; Bacho and Bonye 2006).

WUAs often face the problem that members do not follow their instructions, because the WUA executive boards hardly receive any district level backing, such as bye-laws that would enable them to enforce management rules (van Edig et al. 2002). Furthermore, embezzlement and misappropriation of WUA funds, low accountability and the failure of some executives to organize democratic elections or hand over positions breed distrust and apathy in WUAs and increase the reluctance of some WUA members to pay levies necessary to carry out maintenance activities (Gyasi 2005). The grievances can to some extent be blamed on the missing emphasis on institutional aspects essential to sustain and improve performance under LACOSREP I (Gyasi 2005). LACOSREP II paid much more attention to farmers` participation. However, many people met during the field research were critical about the outcome.

5 FISH FOR LOCAL LIVELIHOODS: PRESENT AND PAST

5.1 Study communities

In the first part of this chapter general details of the study communities including introductory information about their fishing communities are provided. The term fishing community hereby includes all people who generate parts of their income with either fishing activities or selling fish. A fisherman is defined as a person who owns fishing gear and counts fishing as one of his three most important livelihood strategies. The following community profiles are based on interviews with traditional authorities, assembly people, group discussions, PRA exercises with villagers, especially fishermen and fishmongers, and on the author's own observation in the field. The information is complemented with results from questionnaires as well as information from secondary sources.

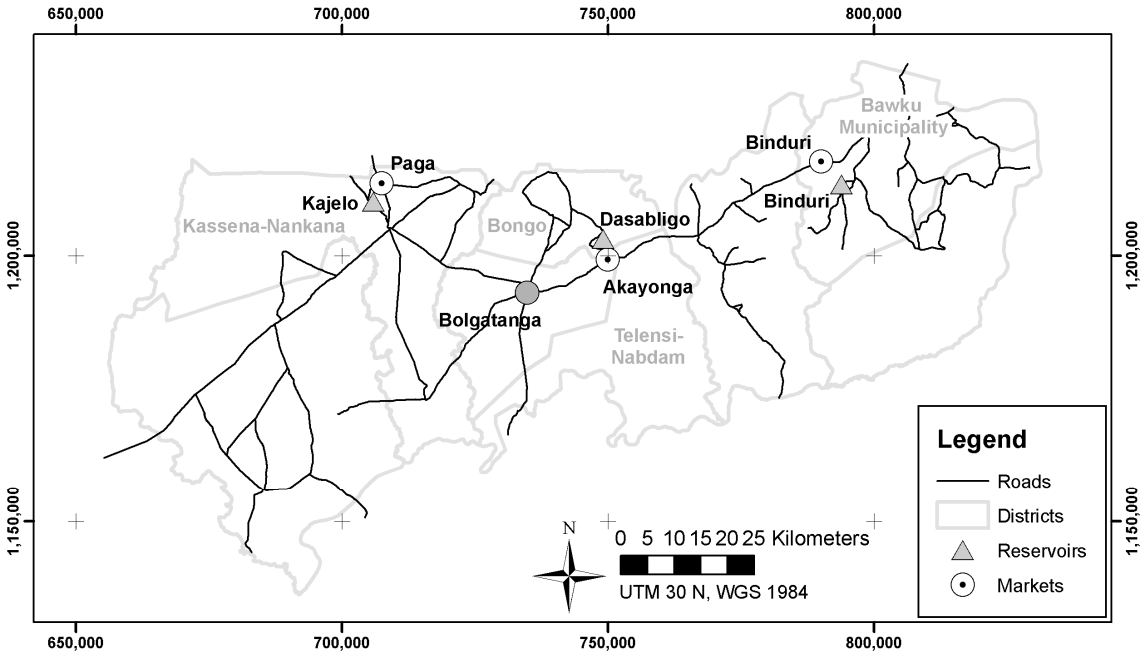


Figure 5.1: Study sites in the UER, Ghana

5.1.1 Kajelo

Kajelo is the westernmost of the four study communities (Figure 5.1) and part of the new Kassena-Nankana West district established in 2008. Kajelo lies between Paga, the

capital of Kassena-Nankana West district, and Navrongo, the capital of the Kassena-Nankana district (see Figure 5.2).

This position has several advantages. Both Paga and Navrongo have supra-regional markets every three days, and even though Kajelo has no market of its own, convenience goods are in close range. Further, Tonah (1994, p. 122) found, that *„the nearness to the main markets of Navrongo and Paga has increased the number of residents involved in market exchanges through the sale of grain and fuelwood, and trading in consumer goods and livestock.*"

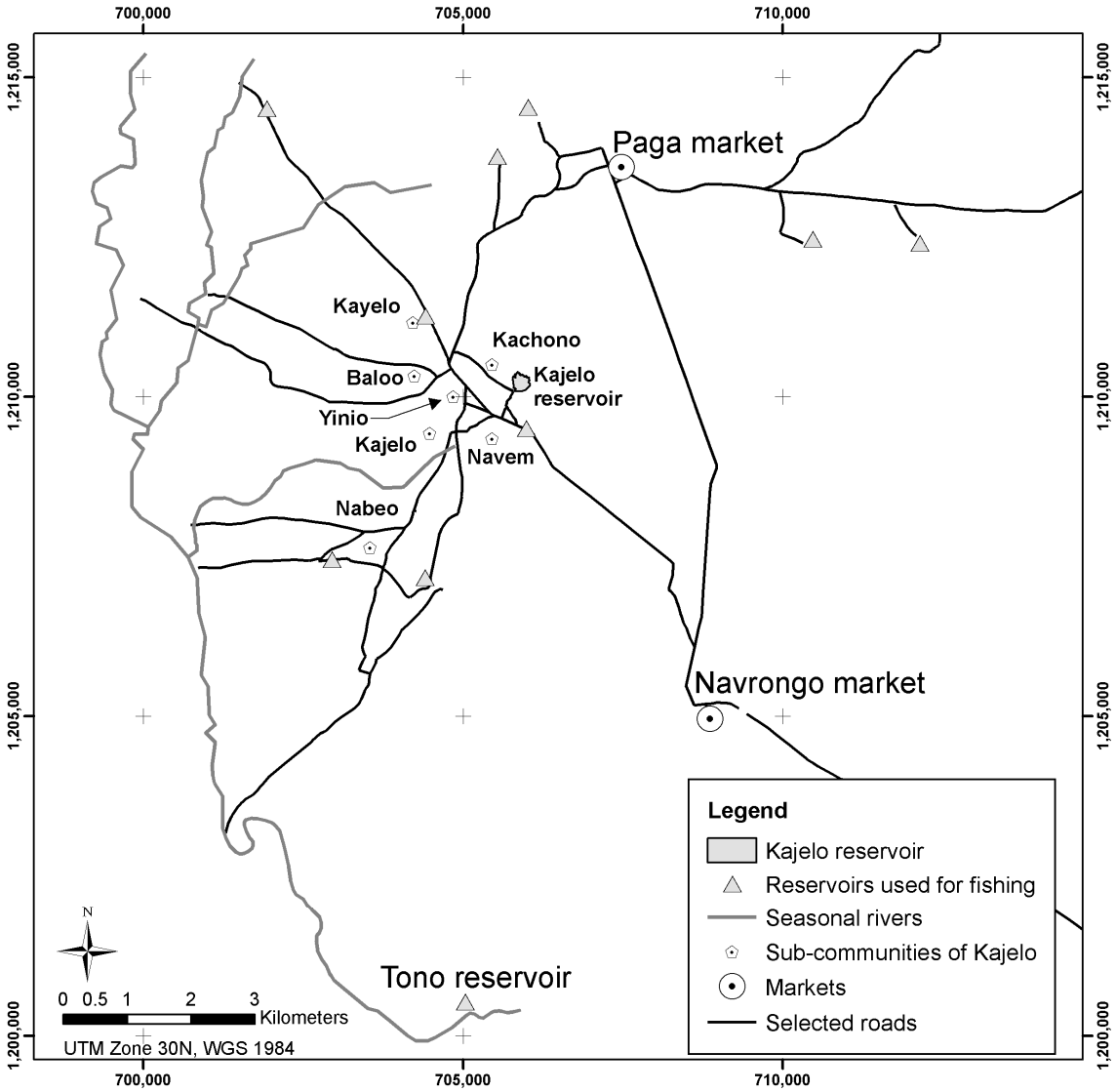


Figure 5.2: Kajelo

Interviews with the community elders and the assembly man revealed that while the community has two primary schools there is no higher education or health care

available. However, close proximity to the two district capitals provides access not only to higher education, but also to basic health care and other services. Furthermore, community members have access to an urban job market. Despite the close proximity to urban centers, only three fishermen reported to have jobs different from those described in section 4.2.6. One fisherman earned part of his livelihood as a watchman, two others worked for NGOs.

It was difficult to obtain exact figures of the total population of Kajelo. The sub-community borders and names set to collect data for the Ghana Living Standard Survey do not correspond to the constituency of the assembly man, and even less to the view of how the villagers segment their community, as discussions with the assembly man and community elders revealed. However, population census data from 2001 collected at the district assembly office in Navrongo include all sub-communities defined by the villagers. According to these data, Kajelo had a total population of 2685 people in 2001 with a balanced gender ratio of 1300 males to 1386 females. The population density is about 126 people per km^2 (Yaro 2007). Unfortunately, the data do not provide detailed figures about the ethnic affiliation of the people, but according to the assembly man and the community elders, the vast majority of the people are Kassenas and the dominating language spoken is Kassem.

The southern sub-communities, especially Nabeo and Batio, are close to the Tono reservoir (Figure 5.2) and many of the fishermen living in these communities only go fishing in Tono. Most of the fishermen from the northern sub-communities use all the reservoirs indicated in figure 5.2. Some of them sporadically go to Tono or to nearby seasonal rivers in the rainy season. During the study period, a list existed in the community of 139 men who considered themselves at least part-time fishermen. After excluding fishermen who temporarily migrate or only go fishing in the nearby medium-size reservoir Tono, 73 fishermen remained for inclusion in this study. The analysis of the questionnaire data reveals that the average age of the fishermen is 32 years, with an average of 3.5 years of education. While all 73 fishermen are Kassenas, their religious affiliation is more diverse. The majority of 60% follow traditional beliefs, while 14% are Catholics. 10% are Muslims and 16% belong to free churches.

The number of fishmongers, again only including women who trade fish from the small reservoirs and not fish from Tono exclusively, totaling about 20 was much

lower than the number of fishermen. As in the rest of Ghana (Atta-Kesson and Atuguba 2007), all those involved in trading are female. The average age of 37 years is higher than that of the fishermen. The women are all Kassenas and are organized in an informal group to share their experiences, exchange advice and discuss prices. The educational level is low with over 60% illiterate; 40% have an average education of 6 years. Only 17% follow the traditional beliefs, 22% are Catholics, 17% are Muslims and 44% belong to various free churches.

5.1.2 Dasabligo and Atonbogoro

The description of the geographic location of the communities using the Dasabligo reservoir is rather complicated. According to the digital district boundaries available (Figure 5.1), the Dasabligo reservoir and the two communities that share it are located in the Bongo district. However, only the community called Beo, west of the reservoir, is administratively assigned to the Bongo district. Beo is mostly populated by Gurensi, who answer to their *tindana* and to their own chief in Beo. Beo is much larger than Dasabligo, the second community.

Dasabligo is administratively and, according to its ethnic majority, officially assigned to the Talensi-Nabdam district. The majority of the people living in Dasabligo are Nabdams, who, according to the elders and the chief fisherman of the community, are under the jurisdiction of the paramount chief of the Nabdams.

The question to which district the reservoir and the irrigation perimeter belongs was subject to much discussion between the different ethnic groups and became problematic after the rehabilitation of the irrigation infrastructure in 2005 under LACOSREP II. The *tindana* of Beo, who was interviewed on the issue, stated that the Nabdams came as peaceful migrants from the Northern Region in search of more fertile land. Some migrants settled in the area around Dasabligo and the *tindana* of the Beo gave them some land. While this land has for many generations been in the hand of the Nabdams living in Dasabligo, today's *tindana* still claims custodianship. While the story is confirmed by the elders of Dasabligo, some of the fishermen interviewed did not accept the continued custodianship and responded to the instructions of their chief as opposed to those of the *tindana*. During the last research trip in 2008 no agreement had been reached as to how to allocate plots in the irrigation area and most gardens still lay

fallow. Irrigation takes place along the distant riverbanks of the Red Volta, which lies about 10 km north-east of Dasabligo and also forms the border to Burkina Faso. Families from both communities move to the Red Volta for several weeks in the dry season and clear small patches of forest for tomato farming.

Trading is difficult as the next larger market town Bolgatanga is far away. The nearby community markets are in Kongo, at one of the main traffic arteries of the UER, the Bawku-Bolgatanga road south of Dasabligo, and in Akayonga market in Beo. The latter was selected for detailed investigations. Although Bongo town is only about 9 km away, closer than Bolgatanga, villagers from both communities stated that the market in Bongo is not frequented, as there is no transport and the market is not large.

The spatially remote location of the two communities Dasabligo and Beo probably contributes to the fact that the area is one of the poorest in the UER (Norton 1995). Observations made during field research in 2007 and 2008 suggest that not much has changed since 1995. In both communities, people live mostly in thatched huts in a poor state of maintenance, and the elders of both communities reported that especially in the dry season the unemployment rate is high and hunger prevails.

Both communities have primary and junior secondary schools and in both communities there were buildings that were supposed to serve as hospital wards. However, during the whole study period they seemed hardly ever to be staffed and only capable of providing the most basic services.

Dasabligo is a small community with only three sub-communities. Population data were provided by the assembly man who counted 656 males and 708 females.

Beo is larger and the associated sub-communities are scattered. Fishermen who use the Dasabligo reservoir were, however, only found close to the reservoir, mainly in a sub-community called Atonbogoro (Figure 5.3). According to census data from 2005 obtained from the Bongo District Assembly office, Atonbogoro and the few other sub-communities that host fishermen have a population of 549 males and 603 females.

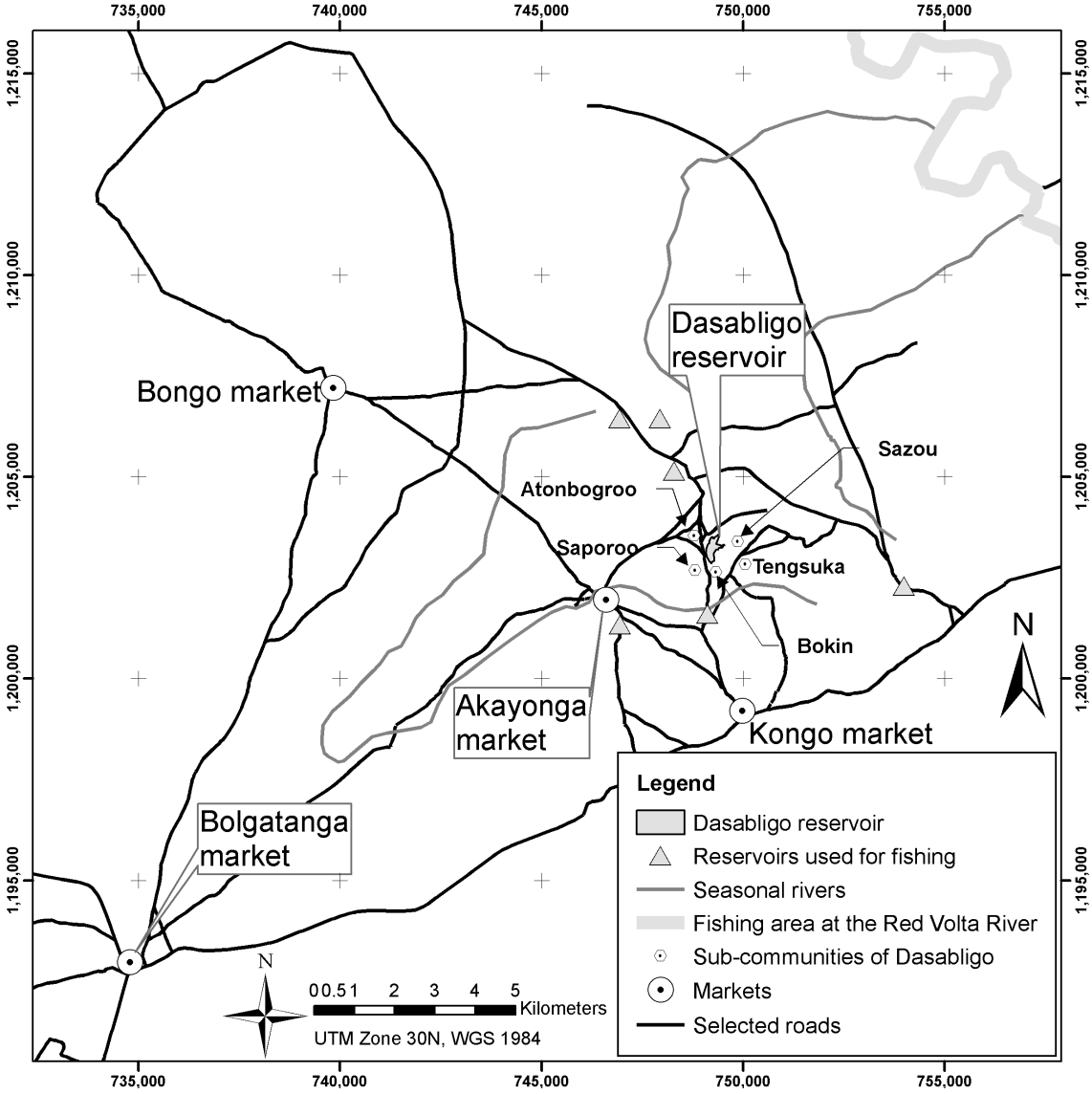


Figure 5.3: Dasabligo and Atonbogoro

Apart from the few reservoirs and seasonal waterbodies (see Figure 5.3), many fishermen frequently go to fish in the Red Volta, especially in the dry season when the river dries up and builds small shallow ponds in which fish are easy to catch. Like tomato farmers, fishermen often camp there for several weeks.

In Dasabligo there are a total of 59 fishermen, although only 38 of them fish in the Dasabligo reservoir frequently. The other fishermen only go fishing in the Red Volta and other seasonal waterbodies and were not included in this study. In Atonbogoro, there are in total 44 fishermen of whom 33 go fishing in the Dasabligo reservoir. Of the fishermen of Dasabligo, the 90% majority are Nabts and only 10% Gurensi. 73% of the fishermen in Atonbogoro are Gurensi, while 21% are Nabts. The

remaining 6% are Bossi, a tribe related to the Gurensi. The average age of the fishermen in Dasabligo is 40 years and in Atonbogoro 37 years. Most of the fishermen of Dasabligo are illiterate, only 4 have basic or higher education; only one was still at school at the time of the interview. The situation is hardly any better in Atonbogoro, where also only 5 can read and write. Religious diversity is very low amongst the fishermen of the Dasabligo reservoir: 93% of the Atonbogoro fishermen follow traditional beliefs, while 7% are Catholics. In Dasabligo, 86% are traditional believers, 9% are Catholics and 5% are Muslims.

The fishmongers from the two communities work independently of each other. There are 8 fishmongers in Dasabligo, of whom 7 are Nabts and one is a Gurensi. In Atonbogoro there are 25 mongers, 76% of them are Gurensi and only 6% are Nabts. The average age of the fishmongers is 36 and most of them are illiterate; only 4 have primary education. Apart from one Muslim, the women all follow traditional beliefs.

5.1.3 Binduri

Binduri is the easternmost of the study communities, located in the Bawku municipality district. The community lies 12 km north-west of the district capital Bawku, the second largest urban agglomeration in the UER. In the north, the community borders on the Bawku-Bolgatanga road. In the south-west, the community is confined by the White Volta River (Figure 5.4).

Binduri offers primary and secondary education, very basic health care, and hosts a local NGO, Zuuri Organic Vegetable Farmers Association (ZOVFA), founded by one of the community members. Although the NGO was meant to focus on vegetable farming, over the years the NGO implemented a number of very different programs including hand-dug wells with the financial support of OXFAM, improvement of women's rights, and mental health care.

Binduri has its own market every three days. However, it is small with only a few dozen women crouching on the ground selling locally produced vegetables, prepared food, and convenience goods. Many of the women also go to the Bazua market 8 km away, along the Bawku-Bolgatanga road (see Figure 5.4).

According to population data acquired from the Bawku Municipal Assembly, Binduri is by far the largest of the four study communities with a population of almost

10,500 in 2004, with 4,650 males and 5,850 females. The female dominance most probably reflects the high out-migration of young men, either seasonal or permanent. This is due to the fact that land pressure is highest in this area as population density in Bawku municipality is the highest in the Upper East Region (169 people per km^2) (GSS 2002).

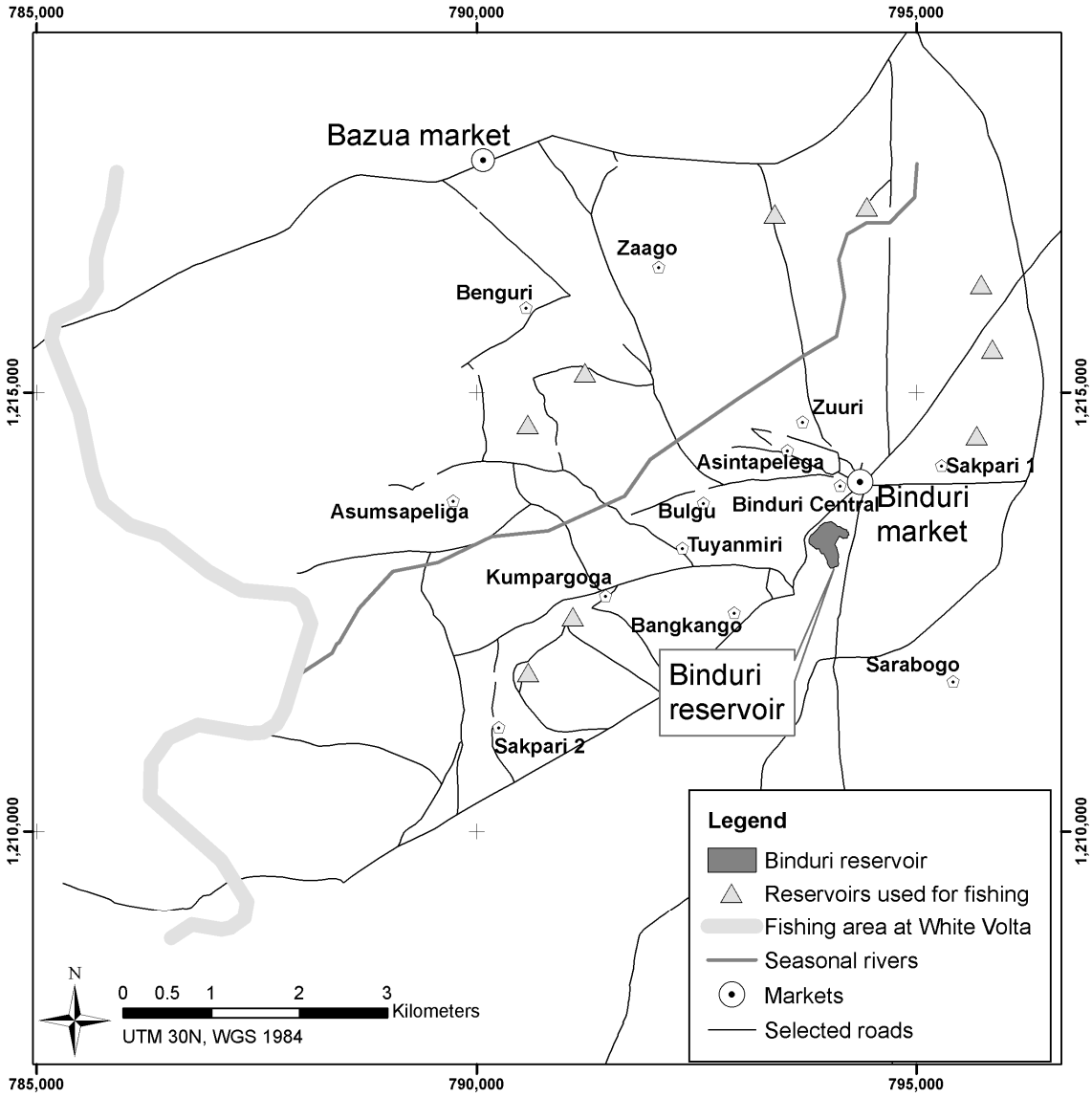


Figure 5.4: Binduri

The different ethnic groups in the community live more or less separated in scattered sub-communities. According to the Bawku Municipal Assembly data, about 6000 people are Kusasi, 1800 are Mamprusi, 1200 are Busansi, 1000 are Moshi and 500 are

Yarsi. The elders of the different sub-communities stated that the ethnic groups in Binduri generally live peacefully together, and intermarriage is common. Yet, the tensions between Kusasi and Mamprusi (see section 4.2.4), which are mainly fought out in Bawku town, are extending to Binduri. For example, the curfew which was enforced by military power to stop the fighting in the forefront of the presidential elections of 2008 also applied to Binduri. Furthermore, interview partners explained that due to the politicization of the ethnic rivalries, decision-making in Binduri is often difficult.

When the four study communities are compared, Binduri seems to be better off than the other communities. The mostly large compounds looked well maintained, even after the floods in 2007, and many of them have costly corrugated iron roofs. Sundong (2005) suggests that the district, with its two international borders, is in a strategically advantageous position for smuggling, allowing high profits. Another factor are the activities of the NGO ZOVFA, which frequently raises money and humanitarian aid for the community. To explain the relative wealth of the community, the extension officers interviewed in Binduri mentioned the higher agricultural production in the rainy season due to an increased use of fertilizer and more advanced technology.

This also applies to dry-season gardening in irrigation areas beyond the reservoirs (Figure 5.4), and to irrigation in depressions where the groundwater level is near the surface. Many people are involved in gardening, and some of the gardeners even stated that gardening earns more money than rainfed farming. One gardener stated: *„Some of us even travel down south in the rainy season to earn money to buy inputs for gardening in the dry season.*" Gardening in Binduri mostly means onion cultivation, as the storability of onions increases the producers' influence on the market price. This capability is enhanced by mobile phones as described by Overå (2006) and Blench (2006). Despite the benefits people reap from the reservoir and the awareness of the consequences of dam failure, as the dam wall broke in the early 1990s, the management of the infrastructure is weak. There is little protection of the catchment area to avoid siltation, and collective savings for repairs are low.

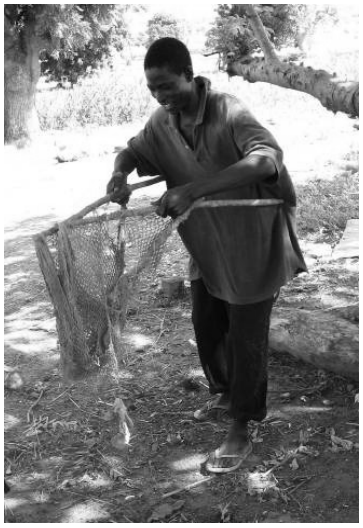


Figure 5.5: Young man in Binduri, demonstrating his old traditional gear that works like a dip net

Binduri reservoir is by far the largest reservoir in the community, and no larger standing waterbody is close by. Only a few fishermen go fishing in the White Volta River, since it is very deep and has a strong current to which their gear and skills are not sufficiently suited. In the rainy season, shallow seasonal waterbodies are used for fishing and even some traditional gear (Figure 5.5) is still available in Binduri.

In comparison with the total population, the total number of fishermen of 66 is small, and only 52 fishermen use the Binduri reservoir. Most fishermen live in the sub-communities surrounding the reservoir. 26 fishermen are Kusasi, 11 are Yarsi, 8 are Mamprusi, 4 are Busanga and 3 are Moshi. 18 of the fishermen are Christians, 19 are Muslims, and 15 follow traditional beliefs. The average age of the fishermen is high at 44 years and corresponds to the high labor-migration of young males. The high average age is surprising, as fishing is a very exhausting activity and most fishermen retire early. Due to a misunderstanding in the questionnaire, no data about the educational level of the fishermen were collected. From personal observation and comments during group discussions it can be assumed that most fishermen are illiterate.

When the research was started in 2007, 35 women declared themselves fishmongers. During the field research, the women formed a group with regular group meetings, where experiences and advice can be exchanged regularly. The women's average age of 32 years is lower than that of the fishermen. Only 8 of the women are not illiterate. 13 are Christians, 18 are Muslims and only 4 follow traditional beliefs.

5.2 Connection between fish and local livelihoods

In the following the number of fishermen and fishmongers, the priority they give to this livelihood strategy, and the income they can generate are given. Further information is provided about the role of fresh and other types of fish in the local markets.

5.2.1 Number of fishermen and mongers

Fishermen

When including the fishermen in Kajelo who only go fishing in Tono, 5.18% of the total are fishermen. When considering that half of the male population is economically active, then even 21.39% of the economically active men are fishermen. The percentages for Dasabligo and Atonbogoro are 0. In Binduri the number of fishermen in relation to the total population is much lower (Table 5.1).

Table 5.1: Number of fishermen per community in relation to the total population and economically active men

Community	Total pop.	Econ. active men.	Fisher-men	% of all fishermen of tot. pop.	% of all fishermen of econ. active men
Kajelo	2685	650	139	5.18	21.39
Dasabligo	1364	328	59	4.33	17.98
Atonbogoro	1152	276	44	3.21	16.00
Binduri	10500	2325	66	0.63	2.84
Average	3925	895	77	2.59	14.60

Mongers

In general, there are far fewer fishmongers in the communities than fishermen. When the women were asked in a group discussion for the reasons, they agreed that it is because of the limited supply of fish. Another reason that prevents women from entering the business is the initial investment required to start mongering. Fish must be purchased and smoked, which requires firewood and a grate. Often, the women also have to pay a market fee and need a tray to display the fish. Skills to smoke the fish, either learned from another monger or from a fisherman, are required as well. The newer mongers also explained that it is very helpful to have an experienced monger to introduce them to the market, get them a place, and explain the rules of negotiating prices.

In Kajelo, only the mongers who sell fish from the reservoirs were counted. The 20 mongers of Kajelo comprise 0.74% of the total population and 1.44% of the female population. In Dasabligo, 0.59% of the total population and 1.13% of the female population are mongers. Atonbogoro has the highest percentage of mongers, 2.17% of the total and 4.15% of the female population. The 35 mongers in Binduri comprise 0.33% of the total and 0.60% of the female population.

Table 5.2: Number of mongers per community in relation to the total and male population

Community	Total pop.	Female pop.	Mongers	% of mongers of tot. pop.	% of mongers of female pop.
Kajelo	2685	1386	20	0.74	1.44
Dasabligo	1364	708	8	0.59	1.13
Atonbogoro	1152	603	25	2.17	4.15
Binduri	10500	5850	35	0.33	0.60

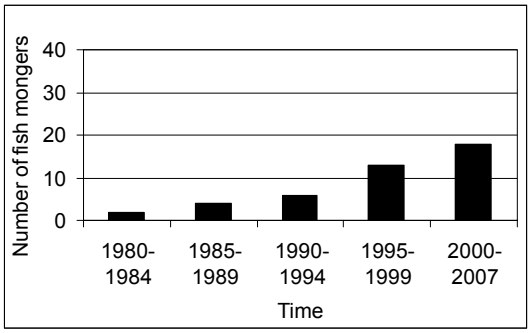


Figure 5.6: Number of fishmongers over time, Kajelo

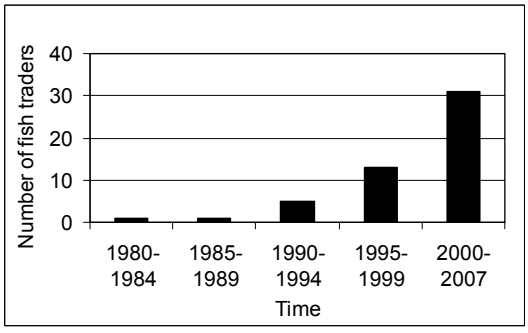


Figure 5.7: Number of fishmongers over time, Dasabligo and Atonbogoro

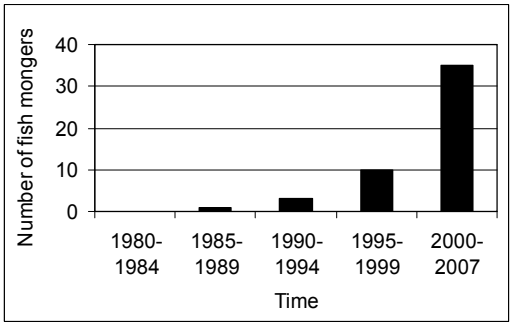


Figure 5.8: Number of fishmongers over time, Binduri

Due to the growing difficulties in organizing a livelihood, women also become involved in income generation, especially in trading (see section 4.2.5 and 4.2.6). This trend is reflected in a growing number of women involved in fish mongering (Figures 5.6, 5.7 and 5.8).

The trend started early in Kajelo. This is, according to the fisheries extension officer of the MoFI in Navrongo, the result of multiple training courses for mongers at the Tono reservoir, where the women were taught how to smoke fish, store it, and cook it. Another issue accelerating the development in Kajelo might be the proximity to the larger markets of Navrongo and Paga, where the demand for fish might have been higher.

In Binduri, Dasabligo, and Atonbogoro, the business started more slowly. But, especially in the last 10 years, many women have joined the business.

