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The impact of socio-economic development and climate change on livestock management in Benin

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Abstract

The impact of socio-economic development and climate change on livestock management in Benin

Ina Gruber

Livestock management is a rapidly changing sector in developing countries due to increasing demand for animal products and changes in the availability of common resources. Moreover, livestock management is important as it can contribute to achieving the Millennium Development Goals with regard to poverty alleviation, health improvement, and environmental sustainability. In this thesis, the impact of three major driving forces (population growth, increasing income, and climate change) on livestock husbandry in Benin is analysed. This study aims to contribute to and deepen the general understanding of livestock management in Benin and its possible developments in order to benefit from the potential of the sector.

The methodological approach of triangulation is used both for the analysis of the current situation and for the future development. To capture the status quo, two surveys were conducted among livestock keepers and local experts supplemented by secondary data. To identify possible future development paths, agricultural development theories, experiences in other developing countries, and the results of the expert survey concerning future trends have been used. The findings of this analysis enter the quantitative agricultural sector model BenIMPACT which has been further developed and applied to the livestock sector for scenario analysis.

The current situation in livestock husbandry is characterised by extensive production methods depending heavily on the common resources of water and pasture. The low productivity is accompanied by a multi-purpose motivation for livestock keeping that is not only income-orientated. The survey reveals that the major production problem is the inadequate and insufficient supply of fodder, and market behaviour of livestock producers differs according to region. The findings of the study concerning future development disclose that population growth has a greater impact on the livestock sector in Benin than increasing income. Shifts in function and species, geographical location, input intensity, and higher market orientation in the course of development are to be expected, as has been seen in other developing countries. The BenIMPACT results confirm the importance and necessity of natural resources and the relevance of increasing land scarcity. Although the latter aspect could be an incentive to establish (semi-)intensive livestock production, the model indicates that unidentified costs currently prohibit semi-intensive production. Furthermore, the agricultural sector model reveals that different conservation measures for forests will impose different regional consequences on livestock distribution and income. Generally, livestock management will be more differentiated in the future according to region and input intensity due to regional comparative advantages.

Keywords: livestock management, Benin (West Africa), triangulation, agricultural sector model, development, climate change, agriculture

Kurzfassung

Auswirkungen von sozio-ökonomischen Veränderungen und Klimawandel auf den Tierhaltungssektor in Benin

Ina Gruber

Derzeit unterliegt der Tierhaltungssektor in Entwicklungsländern einem starken Wandel. Ursachen dafür sind die steigende Nachfrage nach tierischen Produkten und die Veränderung in der Verfügbarkeit von allgemein zugänglichen natürlichen Ressourcen. Zum Erreichen der Milleniumsentwicklungsziele kann die Tierhaltung einen wichtigen Beitrag hinsichtlich Armutsbekämpfung, Verbesserung der Gesundheit und der ökologischen Nachhaltigkeit leisten. In dieser Studie werden die Auswirkungen der drei wichtigsten treibenden Kräfte (Bevölkerungswachstum, steigendes Einkommen und Klimawandel) auf den Tierhaltungssektor in Benin untersucht. Ziel dieser Arbeit ist es, neue Erkenntnisse über die beninische Tierhaltung zu gewinnen, bestehendes Wissen zu vertiefen und mögliche Entwicklungspfade zu erkennen, um das Potential des Sektors hinsichtlich der Milleniumsentwicklungsziele besser nutzen zu können.

Der methodische Ansatz der Triangulation wird sowohl für die Analyse der aktuellen Situation als auch der zukünftigen Entwicklung verwendet. Um den Status quo zu ermitteln wurde sowohl eine Produzentenbefragung als auch eine Expertenbefragung durchgeführt, die zusammen mit Sekundärdaten ausgewertet wurden. Mögliche Entwicklungspfade werden in der Arbeit mit Hilfe von landwirtschaftlichen Entwicklungstheorien, Erfahrungen in anderen Entwicklungsländern und den Ergebnissen der Expertenbefragung, die sich mit zukünftigen Trends beschäftigen, analysiert. Diese Erkenntnisse gehen in das quantitative Agrarsektormodell BenIMPACT ein, welches im Rahmen der Studie weiterentwickelt und auf den Tierhaltungssektor für Szenarioanalysen angewendet wird.

Die Tierhaltung ist derzeit gekennzeichnet durch extensive Produktionsmethoden, die auf den allgemein zugänglichen natürlichen Ressourcen Wasser und Weide basieren. Die niedrige Produktivität geht einher mit einer multifunktionalen Tierhaltung, die nicht ausschließlich einkommensorientiert motiviert ist. Die Befragung zeigt, dass das größte Produktionsproblem in der unzureichenden und qualitativ schlechten Futterversorgung liegt, und dass das Marktverhalten der Produzenten regional unterschiedlich ist. Auf die zukünftige Entwicklung der Tierhaltung in Benin wird das Bevölkerungswachstum stärkere Auswirkungen haben als das steigende Einkommen. Zudem sind in den nächsten Jahren Verschiebungen in der Verwendung und Funktion der Nutztiere, der geographischen Verteilung als auch Veränderungen bei den eingesetzten Tierarten und der Faktorintensität zu erwarten. Diese Entwicklungen sind zusammen mit einer stärkeren Marktorientierung auch in anderen Entwicklungsländern zu beobachten. Die Modellergebnisse bestätigen die Bedeutung der natürlichen Ressourcen und der zunehmenden Landknappheit. Obwohl letzteres ein Anreiz sein könnte die Tierhaltung zu intensivieren, verhindern momentan hohe Extrakosten, zusätzlich zu den Produktionskosten, die semi-intensive Tierhaltung im Modell. Außerdem verdeutlicht das Agrarsektormodell, dass verschiedene Waldschutz-

maßnahmen unterschiedliche regionale Auswirkungen auf die Verteilung der Tierbestände und das Einkommen haben. Grundsätzlich wird die Tierhaltung aufgrund regionaler komparativer Vorteile in der Zukunft stärker nach Faktorintensität und Region differenziert sein.

Schlagwörter: Tierhaltung, Benin (West Afrika), Triangulation, Agrarsektormodell, Entwicklung, Klimawandel, Landwirtschaft

Résumé

L'