5.2.2 Strategy rankings

Fishermen

Fishing as a livelihood strategy has two main issues. First, fishermen go fishing to sell the catch to earn an income. Even mongers who are married to a fisherman have to buy the fish that they want to resell from their husbands. However, it was observed that the share of the catch used for home consumption was free. Second, there are also fishermen who mainly go fishing to provide their families with protein, and only sell a part of their catch if it is more than they can eat or if they urgently need money. A categorization was not possible, as many interviews were conducted in May and June 2007, a time of extreme hunger due to the late rains, and many of the fishermen who are usually subsistence fishermen sold their catch to buy staple foods such as millet or corn.

In Kajelo, 8 fishermen stated fishing as their most important livelihood strategy, 59 as their second and the rest as their third most important livelihood strategy. Farming usually ranked first. In addition, 19 fishermen indicated dry-season gardening as either the second or third most important strategy. Only 5 fishermen stated that they had another livelihood strategy apart from those mentioned above. One earned his major income with trading, one was a watchman, one was a retired extension officer who received monthly allowances, one was selling firewood, and one was a consultant for an NGO.

In Dasabligo and Atonbogoro, 50 fishermen ranked farming as their most important livelihood, while 29 ranked fishing as most important. As second most important, 50 men stated fishing and 29 farming. Apart from fishing and farming, only 6 men had a third strategy. One fisherman went hunting, one was a gold washer, one cut hair, one sold firewood, one sold fishing gear, and one was in leather production. During the second field trip, the number of fishermen had increased by five. These were, however, not new fishermen, but in 2007 they had not been present as they had migrated. One fisherman explained:

> *„When the dry season starts, we go test fishing in the Red Volta. If catches are good we stay at the Red Volta and earn money with fishing. If catches are poor we travel to nearby towns to work there. In 2007, catches were poor so I decided to travel to Bawku to push carts in the market.*"

In Binduri, most fishermen ranked fishing only as their third most important strategy, 63 ranked farming in first place followed by 56 who ranked gardening second. Only 7 men made fishing their second most important livelihood. Although the fishing frequency and catches in Binduri are the same as or better than in the other communities (see Chapter 6), farming and gardening are more important. One man explained it as follows:

> *„With the farming and gardening, we earn money all at once when we sell it. This money we need to buy fertilizer, seeds and other inputs for our farms or gardens or to roof our houses. With fishing we earn only little money at a time, which we use to feed our families.*"

The ranking of livelihood strategies was included in the questionnaires of the fishermen and it was not split into two rankings according to season. Although most men stated rainfed farming as their most important livelihood strategy, they also explained that the importance of the strategies changes with the season. Whereas most of the men spend most of their working hours on their farm in the rainy season and only go fishing two to three times a week, they go fishing five to six times a week in the dry season. Not only the number of fishing days changes with season, but also the fishing location. While fishermen fish in seasonal streams and close-by standing waterbodies in the rainy season, they migrate to more distant waterbodies in the dry season.

Dry-season gardening is a time-consuming activity which follows a strict schedule and once the plants start growing, much attention must be paid to every-day watering and frequent weeding. Yet, since the fishing activities can be handled flexibly

there is usually no conflict of workloads, but instead activities complement each other. Like the workloads, the income from the different activities is also used complementarily to invest in the other activities. Many fishermen pointed out that in years with bad harvests, the money from fishing not only helps to buy food, but also to buy inputs for their farms. In turn, the money earned with farming and gardening is often used to buy fishing gear or material to mend broken nets.

Mongers

The livelihood strategy ranking of the mongers was conducted as a group exercise. In Kajelo, almost all 20 women attended the lively discussion as they were used to gatherings like this based on their experience with the informal group. They ranked the selling of fish amongst their most important livelihood strategies although, following the supply patterns of fish, trading becomes less important in the rainy season. In the rainy season, farming takes the topmost priority. In addition, the women are involved in manifold activities (see section 4.2.6) and each woman has different priorities. Although it was not ranked as a strategy, all women agreed that helping each other without payment is also important to overcome their problems (see section 7.1).

In Dasabligo and Atonbogoro, it was much more difficult to organize a group discussion, as no group existed and the groups of 3 women in each community were small. Their statements, however, were similar. In both communities, the women ranked selling of fish either as the first or second most important activity, depending on the season. While in the dry season they earn their money with fish, in the rainy season most of their time is invested in farming. As a third important strategy, the women emphasized activities around sheanuts, as there are many trees in the area. The collection and processing of sheanuts and the selling of the final product, sheanut butter, had a high priority in the area, and ripe fruits were eaten as a snack. A few women sold prepared food, alcohol, or were involved in other petty trading in addition to selling fish.

The mongers in Binduri were, as in Kajelo, organized in an informal group and assembling them for the ranking was easy. It is interesting to mention that while in the other communities the fish from the reservoir is mainly sold smoked, in Binduri it is sold both smoked and fried. While the younger mongers fried the fish and carried it

around, mostly to the places where *pito* and other alcoholic beverages were sold, the older mongers smoked the fish and sold it on the markets. However, none of the women attached high rankings to smoking or frying. In the rainy season, the trading of fish was not even amongst the 10 most important strategies, and in the rainy season the activity only ranked 6.

5.2.3 Income derived from - and assets needed for - fishing and selling fish

Fishermen

The question of the actual income from fishing was extremely difficult. As mentioned above, many fishermen went fishing to supply their families with fish and sold only occasionally. The fishermen who sold their fish did not keep records of their catches, and prices are subject to considerable fluctuations even from one day to the next.

Two strategies were used to obtain estimates about incomes from fishing. First, the 194 fishermen interviewed in 2007 were asked for their incomes in the dry season of 2007 and the 63 fishermen interviewed in 2008 were asked about their income in the rainy season of 2007 and the dry season of 2008. Second, the results of both surveys were discussed with a large group of fishermen in each community at the end of the two field research trips.

In both surveys, most fishermen answered that in the rainy season they only went fishing for subsistence purposes and hardly sold any fish. In the dry season in 2007, the approximate average income was 1 GHS. (Average Euro/GHS exchange rate in 2007 was 1/1.35 and in 2008 it was 1/1.60). Based on the torrential rainfall in 2007, the catches were slightly better in the dry season of 2008, and the income increased to an approximate average of 1.50 GHS per day or even to 2 GHS in Binduri. Consequently, even in bad years, the men live above the lower poverty line of GHS 0.78 per capita per day in the dry season. In a good year the men can live above the national poverty threshold of 1.47 GHS per capita per day, at least in the dry season. In the rainy season the men stated that the income was much lower than in the dry season, since they did not go fishing often.

Another advantage of fishing as an additional income strategy is that the running costs are low compared to farming and gardening. Once the initial investment in the net is made, costs only arise for mending when the net tears. Sacrifices for better

catches, such as chicken or flour, can be made but are not a necessity. Beside the gear, fishing requires certain skills. Apart from fishing and net construction skills, swimming skills are helpful, which is not self-evident. However, all experienced fishermen stated that they were ready to train those interested.

Mongers

Average profits of mongers were around 20 GHS per month in the dry season in 2007 and around 6.50 GHS in the rainy season in 2006. No figures were collected in 2008. Their income was lower than that of the fishermen, as the initial investment before the fish can be sold is comparatively high. Yet the women in Kajelo, Dasabligo and Atonbogoro explained that they prefer selling fish to most other activities, as the workload was lower than, for example, preparing food, producing sheanut butter, or brewing *pito*. Mongers further stated an increased share of fish for their families as a reason to enter this business.

5.2.4 Problems associated with livelihood strategies

Fishermen

There are several health issues associated with fishing. One of the extension officers interviewed explained: *„The fishermen are in the dirty water all the time. They get all types of diseases; sometimes they don't even know that the water makes them sick until it is too late.*" Hunter (2003) found an immediate flare-up of endemic parasitic diseases, especially schistosomiasis (bilharzia), with a three-fold increase in schistosomiasis only a couple of years after construction of the reservoir. Other dramatic spreading of diseases in the same area of northern Ghana include malaria, lymphatic filariasis (elephantiasis), and dracunculiasis (guinea-worm disease) (Hunter 2003).

Another common health problem often arises at the beginning of the fishing season in January and February. Water and air temperatures are low during the night, and fishermen suffer from common colds accompanied by fever that cost them several working days.

Many of the retired fishermen explained that they had to stop fishing because of spinal disorders. One old fisherman in Kajelo explained: *„We stand in the cold water*

all the time, throwing the wet net that is heavy and bend down to inspect the net for fish. I had to stop because my back was hurting all the time."

Many of the reservoirs are also home to small freshwater crocodiles. Several fishermen reported that they were attacked by them. During the field research in 2008, one fisherman was bitten in the Kajelo reservoir and he stated: *„The bites are not deep, but with the open wounds I cannot enter the water to go fishing. So I sit at home idle and have to wait until my leg has healed.*"

More problematic than the health issues are, according to most of the interviewed fishermen of all communities, the dwindling catches in terms of numbers of fish and also in overall size. Years with low rainfall, which are increasing according to the fishermen of all communities, are followed by years with bad catches. But also the increasing number of fishermen was mentioned as part of the problem of declining catches (see Chapter 6).

Most fishermen also find the limited availability of gear very problematic. The men still have to go to Bolgatanga, some report that they even go to Tamale, as the gear is cheaper there.

Mongers

As mentioned above, in comparison with other livelihood strategies selling fish is more comfortable, and once the initial investments were covered, the women were satisfied with their profit margins. The growing number of mongers, however, increased the competition for fish and often impaired profits. Another problem is that fish is perishable. Even when smoked it can be kept only for some days, and if the markets were poorly attended the mongers work at a loss, which, according to the women, happened from time to time.

5.2.5 Market structures and fish products in the Upper East Region

The Binduri, Akayonga and Paga markets were investigated based on recommendations of key informants. However, in all three markets the number of mongers who traded freshwater fish was lower than stated. Only 21 of the 88 women (Table 5.2) were found selling fish from the reservoirs at the three markets, most of them in Paga. The number of vendors varies randomly from one market day to another, and from dry to rainy

season. Since 2007 was a dry season with poor catches, it was assumed at first that many of the women who called themselves mongers were not in business due to a lack of fish. However, after the first analysis of the 88 women's questionnaires halfway through the field research it turned out that especially the women from Binduri, Dasabligo and Atonbogoro accept long-distance walks to sell the fish in other markets, as the prices for fish on the local markets are low. One woman from Dasabligo explained the situation as follows: *„Most families around the reservoir have at least one fisherman and are supplied with fish frequently and do not have to buy it.*" Women from Atonbogoro sold their fish either at the Kongo or Zebilla market, which are located directly along the Bolgatanga – Bawku road. Wholesalers usually visit these road markets early in the morning to buy the freshwater fish collectively and resell it in the urban markets of Bolgatanga or Bawku. The same applies for most mongers of Binduri, who sell smoked fish. They prefer to walk 8 km to the road market in Bazua instead of selling fish in Binduri itself. In Kajelo women who live closer to Paga sell their fish at the Paga market, whereas women closer to Navrongo prefer to sell their fish there.

In addition to freshwater fish, three other fish products (anchovies, sun-dried freshwater fish, and iced fish) were sold at all the three study markets. In total, 77 women sold fish, of which 49% (see Figure 5.5) sold anchovies, which are dry-smoked to a very low moisture content. The anchovies are caught, for example, in the Keta lagoon, which gave them their local name "Keta school boys" or just "Keta boys". The source of anchovies in the UER usually varies with the quantity a woman can afford to buy. Wealthier women travel to the big fish markets in southern Ghana or at least halfway to Techiman to purchase larger quantities. Most women, however, cannot afford to travel and purchase fish in small quantities from the nearest large wholesale market.

Small pieces of sun-dried freshwater fish called "French fish" are also sold, almost always together with - or as substitute for - the anchovies. It was called French fish, since it was imported from the surrounding francophone countries. Sources or species could not be identified. A small but increasing number of women sold iced marine fish, which comes iced and packed in cartons and is sold either fried as a snack, or smoked.

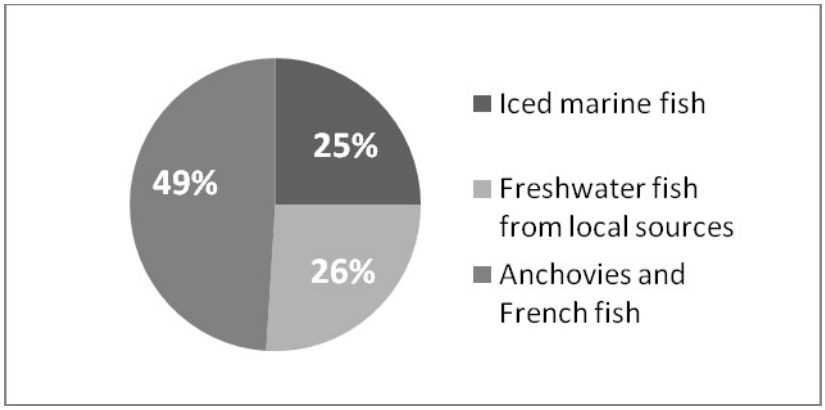


Figure 5.9: Percentage of women selling different fish products

The species sold as iced fish are mainly cheap species such as mackerel and sardinella. Ghana is only 60% fish self-sufficient, and fish is imported to meet the shortfall (Mensah et al. 2006). This holds true for the species mentioned above, and a monger from Bolgatanga confirmed in an interview that according to the labels on the cartons frozen fish comes from EU countries, Russia, South America, Mauritania, Angola, Namibia and Senegal. The interviewed monger owned a large cooling facility and was the major supplier of iced fish in the UER. The one monger, who sold iced fish at the Akayonga market, traveled to Bolgatanga every market day to buy the iced fish from the above wholesaler. There was a wholesaler of iced fish in Paga, who also got her fish in Bolgatanga. She started her business five years ago, and as the business flourished she became the supplier of more than 10 new mongers who sold iced fish at Paga. This is a rapid development, especially when considering that the prices for iced fish have also increased rapidly and investments for transportation are high.

Sales and prices

Apart from wholesale, the anchovies were sold in small quantities, which were not weighed but measured in small heaps or bowls of varying size, or estimated by hand. They were sold either in small transparent bags, leaves, or newspaper. The most common units sold were 10, 20 or 50 Peswas (100 Peswas = 1 GHS). Prices are fixed, but the amount as well as the quality of the fish varies with season. On average in 2007, 10 Peswas bought about 25 g of anchovies. Apart from seasonal fluctuations, mongers

who have been in the business for a long time reported a steady increase in prices, which was mainly attributed to an increase in both population and demand.

The freshwater fish was also sold in heaps. 4-5 small Tilapias were sold for 10 or 20 Peswas per heap, depending on heap size. The catfishes were usually much bigger and cost 50 Peswas and more. The average weight of fish purchased for 10 Peswas was 35 g, dried or fried. The fact that the freshwater fish was cheaper than the anchovies can be attributed to the fact that unlike with all other products there were no costs for transportation.

Iced marine fish was either sold fried in small pieces from 5 Peswas for a head or 10 Peswas for a body piece, or smoked. The whole fish was smoked and prices varied with size between 30 and 50 Peswas.

5.2.6 Fish demand in the Upper East Region

Fish is the primary source of animal protein in Ghana (Brashares et al. 2004) and is consumed by the majority of people from the rural poor to the urban rich (Antwi 2006). The comparison between the Ghana Living Standards Survey 3 and 4 conducted by Ackah and Appleton (2003) shows that the proportion of expenditure for fish increased even in the UER, despite rising prices for fish. Biederlack and Rivers (2009) provide data on the consumption of fish in northern Ghana. They found that, on average, people eat fish 5.4 days per week while meat is consumed 2 days per week. While they admit that their data might be biased because they included fish that was eaten as a condiment, this still shows that there is a high demand for fish in the UER.

A growing demand for fish was also observed during the field research. Almost all mongers interviewed reported an overall increase in demand for all types of fish. Freshwater fish from local sources was especially cheap and the demand, according to the mongers, exceeded the supply by far. A few consumers who were interviewed also stated increased fish consumption, but they also stated that their purchasing power for fish was limited in favor of staple food. This was supported by calculations of their weekly food expenditures, which revealed that the proportion of money used to purchase fish was much lower than 5%. Unfortunately the limited time did not allow a representative survey of fish consumers.

What made fish very popular was that it could be bought in small quantities and usually served as a condiment. Meat was hardly ever bought, especially amongst the lower income groups, since it was hardly available in smaller, affordable quantities. There was also a growing awareness that animal and especially fish protein should, for health reasons, be part of the diet. The awareness was raised by radio programs, during NGO training programs, or children passed on the message learned in school. An increased availability of fish due to improved transportation and distribution systems and consequently a habit of consuming fish also contributed to the increasing demand.

5.3 Developments in fisheries and fisheries management in the Upper East Region

This section explains the history of the meaning of fish for livelihoods and the development of fisheries management is investigated. The section is divided into three time categories, starting with fisheries in pre-colonial Ghana and colonial influences, followed by the post-colonial period and developments during the late 1980s and 1990s, and in recent years.

5.3.1 Fisheries in pre-colonial Ghana and colonial influences

Some geological layers of the region seal parts of the surfaces, and runoff water forms shallow ponds in depressions. These waterbodies are naturally stocked with fish. Historical literature (e.g., Fortes 1937, Klages 1953) as well as local interview partners reported that these ponds have always been used for fishing before they dry up in the course of the dry season, either by hand or using traditional gear (Figure 5.5).

Besides this exploitative approach, Braimah (1990) lists a number of traditional management strategies that can be found in northern Ghana, which he assumes to have evolved around riverine systems such as the Red or White Volta. Some of the main features are:

> *„a) Closed season, to allow fishing in certain periods only. b) Restrictions on some fishing methods, in particular those which are not conventional. c) Restrictions on fishing, to protect fish and make sure there is enough for other animal species […]. d) Commercialization of temporary fisheries, such as the insulated pools that can be auctioned based on their size, or where production is equally shared between the chief and the fishermen. e) Communal fishing of water bodies which are far away in the bush. f) Stocking exercises of some bush ponds at the onset of the rains.*" (Braimah 1990, p. 36).

According to Pogucki (1955) and Ramazotti (1996), fishing rights were usually open to the entire community, apart from the above mentioned protective measures. Professional fishermen from outside the community had to obtain permission from the *tindana* or the chief. Often a fee had to be paid to the local authorities to obtain fishing rights for a waterbody.

Apart from these more technical aspects, it appears that fishing was a highly ritualized activity in the pre-colonial and early colonial days. Fortes (1959) describes that before the men of a household went fishing, it was the responsibility of the household head to consult the local diviner. The diviner was perceived to be the transmitter of the wishes of the ancestors and could ask them about the prospect of the trip and receive their blessings.

Both sacrifices and fees acted as a threshold for entering fisheries and, intentional or not, probably contributed to a sustainable resource use. But these were not the only limitations (COFAD 2002).

There used to be only a few permanent waterbodies in the region, and most of them were perceived as homes of gods or ancestors. In these sacred groves, fishing was usually forbidden altogether, and it can be assumed that they play an important role for natural restocking.

> *„During dry season, the Red Volta, like other arid rivers, breaks up into a series of stagnant pools in which river biota concentrate. Especially the larger, perennial pools are critical for survival of aquatic animals, including hippopotami, crocodiles, and fish. Fishing is forbidden in certain pools by traditional regulation and rituals, such as prayers and sacrifices, are carried out in order to seek the favour of river deities. In this way, reproductive stocks are maintained through the dry season and re-colonise the river as the waters return with the onset of the rains." (COFAD 2002, p. 27).*

The most vivid traces of these traditional laws and strategies were found in Dasabligo and Atonbogoro. An old fisherman from Atonbogoro explained: *„My father taught me how to fish. At that time we used traditional fishing gear. The modern fishing gear came much later.*" According to an elder of Atonbogoro, the villagers believed that the rivers in the area were protected by gods or spirits and that fetish priests acted as custodians and served as a link between the spiritual and the corporeal worlds. He explained:

> *„The spirits that live in the waterbodies are dangerous, because they can eat people. The water priests plead with the spirits so that they make fish rise to the*

> *surface waters to feed the fishermen and their families. So before the fishermen moved to the river in the dry season, they went to the local water priest, who sacrificed small animals for them to get the blessings from our ancestors.*"

The old chief fisherman from Atonbogoro added: *„There was always some sort of chief fisherman who was responsible for fishing operations and the sacrifice."*

While sacrifices were usually made for fishing in the Red Volta River, the following, which is widely known amongst the fishermen from Atonbogoro, applies to all fishing activities independent of the fishing grounds. Fishing is strictly forbidden in August and September, when the late millet is about to form its seeds. Fishing is believed to cause strong winds, which in turn could jeopardize the formation of millet seeds. Coincidence or not, the 2-month fishing ban coincides with the main reproduction phase of many fish species, which thus have the opportunity to reproduce before they are caught.

Another example of a traditional rule could be found in Kajelo. An elder from there reported: *„We believe that when a waterbody is fished empty, the water will follow. This is why we try to stop the fishermen at the end of the dry season catching all the fish. If the water goes, our animals have nothing to drink and they die.*" While there are some fishermen in Kajelo and also in Atonbogoro and Dasabligo who remember the traditional rules, adherence is another matter altogether as will be seen later.

In Binduri there were hardly any traces of traditional rules apart from rare sacrifices, but some fishermen still had their traditional fishing gear, indicating that fishing is also a part of the traditional livelihood strategies.

According to Baijot et al. (1997), the first reservoirs in the north were established in the early 1940s. The main aim was to ensure a safe water supply to both humans and livestock (Braimah 1990). According to MacPherson and Agyenim-Boateng (1991), the facilities were, on completion, usually handed over to the traditional authorities, either chiefs or *tindanas* or both.

Braimah (1990) reports that some of the dams were stocked by the Department of Rural Water Development in the early 1940s. The vast majority was stocked naturally with fish from adjoining rivers which overflowed their banks during the rainy season and created passages for fish. A Fisheries Department was established in 1946 (Atta-Kesson and Atuguba 2007) that, amongst other tasks, took over the responsibilities for fisheries administration and development of some of the reservoirs.

Old fishermen and elders from the four study communities, where the reservoirs were built in the early 1950s, reported that nobody helped them with the use of the reservoirs, and as they had neither fishing skills nor gear for deep waterbodies, the reservoirs were not used for fishing at first.

Fishermen from Dasabligo explained that the old water priest, who was responsible to oversee the fishing activities in the Red Volta River and other seasonal waterbodies, also did not feel responsible for the reservoir. He said that he had neither experience nor influence on the fishing potential of man-made structures.

Although the colonial administration was never directly involved in the fishing affairs of the study communities, their overall ignorance of the *tindanas* and preference for chiefs (see section 4.2.5), probably did have an impact (see Chapter 7).

5.3.2 Fisheries in newly independent Ghana

In 1964, seven years after independence, the new Government of Ghana passed the Fisheries Act and the Fisheries Regulations 1964:

> *„a) to institute a training program on net making and mending and also the techniques of using them. b) to shift from exploitation of the capture fisheries only in the natural water bodies to development of aquaculture. c) to integrate fish farm development with that of public irrigation schemes. d) to regulate the exploitation of water resources. f) to strengthen the research capacity of the Fisheries Department.*" (Braimah 1990, p. 36).

Even before the official policies were published in 1964, the potential of fisheries resources to alleviate malnutrition and protein deficiency diseases was already ascertained. The Fisheries Division of the Ministry of Food and Agriculture started straight after independence with an assessment of the resources of the Upper Region, and a fisheries station was opened in Bawku town in January 1961. (Upper East and Upper West Region were at that time united and called Upper Region.)

One of the main results of the assessment of the reservoirs, which were at that time called ponds was:

> *„The one set-back to the development of fisheries in these ponds is the fact that many ponds dry up during the dry season particularly in the Upper Region or are flooded and damaged during the Volta Floods from July to October, and thereby destroying valuable fish resources. The main task of the Unit is to encourage and urge the local fishermen to fish the ponds intensively before the hazards set in.*" (Fisheries Division 1962, p. 11).

As a consequence of this assessment, training fishermen in an exploitative approach became a very important task. The enthusiasm of these days is best captured by a report from a fisheries officer from 1969:

> *„The training is carried on at Fisheries Training Camps manned by experienced fishermen. There are seven such Camps in Bawku and Navrongo Districts and twelve in Lawra and Wa Districts. […] Several hundred people have passed out of the training centers some of whom work on their own even in river systems. Chiefs and people of all areas involved have shown keen interest in the scheme and have always been a source of encouragement. […] In the early days of the scheme, Learner Fishermen were provided with all materials for their gear by Government without any charges. Now, they are encouraged to use Government nets (which they have been given cords to make) to learn to fish. The money they get from selling their catches they save and later use to acquire their own nets. […] To establish the fishing habit firmly, an exclusive Fishery Programme for schools was begun in 1962 with the co-operation of the Regional Education Authorities. By this means, school pupils are taught net weaving etc. during Art and Craft periods. Besides providing a profitable pastime, it offers some an occupation. The scheme attracts far more people than the Division can provide materials for. The Regional Education Authorities used to help generously with cords. […] The Instruction Scheme and the development of the dam fisheries have made possible a good supply of fresh fish in the rural areas, a fraction of which reaches a few towns.*"

However well these activities started, very soon, in the early 1970s, the number of trainees decreased significantly as based on a lack of funding no material to construct fishing gear could be offered to those interested. The situation improved slightly when money came from the "Freedom from Hunger Campaign" (FFHC) launched by the FAO back in 1959/1960. Although the fisheries division staff only served as retailers of the material, the fishermen at least had access to it. In the late 1970s the renewed lack of material and the lack of vehicles for extension services led to a further decline in the number of students trained.

Although very important, training fishermen was not the only task the fisheries division had. The retired extension officers who were interviewed listed the exploitation of reservoir resources by departmental fishermen to meet the market demand for fresh fish as another important task. In addition, the division was also occupied with intensive aquaculture in order to produce fingerlings in large quantities that were frequently used to stock the reservoirs. Furthermore, the staff at the training camps collected data on catches and oversaw the management of the fisheries activities in the reservoirs. The main funding at that time came from URADEP, which boosted the fisheries sector.

While these developments were positive for the fisheries sector, the programs, like so many other activities, were financed with credits and the national debts grew fast.

In order to counteract the growing mountain of national debts, the Structural Adjustment Program described in section 4.2.1 also arranged for budget cuts in the fisheries division. Despite cuts in the funds for material and vehicles, there was also a growing lack of funding for staff. Retired staff was not replaced and many of the training camps were closed down. The analysis of quarterly and annual reports of the fisheries division at the end of 1979s and early 1980s further reflects the shift in governmental attention away from small-scale and towards larger-scale developments. Governmental activities in the fisheries sector focused then on the development and management of the resources and led to the new medium size reservoirs Tono and Vea (see section 4.2.1). Besides training fishermen, the main effort went into the set-up of the aquaculture ponds for fingerling production and also for production of table-size fish to satisfy the growing demand. So the remaining resources were by and large dedicated to the development of aquaculture. However, according to MacPherson and Agyenim-Boateng (1991), the returns on the investments in the aquaculture programs were extremely disappointing. MacPherson and Agyenim-Boateng (1991) give the following explanation: *„One of the central reasons for this disappointing outcome has been the failure of government to support its promotional campaign with advice, information and extension to the aspiring producers.*"

The continued lack of funding for fishing material and the preoccupation with aquaculture at Tono and Vea meant that hardly any fishermen were trained during the 1980s in the training camps, but only around the Tono and Vea reservoirs.

All of the developments described so far are reflected in the interviews conducted with senior fishermen and extension staff in the study communities and at regional level. After independence, the fisheries division opened one of the first offices in Binduri in 1960. The retired extension officer from Binduri, who was also stationed in Kajelo in the late 1960s reported:

> *„Fishermen from the Ewe tribe in the Volta Region were employed to train us how to use and construct the modern gear. After the training we were employed as trainers and taught those interested. A few years later a training camp was opened in Kajelo. In both villages many men were interested and came to be trained at the camps.*"

In Kajelo and Binduri administration, development, and management of the reservoir fish stocks were completely in the hands of the fisheries officers. According to the local authorities of the communities, this was not a problem for them, since the fisheries staff was seen as an enrichment to the community as they provided free material and introduced a new livelihood strategy. Despite the quickly growing enthusiasm on both sides to exploit the newly discovered livelihood strategy, the fisheries officers explained that they had certain management rules at that time to ensure the sustainable use of the resources. The officer in Binduri explained:

> *„Fishermen had to complete a training, and the fishermen had to be officially registered together with a limited amount of gear. The gear was only approved when it fulfilled certain requirements. The most important requirement was the mesh size of the nets and fishermen had to bring their catches to our offices so that we could record them."*

According to Lenselink (2002), the nets of mesh sizes less than 25 mm in stretch diagonal length were strictly prohibited. In Kajelo, the number of fishing days were limited in addition to the above-mentioned restrictions. An elderly fisherman from Kajelo stated: *„We used to follow the advice of the men from the fisheries office and we did not quarrel with them.*"

Fishermen from Binduri and Kajelo also stated that the exploitation of the resource by the departmental fishermen for selling at larger markets was accepted. They even helped to drag the huge fishing net. In return, the reservoirs were stocked frequently and both sides were satisfied.

However, based on the budget cuts described above, the training camp in Kajelo was run only for a few years and was closed down in 1972. All the staff was transferred to assist in building up the structures of the nearby Tono reservoir. Many fishermen followed, since most of the reservoirs in the community were in bad condition and did not offer good catches. One of the fishermen who stayed behind stated: *„The people from fisheries abandoned us. It is their task to enforce the fishing rules, but they never show up to do their job, but only come to fish in our reservoir and take the catch away.*" Accusations of this kind were also voiced by elderly fishermen in Binduri, and it was probably back then when fishermen first began to resent fisheries staff.

Fishermen in Binduri stated that at the beginning of the 1970s fish catches from the Binduri reservoir started to decline. With the decreasing catches and limited availability of gear, it seems that the number of fishermen stagnated or even decreased towards the end of the 1970s, and the number of trainers was also reduced. In the mid 1980s, a single trainer was left who took catch records and managed the resource. In his interview, the fisheries extension officer also mentioned that he undertook a first group formation attempt around 1984/85 and even opened a bank account for the fishermen. After a few meetings, however, the fishermen stopped attending and contributing for reasons the extension officer could not explain. The money in the account was used up for account maintenance fees and after some years nothing was left. In interviews senior fishermen in turn explained that the extension officer did his job half-heartedly, as they could go fishing without restrictions. Furthermore, they did not understand the matter of savings very well, and when the money was gone they felt betrayed.

In Binduri and Kajelo, the enforcement of fishing rules was perceived to be the task of the fisheries staff, and local authorities in both communities stated that they hardly got involved in fisheries management. Their knowledge of modern fisheries management consequently remained limited and when the fisheries offices closed down, no authority was left to enforce fishing rules and the reservoirs were open to everybody and every type of gear at all times.

The situation in the Dasabligo reservoir was different, since the fisheries division never got involved in the two user communities, and no fishermen were officially trained. Today, the reservoir is used for fishing with modern gear. A few of the communities' older fishermen explained that they picked up their skills from foreign fishermen who came in the dry season to fish in the Red Volta River in the late 1970s. However, fishing activities were mainly centered at the Red Volta River, as the reservoir was not operational due to a broken dam wall. After the dam wall had been rehabilitated in the late 1970s, the government also established an irrigation scheme whereby people from the communities were employed to cultivate tomatoes. Fishermen reported that it was after this first rehabilitation that some of those who cultivated tomatoes also started fishing in the reservoir.

Under the first Rawlings regime in the early 1980s, the payments for gardening activities stopped, the infrastructures collapsed and many of the men

preferred seasonal migration. An old fisherman however stated: *„Many of us did not have the means to travel down south, and those who stayed behind and did not have an alternative started to go fishing when they could afford to buy gear.*"

According to a fisheries officer from the regional fisheries division office in Bolgatanga in the early 1980s, fishing gear became more easily available in the region. Accordingly most of today's older fishermen they only started fishing around that time.

5.3.3 Decentralization and participation in the late 1980s and 1990s and trends in recent years

With the emerging enthusiasm for decentralization, the fisheries division's agenda and with it the style of fisheries management changed again at the beginning of the 1990s. The fisheries extension staff was integrated into normal agricultural extension services to improve the scope of fisheries activities (Kapetsky 1991; Lenselink 2002). This meant not only that the infrastructures of Tono and Vea were more or less abandoned, but according to a retired extension officer fisheries activities played only a minor role in their new job description. According to an employee of today's Ministry of Fisheries in Accra, the focus of activities and budget was on marine fisheries and fisheries in the large Volta Lake. Based on the perception of most policy makers that people in northern Ghana do not eat fish anyway, fisheries development was even further neglected.

> *„Inland capture fisheries have received less development assistance than other sectors of primary production, whether from African governments or from aid agencies. Reasons why the sector has been kept out of the mainstream of development include the low degree of socio-political representation of the fishers as well as the fact that inland fisheries are mostly part of the informal sector of the economy.*" (COFAD 2002, p. 97).

With the onset of the first Land Conservation and Smallholder Rehabilitation Project (LACOSREP I) in 1994, the concept of community-based management was introduced to the UER in the form of Water User Associations (see section 4.3.3). The reservoir rehabilitation projects had a fisheries component, and WUAs were meant to include a fishermen association responsible for the sustainable use of the aquatic resources in the reservoirs. The fishermen were asked to elect a chief fisherman to represent the fishermen association, a secretary to record the discussions during monthly meetings and a treasurer to be responsible for the collection of the water levies from the fishermen. In addition, the associations were urged to build savings groups in

order to become creditworthy. When the fishermen agreed to these conditions, the reservoir was stocked with fingerlings to accelerate the development of fish stock.

All the current and retired fisheries extension staff reported that their training in initiating and supervising such associations was rudimentary at the most, as it was perceived to be an easy task. An extension officer, who did not originally come from the fisheries division, but instead from the MoFA explained: *„The majority of us were uneducated concerning fisheries and we usually left out this task as we did not know what to do and most of the WUAs do not have a fishermen association.*"

In the late 1990s, it was ascertained that the reservoirs' full potential concerning fish production was not reached (FAO 2004a). This was acknowledged by the Government of Ghana (Quanshiga 2004) in the country's Poverty Reduction Strategy Paper (World Bank 2003; Thorpe 2005) and the general legal framework of fisheries management (FAO 2004b). Based on the realization that the integration of the fisheries staff into normal agricultural extension services did not lead to an improved scope of fisheries activities but instead rather the opposite, the fisheries staff was disburdened of general agricultural extension activities again and could focus on the development of fisheries in the UER. The developments went even further and after the parliamentary elections in 2004, the fisheries division was even separated to form a new Ministry of Fisheries in 2005. However, the creation of the new ministry did not yield an increased budget for fisheries activities in the UER. Thus the activities of the new ministry were very limited due to a small number of staff and funding. In the Upper East not even every district had a fisheries officer, and many of them did not have any means of transportation or money for fuel to enable them to visit the communities. Only in 2007, during the time of the field work for this study, did the first if rather humble funds in excess of the staff salaries arrive in the UER from the ministry`s headquarters. However, before they could commence work, the Ministry of Fisheries merged again with the Ministry of Food and Agriculture in the aftermath of the parliamentary elections in 2008. The consequences of this reunification remain to be seen.

Binduri was the first of the three reservoirs to be rehabilitated in 1996 under LACOSREP I. The fishermen were urged to form a fishermen association and to elect the required representatives. As the fisheries extension officer did not speak the local language, it was necessary to select a chief fisherman with a good knowledge of

English, despite the fact that not every fisherman agreed with the choice. Further, a bank account was opened again, contributions were made, the reservoir was stocked and the organization of regular association meetings was attempted. However, the money was embezzled and one of the few fishermen who were prepared to talk about the situation explained: *„Those who chopped the money would not come to the meetings to avoid questions and soon the meetings stopped.*" The fishermen split up into several groups according to sub-communities and dislike for each other developed, which could not even be resolved by local authorities, whose influence was also otherwise very limited.

Under LACOSREP II, yet another attempt was undertaken by the extension officer to revive the fishermen association in the early 2000s, including the encouragement to form a savings group. This attempt was also supported by the Challenge Program on Water and Food Project No. 6: Strategic Innovations in Dryland Farming (CP6). The project had a small fisheries component and selected Binduri in 2005 (see section 7.3).

According to the extension officer responsible for Kajelo, the fishermen who fished mainly in the small reservoirs were not organized in a group. After the Kajelo dam was rehabilitated in 2004, the officer started to form an association, the reservoir was stocked with fingerlings and he also recommended the community for CP6. When Kajelo was selected for this study, it was assumed that it had a working fishermen association. During the field research it turned out that this group only existed on paper, and fishermen were not meeting at all. Closer investigations revealed that the situation was exactly the same as in Binduri. The group was formed after the dam rehabilitation as a condition for the community to have the dam stocked with fingerlings. The money saved during the first rounds of meetings was embezzled and the group split into several sub-groups (see section 7.1).

When the infrastructure of the Dasabligo reservoir was rehabilitated in 2004, a pond was built behind the dam wall. This pond was meant for fingerlings for stocking the reservoir and, according to information from the MoFI, a fisheries extension officer visited the community at least twice. When asked about the person or the pond, most interview partners in the communities, however, answered that they were neither aware of the extension officer's visits, nor of the purpose of the pond. The extension officer

responsible for the area explained that based on the unclear ownership of the land, the two districts involved could not agree which office should send staff, and thus the plans for the ponds could not be followed up.

Interesting is the fact that even without the involvement of any governmental fisheries organization apart from the two visits mentioned above, some fishing rules can be found and are still adhered to by some fishermen. Apart from the traditional rules (see section 5.3.1), there is a quite new regulation of the use of poison as a catch method. In the past, the water priest prepared poison from the Dawadawa fruit to stun the fish that were left in the ponds of the Red Volta by the end of the dry season. The fishermen could then go in and collect the fish. The rather harmless poison was replaced with the insecticide DDT in the late 1990s. This poison not only killed the fish, but also destroyed the brood of the fish in the Red Volta River, and fish stocks hardly recovered. The chief fishermen from both communities remembered that an extension officer from the Ministry of Lands, Forestry and Mines (MLFM) in Bolgatanga came to visit them at the Red Volta and explained to them that they should not use the new poison. The fishermen had already noted dwindling catches following the years they used the new poison, and they readily followed the instructions given by the government officers.

5.4 Fisheries today: an important livelihood strategy

The people in the UER of Ghana are exposed to a number of challenges from the environment in which they live. Independent of whether the climate is changing or not, people are exposed to an erratic climate, which makes rainfed farming a gamble. On top of that come the climatic extremes as seen in 2007 when drought was immediately followed by flooding. The soils are naturally low in water holding capacity and nutrients, and are increasingly degraded. Plant growth is in general limited to the rainy season due to the low water supply in the dry season. However, people in the UER have learned to live with environmental difficulties and over hundreds or even thousands of years have developed sophisticated strategies for survival. Yet the increasing rates of poverty show that people have increasing difficulties in coping with the environmental conditions. However, the environment is not the only challenge people face. Major contributions to the persistent poverty stem from the time of British rule when the economic exploitation started. Even after independence the region stayed marginalized,

and despite considerable efforts, development initiatives could not change the situation up until now. The list of problems is long: ethnical conflicts and political neglect, exposure to the pressure of the world market, high population density, few income alternatives besides the agricultural sector, poor access to education and health care and other public services, poor infrastructure, corruption and partisanship, and changes in social structures that undermine social safety nets and challenge traditional rules and authorities.

Nevertheless, people are not passively waiting for change, but seek out new strategies to survive and improve their situation in the process. In the case of small reservoirs this means that although the water use efficiency of the reservoirs is low (Mdemu 2008), at least according to our standards, many people depend on them nowadays and have learned to utilize their potentials. The results of this study prove wrong the assumptions that fish consumption is low and northern Ghanaians are not particularly interested in fishing. Multiple records, such as old literature sources, reports from elderly fishermen and elders and the traditional gear suggest that even before the construction of the reservoirs fishing activities used to have their place in the traditional livelihood portfolios of the people in the UER. However, technical skills and know-how were not sufficient to utilize the aquatic resources from the reservoirs. The situation changed considerably with the involvement of the fisheries division in the region shortly after independence. There was great enthusiasm in the division about the reservoirs' fisheries potential but, more importantly, the men in the communities were also very enthusiastic.

Great attention was given by governmental organizations to the establishment of the fishing activities in the 1960s. This was accompanied by a steadily growing number of fishermen. However, the free access to know-how and more importantly to equipment also caused problems. The villagers quickly got used to the free gear provided and were very disappointed when the free flow of equipment stopped. Tension began to rise in the relationship between extension staff and fishermen. The disappointment was intensified by the fact that the fisheries division was the only source of modern fishing gear, and the limited availability of gear placed a limit on the expansion of fisheries activities in the 1970s and early 1980s. However, since the late 1980s the availability of fishing gear has improved and at least there is no constraint on

the study village's access to fishing gear. Yet the preliminary survey showed that there is still a considerable number of reservoirs which are not used for fishing. Reasons are the lack of know-how and many of the villages are very remote so that for them access to urban markets such as Bolgatanga where fishing gear is sold is still difficult.

Contrary to the gear, the access to the resources in the reservoirs is hardly ever restricted and every villager who has gear and skills has the freedom to use resources as he wants. However, having "only" small reservoirs nearby might limit fishing activities due to a finite fish production. This might be one reason why the number of fishermen in relation to the total community population is so much lower in Binduri than in the other three communities. Fishermen in Kajelo, Dasabligo and Atonbogoro have access to a much larger supply of aquatic resources. In Kajelo it is the Tono reservoir and in Dasabligo and Atonbogoro it is the Red Volta that complements supplies from the reservoirs. Although Binduri is quite close to the White Volta, most fishermen cannot fish in the deep water due to a lack of skills and equipment. Another reason for the low number of fishermen in Binduri in comparison to the other communities might be the access to other income strategies, which are preferred to the exhausting fishing activities.

While the gear for fish mongering is in general easily accessible for the women, as is the knowledge of how to process the fresh fish into a salable commodity, the initial investment for mongers is much higher than that of the fishermen. Frying or smoking gear and the - often expensive – firewood and boxes or plates for transport and selling. Despite these initial costs the number of mongers is also increasing and there is a lot of competition for the fish provided by the fishermen from the reservoirs.

Despite these drawbacks the livelihood outcomes of the two strategies, fishing and trading fish are still considerable, which is the reason why the number of fishermen and mongers is continuously increasing, even in Binduri. For most of the fishermen, the income from fishing is not incidental, but amongst the three most important livelihood strategies and, at least in the dry season, it means that the men and their families live above the lower poverty line.

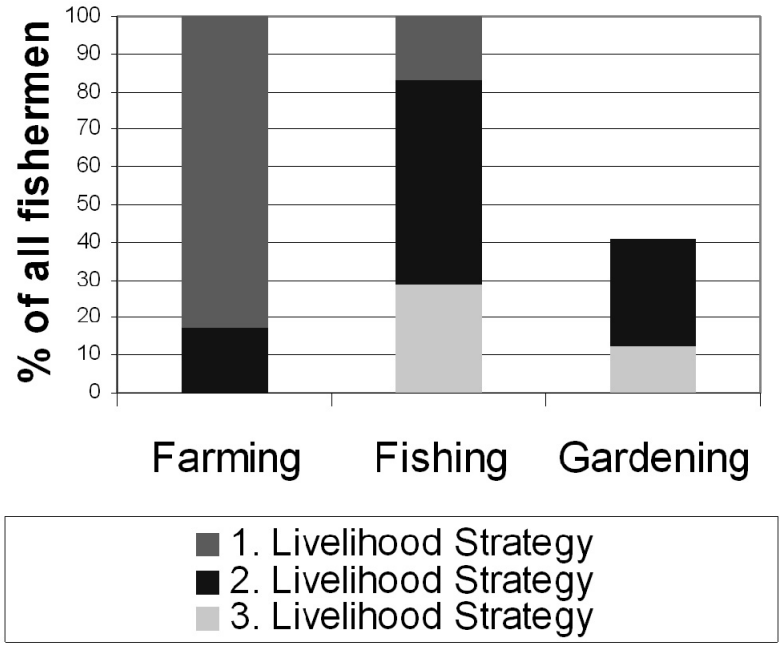


Figure 5.10: Prioritization of livelihood strategies in the four study communities

Figure 5.10 shows that although farming is still the most important livelihood strategy for over 80% of the men interviewed, for over 50% fishing is the second most important strategy. Especially for those fishermen who also have a garden, this activity is often the second most important strategy and fishing comes only in third place. Most of those who do gardening and fishing state that these two livelihood strategies complement each other very well. The money earned with the activities opens a range of possibilities. It often is reinvested in other farming activities, education or simply to buy other foodstuffs to save the family from starving, especially during the hunger season.

For the fishmongers the situation is slightly different. Although all mongers, except those in Binduri, rank the income from fish mongering very high, the number of women in the business is much lower than that of the men and so is the income. Yet especially the women point out that the fish contributes to a large extent to the supply of proteins for families and they even state that they observed improvements in their children's development. This is, however, very vague and was not assessed in this study.

With the growing importance of fish as food and for income generation, problems arise. According to those involved in fisheries, considerable health costs

mount up, which unfortunately could not be quantified in this study. Another more serious problem than the health costs, at least according to the fishermen, is the decline in catches. The encouragement of the fisheries division for unrestricted exploitation of the reservoirs during the time immediately after independence caused many of today's problems in the attitude towards fisheries management. Environmental concerns or the concept of sustainable resources usage were not high on the agenda at that time and vanished completely when human development took priority. After this first phase of unrestricted exploitation, the officers from the then so called Department of Fisheries started managing fish stocks and catches for more sustainable exploitation of resources. However, they did that in a strict top-down manner which they had adopted from the colonial rulers. The enforcement of fisheries management rules starting in the 1970s was completely in the hands of the extension staff and the fishermen had to follow their instructions. By not involving the villagers in management did they not only fail to teach them the rules of sustainability, but also undermined the authority of traditional rulers. This was based on the assumption given by one of the retired extension officers: *„We did not involve the fishermen, as we thought we would always be there to manage the resources for them.*" When the extension officers vanished the fishermen fell back into the unrestricted exploitation as they had not learned how to enforce rules.

The withdrawal of the extension staff from the communities had further consequences. The villagers felt abandoned, a feeling that intermingled with hostile feelings as, at least according to the fishermen, extension staff only came to exploit their resources without providing something in return.

These were not good starting conditions for the acceptance of the community-based management concept through fisheries extension staff as introduced in the 1990s (for details, see Chapter 7). Despite the high acceptance of fisheries as a source of livelihood and a growing demand for fish, the limited and decreasing supply of fish from reservoirs and failed attempts to manage the resource in the past to increase production pose the question about the prospects of further developing fisheries as a livelihood strategy.

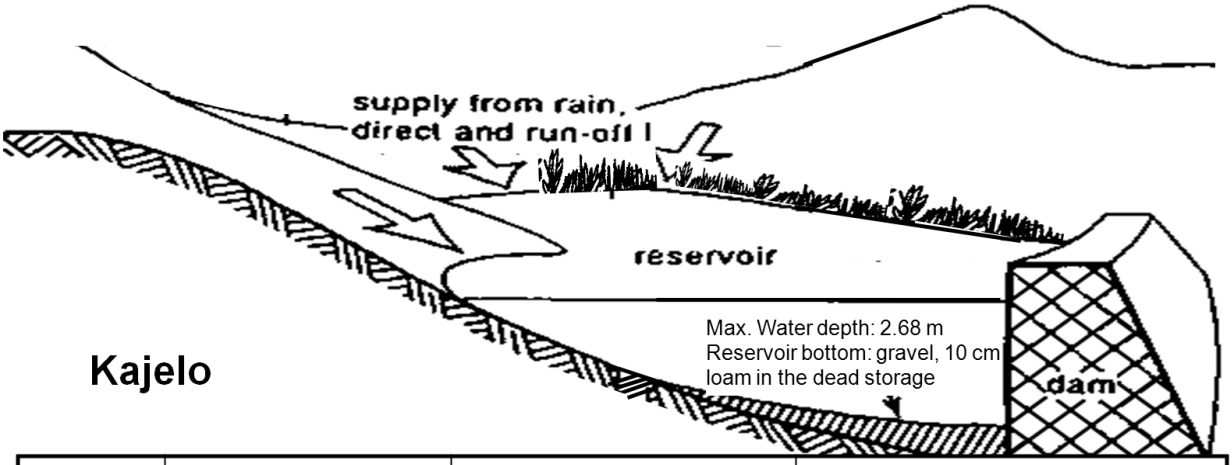
6 SMALL RESERVOIRS AS AQUATIC ECOSYSTEMS

6.1 Reservoir characteristics

The following sections give a brief introduction to the reservoir characteristics.

6.1.1 Kajelo

The geographic coordinates of the Kajelo reservoir are 10°56'25.90" north and 0°07'77.33" west at 214 m above sea level (asl). It is with a maximum surface of 6.75 ha by far the smallest of the three study reservoirs.



	Catchment area	Reservoir surrounding area	Reservoir
Age			Built: mid 1950s Dam failure: 2003 Rehabilitation: 2004
Size	148.92 km²		Surface when full: 6.75 km² Surface dry season 2007: 5.44 km²
Altitude			214 m
Soil type and grain size	Gleyic Lixisols	Mostly gravel, some sand and loam	Mostly gravel, some sand and loam
Geology	Migmatite and Granite	Migmatite and Granite	Migmatite and Granite
Tributaries			One
Human use	Subsistence farming, animal grazing, few settlements		Irrigation, animal watering, fishing, domestic
Vegetation	Tress, shrubs, grassland	Discontinuous Vetiver grass belt	Few aquatic macrophytes

Figure 6.1: Details of the Kajelo reservoir and surroundings

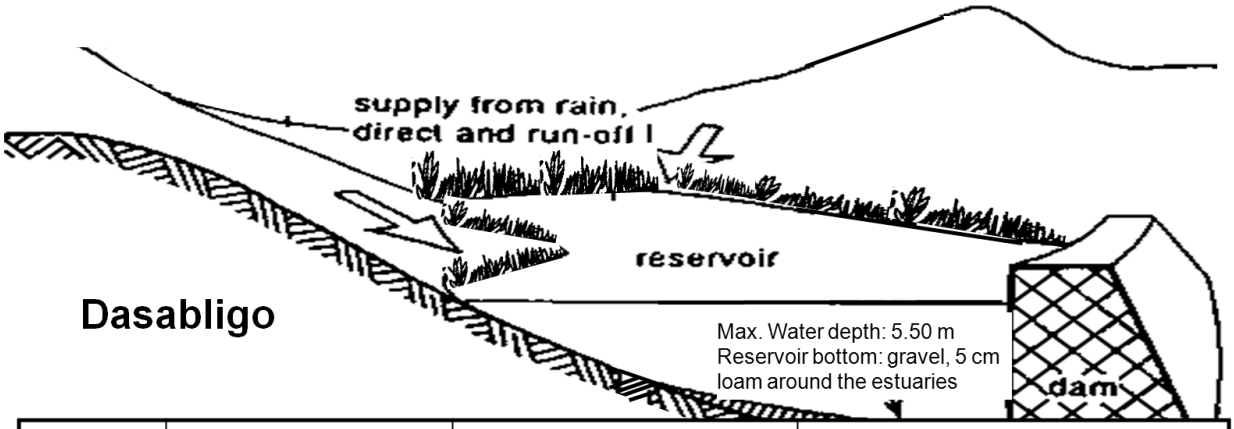
The catchment area (148.92 km^2) is comparatively small and the reservoir has only one tributary. The reservoir was built in the mid 1950s. The dam wall broke in 2003 and was rehabilitated together with the irrigation infrastructure under LACOSREP II in 2004. The activities of the Challenge Program on Water and Food Project No. 6:

Strategic Innovations in Dryland Farming (CP6), sub-project: Dugout Maintenance and Enhanced Fish Production (see section 5.3.3), included so-called *hapa* trials. *Hapas* are bags made from fine-meshed nets suspended inside ponds or enclosures. In Kajelo, the *hapa was* used to provide an *Oreochromis niloticus* brood stock to reproduce. Fish offspring was released after reaching a considerable size. The trial was successful after the third attempt in 2006. After 2006 the trial was not repeated.

The reservoir is used exclusively by the members of Kajelo, with the exception of a few fishermen who come once in a while from neighboring communities. Until 2007, the reservoir was mainly used for watering animals and fishing. Domestic uses include washing dishes and clothing, and bathing. The few patches where sand and loam can be found are used for brick making, and some people come to fetch water with donkey carts to deliver it to house construction sites. From 2008 onwards irrigation activities expanded, and large scale water withdrawal caused considerable tension between the different water users. Although some Vetiver grass protects siltation, especially at the mouth of the tributary, no further protective measures have been taken to prevent siltation or damage.

6.1.2 Dasabligo

The geographic coordinates of the Dasabligo reservoir at 246 m asl are 10°52'20.38" north and 0°18'36.95" west. With a maximum surface area of 19.8 km^2, Dasabligo is the largest reservoir although the catchment area is with 320.22 km^2 slightly smaller than that of Binduri. The reservoir has two tributaries. The reservoir was built in the mid 1950s and people were instructed to plant a belt of Vetiver grass to prevent siltation, resulting in a thick belt of grass around the reservoir probably contributing to the clarity of the water. The reservoir is with a maximum depth of 5.5 m along the dam wall the deepest and has water supplies throughout the dry season; the water is hardly used for irrigation. Although the irrigation infrastructure was only rehabilitated in 2006, also under LACOSREP II, it is not used, as the two communities that share the reservoir could not overcome differences in land allocation and thus the reservoir is mainly used for watering animals, fishing and domestic use.

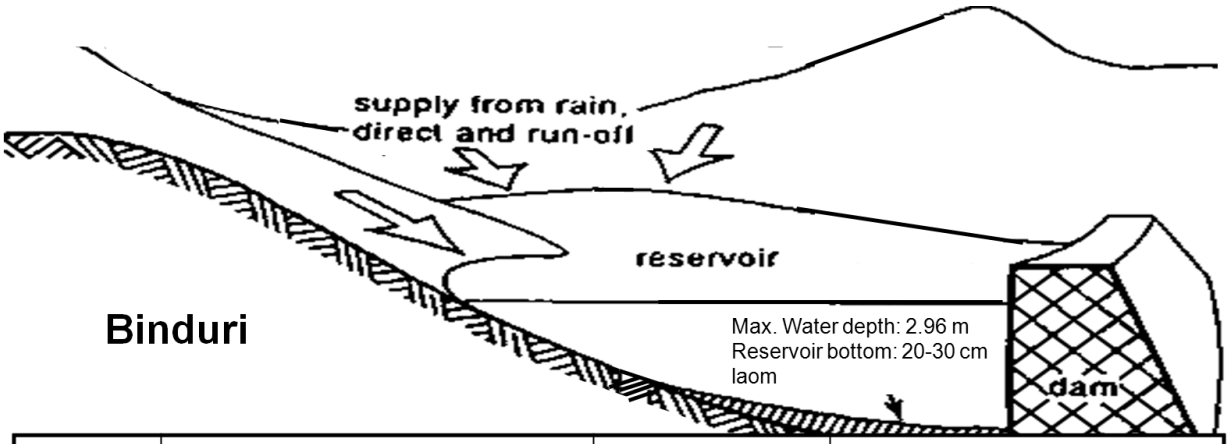


	Catchment area	Reservoir surrounding area	Reservoir
Age			Dam construction: mid 1950s Dam failure: mid 1970s Rehabilitation: late 1970s
Size	320.22 km²		Surface when full: 19.8 km² Surface dry season 2007: 13.4 km²
Altitude			246 m
Soil type and grain size	Ferric Lixisols	Mostly gravel, some sand and loam	Mostly gravel, some sand and loam around the estuaries
Geology	Hornblende Biotite Granodiorite	Hornblende Biotite Granodiorite	Hornblende Biotite Granodiorite
Tributaries			Two
Human use	Subsistence farming, animal grazing, few settlements		Animal watering, fishing, domestic, hardly irrigation
Vegetation	Tress, shrubs, grassland	Thick belt of Vetiver grass	Few aquatic macrophytes

Figure 6.2: Details of the Dasabligo reservoir and surroundings

6.1.3 Binduri

The geographic coordinates of the Binduri reservoir are 10°57'57.52" north and 0°18'36.95" west at 211 m asl. Binduri has a maximum surface area of 15.8 km^2. The reservoir has the largest catchment (385.64 km^2) and is drained by two tributaries, which in combination with the sparse vegetation contribute significantly to the thick silt layer in the reservoir. Due to massive siltation, the reservoir is relatively shallow (2.96 m). In comparison with the other reservoirs, Binduri is mainly used for irrigation, but also for animal watering. It was the first of the three reservoirs to be rehabilitated in 1996 under LACOSREP I.



	Catchment area	Reservoir surrounding area	Reservoir
Age			Built: mid 1950s Dam failure: early 1990s Rehabilitation: 1996
Size	385.64 km²		Surface when full: 15.8 km² Surface dry season 2007: 9.1 km²
Altitude			211 m
Soil type and grain size	Hablic Lixisols	Mostly loam and sand, some gravel	Mostly loam and sand, some gravel
Geology	Dixcove Granite	Dixcove Granite	Dixcove Granite
Tributaries			Two
Human use	Subsistence farming, irrigation along the tributaries, animal grazing, settlements		Intensive irrigation and animal watering, fishing, domestic
Vegetation	Mostly grassland and bare soil from farming	No grass belt	Few aquatic macrophytes

Figure 6.3: Details of the Binduri reservoir and surroundings

6.2 Fish yields

In the following the data collected by a survey, assessing the fishing pressure on the reservoirs as numbers of fishermen, their fishing days and gear used, are presented, followed by the fishermen's recalled catches. These recall data are cross-checked with data from the area catch study.

6.2.1 Fishing pressure

Data for the Kajelo reservoir about the fishing pressure and catch estimates, which are described in the next section, were gathered during 19 interviews with fishermen randomly sampled from a total of 73 fishermen (Table 6.1) fishing in the Kajelo reservoir. The main type of fishing gear used in the Kajelo reservoir was the castnet and every fisherman fishing there had one. Roughly 30% of the fishermen had additional gillnets and 45% had lines and hooks, which they used in addition to the castnets.

Table 6.1: Surface area, number of fishermen and number of fishing days in the Kajelo reservoir

	Reservoir	**Fishermen**			**Fishing days**	
	[ha]	[men]	[men /ha]	[days/week/ men]	[days/total]	[days/total/ha]
Dry season (6 month)	5.44	73	13.4	3	5694	1047
Rainy season (6 month)	6.75	58	8.6	3	4524	670
Total (12 moth)					10218	1717

In the Kajelo reservoir there was no difference in the number of fishing days per fishermen between seasons. Fishermen went fishing three days a week. However, there were fewer fishermen in the rainy season (8.6/ha) than in the dry season (13.4/ha). Fishermen explained that many of them stop fishing in the rainy season as they were involved in farming activities. Furthermore, the catches were lower in the rainy season because of the increasing surface area, increasing water depth and decreasing temperature, which drops due to the relatively cold rainfall and air temperature of the water, making fishing in reservoirs difficult. However, with an annual average of 11 fishermen/ha, Kajelo had the highest number of fishermen of the three reservoirs.

In the Dasabligo reservoir 27 of a total of 71 fishermen were interviewed. As in Kajelo, all fishermen had a castnet. In addition, 60% of the fishermen had gillnets and 14% had lines and hooks. The number of fishing days per week was 2.5 in the dry season and 2 in the rainy season (Table 6.2). Interesting about these figures is that in the dry season the number of fishermen was much lower than in the rainy season.

Only 30 fishermen went fishing in the dry season compared to the 71 fishermen in the rainy season. Fishermen explained this with the migration to the Red Volta in the dry season. Many of them usually leave their community for some months to camp along the river in order to be closer to the fishing grounds there and to their tomato farms. Others migrate to nearby towns such as Bolgatanga or Bawku to earn the cash they need to invest in their farms in the rainy season.

Table 6.2: Surface area, number of fishermen and number of fishing days in the Dasabligo reservoir

	Reservoir	**Fishermen**			**Fishing days**	
	[ha]	[men]	[men/ ha]	[days/week/ men]	[days/total]	[days/total/ ha]
Dry season (6 month)	13.4	30	2.24	2.5	1950	146
Rainy season (6 month)	19.8	71	3.59	2.5	4615	233
Total (12 moth)					6565	379

It is only those who stay behind who go fishing in the Dasabligo reservoir in the dry season. In the rainy season, the men come back to their communities for the rain-fed farming and fishing in the reservoir. Yet in comparison with the other two reservoirs, the number of fishermen per ha was low: From 2.2 fishermen/ha in the dry season, the figure increased to 3.6 fishermen/ha in the rainy season (Table 6.2). With an annual average of only 2.9 fishermen/ha, this was the lowest figure of the three reservoirs.

Table 6.3: Surface area, number of fishermen and number of fishing days in the Binduri reservoir

	Reservoir	**Fishermen**			**Fishing days**	
	[ha]	[men]	[men/ ha]	[days/week/ men]	[days/total]	[days/total/ ha]
Dry season (6 month)	9.1	52	5.71	3	4056	446
Rainy season (6 month)	15.8	37	2.39	3	2886	182
Total (12 moth)					6942	628

In Binduri, 17 of the 52 fishermen who went fishing in the Binduri reservoir were interviewed (Table 6.3). Almost every fisherman had a castnet, whereas only half of the fishermen also used a gillnet. Of the 17 fishermen interviewed, none owned lines and hooks. As in the Kajelo reservoir, the fishermen in Binduri went fishing 3 days a week in the dry season. This figure dropped slightly to 2.5 in the rainy season. The number of fishermen dropped from 6.7 fishermen/ha to 2.4 fishermen/ha, also due to the fact that

the surface of the waterbody almost doubled and the men worked intensively on their rain-fed farms.

6.2.2 Catch estimates

The catch estimates derived from the recalls of fishermen about their catches seem rather high. As the reason for the enormous deviation is unknown, for the comparison with the data from the area catch study only the Cichlidaes are taken into consideration. For the Cichlidaes the 19 fishermen surveyed in Kajelo state that they catch about 346 kg/ha/year (Table 6.4).

The catch estimates of the 27 fishermen interviewed for the Dasabligo reservoir (Table 6.5) are lower for two reasons. First, since the number of fishermen per hectare is considerably lower in Dasabligo reservoir, the total yields are of course lower. Yet the figures of the total yield per fisherman are also the lowest in Dasabligo, which indicates that the catches are not as good as in the other reservoirs. This is in line with statements from fishermen from Dasabligo, who observed that their catches in the reservoirs are lower than those from other reservoirs or the Red Volta. Whilst the number of fishermen in Binduri reservoir is also rather low (Table 6.6), the estimated yields are much higher than in the two other reservoirs. Again, it is especially the estimates for the *Clarias gariepinus* that are way out of the ordinary. But even when only considering the Cichlidae yields, Binduri seems to be by far the most productive of the three reservoirs.

Table 6.4: Catch estimates of main species (Cichlidae and *Clarias gariepinus)* and total catch per fisherman in the Kajelo reservoir

	Cichlidae yield		***Clarias g.* yield**		**Total yield**	**Total yield per fisherman**	**Fishing pressure**
	[kg]	[kg/ha]	[kg]	[kg/ha]	[kg/ha]	[kg]	[men/ha]
Dry season (6 month)	1384	**254**	8359	1537	1791	134	13.4
Rainy season (6 month)	622	92	6513	965	1057	123	8.6
Total (12 moth)	2006	346	14872	2501	2847	257	

Table 6.5: Catch estimates of main species (Cichlidae and Clarias gariepinus) and total catch per fisherman in the Dasabligo reservoir

	Cichlidae yield		***Clarias g.* yield**		**Total yield**	**Total yield per fisherman**	**Fishing pressure**
	[kg]	[kg/ha]	[kg]	[kg/ha]	[kg/ha]	[kg]	[men/ha]
Dry season (6 month)	787	**59**	3017	225	285	127	2.24
Rainy season (6 month)	1770	89	8059	407	496	36	3.59
Total (12 moth)	2557	148	11075	632	780	163	

Table 6.6: Catch estimates of main species Cichlidae and *Clarias gariepinus* and total catch figures per fisherman in the Binduri reservoir

	Cichlidae yield		***Clarias g.* yield**		**Total yield**	**Total yield per fisherman**	**Fishing pressure**
	[kg]	[kg/ha]	[kg]	[kg/ha]	[kg/ha]	[kg]	[men/ha]
Dry season (6 month)	4888	**537**	30212	3320	3857	675	5.71
Rainy season (6 month)	1856	120	25433	1643	1763	738	2.39
Total (12 moth)	6744	657	55645	4963	5620	1413	

The following section describes results from the area catch study and afterwards the results from the area catch study and the estimates from the fishermen are compared.

6.2.3 Area catch studies

The fishes identified in the Kajelo reservoir belong to three families, four genera and four species (Table 6.7). *Oreochromis niloticus* clearly dominated with respect to the total weight and, together with *Tilapia zillii,* the Cichlidae family made up 96.87% of the total catch. The proportion of *Clarias gariepinus* and *Barbus macrops*, Boulenger, 1911, in terms of total numbers and weight were very small.

Table 6.7: Fish species composition, abundance, size range and mean, weight range and mean and total weight of fish from 3 hauls (2 in February 2007 and 1 in May 2007) in the Kajelo reservoir

Family *Species*	**Total No.**	**Length**		**Weight**			
		Range	Mean	Range	Mean	Total	Share of species
		[cm]		[g]			[%]
Cichlidae							
Oreochromis niloticus	9166	3.2-14	8.3	1-30	8.6	7815	79.88
Tilapia zillii	4449	3.5-16	7.1	1-25	3.7	16625	16.99
Clariidae							
Clarias gariepinus	68	11.5-44	19.7	10-600	43.8	2983	3.05
Cyprinidae							
Barbus macrops		9-10.50	9.9	8.3-12.5	10.7	75	0.08

Table 6.8: Fish species composition, abundance, size range and mean, weight range and mean and total weight of fish from 4 hauls (2 in February 2007 and 2 in May 2007) in the Dasabligo reservoir

Family *Species*	**Total No.**	**Length**		**Weight**			
		Range	Mean	Range	Mean	Total	Share of species
		[cm]				[g]	[%]
Cichlidae							
Oreochromis niloticus	75	4.7-12.8	7.1	5.6-33.3	7.6	577	4.56
Tilapia zillii	526	3.7-12.5	8.3	2.2-25	9.9	5153	40.71
Hemichromis bimaculatus	16	4.4-8.5	6.8	6.3-12.5	7.8	125	0.99
Sarotherodon galilaeus	575	3.2-15.3	6.2	2.5-75	9.6	5496	43.41
Hemichromis fasciatus	25	7.5-17.5	11.3	13.3-70	28.5	719	5.68
Clariidae							
Clarias gariepinus	10	14-27	17.9	26-145	53	530	4.19
Cyprinidae							
Barbus macrops		9.1-10.1	9.5	5-12.5	5.3	47.5	0.38
Claroteidae							
Auchenoglanis occidentalis (Valenciennes, 1840)		20.5	20.5	12	12	12	0.09

In the Dasabligo reservoir four families, eight genera and eight species were found (Table 6.8). The Cichlidae family dominated with more than 95% of the fish stock. Unlike Binduri, and Kajelo especially, the *Oreochromis niloticus* was very small (less than 5%).

The fishes identified in the Binduri reservoir belong to three families, six genera and six species (Table 6.9). Again the Cichlidae family, with almost 86 %, dominates the stock structures.

Table 6.9: Fish species composition, abundance, size range and mean, weight range and mean and total weight of fish from 4 hauls (2 in February 2007 and 2 in May 2007) in the Binduri reservoir

Family ***Species***	**Total No.**	**Length**		**Weight**			
		Range	Mean	Range	Mean	Total	Share of species
		[cm]			[g]		[%]
Cichlidae							
Oreochromis niloticus	1490	2-17.4	7.5	2-62.5	8.1	11971	19.39
Tilapia zillii	3622	16.3-2.7	6.7	1-32.5	4.4	15857	25.68
Hemichromis bimaculatus	590	3.7-9.3	6.63	2.5-12.5	6.2	3639	5.89
Sarotherodon galilaeus	2724	2.3-11.9	6.87	2.5-25	7.9	21468	34.77
Clariidae							
Clarias gariepinus	49	11.5-43.5	25	11.5-43.8	173.5	8501	13.77
Cyprinidae							
Barbus macrops	39	6.5-11	9.5	10-11.7	8	310	0.50

For all reservoirs the surface area covered with the drag net, the sample area was 0.06 ha. For Kajelo this means the area sampled was little more than 1% of the total reservoir surface (Table 6.10). The average yield of the two drags per reservoir was 43 kg in February and 13 kg in May. Extrapolated to the whole reservoir, this adds up to 731 kg/ha in February and 252 kg/ha in May. The time between the two area catch studies was roughly four months. These were the four months that were considered to be the main fishing season. The difference in the yield of Cichlidae between February and May amounted to 470 kg/ha. No area catch studies were undertaken in the rainy season, but

the information from the fishermen indicates that fishing pressure was reduced in the rainy season.

Table 6.10: Yields from area catch studies in February and May 2007, Kajelo reservoir. As there was only one sample in May, catch relations from February were assumed in order to compute an average

Study month	**Surface area**	**Surface area sampled**		**Avg. yield of area sampled**	**Est. total stock**		**Share Cichlidae**
	[ha]	[ha]	[%]	[kg]	[kg]	[kg/ha]	[kg/ha]
February	5.77	0.06	1.07	43	4254	737	714
May	5.10	0.06	1.22	13	1284	252	244
Difference							**470**

Table 6.11: Yields from area catch studies in February and May 2007, Dasabligo reservoir

Study month	**Surface area**	**Surface area sampled**		**Avg. yield of area sampled**	**Est. total stock**		**Share Cichlidae**
	[ha]	[ha]	[%]	[kg]	[kg]	[kg/ha]	[kg/ha]
February	13.79	0.06	0.44	5	448	32	31
May	12.95	0.06	0.46	2	178	14	13
Difference							**18**

Table 6.12: Yields from area catch studies in February and May 2007, Binduri reservoir

Study month	**Surface area**	**Surface area sampled**		**Avg. yield of area sampled**	**Est. total stock**		**Share Cichlidae**
	[ha]	[ha]	[%]	[kg]	[kg]	[kg/ha]	[kg/ha]
February	12.31	0.06	0.49	25	2521	205	176
May	5.97	0.06	1.01	5	532	89	76
Difference							**100**

Since the Dasabligo reservoir's surface area is considerably larger, namely 13.79 in February and 12.95 in May, the reservoir area covered for the area catch study was much smaller in Dasabligo, 0.44% and 0.46% respectively. The average yield of the two drags per reservoir was 5 kg in February and 2 kg in May. Extrapolated to the whole reservoir, this adds up to 32 kg/ha in February and 14 kg/ha in May. The difference in the yield of Cichlidae between February and May amounted to 18 kg/ha. The figures from the area catch study (Table 6.11) show that the Dasabligo reservoir has by far the lowest fish yield of the three reservoirs.

In February, the drag net covered about 0.5% and in May 1% of the total surface area of the Binduri reservoir. As in the two other reservoirs the yields dropped

considerably from February to May indicating heavy fishing activities, but most likely also reflected some loss due to fish mortality as the surface of the reservoir decreased from 12.31 to 5.97 due to massive irrigation.

6.2.4 Discussion

As can be seen from table 6.13, the data from the fishermen's catch estimates and those from the area catch studies vary considerably from each other. While in Kajelo the estimates are much lower than the results from the area catch studies, Binduri fishermen are much more optimistic than the area catch studies. Figures for Dasabligo also vary, but the difference is not as large.

The high variations make it impossible to draw conclusions for the yield potentials of the single reservoirs and much less for the fish yields of small reservoirs in general. Therefore the results are compared with the findings of other authors.

Baijot et al. (1997) found catches in small reservoirs in Burkina Faso to be on average 70 kg/ha/year. In a project with stocking experiments, de Graaf (2003) found a maximum yield of 269 kg/ha/year, however only after stocking the reservoir with fingerlings. Ouattara and Ouedraogo (2002) found an average yield of 159 kg/ha/year for 8 reservoirs in Burkina Faso and came to the conclusion that the smaller the reservoir, the higher the yield per ha. Laë et al. (1999) found an annual yield of 230 kg/ha for very shallow lakes, and Kolding and van Zwieten (2006) report yields of up to 329 kg/ha/year for small reservoirs in Africa.

It is impossible to extrapolate the results from the area catch study to a full year, as the data were collected at the time with the highest harvest and is not representative for the whole year. In order to compare the data anyway, yields were all broken down to 4 month periods. Data from other authors are not separated according to dry and rainy season and this causes a bias, as the low yielding rainy season is also included in their average while this study has only data from the dry season.

Table 6.13: Fish yields for the three study reservoirs in comparison with fish yields found by other authors

Reservoir	Cichlidae Catch est. by fisher men	Area catch study Cichlidae yield	Baijot et al. (1997)	Ouattara and Ouedraogo (2002)	Laë et al. (1999)	de Graaf (2003)	Kolding and van Zwieten (2006)
	kg/ha/4 month, dry season (kg/ha/6 month, dry season)		kg/ha/4 month (kg/ha/year)				
Kajelo	163 (254)	470	42 (162)	53 (159)	77 (230)	90 (269)	109 (329)
Dasabligo	39 (59)	18					
Binduri	358 (537)	100					

The comparison with other authors' data shows that Dasabligo has very low yields, especially when taking into consideration the above mentioned bias. Although the fishermen's estimates are way above average in Binduri, the yields of the area catch studies show normal values when taking the bias into consideration. Only Kajelo lies way ahead of all other values. Both the estimates and the yields of the area catch study are above the other figures. The average yield according to the data provided by the five publications mentioned above is 230 kg/ha/year. When taking into consideration the bias, Binduri and Kajelo are in range of this value or even above. Only for Dasabligo are the yields considerably lower and may not be above the 70 kg/ha/year that Baijot found for their study reservoirs in Burkina Faso. A number of reasons for the higher or lower than normal yields are discussed in the following.

6.3 Factors influencing fish yields

A ranking of the factors that influence fish production and yields provided by six interviews and group discussions with a Ghanaian fisheries scientist, staff of the Ministry of Fisheries, and fishermen is used as a guideline for the discussion. In the following, the explanations for each factor given by the interview partners are compared with results from the measurements and findings from scientific literature. In all six interviews rainfall patterns were pointed out to be a very influential factor and on average was tanked highest (Table 6.14).

Table 6.14: Factors influencing fish yields in reservoirs

Influence factors	Mention	Average Ranking	St. deviation.
Rainfall patterns	6	0.79	0.20
Natural fish food availability	6	0.69	0.37
Passive management	6	0.68	0.21
Water depth/ volume	6	0.63	0.28
Active management	6	0.52	0.24
Species composition	3	0.33	0.30
Predators	3	0.10	0.11
Other water uses	2	0.07	0.13
Water temperature	2	0.06	0.10
Connection to streams	2	0.03	0.05
Fish disease	1	0.03	0.07
Infrastructure	1	0.02	0.04

All interview partners mentioned the availability of natural fish food as being important, less important however than rainfall and that not all interview partners agreed that this factor has a very high importance is reflected in the standard deviation. Water depth and volume are also considered to be important environmental factors by all discussion groups. In three out of six group interviews, the species composition was mentioned as being of moderate importance. Other natural factors mentioned but not listed with a high influence are predators, water temperature and quality, connection to a stream in the rainy season, fish disease, and functioning infrastructure.

In addition to natural factors, human interventions are considered to be very important processes. Especially the regulation of mesh sizes and also stocking were considered to have a high impact on yields. Water depth is also partly influenced by humans and was taken into consideration together with other harmful water uses such as washing cars in the reservoir.

6.3.1 Natural impacts

Rainfall patterns and related water depth

Based on their long-term observations, fishermen and the other interview partners pointed out that a year with low rainfall is usually followed by a year with low fish production, whereas a year with high rainfall is followed by high fish production in the subsequent year. These observations can be explained by a number of reasons. One is that the higher the rainfall, the larger the floodplains, hence the greater area of feeding

and breeding habitats. In addition, more feed is washed into the reservoir. This statement is confirmed by Welcomme (2001), who noted that fluctuations in abundance of fish are a response to varying rainfall and flood strength. Based on their research, Baijot et al. (1997) also concluded that years in which rains are early and ample, production increases significantly. Early floods reduce the period in which fish populations are concentrated in turbid and partly deoxygenated waters of the dry season. Concomitant lengthening of the duration of the breeding and growing season occurs.

According to the fishermen, low amounts of rainfall in 2006 were followed by a bad fishing year in 2007. The floods in 2007 caused large and long-standing areas of floodplains, and fishermen recorded much higher catches in 2008. This explains to a certain extent why catch estimates from the fishermen given in 2008 are higher in Binduri and Dasabligo than the estimates from the area catch study conducted in 2007. However, the high catches from the area catch study in Kajelo remain unusual.

While there is agreement regarding the positive influence of high rainfall concerning the floodplains, the impact of high water levels on yields was discussed controversially between interview partners and in the literature.

As explained above, shallow waterbodies are associated with higher production (e.g., Laë et al. 1999; Moss 2003). While the production in the floodplains would be higher, the production in the reservoirs would have to be lower as reservoirs are deeper after a year with high rainfall.

Statements from the fishermen in Dasabligo, however, confirm the greater importance of long periods of rain and extended floodplains in comparison with water depth. The water level in 2008 was higher than that of 2007, but nevertheless the fishermen stated that the catches were much better in 2008 than in 2007.

The situation for Binduri and Kajelo was influenced by the water abstraction for irrigation and is discussed below.

Natural food availability

While varying rainfall patterns can explain inter-annual variation, they cannot explain the variation between the reservoirs, as all of them are to a large extent subject to the same climatic events and conditions. Fishermen who fish in different reservoirs and other waterbodies explained differences in production levels with varying food

availability for fish. This was confirmed by the extension staff and scientists, who also ranked this factor as being very important.

As no data about phytoplankton content, chlorophyll or phosphorus content were collected, the classification of natural food availability is difficult The natural food availability can also be assessed indirectly using conductivity, transparency, total dissolved solids, pH-value, carbonate content, and the size of the catchment area.

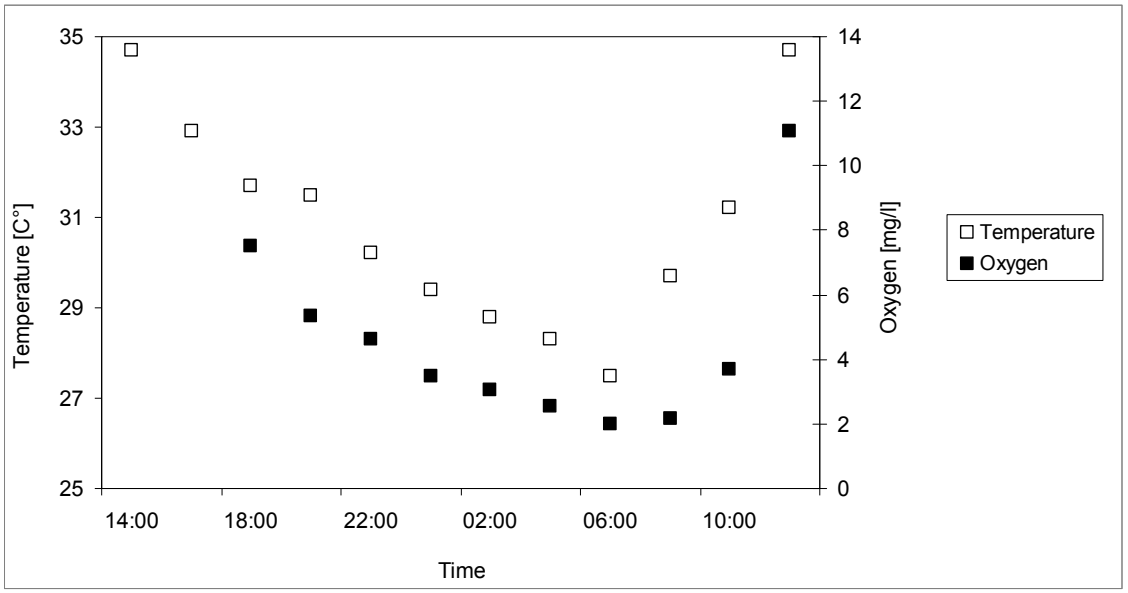


Figure 6.4: Diurnal oxygen cycle Kajelo reservoir, 11. – 12. 04. 2008

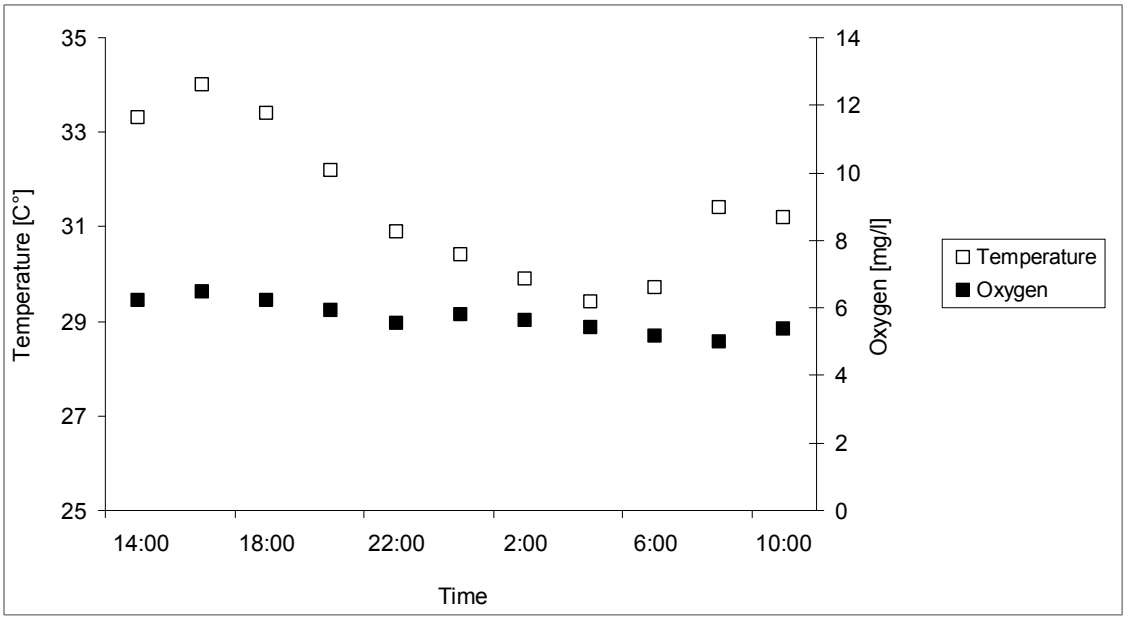


Figure 6.5: Diurnal oxygen cycle Dasabligo reservoir, 16. – 17. 04. 2008

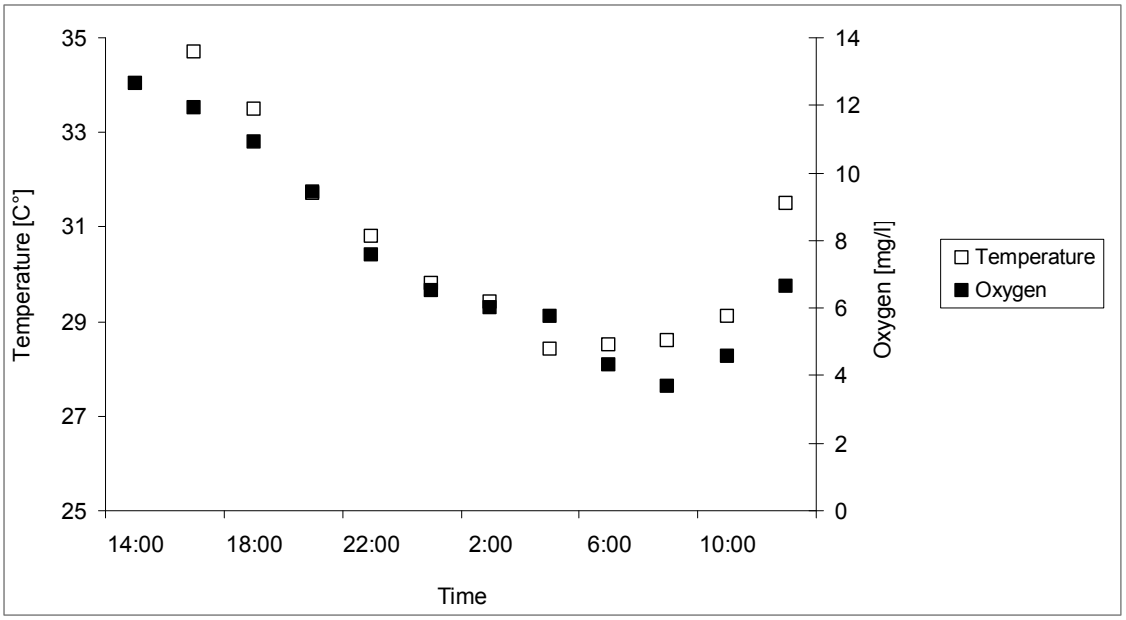


Figure 6.6: Diurnal oxygen cycle Binduri reservoir, 14. – 15. 04. 2008

Especially oxygen measurements can, according to Wetzel (2001), help to assess the nutrient contents. Plants produce oxygen by day and consume by night. If the oxygen curve shows a high amplitude, it can be assumed that the water body has a high productivity. Following Wetzel (2001), based on the oscillation of the oxygen curve during the diurnal cycle, Kajelo and Binduri belong to the eutroph category; Dasabligo is oligotroph.

The low transparency values of Kajelo and Binduri (Figure 6.7) also indicate that there is high production in the reservoirs. However, there is also a thick mud layer in the reservoirs and due to their being so shallow, it can be assumed that the mud also contributes to the turbid water. Satellite images show heavy land-use in the Binduri reservoir catchment area, which is with 385.64 ha also the largest of the three reservoirs. Soil erosion over a large area contribute to the thick mud layer and thus to the turbid, but probably also nutrient rich condition of the reservoirs.

In the Dasabligo reservoir, transparency is higher and like the low oscillation of the oxygen curve, this suggests low primary productivity. The high transparency can also be attributed to the thin sediment layer in the reservoir. The thin mud layer is a result of an almost closed, thick belt of Vetiver grass (Family: *Poaceae*, probably *Chrysopogon nigritana or zizanioides)* around the reservoir. The communities were

asked to plant the grass to prevent soil erosion. Because of its dense and deep-reaching root system, it keeps soil in place and it is also known to purify water (Juliard 2006).

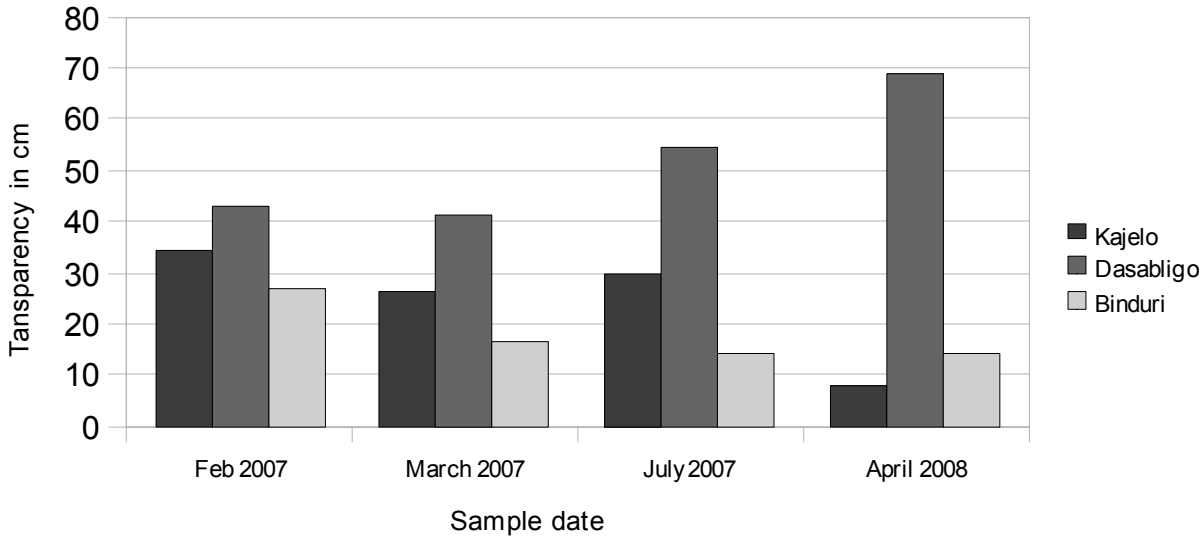


Figure 6.7: Transparency derived from Secchi depth.

Fluctuations in pH-values in Binduri and Kajelo (Figure 6.8 and 6.10) again suggest algal production, whereas in Dasabligo the even curve indicates low production (Figure 6.9). However, the oscillation of pH-values in Binduri is not as pronounced as in Kajelo.

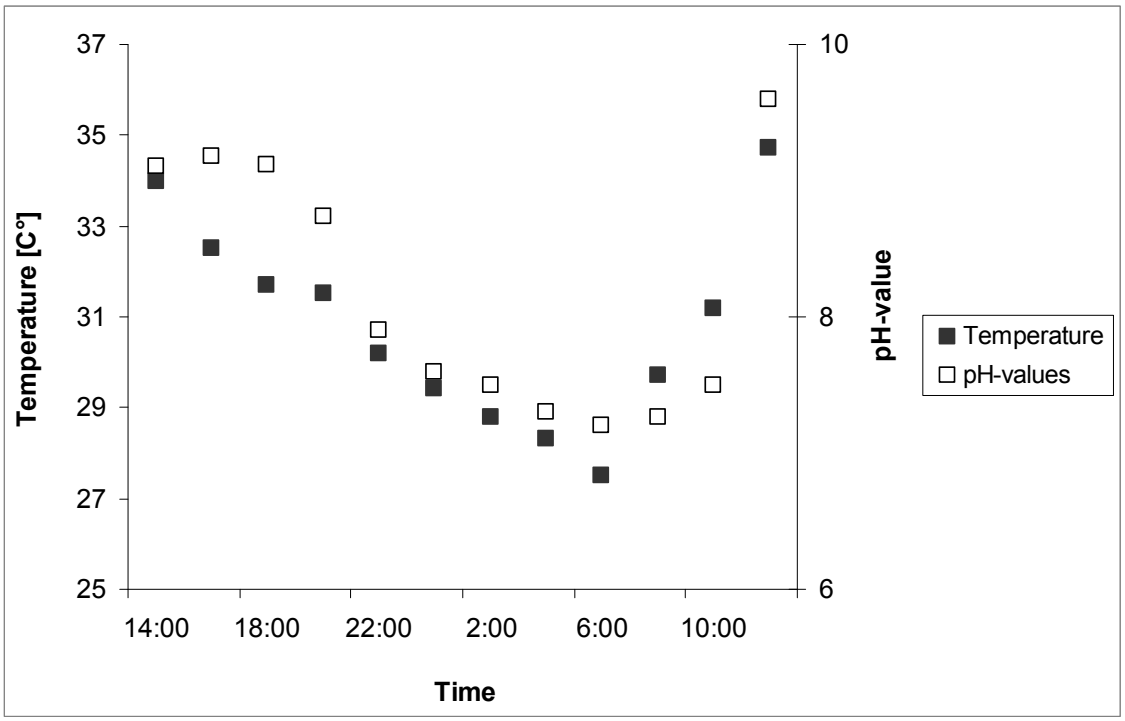


Figure 6.8: Diurnal cycles of pH and temperature, Kajelo reservoir

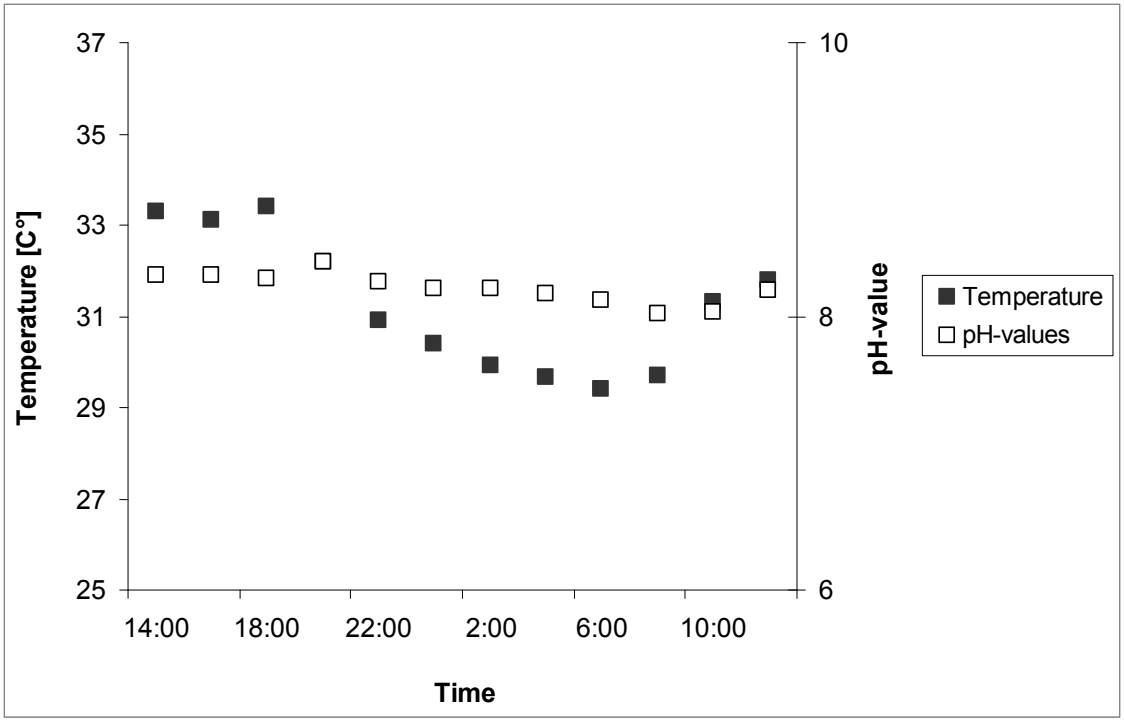


Figure 6.9: Diurnal cycles of pH and temperature, Dasabligo reservoir

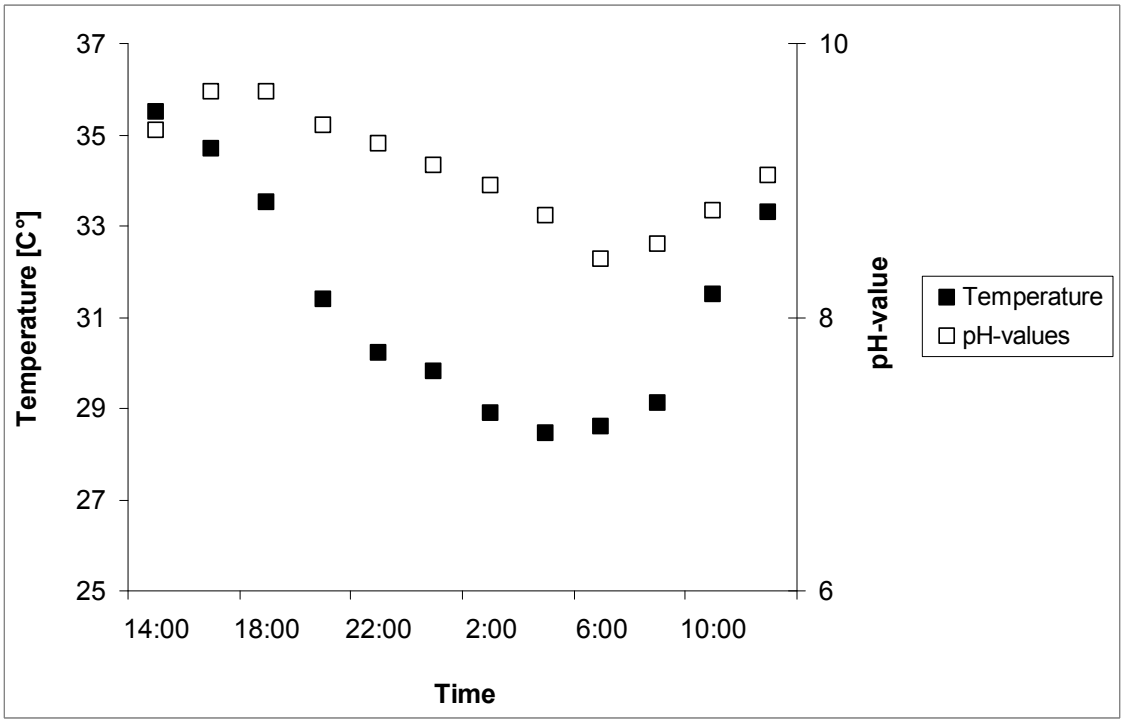


Figure 6.10: Diurnal cycles of pH and temperature, Binduri reservoir

This is probably due to the fact that the carbonate content (Table 6.15) is higher and thus oscillation is better buffered. In addition, the relatively high carbonate content allows algae to convert nutrients into fish food. However, while the carbonate content in

Binduri is the highest amongst the three reservoirs, in comparison with recommendations for aquaculture (see section 2.2) it is rather low and probably limits primary production.

Compared with the findings for Kajelo so far, it is rather strange that the values for conductivity and TDS (Table 6.15) are rather low in this reservoir especially since the high fish yields suggest a good nutritional status for the fish stock. However, these are only indirect measurements of the nutrient contents and can be subject to the influence of a number of other factors.

Table 6.15: Conductivity, total dissolved solids and carbonate

Reservoir	**Conductivity** [µS/cm]			**TDS** [mg/l]			**Carbonate** [mg/l]
	Feb 07	May 07	Apr 08	Feb 07	May 07	Apr 08	Apr 08
Kajelo	61	66	44	34	43 (± 1.5)	22 (± 1)	30
Dasabligo	72	65	85	36	41 (± 0.5)	42	54
Binduri	128	116	146	64	76	71 (± 5)	72

The results of the measurements taken from the Dasabligo reservoir fit much better. In line with the straight course of the oxygen curve, which suggests low algae production, the transparency is the highest of all three reservoirs, also indicating low algae production. Taken together, it can be assumed that there is a relation between low nutritional contents and low fish production in Dasabligo reservoir.

As pointed out above, in comparison with carbon content recommendations for aquaculture of the contents of all three reservoirs, they are far below the minimum, especially in Kajelo.

Looking at the aquatic macrophytes, all reservoirs are rather sparsely populated. Apart from the Vetiver grass, which is of course not an aquatic macrophyte, Kajelo reservoir also has such a grassy zone, some unidentified grasses, and some waterlilies (Family: *Nymphaeaceae,* Genus: *Nymphaea*) can be found. In Dasabligo the lilies are at the very tail end of the reservoir. In addition, in the Kajelo reservoir at the littoral shallows at the river mouth, one of the diverse species of the water primroses (Family: *Onagraceae*, Genus: *Ludwigia*) can be found. Apart from waterlilies and Vetiver grass, the Binduri reservoir hosts water paspalum (Family: *Poaceae*, Genus: *Paspalum*), again at its shallow tail end. In general, it can be said that the reservoirs have a low amount of aquatic macrophytes, barring the few plants mentioned above.

Reasons for this could be the severe ecological conditions when water levels are low, and the low carbonate contents. And again in Dasabligo it is the thin mud layer that hampers the growth of such vegetation.

Species composition

Species composition was only mentioned in three of the six interviews as being influential. In comparison to findings of Quarcoopome et al. (2008) (Table 6.16), richness and diversity are low in all three reservoirs and especially low in Kajelo.

Table 6.16: Estimated diversity indices of fish species in the Kajelo, Dasabligo and Binduri reservoirs and from two reservoirs in northern Ghana drawn from Quarcoopome et al. (2008)

Reservoir	Own data	Own data	Own data	Quarcoopome et al. (2008)	Quarcoopome et al. (2008)
	Kajelo	Dasabligo	Binduri	Bontanga	Libga
Richness (D)	0.42	1.12	0.66	1.11	2.4
Diversity (H)	0.66	1.11	1.27	1.55	2.36

Table 6.17: Ratio of forage fishes to carnivore fishes (F/C ratio) in the Kajelo, Dasabligo and Binduri reservoirs, February and May 2007

Feeding type	Kajelo	Dasabligo Weight [g]	Binduri
Detrivores and herbivores			
Tilapia zillii	16625	5154	16832
Oreochromis niloticus	78150	577	11971
Sarotherodon galilaeus	0	5496	21386
Semi pelagic omnivores			
Barbus macrops	75	48	210
Benthic omnivores			
Auchenoglanis occidentalis	0	12	0
Total weight of foragers	94850	11286	50399
Carnivores			
Clarias gariepinus	3013	530	8329
Hemichromis bimaculatus	0	125	3559
Hemichromis fasciatus	0	719	0
Total weight of carnivores	3013	1374	11888
F/C ratio	**31.48**	**8.21**	**4.24**

This can be attributed to water level fluctuations and difficult environmental conditions at low water levels, which tend to eliminate any species with a low level of robustness

and, especially, low tolerance for low oxygen contents (Baijot et al. 1997). Further, Kajelo was only rehabilitated in 2004, and it takes some time until a more rich and diverse stock can establish.

Of special importance seemed to be the relation of forage fish and carnivores. Some fishermen, but especially the other interview partners, pointed to the fact that too many carnivorous species have a negative effect on the fish stock.

According to Blay (1984) and Ofori-Danson and Antwi (1994), a balanced fish population has an F/C ratio between 1.4 and 10.00. In Kajelo, the reservoir has a high actual fish production, and an F/C ratio (Table 6.17) three times higher than recommended. The Kajelo reservoir has not only the most unbalanced F/C ratio, but also the lowest diversity (Table 6.16). Yet fish yields are the highest. Reasons are discussed below.

Connection to streams

Although the connection of the reservoirs to other water bodies and especially to floodplains in the rainy season were only mentioned by two groups of interview partners, this factor probably plays a very important role for natural restocking of the reservoirs in the rainy season. The recruitment of new stock from other water bodies, from the Red or White Volta, and especially from the new stock breed in the floodplains during the rainy season is most likely the reason why fishermen still have continuous fish yields during the dry season.

Other factors

Predators such as crocodiles and birds were mentioned three times during the interviews. Apart from attacking the fishermen directly, crocodiles destroy the gillnets set in the water and remove the fish caught in the net.

Water temperature and quality were also mentioned by two interview groups. Baijot et al. (1997), set the critical temperature values at 20 °C and below in cases when the temperature remains that low for at least 15 or more days. According to Baijot et al. (1997) water temperatures are usually lowest during November, December and January. However, as the temperature measurements were only started in February and values

were well above 20°C, no conclusion can be drawn about the impact of low temperatures.

Fish diseases were mentioned by the extension staff but were not considered to be very influential and were not mentioned as a problem in the communities. Fishermen in Binduri mentioned an intact dam wall as being crucial for fishing activities.

6.3.2 Human factors

Passive management

Passive management here includes two things. Besides the management of the actual fishing activities, maintenance of the infrastructure and prevention of soil erosion is of special importance. Maintenance activities include, for example, refilling eroded portions in the dam wall, planting grasses at the downstream slope, clearing the dam wall of regenerated trees and shrubs or removing dangerous aquatic weeds. Catchment area protection includes the enforcement of no-farming regulations within the catchment area, the prevention of bushfires and planting and maintaining trees and grasses or the reshaping of contour bounds where they have been constructed (Gyasi 2005). While the well maintained state of the infrastructure is closely related to the livelihoods of so many people – not only fishermen, but also irrigators and livestock owners, it is astonishing how little the people in all four villages contribute to the maintenance of their infrastructure.

The most important point stressed by all interview groups and further by a large number of fishermen interviewed during the catch survey is the regulation of the mesh size of the fishing nets. The officially recommended minimum size of 6.35 cm is well known in the communities. Another well known rule is the ban on fishing during the main reproduction period of many fish species, which falls together with the onset of the rainy season.

Although these rules and recommendations are well known, at least among the fishermen in Kajelo and Binduri, they are not implemented. The fact that the fishing pressure on the reservoirs is lower in the rainy season, can be – as explained above – attributed to the workload on the farms, and not due to the fact that there is a rule that prohibits fishing. However, this reduction in fishing pressure is also contributing to continuous catches during the dry season. According to the fishermen there is a limit to

this natural recovery. Very self-critically the fishermen admit that the high fishing pressure with inappropriate gear is most probably the reason for the declining catches. Especially the older fishermen, who had been fishing since the 1960s or 1970s stated that the catches were much higher when the fisheries officers were in charge of the management and regulated both fishing pressure and gear. However, a number of other reasons can also be considered responsible for the decline.

Yet again, these assumptions seem strange for the Kajelo reservoir. The number of fishermen fishing in the reservoir, and more importantly the number of actual fishing days are very high for Kajelo. Kajelo, with 1717 fishing days/ha/year, has by far the highest fishing pressure. Binduri with 628 fishing days/ha/year and Dasabligo with 379 fishing days/ha/year have much less fishing pressure. The number of fishermen increased continuously over the years (see section 5.3) and when assuming that the number of fishing days remained constant over the years, the number of fishing days/ha/year also increased. So what is it that actually makes Kajelo so productive that it can even cope with the massive fishing pressure? The answer is given in the next section.

Active management / fisheries enhancement

Active management was considered to be helpful for increasing stocks by all interview groups. Fishermen from Kajelo and Binduri, where in the past the reservoirs had been stocked several times, reported that they had experienced the positive influence of stocking on fish yields. This was confirmed by the fisheries biologist and the extension staff as well as by scientific literature.

The case study of the Kajelo reservoir also confirms this. The dam wall broke and was only rehabilitated in 2004. Soon after the rehabilitation the reservoir was stocked with an unknown number of *Oreochromis niloticus*. Furthermore, in 2006 Kajelo was subject to a successful *hapa* trial using *Oreochromis niloticus* as brood stock. As results from the other two reservoirs and other studies (e.g., Baijot et al. 1997; de Graaf 2003; Quarcoopome 2008) show, the proportion of *Oreochromis niloticus* is usually much lower. However, in Kajelo *Oreochromis niloticus* was the predominant species. It is unlikely that the stock would have established to such a level, naturally, in such a short time, and the stockings most probably contributed considerably to the high

fish yield there. Yet no prior figures were available for comparison to support this assumption.

Binduri was not stocked for an unknown number of years and this most likely contributes to the decline in fish stock just as much as the fishing pressure.

The Dasabligo reservoir had never been stocked, and stocking was not mentioned during the discussions with the fishermen. Apart from the low nutrient contents, this could be another reason why production is so low.

Irrigation and other water uses

Other water uses have considerable effects on the fish stock in the reservoirs. As the three reservoirs are hardly used for domestic water supply, the defecation of the animals is not considered problematic. Instead, animals seem to have a positive influence as, through defecation, they fertilize the water and contribute to natural food production. However, there are also disadvantages caused by a large number of animals. For example, in the dry season the animals are allowed to roam freely on the dam walls, embankments, and in the catchment area, where they contribute to infrastructure degeneration and soil erosion.

Fluctuations in the water level, caused by water withdrawal for irrigation, have the highest impact. According to the interview partners, when water levels are low, fish can be caught easily, which is the reason why they indicate that low water levels are bad for the stock as the stock is more prone to depletion. High water levels in turn are good, as fish can hide in deeper water, and are thereby inaccessible to the gear used by fishermen. Some other constraining factors are pointed out by Moses (1992): Fish mortality is increased by predators, as prey fish have less opportunity to hide in shallow and smaller waterbodies. Deoxygenation can also become a problem and cause increased fish mortality. Baijot et al. (1997) suggest that the main constraints to fish production in the reservoirs of Burkina Faso might be the sudden variations in water level with change of season and the critical ecological conditions prevailing during low water. Only the most robust species survive, and high fluctuations are associated with low biodiversity. There were considerable water level fluctuations of at least 40 cm in both Kajelo and Binduri, and both reservoirs have extremely low diversity of species.

On the other hand the literature suggests that shallow waterbodies are usually associated with higher nutrient levels (Moss 2003) and a higher productivity due to resuspension of nutrients from the sediment. The importance of depth is also confirmed by, e.g., Laë et al. (1999), who found a linear decrease between fish yield and depth from 230 kg/ha/year for very shallow lakes to 50 kg/ha/year for deeper ones (500 m).

Other harmful water uses, such as washing cars and polluting the water were mentioned by the extension staff, as they observed this in some reservoirs. None of the fishermen reported such harmful water uses in the three study reservoirs.

6.4 Potentials for enhanced fish yields

Again it has to be emphasized that the present study is far from being statistically representative, and figures are difficult to interpret even with the support of the observations from fishermen and the literature. Thus, results remain assumptions rather than facts and have to be treated with caution.

The table 6.18 summarizes factors and processes that are potentially influencing yields. It is impossible to draw a conclusion about the robustness of the fish stocks and yields in the Kajelo reservoir, since it has only recently been stocked. However, something else can be concluded from that. Even in a reservoir with difficult conditions such as high fishing pressure, considerable water level fluctuations or high temperatures, the stocking probably has a huge impact on the stock. And while the data, to make a comparison with the stock before the stocking, do not exist, it is safe to say, that in general the fish yields in the reservoirs could be enhanced considerably by stocking. Yet while the data for the benefits of fishing in reservoirs are clear, even in monetary terms (see chapter 5), costs for stocking are missing. However, if *hapas* would be set regularly, the fish yields could perhaps be stabilized on a higher level without high costs.

Fish production in Binduri is remarkable. Despite considerable stressors such as low rainfall in years prior to the flood events in 2007, intense water level fluctuations as well as pH-value fluctuations and low species diversity, and especially without recent stocking (Table 6.18), its yields can still be estimated at around 200 kg/ha/year. In a good year in terms of rainfall or with some passive and active management, the yields could be increased.

Table 6.18: Summary of influence factors and processes

Influence	Binduri	Kajelo	Dasabligo
Natural impact			
Rainfall patterns	erratic	erratic	erratic
Feed availability	limited	limited	very limited
Species composition	low	low	medium
Crocodiles	none	some	few
Temperature	same	same	same
Connection to river	none	none	none
Human impact			
Regulation of mesh size	no	no	no
No. of fishermen	medium	high	low
Recently stocked	no	yes	no
Irrigation	high	high	low
Other harmful water uses	none	none	none
Infrastructure	intact	intact	intact
Age of the reservoir in years	≈ 55	≈ 55	≈ 55
Years since last dam wall breakage (before 2008)	≈ 15	4	≈ 25

In contrast yields in Dasabligo were very low. The reservoir suffers neither from heavy water level fluctuations, nor high fishing pressure and in terms of the trophic degree most ecologists would even describe it as healthy (Reynolds 2002), as there is no risk of eutrophication. Yet it is exactly the poor nutrient state that causes a lack of feed, and this is most likely, together with the fact that the reservoir has never been stocked, the factor that influences the low yields.

Approaches to enhanced production

In the following a number of easy-to-use, low cost techniques are pointed out that might help to enhance fish yields (Hauck and Prein 2009). Setting up no-catch zones in the reservoirs, refuges where fish can hide and breed, is a measure that is rather simple and easily done. These no-catch zones could be marked with heavy tree stems, too heavy to just push them aside and with lots of branches, so that the fishermen would not be tempted to go fishing there, as the net would get stuck in the branches and tear. In addition, fishermen could feed the fish in these places to foster reproduction and growth. Feed that is quite easily available and not too expansive would be the mash from the locally brewed bear or weed bran. A second important step is not to fish-out the reservoir totally in the dry season, but instead leave some larger adult fish as breeding stocks. The waterbody could also be excavated in some places to provide the

remaining stock in the dry season with better chances of survival. Another measure is adhering to the ban on fishing in the main re-productive season and of course the net mesh-size regulations and gear limitations.

Liming could also be an option to look into. Lime is usually not very expensive, however more difficult to buy as it might not be readily available everywhere, but it would enhance primary production in the reservoirs and thus increase the feed availability for the fish. Another method to enhance the stock would be of course the stocking. Still the most common method is to catch either wild brood stock or to take brood stock or fingerlings or both from a hatchery. However, this is rather expensive and needs special equipment, not only for the production of the fish but also for transportation. Hapas as described above might be an alternative. However, know-how and also care are needed to encourage the fish to breed in the enclosures and more experiments need to be done in order to understand the potentials of the method fully.

While the data base of this study concerning the aquatic ecosystems is shallow, the study could show that the environmental circumstances provide a lot of uncertainty, let alone the social systems. It therefore has to be emphasized again that management using target reference points, meaning a defined increase in catch/per year, would lead in most cases at least to serious frustration and worse. Longer-term management implications revolve around the dynamic nature of water resources over time and the need for flexible management systems that consider the inherent uncertainty in the resource base (Conway et al. 2005). The reservoirs are multi-purpose and changes in management such as alterations of food webs through fertilization of the reservoir could greatly affect other water users. In order to avoid potential conflicts amongst water users, experiments with the above given ideas would need to be accompanied by research that does not only capture short-term, but also slowly changing variables.

Flexible management is highly demanding, not only in a monetary sense, but also in terms of time and commitment. As the results of chapter 5 show, community-based management did not function very well in the past. Commitment from the government and donors was even lower. Subject of the next chapter is the analysis of social networks in order to detect further obstacles and opportunities for managing reservoirs for resilience.

7 SOCIAL NETWORKS FOR ADAPTIVE CO-MANAGEMENT OF FISHERIES IN SMALL RESERVOIRS

7.1 Social networks in Kajelo

Nine network maps with 31 participants were drawn for Kajelo. The first map was developed with the elected chief fisherman. The interview was followed by a large group of 21 fishmongers who all insisted on participation as they wanted to act as one group. During these first interviews, two fishermen were considered informal leader of the fishermen of their respective sub-communities. Both were interviewed individually. A retired fisheries extension officer, who now considers himself and is also considered by others as a fisherman, was interviewed next followed by a group of three randomly selected young fishermen who were not mentioned in any interview so far. The current fisheries extension officer was interviewed. As the livestock owners were mentioned as being influential, their opinion leader was interviewed. The last interview was conducted with the elder of the sub-community where the reservoir is located.

Besides the chief fisherman, mongers and elders, and the extension officer from the MoFI were mentioned during all interviews (Figure 7.1). All interview partners mentioned other fishermen as being influential and in general the same persons were mentioned. Competing water users, especially gardeners but also livestock owners, were mentioned quite frequently. Only the extension officer admitted that he did not know about the livestock owners' and gardeners' role in the network, and the young fisherman also neglected the role of the gardeners. As in the other study communities, domestic water use did not play a role, as there are enough water pumps in the communities, and reservoir water is hardly used for drinking water.

Although researchers from the Challenge Program on Water and Food Project No. 6 (CP6) visited the community, a *hapa* was set up in the reservoirs in 2006, and the chief fisherman attended several program meetings and training sessions, only the chief fisherman and the extension officer were aware of the program. The assembly man from Kajelo was also only mentioned twice.

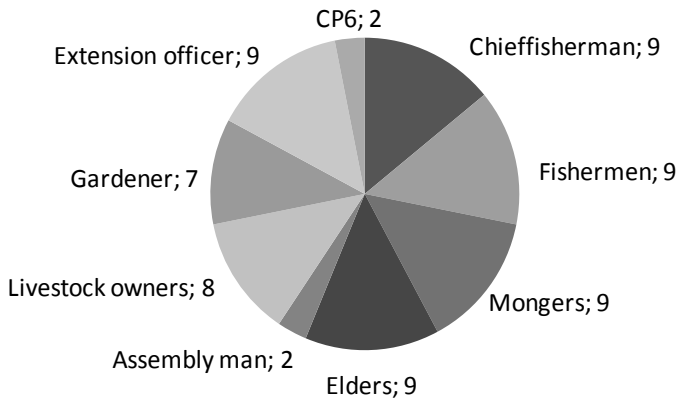


Figure 7.1: Number of times the different actor groups were mentioned in Kajelo

Influence towers

As described in chapter 3 the amount of influence was enquired using the height of an influence tower (small discs stacked on top of each other). In order to visualize the influence, three influence categories were established. The low influence category comprises all actors and actor groups that have scores between 0-0.33, which means that they only received a few discs from most of the interview partners. Groups with scores between 0.34 and 0.60 are in the medium influence category as they received a medium number of discs. Groups with scores above 0.60, thus the highest towers, are considered highly influential.

The extension officer was the actor with the highest influence with respect to fisheries activities, and most interview partners agreed on that. The extension officer is followed by the elders of the sub-community where the reservoir is located. However, their influence was contested, meaning that some interview partners gave high towers while others gave only low towers. This difference is reflected in the high standard deviation. In contrast to the other study communities, earth priests or the chief have no influence on fisheries activities and they are not even mentioned.

Table 7.1: Number of times the different influence groups were mentioned, average influence assigned through 8 interviews, and direction of influence in Kajelo

Actors	Average influence (min 0; max 1)	Average influence Stand. dev.	Influence categories	Influence direction
Assembly man	0.14	**0.3**	low	+++
CP6	0.17	**0.35**	low	++
Mongers	0.27	0.17	low	+++
Fishermen	0.35	0.13	medium	+++
Gardeners	0.36	**0.32**	medium	+
Livestock owners	0.54	**0.31**	medium	+
Chief fisherman	0.61	0.13	high	+++
Elders	0.69	**0.32**	high	+++
Extension officer	0.87	0.17	high	++

\+ *encourage fishing, when water level is high;* ++ *encourage fishing, when rules are followed;* +++ *always encourage fishing.*

The chief fisherman was also considered highly influential, and the comparatively low standard deviation shows that most interview partners agreed with this. In Kajelo, other water user groups, namely gardeners and livestock owners, had medium influence, although the influence of the gardeners is contested. While the retired extension officer gave them the highest influence tower, mongers and one of the interviewed fishermen perceived the influence of the gardeners as very low. In Kajelo, the mongers seemed to have low influence, as do the CP6 and the assembly man. The high standard deviation of the latter two is due to the fact that they were not mentioned often, but the extension officer and chief fisherman thought the CP6 to be highly influential.

In the figures displaying the networks (Figures 7.2, 7.3, 7.4 and 7.5), the influence level of the various actors is reflected by their placement in the spaces between concentric rings. Actors placed in the outer ring are the least influential, while actors close to the center have high influence.

Direction of influence

The average influence becomes interesting in combination with the direction of the influence (Table 7.1). The answers discussed here focus on the question: Does this actor encourage or discourage fishing activities?

The encouragement of community authorities, chief fisherman, fishermen, and mongers for indiscriminant fishing was high in Kajelo. Although fishing was

encouraged by the fisheries extension officer and the CP6, both emphasized the observance of fishing rules and mentioned the importance of infrastructure and catchment area protection. Livestock owners and gardeners also require water and encouraged fishing only when the water level was sufficiently high.

Networks

The types of influence mentioned by the interview partners in Kajelo as impacting on fisheries activities in the reservoirs were advice, instruction, help and support, and conflict or disturbance. The link categories were defined by asking the people to provide examples for the various influences. All nine interview partners pointed to the influence through advice, help and, support and instruction, and by and large the same examples were given. The conflict link was only mentioned eight times, as the chief fisherman did not want to admit to any conflict within the group that he was supposed to lead.

The links in the advice, help, and support networks were usually reciprocal in almost all interviews in the four communities as can be seen in the strong similarity of in- and outdegree (Tables 7.3 and 7.4). In order to improve the readability of the network figures, arrowheads were not added as almost all links are reciprocal. This is different, because the network of conflicts described in the following were disturbances only by particular people.

Network of conflicts

The Kajelo reservoir is comparatively small (see section 6.1.1). During the dry season water can easily become scarce, and the various water users start to compete for it.

The gardeners want to ensure the flow of water as long as possible in the dry season. Livestock owners want as much water as possible to remain in the reservoir to ensure the water supply for their animals throughout the dry season. When animals die of thirst, it not only means the loss of income but often the loss of the only savings the families have. Livestock owners also mentioned water quality requirements. If the water is too dirty, they believe that sediments accumulate in the animals' stomachs and eventually cause death. Thus, they wanted the fishermen to stop fishing when the water level became low, as the nets raised sediments from the bottom of the reservoir into the water. But, in general fish is easiest caught when the water level is low, and the end of

the dry season is the most critical time of the year, the so-called hunger season and many of the fishermen were not willing to stop fishing. This especially applied to the younger fishermen, who usually owned only a few animals. One young fisherman stated: *„We will continue fishing, because how can the livestock drink and be ok, while we go to bed hungry?*" Gardeners also did not want the water to be too turbid, as they were afraid that the sediments would block the valves connecting the reservoir with the irrigation perimeter.

Conflicts were usually brought forward to the elders, who decided what to do on a case-to-case basis. The livestock owners were closest to the elders or were even elders themselves, so that they could best express their interests. Especially the younger fishermen did not easily accept the decisions made by the elders and accused them of deciding in their own personal interest rather than in the interest of the community. The fact that the younger fishermen often ignored the instructions given by the elders was often mentioned to be disturbing. Not mentioned at all were the many and frequent violations of the maintenance rules and protection of the catchment area. The most likely explanation for that is that none of the water users observed these rules, or did little to protect the catchment area.

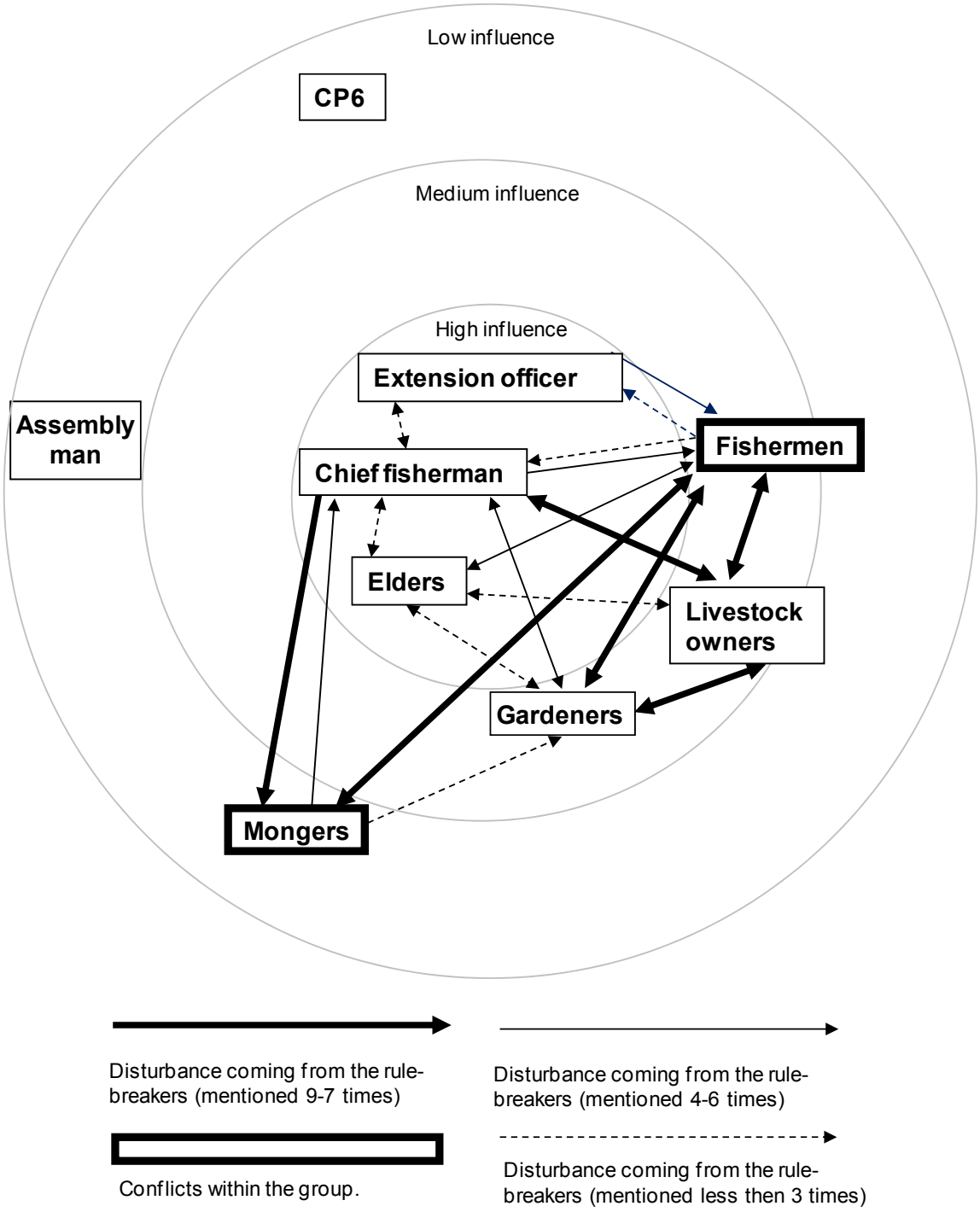


Figure 7.2: Network of conflicts in Kajelo

In addition to the conflicts amongst the different water users, there were a lot of conflicts amongst the fishermen themselves. Although all interview partners agreed that the chief fisherman was the elected leader, not all fishermen agreed with the choice and some refused to accept his advice or instructions.

Again the young fishermen complained that: *„the leaders of the fishermen often don't explain the rules properly and do not stick to the rules themselves and they even chopped the contributed money.*"

When the new fishermen group was formed in 2004, discrepancies regarding the handling of the financial contributions emerged, and some fishermen refused to pay. The situation worsened when the reservoir was involved in breeding trials with the *hapa* in the course of the CP6. After the first trials were finished, the *hapa* gear partly disappeared and fishermen accused each other of having taken it.

Another factor adding to the difficult situation was pointed out by the extension officer. The frequent alcohol abuse of the lead fishermen, who often started drinking in the morning, made constructive group meetings or even interviews extremely difficult.

The extension officer was also not free from critique. Especially the other lead fishermen did not like to see that he mainly contacted the chief fisherman. When visiting the community, e.g. for stock assessment, they sometimes discouraged other fishermen to help dragging the net. When asked about the reason one of them explained: *„the fish taken from the reservoir is not shared properly amongst those who helped dragging the net*." He, as well as other fishermen, thought that too much of the fish harvested on such occasions left the community with the extension officer.

Conflicts between mongers and fishermen were mainly about the price of fish. The mongers explained that they had formed a group some years ago and tried to enforce lower prices in order to ensure at least small profits. Fishermen refused to sell the fish at the dumping price, and the issue was brought to the community elders, who asked the mongers to pay fair prices and the issue was resolved peacefully.

A few mongers bought the fish on credit and did not pay back the money. Many of the fishermen refused to work with them. In order to come back into business, these mongers started to pay higher prices and provided fishermen with food. This in turn upset the other mongers, and the unreliable mongers were excluded from the informal monger group.

Table 7.2: Centrality measures of the conflict networks in Kajelo

Actors	Indegree	Outdegree	Closeness	Betweenness
Fishermen	4	4	0.22	1.19
Chief fisherman	3	4	0.22	1.19
Livestock owners	3	3	0.02	0.12
Gardeners	3	2	-0.11	0.33
Mongers	2	2	0.01	0.12
Elders	2	2	-0.27	0.04
Extension officer	0	0	-0.84	0.00
Assembly man	0	0	-1.00	0.00
CP6	0	0	-1.00	0.00

Usually centrality is associated with power or influence. Interesting to note is that the centrality measures (Table 7.2) do not correspond with the perceived influence expressed by the interview partners as indicated by the height of the influence tower (Table 7.1). While, for example, the elders and the extension officer had high influence towers, their centrality measures are low. Fishermen who are only in the medium influence category, however, lead the table with the centrality measures.

Network of advice

The advice network includes the flow of information as well as practical teaching. The experienced fishermen showed the young men how to weave and repair nets and how to cast them or set them. The advice shared amongst mongers and between mongers and fishermen was intense and included mainly information on fish processing, prices and market opportunities.

A few fishermen perceived the fishing rules explained by the fisheries extension officer as advice, while most interview partners saw them as instructions. It is interesting to note that while the older fishermen interviewed felt troubled by the extension officer, the young fishermen admitted that they would rather listen to the advice of the extension officer than to that of the elders. The reason was that the extension officer explained the rules to them while the advice or instructions of the elders were not always transparent.

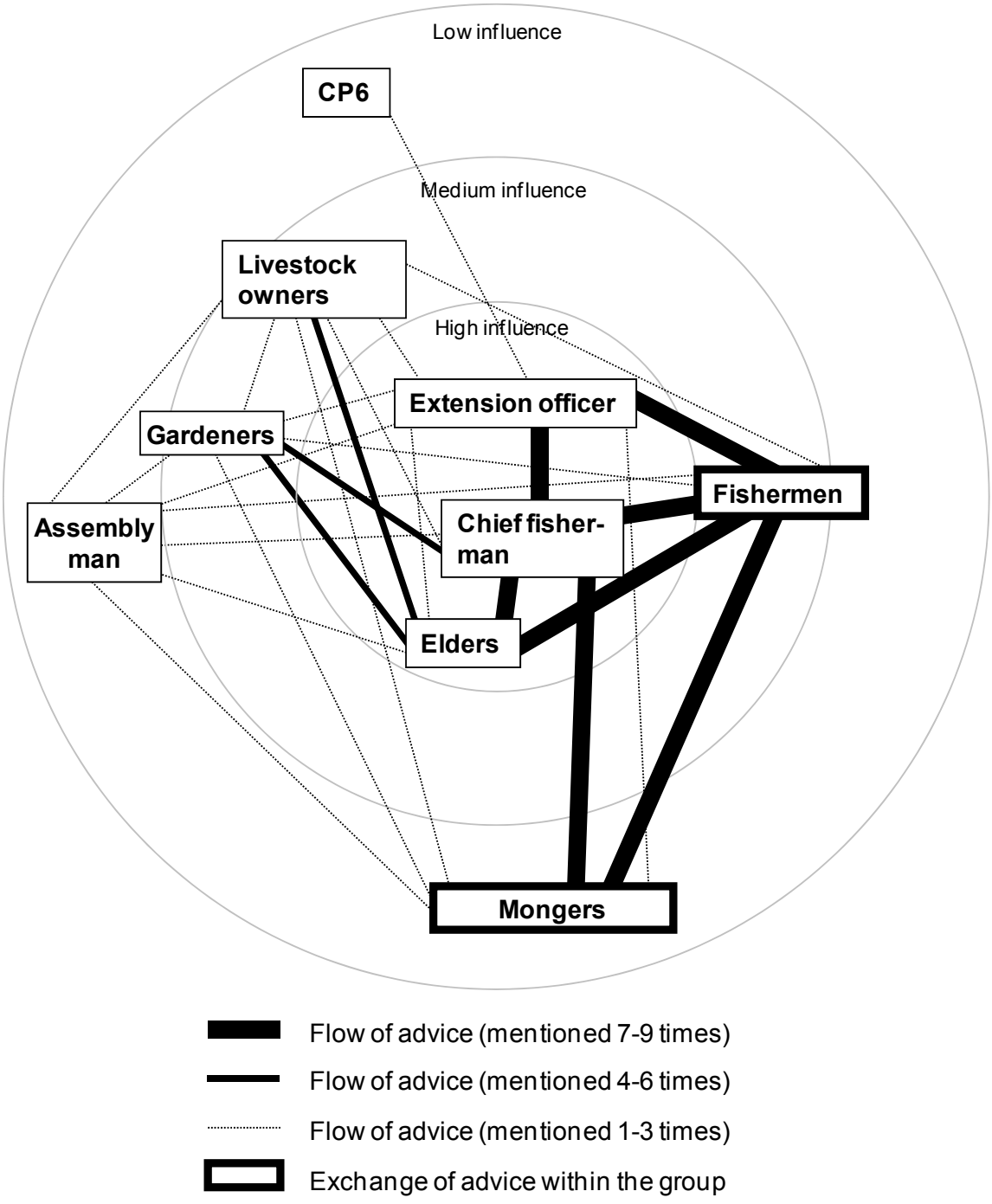


Figure 7.3: Network of advice in Kajelo

The extension officer himself emphasized that he could only advise the fishermen and that he had no authorization to take action against fishermen who breached the rules.

Striking is the absence of awareness of the CP6 program, despite the fact that the reservoir was involved in the trials. Although the people knew of the *hapa* in the reservoir in 2006, when asked where they believed the material came from, they stated

that the extension officer brought it and that they did not know where he got it from. Most of the interview partners did not even know what the *hapa* was meant for as the chief fisherman did not inform them.

Table 7.3: Centrality measures of the advice networks in Kajelo

Actors	Indegree	Outdegree	Closeness	Betweenness
Chief fisherman	4	4	0.17	1.98
Fishermen	5	4	0.17	1.76
Elders	5	5	0.01	1.19
Mongers	5	2	0.12	0.02
Extension officer	2	3	0.13	1.22
Gardeners	2	2	-0.38	0.63
Livestock owners	2	1	-0.26	0.07
Assembly man	1	1	-0.75	0.69
CP6	0	0	-0.76	0.00

The chief fisherman had the highest betweenness score (Table 7.3). This came from his position in between the gardeners and the fishermen. The chief fisherman was a gardener himself, and therefore some of the interview partners believed that he was more in touch with the gardeners than other fishermen were. The relatively high betweenness score of the extension officer came from his position between the CP6 and the fishermen community, as none of the interview partners indicated a direct link between the CP6 and the fishermen community, despite the fact that researchers from the project visited the site at least twice and the chief fisherman participated in several CP6 meetings and training sessions. Again, the centrality measures differ from the height of the influence towers.

Network of help and support

The most surprising and interesting result of the whole net-mapping exercise is that despite all the conflicts described above, there was still a strong help and support network that included all the conflict parties. Like the advice network, almost all help and support links were reciprocal. One of the lead fishermen made it very clear: *„If somebody gets help, he also has to help in return.*"

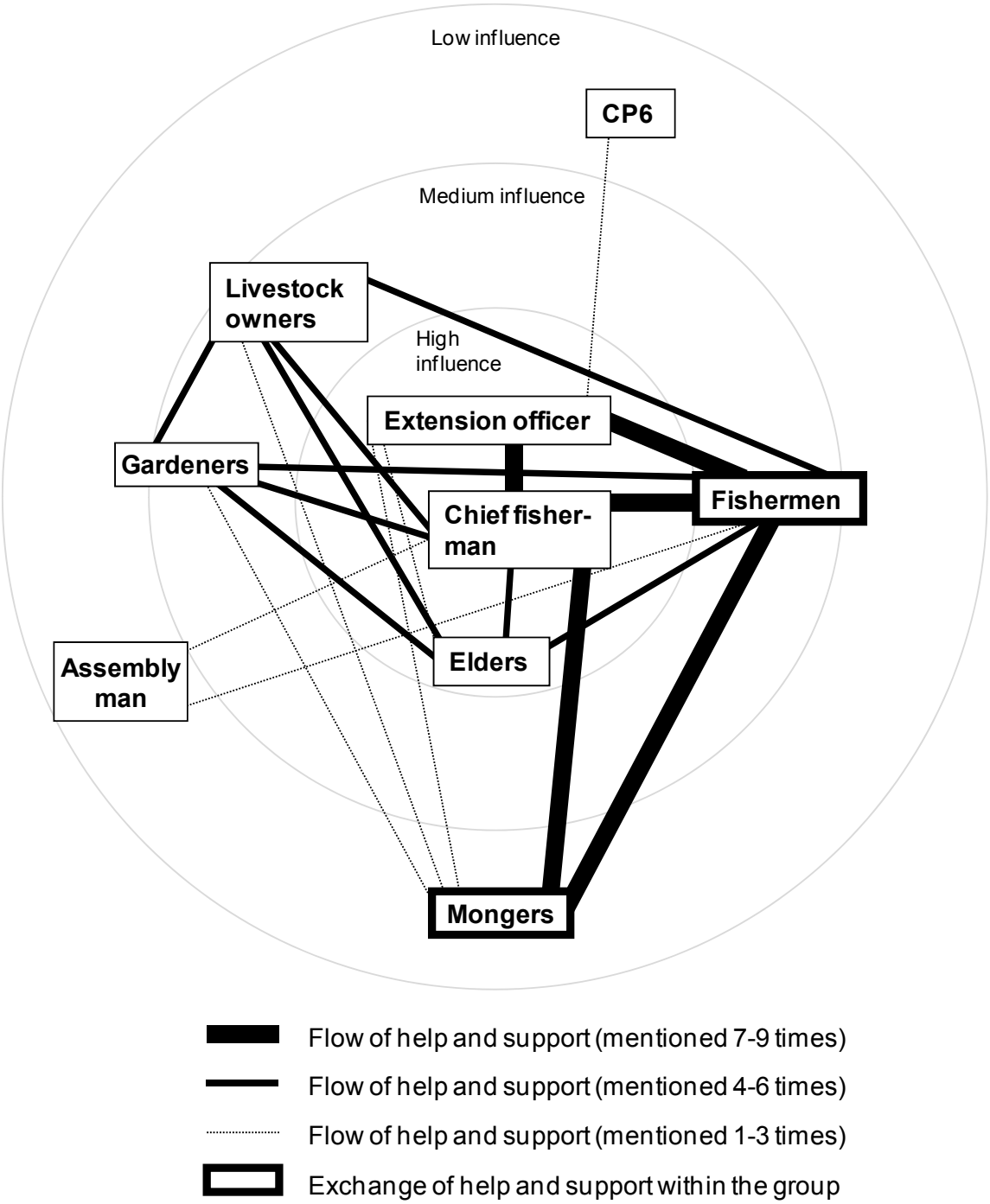


Figure 7.4: Network of help and support in Kajelo

Help amongst the fishermen included the exchange of gear and material for repair work. The young fishermen further reported: *„The leaders of fishermen help us as they sometimes go with us to dams outside the village and introduce us to the elders of that place and seek permission to go fishing there.*" Without such an introduction, fishing permission could be refused.

There was furthermore a strong connection of help and support among the fishmongers and also between mongers and fishermen. When greeting the elders of a place and asking for permission to go fishing, it was the tradition to bring *kola* nuts or *akpeteshie*. One of the lead fishermen explained: *„When we go to the Paga dams to fish, the mongers at times help us to buy Kola and Akpeteshie*." Other fishermen added that the mongers provided small credits, material to repair the fishing nets, and food.

A vital help and support network was also found between the different water users. The chief fisherman explained that the rich livestock owners gave financial help when the dam wall was broken, and consequently it could be repaired. In return, the fishermen helped the livestock owners to get back their animals when they were caught by a crocodile. Mongers explain that they often lack the money to buy fish from the fishermen and livestock owners sometimes help out with credits.

There also was a frequent exchange of produce between the gardeners and fishermen, which was considered to be very helpful. The elders were responsible for resolving the conflicts amongst the villagers. To show their appreciation and probably to win favors with them, all water users gave, more or less frequently, produce from the garden or fish, *kola* nuts, and other things.

Table 7.4: Centrality measures of the help and support networks in Kajelo

Actors	**Indegree**	**Outdegree**	**Closeness**	**Betweenness**
Chief fisherman	5	5	0.18	2.92
Fishermen	5	5	0.18	2.92
Mongers	3	3	0.01	0.67
Extension officer	2	2	0.14	0.56
Gardeners	2	2	0.09	0.10
Livestock owners	3	2	-0.26	0.06
CP6	0	0	-0.75	0.00
Elders	2	2	0.10	0.22

Despite the resentment towards the extension officer described above, most interview partners appreciated the help from the extension officer in the form of fingerlings for stocking their reservoir and the *hapa* material. They showed their appreciation by giving the extension officer the highest influence tower. His supreme position, which was based on material flows, was, however, not reflected by the centrality measures (Table 7.4).

Network of instructions

A look at the network of instructions in combination with the height of the influence tower, the outdegree and the betweenness (Table 7.5) shows that the elders in Kajelo still had authority.

Table 7.5: Centrality measures of the instructions networks in Kajelo

Actors	Indegree	Outdegree	Closeness	Betweenness
Elders	0	3	0.14	3.23
Fishermen	3	0	0.70	0.85
Chief fisherman	2	1	0.59	0.85
Extension officer	0	2	0.11	0.48
Assembly man	0	1	-0.53	0.81
Gardeners	1	0	-0.17	0.00
Livestock owners	1	0	-0.17	0.00
Mongers	0	0	-0.54	0.00
CP6	0	0	-0.78	0.00

When looking at the direction of influence (Table 7.1), however, it becomes clear that the elders did not feel responsible for, or were not aware of, the fishing rules, and thus also did not try to enforce them. Their influence was derived from tradition as well as from the experience they had, being the eldest and wisest men of the community. As described above their authority was challenged, especially by the young fishermen.

Most interview partners stated that it was actually the responsibility of the extension officer to enforce fishing rules and sanction violators. As pointed out above, the extension officer stated that he did not have any formal authority, Lack of manpower and means further prevented him from assisting the villagers in enforcing the rules. He tried to hand over the task to the chief fisherman. However, the other fishermen interviewed stated that the chief fisherman was known to breach the rules himself and was thus in no position to enforce them.

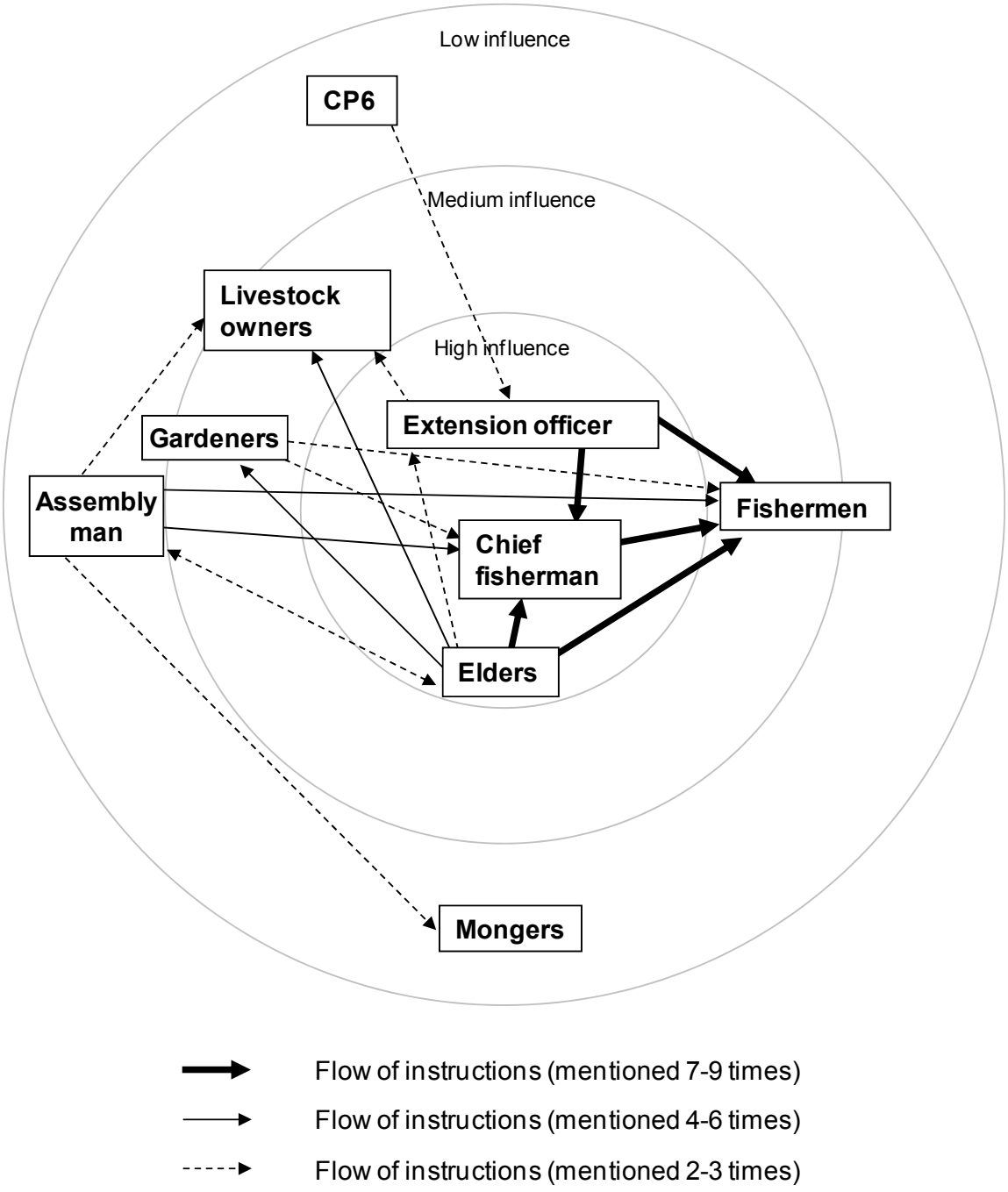


Figure 7.5: Network of instructions in Kajelo

While two interview partners indicated that the assembly man could give instructions, this opinion was not shared amongst the majority of the interview partners.

7.2 Social networks in Dasabligo and Atonbogoro

In total, seven network maps were drawn for the two communities with 13 participants. The first two maps were drawn with the chief fishermen of the two communities and their deputies. A group of three fishmongers from Atonbogoro were interviewed next. In all three interviews, one important monger from Dasabligo was mentioned, who was then interviewed. From the list of all fishermen, two groups of young fishermen were sampled, one in each community, who were not mentioned in the first four interviews. As the maps resulting from the interviews were very similar, it was decided to stop after the interview with a randomly sampled rich fisherman from Dasabligo. Unlike in Kajelo and Binduri, no other water users were said to be influential. This was explained by the fact that the reservoir is large enough, and since no irrigation takes place, water scarcity is not an issue. As there is hardly any silt in the reservoir, muddy water that can harm the cattle is also not a problem.

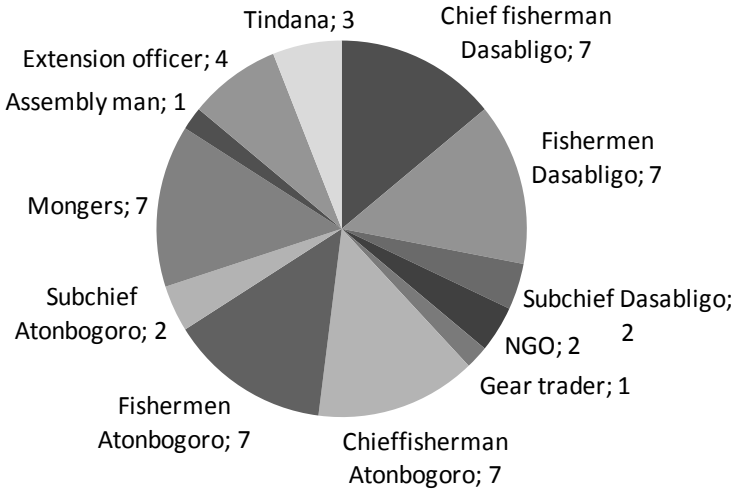


Figure 7.6: Number of times the different actor groups were mentioned in Dasabligo and Atonbogoro

In every interview, fishermen and chief fishermen were separated by community. Each chief fisherman had a deputy and a small group of informal advisors. Mongers were also perceived to be influential by all interview partners and, in general, the same names were mentioned.

The extension officer mentioned during four interviews did not come from the DoF, but was the officer from the Ministry of Lands, Forestry and Mines (MLFM) (see

section 5.3.3), who came once to instruct the fishermen at the Red Volta to not use poison for fishing. None of the interview partners could remember the extension officers from the MoFI who built the pond or did not assign them with any influence.

The rich fisherman from Dasabligo, who met the extension officer once, stated: *„Those who built the pond never finished the job and so there is no influence from there yet.*" This was confirmed by observations during the field research, where no activities were found related to the pond.

During the interview with the chief fisherman and deputy chief fisherman of Atonbogoro, their assembly man was mentioned to be influential. They also mentioned the *tindana* to be influential. This was confirmed in the interviews with young fishermen and the rich fisherman from Dasabligo, who also found the subchiefs of the two communities to have some influence. The chief fisherman and the young fishermen from Dasabligo mentioned an NGO called *Finnish-Ghanaian Friendship Association* as being influential based on a development project described later. In addition, the young fishermen from Dasabligo mentioned a trader, who traded cattle to southern Ghana. After selling his cattle he usually buys fishing gear and sells it to the fishermen in Dasabligo.

Influence towers

The chief fisherman of Dasabligo was considered to be most influential, closely followed by the chief fisherman from Atonbogoro. The fishermen of both communities had medium influence on fishing activities. The mongers had a medium influence score, but the high standard deviation shows that while some of the interview partners rated the influence of the mongers higher, others did not assign them much influence. As in the other communities, there were many mongers in Dasabligo and Atonbogoro, resulting in strong competition, and as they were not organized they could not put pressure on the fishermen.

Table 7.6: Number of times the different influence groups were mentioned, average influence assigned through 7 interviews, and direction of influence in Atonbogoro and Dasabligo

Actors	Average influence (min 0; max 1)	Avg. Influence Std. dev.	Influence categories	Influence direction
Assembly man	0.00	0	low	++
Gear trader	0.11	0.28	low	+++
Subchiefs Dasabligo	0.14	**0.39**	low	++
Subchiefs Atonbogoro	0.21	**0.39**	low	++
Extension officer	0.29	**0.36**	low	++
NGO	0.32	**0.38**	low	+++
Tindana	0.36	**0.48**	medium	++
Fishermen Atonbogoro	0.46	0.14	medium	+++
Mongers	0.48	**0.34**	medium	+++
Fishermen Dasabligo	0.52	0.14	medium	+++
Chief fisherman Atonbogoro	0.81	0.18	high	+++
Chief fisherman Dasabligo	0.88	0.15	high	+++

\+ *encourage fishing, when water level is high; ++ encourage fishing, when rules are followed;* +++ *always encourage fishing.*

The fourth person with medium influence was the *tindana*. It is interesting to see that those who mentioned him also assigned him a very high power tower, whereas the other three interview partners stated that they think the *tindana* has no influence at all and did not want him on their map. The other actor groups only reached low influence scores; the chief fisherman of Atonbogoro, who insisted on putting the assembly man on the map, said that he had no influence.

While in Kajelo the height of the influence tower and the centrality measures did not correspond, the centrality measures for Atonbogoro and Dasabligo (see Tables 7.7, 7.8 and 7.9) are mostly consistent with the height of the respective influence tower (Table 7.6).

Direction of influence

Most of the actor groups encouraged fishing activities without constraints. The *tindana* was said to encourage fishing although he insists that the traditional rules (see section

5.3.1) are followed. When the extension officer from the MLFM came to the Red Volta, he also encouraged their activities but pointed out that the rules must be adhered to. The two subchiefs and the assembly man encouraged fishing; however, the rules that were given by the government and the *tindana* should be followed.

Networks

Unlike the other two reservoirs, Dasabligo and Atonbogoro did not have a network of conflicts, as all interview participants agreed that there were no conflicts in the context of the fisheries activities. While this could very well be true, there is also the possibility that the time spent in the two communities was not sufficient for the villagers to open up and share delicate details. Due to the remote position, villagers from Dasabligo and Atonbogoro were not as used to dealing with foreigners as the villagers from Kajelo and Binduri, and it might have taken longer to gain an insight into tensions and conflicts amongst fishermen or between other actor groups. The link categories advice, help and support, and instructions were mentioned by all interview partners with the exception of mongers from Atonbogoro, who mentioned they did not know whether instructions were given in the context of fisheries activities.

Network of advice

As was the case in the other two communities, advice included the exchange of information and the training of young fishermen. All interview partners mentioned an exchange of advice between the fishermen with one exception. While there was a flow of information across community borders between the normal fishermen and between the two chief fishermen, the chief fisherman of Atonbogoro was not supposed to exchange advice with the normal fishermen of Dasabligo. If he wanted to give advice to the Dasabligo fishermen, he had to talk to their chief fisherman who would spread the information. For the chief fisherman of Dasabligo the same thing applied. This situation explains the higher betweenness score of the chief fishermen (Table 7.7).

Table 7.7: Centrality measures of the advice networks in Dasabligo and Atonbogoro

Actors	**Indegree**	**Outdegree**	**Closeness**	**Betweenness**
Chief fisherman Dasabligo	4	3	0.17	1.50
Fishermen Dasabligo	4	3	0.17	1.28
Chief fisherman Atonbogoro	4	3	0.18	1.80
Fishermen Atonbogoro	4	3	0.17	1.00
Mongers	4	3	0.18	0.85
Tindana	1	1	-0.63	0.10
Extension officer	0	2	-0.52	0.24
NGO	0	1	-0.69	0.07
Subchief Atonbogoro	1	1	-0.63	0.10
Subchief Dasabligo	1	1	-0.63	0.43
Assembly man	0	0	-0.85	0.00
Gear trader	1	0	-0.85	0.06

Only the mongers stated that they think that everybody advises each other, independent of hierarchies. The slight lead of the chief fisherman from Atonbogoro in terms of betweenness results from the connections mentioned between him, the assembly man, and the *tindana*.

The advice given by the extension officer concerned the use of poison. While the fishermen from Atonbogoro and the young fishermen from Dasabligo thought that this was advice, other interview partners perceived this as instructions.

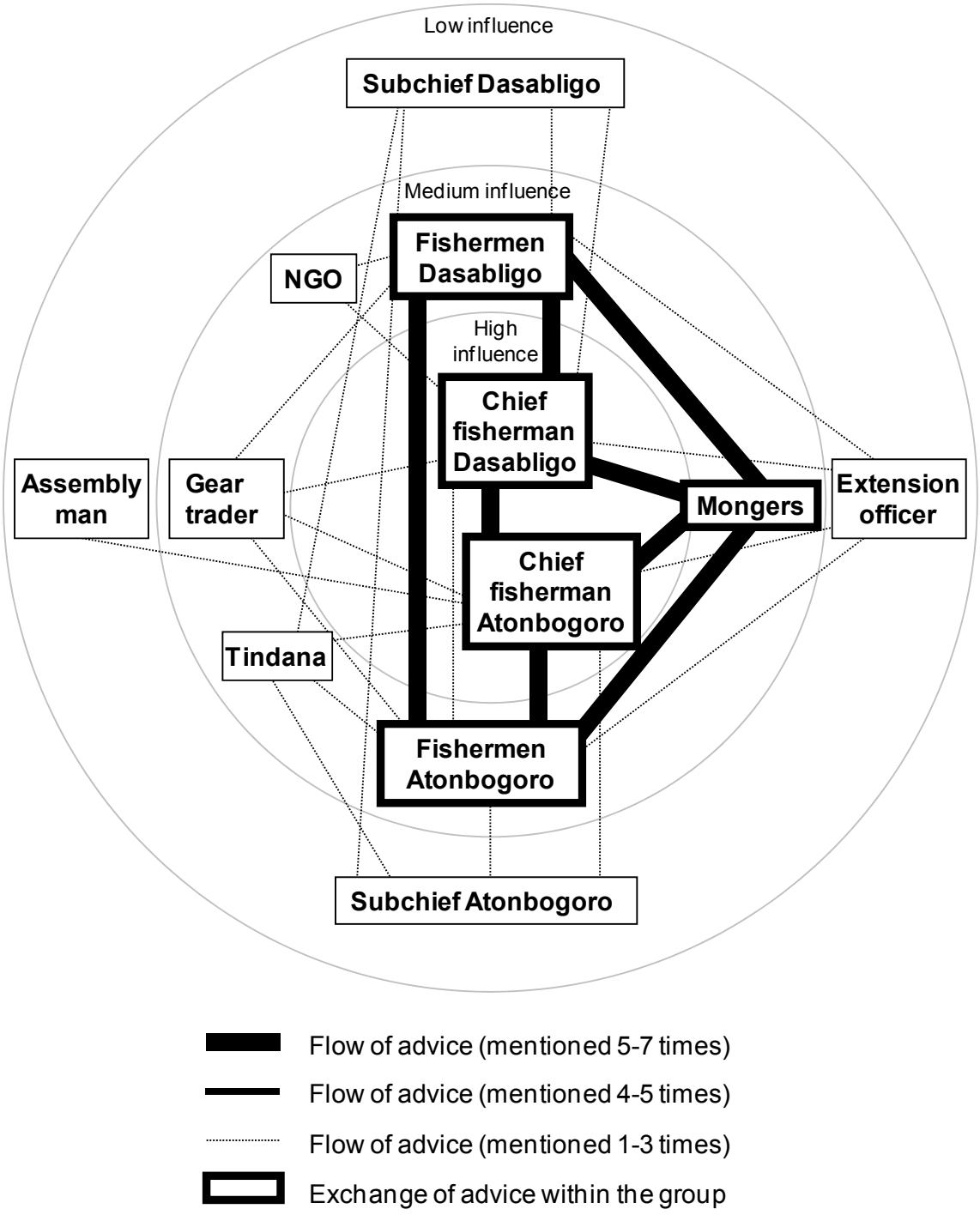


Figure 7.7: Network of advice in Dasabligo and Atonbogoro

Network of help and support

While the exchange of advice was limited, the exchange of help and support included all fishermen, independent of community or hierarchy. The fishermen shared their nets, and young fishermen sometimes borrowed the nets from older fishermen until they had

saved enough money to buy their own gear. Again, other fishermen put their money together, and one or two of them traveled to Bolgatanga to purchase gear for all who contributed.

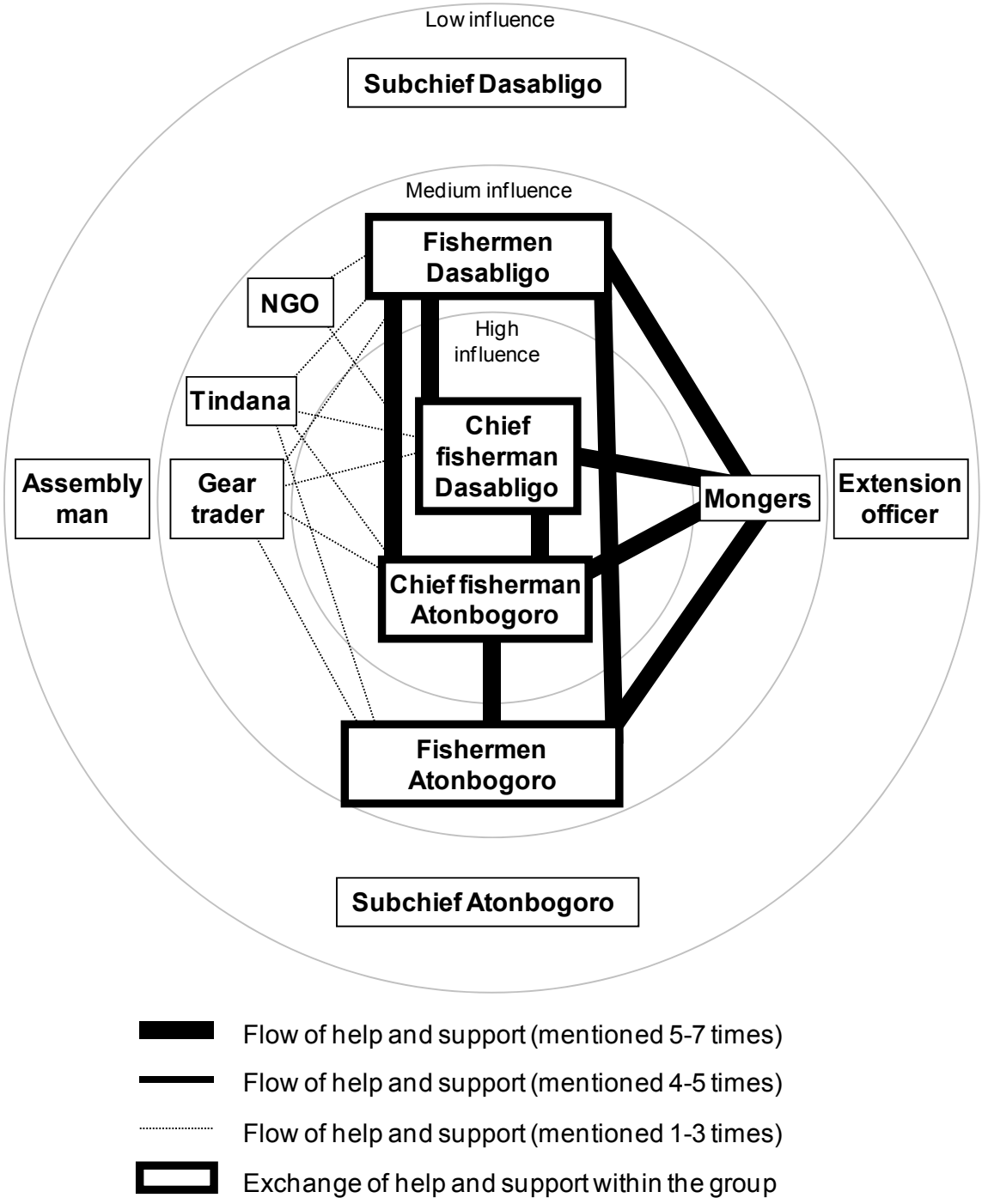


Figure 7.8: Network of help and support in Dasabligo and Atonbogoro

As in the other communities, the mongers were also part of the network of help and support and the exchange of small credits either in cash or in goods. The chief fisherman of Dasabligo added that sometimes the mongers supported the fishermen with food. The rich monger even revealed: *„Fishermen and mongers have business relations and the monger's share of fish is reserved. The mongers meet the fishermen at the dam side or the fishermen bring the fish to them.*" The mongers also helped and supported each other. The fish mongers from Atonbogoro explained: *„Sometimes we help each other with selling fish, if one is already done with selling she helps another woman who has not yet sold her fish.*"

The chief fisherman of Atonbogoro explained that in order to show the *tindana* their appreciation for the advice and guidance, the fishermen from every community bring him fish every once in a while. However, those fishermen who stated that the *tindana* had no influence on the fishing activities gave the *tindana* no fish or other goods.

Table 7.8: Centrality measures of the help and support networks in Dasabligo and Atonbogoro

Actors	**Indegree**	**Outdegree**	**Closeness**	**Betweenness**
Chief fisherman Dasabligo	4	4	0.22	0.57
Fishermen Dasabligo	4	4	0.22	0.57
Chief fisherman Atonbogoro	4	4	0.21	0.07
Fishermen Atonbogoro	4	4	0.21	0.07
Mongers	4	4	0.20	0.00
Tindana	1	0	-0.84	0.00
Extension officer	0	0	-0.69	0.00
NGO	0	1	-0.83	0.00
Subchief Atonbogoro	0	0	-0.84	0.00
Subchief Dasabligo	0	0	-1.00	0.00
Assembly man	0	0	-1.00	0.00
Gear trader	1	1	-1.00	0.00

As mentioned above, the young fishermen from Dasabligo mentioned the gear trader as being very helpful for all fishermen, because when they bought the gear from him, maybe even on credit, they saved the lorry fare to the next town.

The higher betweenness of the chief fisherman and fishermen in Dasabligo (Table 7.8) resulted from the connection with the NGO *Finnish-Ghanaian Friendship*

Association. While the NGO was mainly involved in the establishment of primary education, the chief fisherman reported that they also donated some fishing gear for the fishermen in Dasabligo. However, the other interview partners were not aware of this donation. In return, the chief fishermen stated that they had also contributed something small to the people from the NGO. In the context of this development project, there was much resentment amongst the villagers in addition to the matter of fishing nets, yet people refused to talk about it and it was decided to let the matter rest.

Network of instructions

All of the interview partners who mentioned the extension officer from the MLFM perceived the ban on poison as an instruction with serious consequences when the rule is breached. The chief fisherman from Atonbogoro explained: *„The people from forestry can give instructions and also arrest those people who use poison.*"

As mentioned before, the opinions about the *tindana's* influence were divided, and only some interview partners stated that he can give instructions to the fishermen. The chief fisherman from Dasabligo on the other hand stated that: *„the tindana has nothing to say!*"

Table 7.9: Centrality measures of the instructions networks in Dasabligo and Atonbogoro

Actors	**Indegree**	**Outdegree**	**Closeness**	**Betweenness**
Chief fisherman Dasabligo	2	2	0.16	0.35
Fishermen Dasabligo	3	1	0.16	0.10
Chief fisherman Atonbogoro	2	2	0.18	0.85
Fishermen Atonbogoro	3	1	0.16	0.10
Mongers	1	1	-0.62	0.08
Tindana	1	2	-0.42	3.00
Extension officer	0	1	-0.60	0.69
NGO	0	0	-1.00	0.00
Subchief Atonbogoro	0	1	-0.63	0.00
Subchief Dasabligo	0	1	-0.63	0.00
Assembly man	0	0	-1.00	0.00
Gear trader	0	0	-1.00	0.00

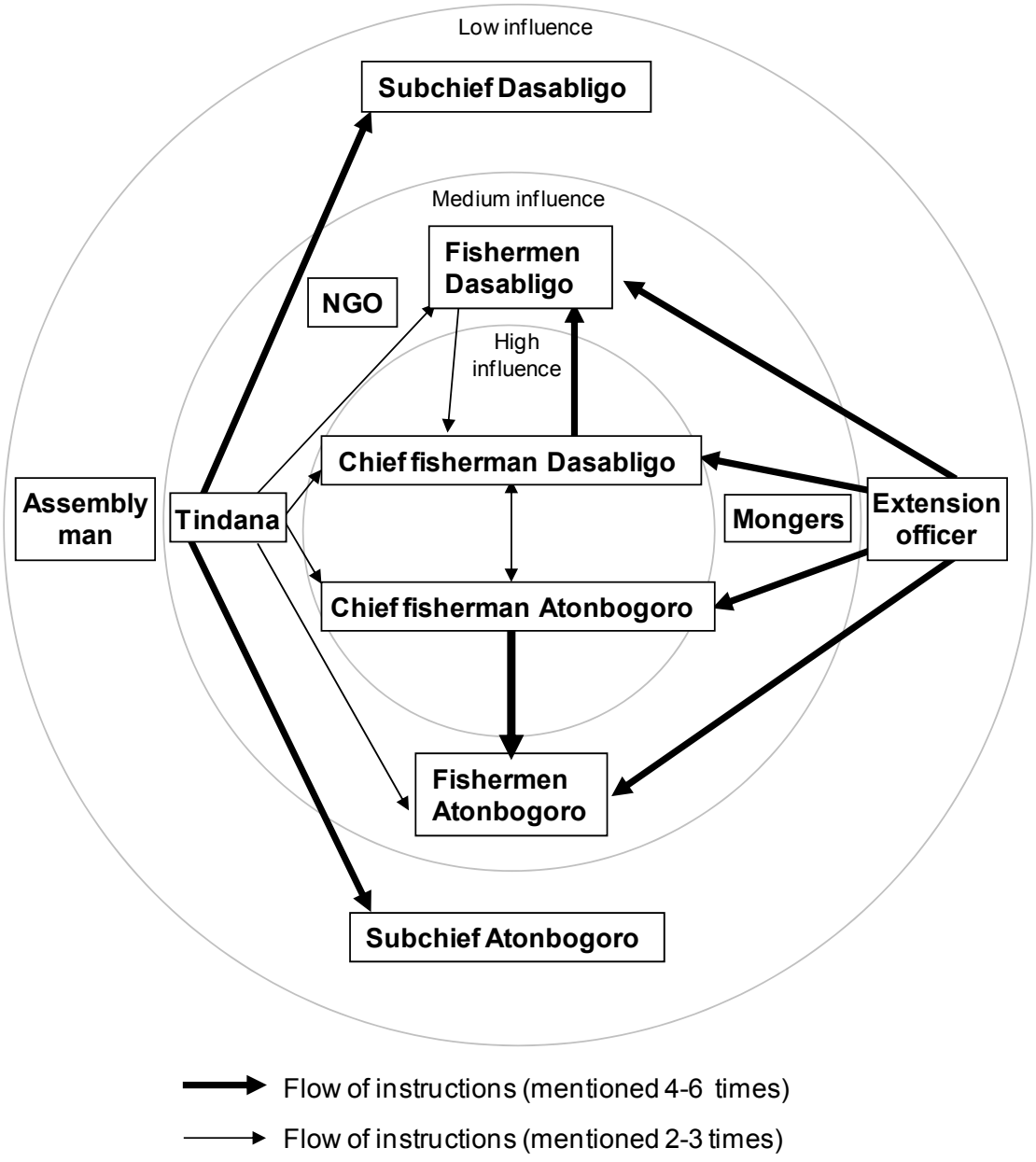


Figure 7.9: Network of instructions in Dasabligo and Atonbogoro

Whether this only applies to issues concerning the reservoir or to the lordship of the *tindana* in general remained unclear. The younger fishermen of both communities explained that they do not believe in the *tindana's* power, which was supposed to come from the ancestors, and they did not adhere to the ban on fishing in August and September.

7.3 Social networks in Binduri

Eight network maps were drawn for Binduri. The interview series started with the chief fisherman and the head of the fishmongers, followed by an interview with two randomly selected young fishmongers. Next came an interview with the chairman of the Binduri reservoir's Water User Association (WUA). It is important to note that the WUA in Binduri did not represent all water users, but mostly the gardeners. However, many of the gardeners were also fishermen, although most of them prioritized their gardens (see section 5.2.2). Apart from the formally elected chief fisherman, the community had another lead fisherman who was also interviewed. A young fisherman who was not mentioned by any other interview partner was randomly selected for an interview from the list of all fishermen from Binduri. During the interviews, all interview partners mentioned a particular fisherman and sometimes his brother, who frequently "disturbed" other fishermen, fishmongers and other people. In order to identify reasons for that disturbance, the fisherman and his brother were also interviewed. The term "disturbance" was explicitly chosen by the interview partners in order to avoid the term conflict. In Binduri, conflict was associated with armed clashes based on ethnic rivalries and associated political issues. All interview partners made sure that it was understood that in the context of fishing no such conflict occurred, and the disturbance had nothing to do with the ethnic conflict and associated violence. In the following the network is called "network of conflict" as the issues described are similar to the network of conflicts described for Kajelo.

In a last step, the extension officer of the MoFI was interviewed. He was mentioned in every interview as being influential (Table 7.10), although most of the interview partners did not know his name. A detailed description usually helped to identify the man. One monger described him as: *„the tall man from Bawku, who comes once in a while with a big fishing net and helps us to harvest the fish from our dam.*" Another interview partner formulated it slightly differently by ending the sentence with: *„… who takes the fish from our dam*." All interview partners mentioned the elected chief fisherman by name. Seven out of eight interview partners reported a few other fishermen, apart from the chief fisherman, as being influential. In this group, the same names were given. They were also assigned a leadership function, based on how often they go fishing and the experience gained from long years of practice. A distinction was

made between those leaders and the chief fisherman, as the former are not formally elected. The fishermen who cause disturbance were mentioned seven times. Amongst other things, they were accused of breaking the rules and encouraging others to do so. Even these fishermen themselves admitted that this was true. Only the extension officer stated that he was not aware of any trouble maker.

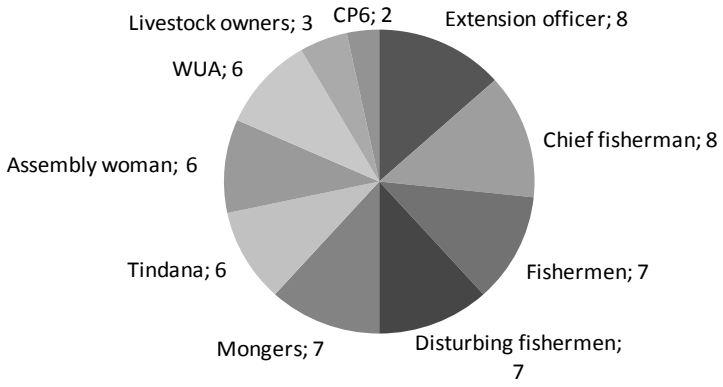


Figure 7.10: Number of times the different actor groups were mentioned in Binduri

The fishmongers were mentioned seven times as being influential. Six interview partners mentioned the assembly woman, the *tindana* and the chairman of the WUA as influential. Livestock owners, representing another important water user group, were mentioned three times and the CP6 was mentioned twice by the extension officer of the MoFI and the chief fisherman. The chief fisherman knew the CP6, since he attended several project meetings and training sessions.

Influence towers

The extension officer had the highest average influence, closely followed by the chief fisherman and the fishmongers. Not all interview partners agreed on the high influence of the mongers. The extension officer and chief fisherman assigned them very little influence, explaining the high standard deviation. After that there is a big gap between these three and the next influential actor, the chairman of the WUA, who represented the interests of the gardeners. Again, not everybody associated him with influence. While the extension officer assigned him the highest power, as should be the case in a properly functioning WUA, the disturbing fishermen, the young fisherman and the old

monger assigned little or no influence at all. The *tindana* scored medium influence, while the other fishermen, disturbing fishermen, and the assembly woman were assigned little influence. The CP6 was mentioned by the chief fisherman and the extension officer, who both assigned high influence scores. However, apart from them nobody knew the Challenge Program, resulting in a low average influence score. Only the livestock owners had less influence than the CP6.

Table 7.10: Number of times the different influence groups were mentioned, average influence assigned through 8 interviews, and direction of influence in Binduri

Actors	Average influence (min 0; max 1)	Avg. Influence Std. dev.	Influence categories	Influence direction
Livestock owners	0.12	0.19	low	+
CP6	0.26	**0.37**	low	++
Assembly woman	0.30	0.25	low	++
Disturbing fishermen	0.31	0.16	low	+++
Fishermen	0.33	0.21	low	++
Tindana	0.34	0.15	medium	++
WUA	0.43	**0.33**	medium	++
Mongers	0.69	**0.39**	high	+++
Chief fisherman	0.70	0.20	high	++
Extension officer	0.83	0.15	high	++

+ encourage fishing, when water level is high; ++ encourage fishing, when rules are followed; +++ always encourage fishing.

Direction of influence

As in the other communities, there were no actors who try to stop or discourage fishing in general. Most actors, even the fishermen themselves, encouraged fishing if the fishing rules are obeyed. This is interesting since even the interview partners such as the *tindana* or the WUA chairman who did not fish themselves were well aware of the basic simple rules of sustainable management. Livestock owners encouraged fishing, although only when there was enough water in the reservoir.

Only the mongers and the disturbing fisherman encouraged indiscriminant fishing. As explained earlier, even the tiniest fish is sold and eaten, thus it does not come as a surprise that the mongers bought all available fish.

Networks

The influence through advice and the influence through helping and supporting each other were mentioned by all of the interview partners. The influence through disturbance was mentioned 7 times, as the extension officer stated that he was not aware of any quarrels amongst fishermen. The instruction link was also mentioned only 7 times as the chief fisherman insisted that there was nobody who could give instructions.

Network of conflicts

The interview partners described the conflict or disturbance as breaking fishing rules and encouraging others to do so, because once the rules were broken nobody complied with them anymore. The young fisherman said about one of the disturbing fisherman: *„The disturbing fisherman is fishing early in the morning when the small fish are coming out to feed and are easy to catch. The disturbing fisherman also does not stick to any bans and fishes at all times*." The other lead fisherman explained:

> *„The disturbing fisherman is a fool. He does not have education and the devil is with him. He went to jail several times. He does not listen to anybody. Trying to stop him from breaking the rules would mean to beat him up and take his fishing gear away."*

The informal lead fisherman, who belonged to the same clan as the disturbing fisherman, denied ethnic rivalries as being a reason for the problematic situation. It could be observed that fishermen from different ethnic groups went fishing together on a day-to-day basis.

Some of the interview partners explained that the rule-breakers did not only disturb other fishermen but that their disobedience is annoying everyone (Figure 7.11). However, the mongers did not feel disturbed by the rule breaking. In their case the disturbing fisherman and his brother had cheated the mongers in the past. The young mongers reported: *„The disturbing fishermen are drinkers. They always drink, threaten others and even beat up each other. They also threaten to beat us up*."

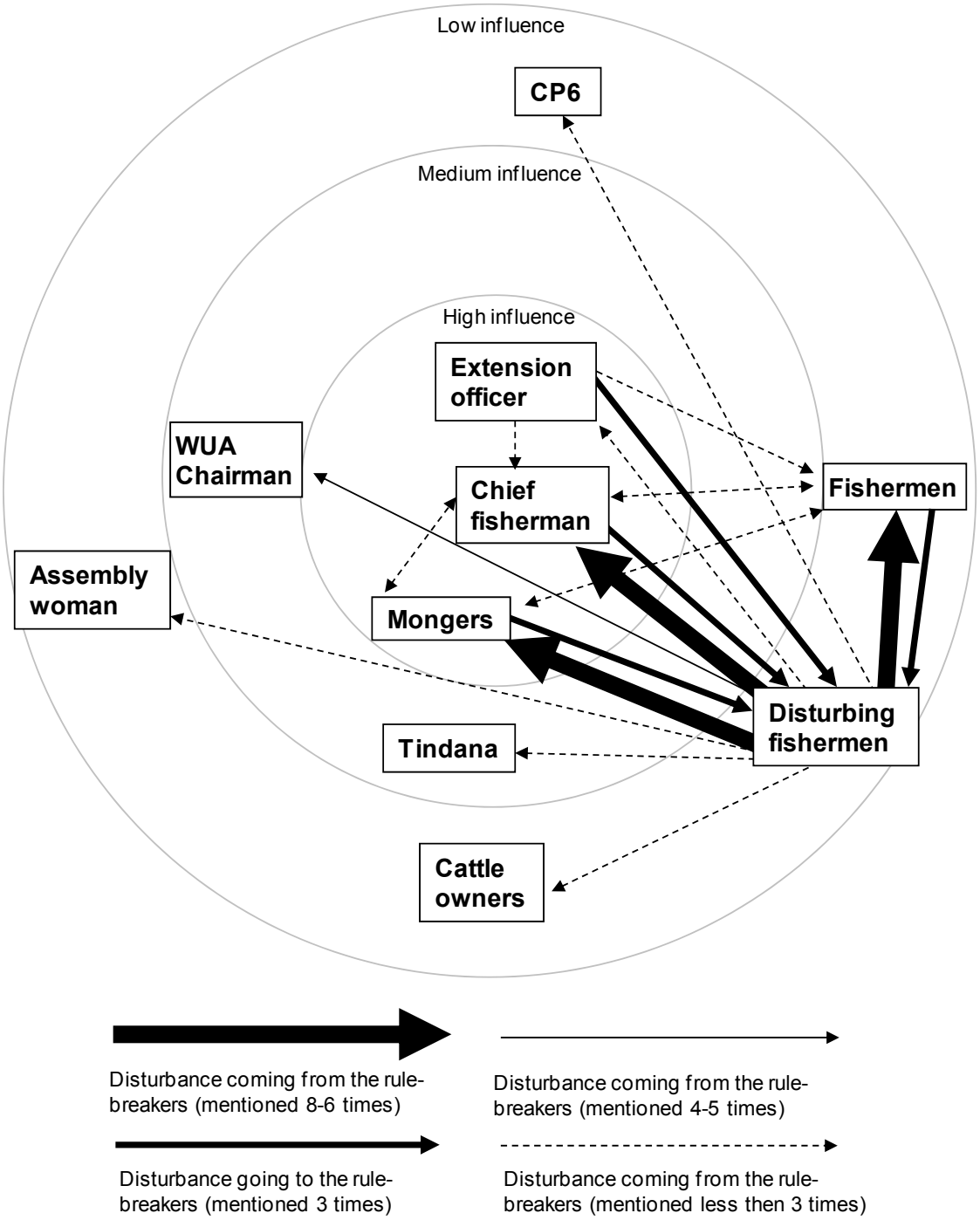


Figure 7.11: Network of conflicts in Binduri

However, the disturbing fishermen were disrupted themselves, which was not only reported during the interview with them, but also by two other interview partners. He and his brother admitted that they disturbed the mongers as they often feel cheated too when they do not get the right prices for their catch. The two men gave the following reasons why they did not obey the rules and even less the men who made them:

„The chief fisherman and other lead fishermen are going to workshops and get free nets and other things. When those fishermen come back they never tell us what happened, but only tell us to stop fishing because the fishes are too small. Then they are using nets with small mesh size themselves. […] The extension officer only talks to the chief fisherman and we never get to know what he has to say. […] Some fishermen from outside came to pay their water levy before they enter the water. That money was chopped by the chief fisherman. […] Some years ago every fisherman paid 5000 Cedis so that they could start a bank account. The money was meant to get a loan and repair the dam. Again the chief fisherman chopped the money."

These accusations were repeated by other interview partners.

Table 7.11: Centrality measures of the conflict networks in Binduri

Actors	**Indegree**	**Outdegree**	**Closeness**	**Betweenness**
Disturbing fishermen	1	1	0.22	12.86
Chief fisherman	2	2	0.17	0.00
Fishermen	2	2	0.17	0.00
Mongers	2	2	-0.02	0.14
Extension officer	0	0	-0.35	0.00
WUA	1	0	-0.22	0.00
Livestock owners	0	0	-0.54	0.00
Tindana	0	0	-0.54	0.00
Assembly woman	0	0	-0.54	0.00
CP6	0	0	-1.00	0.00

While the network and the measures (Table 7.11) suggest that the disturbing fishermen did have quite some influence, this was not reflected in the height of the influence tower, where they rank in the middle.

Practically no disturbance was reported between the different water users because most fishermen were gardeners and most of them owned some livestock that need watering. Most gardeners who did not fish had at least some livestock, and there was hardly any dispute about when to stop irrigation in order to keep enough water for livestock watering in the dry season. As in Kajelo, the violation of maintenance rules and catchment area protection was also not perceived to be problematic in this context, although water users were well aware of the consequences of dam wall failure or siltation.

There were no conflicts amongst the fishmongers. As the mongers were from different ethnic groups, one could have expected rivalries. But like the fishermen, the

mongers worked closely together and their group was inclusive. The women waited together along the reservoir shore until the fishermen had finished their fishing and sold their catches. The fish was shared depending on what each woman could afford to buy, but more or less equally, so that every woman had something to sell on the next market day.

Network of advice

There was a dense network of information exchange amongst fishermen, mongers, the extension officer and the *tindana* (Figure 7.4). Four to five interview partners included other water users and the assembly woman in the network. Information was exchanged about where which kinds of fish were caught and what type of gear was best. Further, this link category included advice not to catch juvenile fish and training for younger fisherman.

Exchange with mongers mostly contained information about how best to preserve and prepare the fish and which type of fish fetched good prices. Sporadically, encouragement was mentioned by the assembly woman, who also once helped to settle a small conflict between fisherman and mongers.

In the case of the advice network, it was not the presence of linkages that is interesting, but the absence. The only source of new technical knowledge in this network was the CP6. But as in Binduri, the knowledge did not reach the community. When asked why he did not transfer the knowledge from meetings and training sessions with the CP6, the chief fisherman answered that he had tried to convene a meeting, but nobody came.

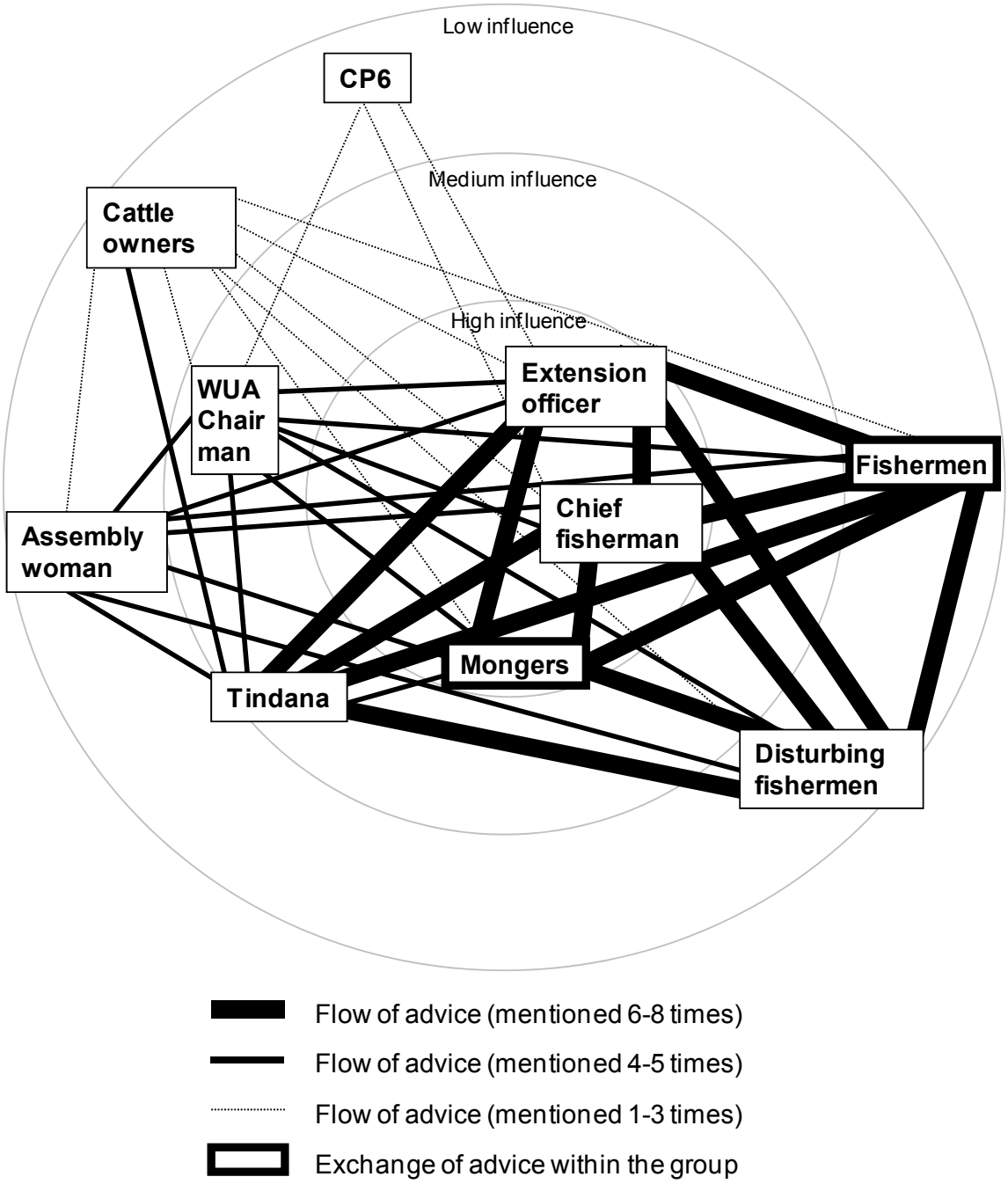


Figure 7.12: Network of advice in Binduri

This was confirmed by the extension officer who explained that, for example, under LACOSREP I it was quite common to provide drinks and snacks for the participants, and many of the NGOs still worked like that during the field research. Under LACOSREP II and in the CP6 no funds for incentives were provided, and the people refused to attend meetings. Other fishermen interviewed stated that the chief fisherman

never tried to call a meeting, because he was afraid that the other fishermen would ask what happened with the contributed money.

As the comparatively high betweenness (Table 7.12) indicates, the extension officer would have been another entry point for the new knowledge. But the extension officer did not speak the local language and usually only talked to the chief fisherman who spoke English (see section 5.3.3). The extension officer also mentioned a connection between the WUA chairman and the CP6 in his interview, explaining the relative betweenness score of the WUA. The WUA chairman himself was not aware of the CP6 and therefore was no entry point for new information.

Table 7.12: Centrality measures of the advice networks in Binduri

Actors	Indegree	Outdegree	Closeness	Betweenness
Chief fisherman	7	6	0.17	0.13
Extension officer	6	7	0.17	0.13
Fishermen	6	6	0.00	0.03
Disturbing fishermen	6	6	0.00	0.03
Mongers	6	6	0.00	0.06
Tindana	6	6	0.00	0.00
Assembly woman	5	5	-0.14	0.00
WUA	5	5	-0.13	0.13
Livestock owners	3	3	-0.58	0.00
CP6	1	1	-0.70	0.00

Despite the language barrier the interview partners insisted on drawing a direct link between the extension officer and the fishermen. It is not clear whether this meant that there was communication despite the language barrier, or whether the interview partners were referring to the retired extension officer from their community.

Network of help and support

As in Kajelo, despite all the conflicts, the help and support network is quite strong and reciprocal (Table 7.13). The informal lead fisherman explained: *„Everybody is included in the help and support network, because we are all one family. Even if some misbehave, in times of trouble we stick together.*" When the issue was investigated in further interviews another fisherman explained: *„He [disturbing fisherman] is a close relative. If I bring him to jail I am also the one to bail him out."*

Fishermen lent gear to each other and pooled their money to buy gear together to reduce purchasing costs. In some cases they even shared catches and lent money and other items to each other. Meals are readily shared, a behavior which was not exclusive amongst fishermen.

Help and support between fishermen and mongers was described as a credit system. Mongers sometimes advanced money as a loan so that the fishermen could buy nets. In some cases, this relationship was extended, for example, the mongers lent money to the fishermen to buy medicine or food. In turn, when mongers were short of money, fishermen provided mongers with fish and received their payment only after the fish was sold.

A few interview partners mentioned the *tindana* as helpful since he sacrifices small animals for the fishermen and pleads with the ancestors for a good catch. In return he receives his share of fish every once in a while. Yet many fishermen do not believe that the success of their fishing operations is in the hands of the ancestors and do not offer sacrifices.

The flow of help and support between the extension officer and the community was controversial. Most of the interview partners stated that it was mostly the chief fisherman who profited from the extension officer's visits, as he was given gear such as rubber boots and nets and was sent to workshops and training courses, where he received food and a daily allowance. The disturbing fishermen even accused him of stealing their fish when he came with the big dragnet. The extension officer explained that he came to Binduri once in a while to carry out stock assessments and to catch fingerlings that he stocks in other reservoirs. The stock assessments are generally necessary to determine which types of fish need to be stocked.

The extension officer explained that he went to other reservoirs and that the fingerlings caught there were then stocked in Binduri, yet he admitted that he took a share of the catch and distributed it to the helpers from outside the community whom he brought to help him with his task.

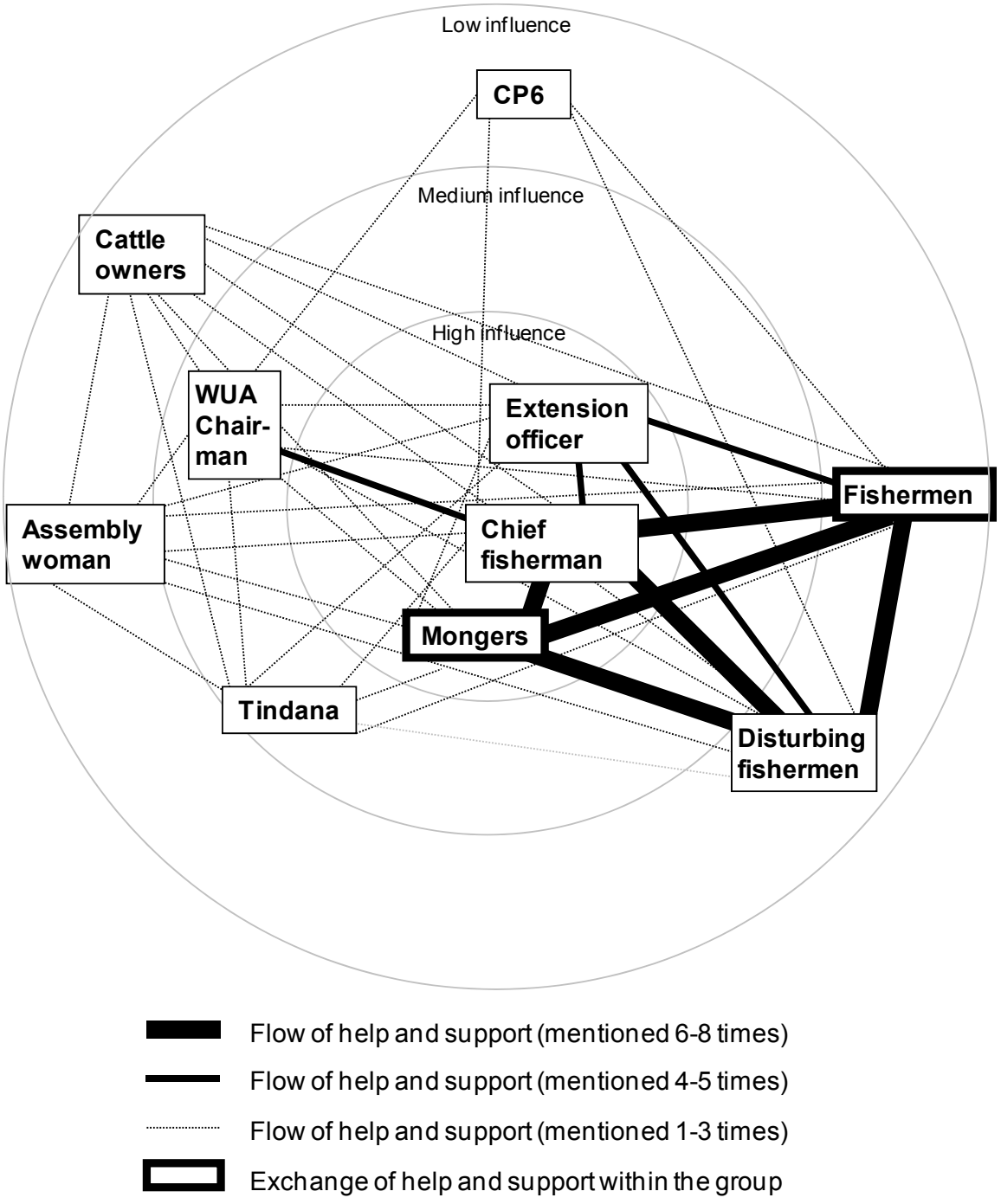


Figure 7.13: Network of help and support in Binduri

He explained that some fish was sold to buy the fuel for the car required to transport the fishing gear and fingerlings. In addition, the fishermen also got their share of the catch and this was confirmed by young fishermen. Furthermore, the extension officer stated

that he helped the community by suggesting them for the CP6, which was, however, not recognized by the community.

Table 7.13: Centrality measures of the help and support networks in Binduri

Actors	Indegree	Outdegree	Closeness	Betweenness
Chief fisherman	5	5	0.22	0.33
Fishermen	5	4	0.06	0.33
Disturbing fishermen	5	4	0.06	0.33
Mongers	4	4	0.05	0.00
Extension officer	3	4	-0.12	0.50
Tindana	3	3	-0.57	0.00
Assembly woman	3	3	-0.57	0.00
WUA	2	2	-0.42	0.00
Livestock owners	1	1	-0.86	0.00
CP6	1	1	-0.69	0.00

Network of instructions

The instruction link was the only relation where the definitions differed considerably from each other. Even when excluding those connections only mentioned one to three times in this context, the network is still consistent (Figure 7.14), and has, like the centrality measures (Figure 7.14), only limited validity. Mostly, instructions were described as rather strong suggestions or recommendations based on customs that are not legally binding. Although most interview partners stated that the extension officer could issue instructions, which was also reflected in the height of the influence tower and high outdegree, he himself explained that this was a wrong assumption. For example he has no legal back-up to arrest fishermen when they break the rules.

He told the following story:

> *„Once I was beaten up by a fisherman in another village when I tried to stop him from fishing in banning season by taking away his fishing net and keeping it until fishing is opened again. I was terrible beaten up, but the judge decided that since I had no right to take the fisherman's net, it was my own fault. Since that time I do not try to stop people from fishing anymore.*"

Another example provided by several interview partners for this link category was an incident that happened some years ago. Fishmongers from Bawku town came to buy the fish from the reservoirs, as they would get a good price for the fish in town. They paid a higher price to the fishermen than the community mongers would pay, and fishermen stopped selling the fish to the local mongers. The local mongers appealed to

the assembly woman, the *tindana,* and the WUA executive, and the mongers from outside and the fishermen were instructed to end their trade relations. These instructions were followed, and the fishermen sold the fish to local mongers again.

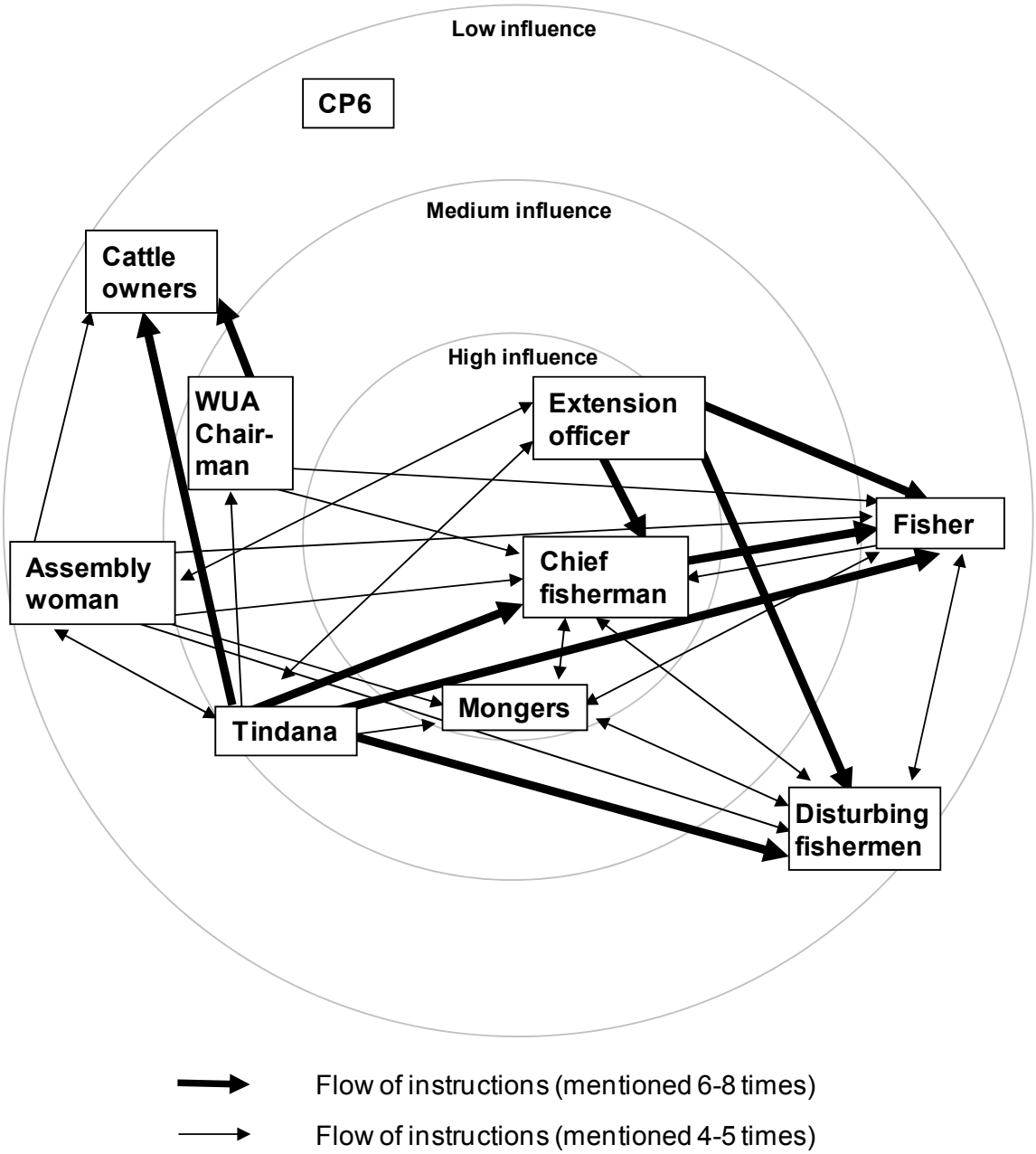


Figure 7.14: Network of instructions in Binduri

As pointed out above, the mongers shared the fishermen's catch. If a monger tried to get more fish or sold fish at dumping prices, the older mongers instructed her to get in line with the others again. While this worked surprisingly well, the mongers could not say

what would happen if one monger were to decide to continue this perceived unfair practice as this had never happened. However, instructions had no effect on the disturbing fishermen, who broke the rules unimpressed by logic reasoning, prompting notes, or threats of sanctions.

Table 7.14: Centrality measures of the instructions networks in Binduri

Actors	Indegree	Outdegree	Closeness	Betweenness
WUA	3	3	-0.14	1.16
Tindana	2	5	-0.02	0.73
Extension officer	2	5	-0.02	0.30
Assembly woman	1	4	-0.03	0.30
Livestock owners	2	2	-0.53	0.11
Chief fisherman	5	3	0.19	0.08
Fishermen	5	3	-0.03	0.08
Mongers	4	2	-0.19	0.07
Disturbing fishermen	5	2	-0.04	0.02
CP6	1	1	-0.79	0.00

7.4 Networks of resource exploitation

In the following, the data described above are discussed within the context of social network analysis concepts, size of the network, reachability, reciprocity, and also individual nodes with their roles and ties in connection with the adaptive co-management approach as described in section 2.3.3.

When the networks depicted all the fishermen, fishmongers and other actors individually, the network would look large. Although there are quite a number of individual actors, this cannot hide the fact that beyond the communities there are hardly any actors apart from the extension staff, and in the case of Kajelo and Binduri the CP6. Yet it is remarkable to realize the influence that international donors have as their paradigms are transported well, even into the most remote villages using, at least in the described case studies, governmental extension service. The ways these paradigms are implemented often leave communities without a choice of accepting or not. In all three cases, the rehabilitation of infrastructure and the stocking of reservoirs with fish in Binduri and Kajelo were closely tied to the establishment of a community-based democratic management approach in the form of Water User Associations and fishermen groups as described in section 4.3.3.

It was the responsibility of the extension staff to establish these groups and make them work according to the pre-defined scheme. Training on group formation for example was not provided to the extension staff, just as there was no money to visit the communities regularly to provide help when needed. So without considering local circumstances, traditions or knowledge, the extension staff implemented the idea of community-based management, in the top-down approach they had been used to since colonial times and which is still highly popular in the administrative structure of the Ghanaian government.

While it is implicit in the idea of "community-based management" that the responsibility of management lies within the community, the complex tasks of reservoir management are generally a heavy burden for the communities, which usually also lacked the experience required for participatory resource management. Neither the patriarchic ruling of the traditional authorities, nor the top-down approaches of the colonials or post-independence extension services prepared the communities for the democratic processes required to organize water use as a WUA, or the use of fisheries resources in fishermen associations. The absence of human capacity to go along with such a process, for example trained extension staff who could moderate and facilitate the negotiation of common mental models, seek solutions for leadership which meet everybody's approval, or establish transparent financial structures, resulted in a complete failure, at least in fisheries management. In the case of Dasabligo and Atonbogoro, the complex requirements of water management even led to the blockage of water use for irrigation and the infrastructure lay fallow (see section 5.1.2). In Kajelo, water allocation at least in the dry season leads to constant conflicts, and although the livestock owners try to use their influence, younger fishermen resist the decisions of the elders which are often in favor of the livestock owners. In most cases, be it water management in general or fisheries management in particular, the implementation of the community-based management did not result in an increased feeling of ownership and subsequent greater efforts to protect resources from deterioration. The impression of state abdication of responsibility, which already established when the training camps were closed down and extension staff was withdrawn, deepened. The communities, however, were not the only ones who felt abandoned. The absence of clear fishing rules and bye-laws, the continued integration and disintegration of fisheries and the Ministry

of Food and Agriculture as well as the limited funding caused a lot of confusion, frustration and eventually most extension staff lost all dedication to their jobs.

The low diversity of actors has furthermore the consequence that the access to diverse kinds of knowledge is limited. In the resilience literature this is associated with limited flexibility to react to sudden events, as knowledge and assets to design new strategies and adapt to new circumstances are rather limited. The results of the interviews about the fishermen's local ecological knowledge as described in chapter 6 show that there is quite some knowledge about the resource as such. Investigations also showed that albeit fishermen were not involved actively in the management of the fisheries activities applied formerly by the extension staff (i.e. recording the catches of fishermen and setting limits to the number of fishing days or enforcing regulations on net mesh sizes), many fishermen are aware of the fishing rules. Even technical knowledge is available to some extent when considering the CP6.

When looking at the advice networks of the villages, there also seems to be a lively exchange of information and knowledge amongst the fishermen and fish monger community in all four communities, which to some extent involved traditional authorities and other water users. The information flow also includes training which is shared readily between older fishermen and young men who want to learn fishing, or knowledgeable fishmongers and young girls. It is important to note that this flow easily crosses ethnic boarders and mixed fishmonger groups are common. Surprisingly, even in Binduri, which was supposed to have the biggest problems with ethnic rivalries, small groups of fishermen from different ethnic groups were observed meeting and going fishing together.

An exception to the free flow of information is the information about the hapa technology. Here the information coming from outside the community did not reach the majority of the community members, not even the fishermen. The reason for this is that not many fishermen from the villages participated in the hapa training and trial. Only the chief fishermen were involved and there the information flow stopped. The extension staff was also not able to bridge the information gap. Reasons for this blockage of information are not revealed by looking at the network structure, but by looking at the roles and characteristics of individual actors discussed later.

Although the networks of advice were also inclusive and reciprocal in the cases of Dasabligo and Atonbogoro, the knowledge about fisheries management was limited to the traditional rules, with the exception of the ban on poison.

According to the adaptive co-management literature, successful management also needs trust and social capital. Trust, that the leaders make the right decisions and do not abuse their power, and trust that fellows also stick to the rules. Social capital, closely connected to trust, is needed to enforce social control and also provide flexibility through providing, e.g., social, financial or other kinds of security when, for example, experimenting with new ideas. When looking at the reciprocity of the help and support networks one might conclude that there is a lot of trust and social capital, especially when interview partners kept emphasizing that these work especially in times of crisis and across ethnic boarders. Yet when taking a closer look beyond network structures, then it becomes evident that social networks cannot be used without further ado to implement fishing rules, as this might jeopardize the sometimes very fragile peace of the community. Especially when, as in Kajelo and Binduri, there is still some fish in the reservoir and the outcome of management efforts is not clear.

Another problem is that the strong help and support networks might only suggest that there is a high level of trust and social capital, when in reality there isn't. Looking at the networks of conflicts give rise to these doubts. There, deep distrust within the communities becomes evident. The analysis of network structures is not sufficient to uncover reasons for deep distrust and conflicts within the communities and beyond. Again it is necessary to look at the roles and characteristics of actors as well as past developments.

One of the most important roles in management is that of a leader who can make decisions and who serves the people as a good example. Furthermore, a leader should be able to mediate controversial discussions in a fair and transparent manner and in many cases leaders have also the role of the broker, by bridging the gap between the community and outside actors.

When looking at the networks depicted above, the actor who should play this role is the chief fisherman, preferably with support from the extension staff. Attempts to establish such a leadership within the communities did, however, result in the opposite, at least in Binduri and Kajelo. Not all fishermen agreed to the democratic election

process and refused to accept the elected leaders. In addition, the accusations that the leaders took a share of the monetary contributions, whether true or not, rocked the trust of the fishermen deeply, and this was amplified by the fact that the management rules were violated by the leaders. The problem of drunkenness was often mentioned in the context of disturbances, and it was also often difficult during the field research to work with those people. High aggressiveness and low acceptance of logical reasoning certainly does not make the cooperation with those fishermen any easier. In this light it is especially problematic that the lead fishermen were also prone to alcohol abuse and it further weakened their position.

Despite their efforts and assured willingness, the extension staff often worsened the situation rather than helping it. Although the preference of some fishermen over others is understandable, it is very problematic and led in Kajelo and Binduri to a disintegration of the fishermen community into hostile sub-groups.

The whole situation worsened even more when the extension staff only invited the chief fishermen to the hapa training and implementation. Based on the difficulties with the chief fishermen in the past, people in both the communities of Kajelo and Binduri were not prepared to listen anymore and rejected the information when the chief fishermen tried to call a meeting to inform the community about ongoing activities.

In the case of Atonbogoro and Dasabligo, the chief fishermen neither had problems with their reputation, nor with distrust. However, they also did not enforce traditional rules and have no contact to actors outside the communities. Whether they would be able to enforce rules, when subject to a fisheries management project, such as the community-based management attempts in Kajelo and Binduri, remains unknown. There are, however, at least some doubts whether such an attempt would be successful, because, as was described earlier, it did not work for the overall water management.

In all four communities, villagers confirmed that the traditional authorities were still in the position to calm down tensions and solve conflicts amongst members of the communities. Yet especially younger and often better educated men who consider themselves as enlightened and who no longer want to believe in the power of ancestors dislike the untransparent decision-making and are less willing to accept traditional authority. Furthermore, the involvement of traditional authorities in fisheries management and enforcement of fishing rules is marginal.

So for differing reasons in none of the villages does anyone feel responsible or is anyone legitimated to facilitate the development of common goals, implement and coordinate management tasks or introduce and promote new ideas. As a consequence the reservoirs are now open for everybody to go fishing without following rules and many actors even encourage indiscriminate fishing either due to ignorance or frustration.

A group of actors that was almost completely ignored in the context of fisheries management, but could possibly contribute to an improvement of the situation were the fishmongers. The two informal fishmonger groups in Kajelo and Binduri seem to be much more cohesive than those of the fishermen, and as retailers they have some power. As their livelihoods usually also depend on the fish yields from the reservoirs, they have a vital interest in the resource and might be able to contribute to its sustainable management.

The same applies to the assembly men. Though they were hardly involved in the fishing activities, they usually have some moderating skills and might be able to connect the fisheries communities better to the outside world. Further, their authority is legitimized by elections, and they have greater influence on those who turn away from the old institutions.

7.5 Difficulties and obstacles encountered during the research

During the research using the Net-Map tool and other participatory appraisal tools, a number of difficulties and obstacles were encountered, which are discussed in the following.

Through a multitude of aid projects, the people in the study communities were very much familiar with participatory appraisal methods. It was observed repeatedly that in the hope that they would be selected for a possible future project, people tried to guess what the author would like to hear in order to give a strategic answer. Much more problematic than the strategic answering were, however, investigations concerning conflicting situations. In Ghana, conflicts based on ethnic rivalries still arise. Signs of these conflicts could be observed during the field trip in 2008 around the Bawku area, where the rivalries developed into deadly ethnic clashes. Although the communities of the case studies were generally peaceful, apart from Kajelo, all communities were home

to at least two different ethnic groups, and no sensitive issues were tackled in open group discussions. Consequently, some conflicts concerning natural resource management remained unsolved, as much more time would have been needed for sensitive and careful investigation.

Especially the drawing of networks was highly sensitive, as some interview partners were chosen according to their opposing roles in the management of reservoirs. Talking about conflicts in social networks requires absolutely complete trust between interviewer and interview partner. Respondents were not familiar with the systematic enquiries about social structures and influence, which proved on the one hand to be extremely helpful in avoiding strategic answering. On the other hand, it took some time to build up trust and assure respondents of confidentiality.

Another challenge during the research process arose from the language barrier and cultural differences, which led to difficulties in developing a common understanding of different terms, such as influence or instruction. A similar problem was the clarity about a situation. Although the interview partners were asked to provide examples in order to explain what they meant concerning the particular types of relations, in some cases it did not become entirely clear whether the actual situation was depicted, or the situation as it should be. Clarification was time consuming and some aspects remain ambiguous.

Theoretically, there could be problems in the comparability of interviews conducted with individuals and small groups. Based on the limited number of cases, no correlation could be found between the number of interview partners and the number of actors or linkages mentioned, and thus no differences were observed during analysis. Possible differences in answering patterns would need to be investigated in a larger study. The same applies in the context of statistical representativeness.

Despite these shortcomings, the experiences show that the Net-Map tool provides a useful tool for collecting network data, as it helps to structure the interviewing process. However, it is agreed with Schnegg (2001) that prior knowledge of the research area remains essential.

8 CONCLUSIONS AND DEVELOPMENT SCENARIOS

8.1 Conclusions

As pointed out in the introduction this study aims to contribute to the resilience of the rural poor in the Upper East Region of Ghana to environmental disturbances through improved understanding of the potentials of fisheries in small reservoirs. Resilience is thereby understood as the potential to create opportunities for doing new things, for innovation and development, even, or especially, during times of disturbance or crisis. Thereby the analysis of potentials was carried out in three steps. In a first step the analysis focused on how fishing in small reservoirs and selling the catch influences the opportunities for doing new things, for innovation and for development. The second step was dedicated to the analysis of the ecological potentials of the small reservoirs to provide aquatic resources even in times of disturbance such as high fishing pressure at the end of the dry season, and the potential to enhance fish yields through increased fish production in harmony with other water uses. The third dimension of the analysis used the methods provided by social network analysis to check the social potentialities for innovation and development necessary to realize the ecological potential of the reservoirs for improved human well-being in times of increasing environmental disturbances.

The assumption that people in the Upper East Region of Ghana neither know how to fish nor eat fish (see section 1.1) leads today to an almost complete neglect of fisheries development in northern Ghana, both by national politics and international donors (see section 5.3.3). Thus, probably the most important finding of this study is the fact that people have integrated fishing and selling of fish into their livelihood portfolios.

The historical analysis (see section 5.3) showed that fishing was part of the traditional livelihood portfolio, although limited to the dry season and to a few waterbodies. It does not come as a surprise that, once villagers learned how to fish in the reservoirs, fishing was quickly integrated into the livelihood portfolios in terms of income generation and of protein supply. The income from fishing is lifting about 15% of the economically active male population in the study communities out of absolute poverty (see section 5.2.1). In dry seasons, which follow ample rainfall, fishing yields

enough income to lift the men above the national poverty threshold of GHS 1.47 per capita per day (see section 5.2.3). The number and income of fishmongers are much lower, yet many women rank the income from fish mongering high, and their growing number shows the attractiveness of the activity (see section 5.2.2).

While income from fishing alone does not ensure the escape from poverty completely, it provides the possibility to diversify the income. Through a diversified income, households become less vulnerable to the failure of their other livelihood strategies. Furthermore, it helps the fishermen and their families to bridge the dry and, more important, the hunger season (see section 4.2.3), when other income sources are scarce and all other resources have to be invested into rainfed farming. Based on statements of most interview partners, it can be assumed that fish not only serves as an income source, but also improves diets. In sum, it can be concluded from chapter 5 that fisheries and selling of fish contributes to the resilience of the people by improving diets and helping to bridge the hunger gap. Furthermore, the income from fishing and selling fish can be used to invest in other livelihood strategies, such as farming and gardening. However, there are also drawbacks, especially negative effects of fishing activities on the health of the fishermen (see section 5.2.4), which would need further research.

Due to the preliminary survey (see section 3.1.3), it was clear that no data existed that allow the analysis of fish yields and enhanced production potentials on a scientifically sound basis. Furthermore, the time and labor constraints made the collection of a statistically representative number of cases impossible. This was clear from the beginning and therefore this research was designed to allow very different sources of data to be combined. At the center of the ecological study stands local ecological knowledge, assuming that fishermen developed a rich understanding of their resources due to long-term observations and, although unintended, trials and errors accomplished during many years of fishing experience in different waterbodies. The fishermen's knowledge was supplemented by collected primary data as well as literature to round up the findings. And while the conclusions are still rather vague, there are a few facts that are very interesting. The first and maybe most important fact is that, independent of whether the reservoirs were initially stocked or not, there is a natural fish population. This can be taken from the case of Dasabligo reservoir, which, without having ever been stocked, has a fish fauna even more diverse than in the other two

reservoirs (section 6.2.3). More important in this context, however, are the comments of the fishermen that there was fish in the reservoirs that were never stocked when they learned fishing from the fisheries department. Their reports from fishing trips to other unstocked water bodies, also support the conclusion that usually a natural fish stock in reservoirs establishes over time.

Although this sounds trivial, for communities that do not use their reservoirs for fishing it is not! It means that many communities have a source of income and protein at their feet and with some training and access to gear, the resilience of many thousands of families could be increased, simply by using the naturally occurring aquatic resources in the reservoirs. Unclear remains in contrast, how high the fish production is on average. Although the Dasabligo case suggests that it is rather low, it is doubtful to conclude an overall low natural fish production in small reservoirs for several reasons. Results from the measurements of oxygen, transparency and other indicators, as well as the statements of other fishermen who compared the conditions in the Dasabligo reservoir with other reservoirs, show that the feed availability in the Dasabligo reservoir is rather low and it can be assumed accordingly that the fish production is low. Furthermore, it remains unclear where the balance is between the natural recovery rate of the fish stocks in the rainy season and the fish catches in the dry season. Interestingly, fishermen of all three reservoirs admit that it is their indiscriminate fishing and their large number that leads to a decline in fishing yields. However, data from this study do not support the conclusion that the higher the fishing pressure, the smaller the fish stock, but rather the opposite. Kajelo, with 1717 fishing days/ha/year, has by far the highest fishing pressure, but also the highest fish yields (section 6.2.1 & 6.2.2). In contrast, Dasabligo with only 379 fishing days/ha/year has by far the lowest fish yields. Yet of course it can be argued that Kajelo is a special case as the reservoir was stocked only recently. However, this fact allows another assumption, namely that the reservoirs have an ecological potential for increased production. Unfortunately, this study remains far from any predictions about possible future yields.

This is, however, exactly the starting point for an adaptive co-management approach, which is designed for the work under high uncertainty. Yet the approach has, as described in the second chapter of this study, a number of pre-requisites that need to be fulfilled in order to manage reservoirs and the user community in a way that the new

livelihood strategies of fishing and selling of fish increase the opportunities for doing new things, for innovation and development, beyond their current levels. These pre-requisites are (social) learning, access to knowledge and a storage facility in the form of a social or collective memory. Participation, collaboration and communication were also perceived to be important, as were common mental models or visions, flexibility, leadership, trust and social capital.

These are very demanding pre-requisites, especially when taking into consideration that, as described in section 6.3.2, the reservoir user communities not only fail to manage the fisheries resources of the reservoirs, but also they hardly even have the capacity to care for infrastructure maintenance. Removing trees and farming in the catchment area, which triggers siltation of the reservoirs, are common, and no money is saved for repairs. Without maintenance, however, the deterioration of the infrastructures is inevitable, as dam wall failures in the communities have already shown.

When striking a balance of which pre-requisites are fulfilled for an adaptive co-management the result discussed in section 7.4 is staggering. While the communities show the capacity for social learning, they have mostly learned bitter lessons from past management experience. Their memories contain state abdication of responsibility, failing leaders and distrust against fellow fishermen and other water users. These and other problems weaken their social networks and looking at these experiences it does not come as a surprise that without evident benefits, they are not prepared to jeopardize their networks further by implementing fishing rules. Some people also developed a dismissive attitude towards new ideas from outside and discouraged others from considering new options. The relationship between extension staff and communities are also more than complicated (Chapters 5 and 7). In more than one situation their involvement worsened the conflict laden situation in the villages. This can be ascribed to the poor training of the extension staff in resolving difficult situations. Moreover, their financial capacity is extremely limited and especially remote communities cannot be visited with the frequency needed to accompany the implementation of a new management approach. In addition, the language barrier, e.g. in the case of Binduri, led to a blockage of knowledge transfer from the extension staff to the fishermen and adverse relations amongst the fishermen. Strong bonding ties and constraining social

norms amongst the community members further limited acceptance of the new technological options.

These developments allow the questions whether the communities need another pre-described management approach such as adaptive co-management, even if it fits perfectly in theory. Past experiences leave at least some doubts that even with most flexible implementation, the approach cannot cope with the complex situations in many communities if so many pre-requisites need to be fulfilled.

In order to learn and to adapt management to uncertainties, the communities need far more than technical solutions, prescribed management concepts, and training. The communities need qualified extension services which support them in finding their own management solutions to fit their needs and that are adapted to the specifics of their reality. They need donors who do not keep telling them what is best for them, but instead are willing to accept the solutions that satisfy communities even if they do not fit the donor's agenda and timeline. Furthermore, much more attention needs to be paid in order to avoid manipulation of the development and research agenda by national, regional and local elites for their own benefits. As demanded by Boonzaaijer and Apusigah (2008, p.10), for example, an endogenous development concept must include *„privileging local control of the development process; taking cultural values seriously; and finding a balance between traditional and external resources and knowledge to manage change (social progress) in ways that are cultural relevant and appropriate.*" This includes allowing the people to chose for themselves whether they want to take risks and manage their resources to increase yields, or take the resource as it is.

8.2 Development scenarios

In this study, scenarios are understood as thinking ahead of complex and linked futures, considering uncertainties and risks in order to estimate the consequences of action in the present. The descriptive scenarios were constructed based on suggestions of Schoemaker (2001), Neumann (2005) as well as Fink and Siebe (2006). The following steps were taken: 1) define the scope of the scenario, 2) identify major players and basic trends, 3) identify key uncertainties and risks, 4) decide on scenario themes, and 5) describe the scenarios and strategies that led to the described developments.

Descriptive scenarios were chosen over simple recommendations. First, to allow stakeholders to choose from multiple suggestions according to their assessment of the situation and needs. Second, the scenarios can be used as a base for further discussion and research, since the number of uncertain variables is still too high for recommendations based on prognostic approaches.

- The scope of the scenarios is to view the living conditions and resilience of the local population and their livelihoods in the UER related to fisheries in small reservoirs.
- The time frame is 10 years, from 2010 to 2020.
- Major players involved are the men and women of reservoir communities, fisheries extension staff from governmental organizations, politicians, NGOs, donors, research organizations, and private entrepreneurs.
- Basic trends are: 1) a growing demand for protein especially in urban centers, 2) growing population, 3) rising costs for food and living, 4) improved transportation, 5) improved education of younger people, and 6) increasingly individual and core family lifestyles.
- Key uncertainties and risks: 1) extreme climatic events, 2) political will to improve the livelihoods of the poor in northern Ghana, 3) valuation of the importance of inland fisheries in the international donor community, and 4) attitude of the stakeholders towards each other.

Scenario 1: Business as usual

State of development in 2020

Not much has changed in the fisheries sector in the Upper East Region in the year 2020 and the aquatic resources of many reservoirs are still not used. However, due to a small development project, four successful enterprises established aquaculture in ponds that receive their water from the Tono and Vea reservoirs. The fish produced is exported to urban centers such as Tamale and even Accra and Kumasi, where, due to a continued increase in incomes, the purchasing power is high. The aquaculture enterprises are run by a few wealthy private entrepreneurs. Although these entrepreneurs had lost three complete harvests and subsequently their investments since 2010 due to a flooding of the ponds after extreme rainfall and 2 dry ups of the ponds during prolonged dry spells,

their savings are high enough to cope with the losses. Apart from an improvement in the livelihoods of a few employees, this development has a rather limited pro-poor impact, as the table-size fish produced is far too expensive for local markets.

The number of fishermen and fishmongers has increased slightly in the last ten years although only in the communities that already had fishermen. There is only a sporadic expansion of the livelihood strategy into communities that did not use their reservoir for fishing 10 years ago. Despite considerable improvements in transport infrastructure, the export of the rather small amounts of fresh fish from the reservoirs is still not viable, as cooled transport is still expensive. Also the availability of fishing gear in rural areas is still limited.

Unlike the fishing activities, gardening in the irrigated areas has prospered, as the demand for the irrigated crops has increased continuously and uncooled haulage to urban centers is better than ever. These improvements are mainly a product of a large development project that started in 2010 and supported the development of market chains all over northern Ghana. Yet the erratic climate as well as plant diseases causes much damage to irrigated crop production. While wealthier households are able to cope with the shocks and improve their situation continuously, poorer households often struggle or fail to repay credits for farm investments. The increasing number of people, individualization and rising costs of living make the irrigation plots very valuable and many poor households are forced to give up or rent out their irrigation plots to wealthier families to repay loans and/or buy food. After a slack period of migration due to worsening working conditions in southern Ghana, especially younger men are migrating more frequently again, since there is not enough land to employ them in the home communities in northern Ghana. Due to lacking perspectives in the countryside, most educated people migrate permanently to the south.

Development strategies that lead to this development

This scenario is based on the assumption that nothing changed in the political will, public interest and funding concerning the development of fisheries and, apart from the above described activities, no strategies were pursued.

Scenario 2: All reservoirs are used for fishing

State of development in 2020

Almost all reservoirs in the UER are frequently used for fishing by fishermen from the local communities. Due to the exploitation of the aquatic resources of the reservoirs, the supply of protein even in remote areas is significantly lower. The hunger season is bridged more easily not only by consuming the fish, but by selling it or exchanging it for other staple foods.

The vulnerability of households with a fisherman or monger towards shocks is, however, only slightly reduced. Financial shocks from the loss of crops due to extreme climatic events or fall in crop prices on the world markets are hardly buffered, since the cash income from fishing is low. This is due to the fact that the natural fish production of the reservoirs is limited and nothing is done to enhance it. Moreover, the health problems many fishermen face discourage those who have an alternative. Despite improved transportation, the export of fish from rural to urban areas is still not viable, as the amount of harvested fresh fish for export is still too small. Due to the rather small financial benefits that can be gained, fishing is usually carried out by the poor and uneducated who have not enough land to sustain their families with rainfed and irrigated farming. While seasonal migration is reduced, permanent migration increases as young and educated men still prefer to move to the urban centers.

The development of irrigation is the same as in Scenario 1. Based on the increased use of reservoirs for fishing, conflicts with other reservoir users, especially those with irrigated plots, has increased and in years with low rainfall many of these conflicts escalate, leading to a hostile atmosphere in many communities.

Development strategies that lead to this development

Despite the political will to improve fisheries in the north, the importance of developing inland fisheries is not very high on the donor agenda, and hardly any funds are spent in this particular sector. However, the regional fisheries department established a small mobile training unit in cooperation with an NGO. In order to fund the unit, the budget of the fisheries department was reallocated. Instead of promoting aquaculture projects that serve just a few better-off entrepreneurs, the training unit is equipped with a vehicle and small additional allowances for the trainers to compensate their travel expenses. The NGO can raise some small funds from donors and assists in the organization of the

trips, community introductions and training methods. The training unit moves into a community that has a reservoir but no fishing skills. The training unit stays for two to three weeks and teaches a few men how to fish and construct gear and commits them to share their knowledge with other interested community members.

Part of the problem for the development of fisheries activities in the UER is the limited availability of fishing gear, especially in the remote communities. Besides training, the mobile units provide gear at moderate prices. The organization of such a unit would certainly take some time, so would the identification of communities. Due to the limited budget, the number of communities that can be trained per year is certainly also limited.

Scenario 3: Fishing and aquaculture as one economic pillar of the UER

Stage of development in 2020

Due to empty oceans, animal diseases and steep increases in demand for protein on the world market, the prices for protein have exploded since 2010, and the Ghanaian government and the donor community have realized the need to enhance inland fisheries and aquaculture. Based on this understanding, an international donor decided to launch a large-scale project to boost fisheries in small reservoirs in northern Ghana in 2014.

As a consequence, many reservoirs in northern Ghana are used for fisheries, and many of them are managed in a way that increases fish production significantly. Thereby every community has developed its own management style including the sharing of profits from increased fish production. In some communities with larger and deeper reservoirs, fish cages have been installed that produce table size Tilapia for export. Smaller shallower reservoirs enhance their fish production by using *hapas* to stock the reservoirs, create breeding grounds in the reservoirs and carefully increase nutrient contents under constant monitoring of the water quality. The monitoring is carried out by trained villagers with guidance from extension staff from the governmental fisheries department. The department further provides technical assistance if needed, e.g., with the construction of aquaculture ponds, which are built with the profits from fish production in the reservoirs. A group of scientists from a local water research institute monitors the long-term effects of the intensified use of the

reservoirs for fisheries, other water uses and the surrounding environment. The health status of the fishermen is also assessed.

Due to the increased production of fish a threshold is crossed, even the export of fish from the more rural areas is profitable, and a number of private entrepreneurs organized the transport and sale of the fish. They also supply the communities with fish food, fingerlings and other material needed for increased fish production. In order to avoid dependencies, NGOs are involved in the supply of small credits and insurances for the loss of income due to extreme climatic events. Also they support the water user associations in the formulation of bye-laws, conflict mitigation or the evaluation of competitive bids for dam wall repairs or other construction work. An international donor oversees accounting of the actors who receive financial and material aid to avoid elite capture, coordinates activities, and facilitates the exchange between practitioners and scientists.

Despite all well meaning, however, western oriented development paradigms could not be overcome in favor of the manifold local realities. In spite of considerable effort to include the communities in all planning steps and work in a participatory way, the process is steered by guidelines given by the international donor, and putting local stakeholders under tutelage cannot be avoided entirely. Thus it is not clear to which extent services, for example offered by NGOs, can be continued after the donor phases out. Furthermore, the elite capture of resources provided by the development project cannot be entirely avoided, and especially private entrepreneurs who build up a supra-regional sales network profit from the developments.

Development strategies that lead to this development

The third scenario is based on a large-scale development project which integrates a large range of fisheries enhancement technologies from low-cost to high tech, accompanied by long-term research that monitors and evaluates the effects of the technologies. Staff for the fisheries department is hired from the Universities of Development Studies in Navrongo and Tamale, which both have a fisheries or an aquaculture branch. Together with the well-versed extension staff, they are trained in technical innovations and assist communities as well as the scientists with data collection and technical problems in the field.

However, the core of the project is a team of scientists and development practitioners who are responsible for the establishment of human capacity for management. They treat communities not as aid recipients but rather as clients, and explain to interested communities the benefits of the project as well as the costs. Costs consist in the beginning mainly of time that needs to be invested in order to design a management approach and implement it. One of the most important tasks of the transdisciplinary team is the development of methods that allow the articulation of concerns and solutions of as many villagers as possible, i.e., including fishmongers and young fishermen, to avoid the manipulation by local elites. Costs for investments in enhancement technologies and networking to ensure that the fish is bought are in the first rounds funded by the development project. Profits from increased fish production are to some extent re-invested in new production cycles and distributed amongst villagers, but some money is also used to pay back initial investments. However, a credit and insurance component of the project ensures that failures in fish production due to climatic events or disease are buffered. Those villagers who take over specific management tasks such as bookkeeping or organization of meetings receive allowances to compensate for their lack of work in their other livelihood strategies. The same applies to those villagers who monitor the water quality and watch over the fish stock to avoid theft. The involvement of fishmongers in the training is essential, as they prove to be excellent at organizing the management groups. But also other water users are involved in the project to strengthen the social networks, e.g., by developing common goals for the reservoir use or confidence-building measures and other exercises to reduce adverse relations. In many communities, the assembly people take over the moderation of discussion processes.

As the three scenarios show, development interventions are always prone to elite capture. The development of fisheries in small reservoirs into a livelihood strategy to strengthen the resilience of the local population and their livelihoods is closely tied to the willingness and efforts of policy makers, international donors and research organizations to focus on the needs of the rural poor and to accept local solutions, even if this means higher costs and longer time spans.

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10 APPENDIX

Questionnaire

Reservoir (Kajelo/Binduri/Dasabligo)
Name of fishermen:_____ No._____
Date:_____ Name of Interviewer_____

How many nets do you have:
Castnet:_____ Gill/Cross-net: _____ Line and hooks:_____?

Why do you prefer the gear you have?
_____
_____

What species do you catch?
_____
_____

Do you target fish species? Why?
_____
_____

Does the profit from fish vary according to size or species?
_____
_____

What do you earn per day from fishing in the 2008 dry season:_____GHS/day
What did you earn per day from fishing in the 2007 dry season:_____GHS/day

How often do you go fishing in this reservoir in the 2008 dry season:_____days/week
How often did you go fishing in this reservoir in the 2007 dry season:_____days/week

How often do you go fishing in general in the 2008 dry season season:____days/week
How often did you go fishing in general in the 2007 dry season season:____days/week

What do you earn per day from fishing in the 2008 rainy season:_____Cedis/day
What did you earn per day from fishing in the 2007 rainy season:_____Cedis/day

How often do you go fishing in this reservoir in the 2008 rainy season:_____days/week
How often did you go fishing in this reservoir in the 2007 rainy season:_____days/week

How often do you go fishing in general in the 2008 rainy season:_____days/week
How often did you go fishing in general in the 2007 rainy season:_____days/week

Are there differences between last year's catch/income and this year? Why?
_____
_____
_____
_____

Castnet

Species	Tilapia small	Tilapia medium	Tilapia large	Clarias small	Clarias medium	Clarias large
Number of fish / day / dry season						
Species	Tilapia small	Tilapia medium	Tilapia large	Clarias small	Clarias medium	Clarias large
Number of fish / day / rainy season						

Crossnet/Gilnet

Species	Tilapia small	Tilapia medium	Tilapia large	Clarias small	Clarias medium	Clarias large
Number of fish / day / dry season						
Species	Tilapia small	Tilapia medium	Tilapia large	Clarias small	Clarias medium	Clarias large
Number of fish / day / rainy season						

Line and hooks

Species	Tilapia small	Tilapia medium	Tilapia large	Clarias small	Clarias medium	Clarias large
Number of fish / day / dry season						
Species	Tilapia small	Tilapia medium	Tilapia large	Clarias small	Clarias medium	Clarias large
Number of fish / day / rainy season						

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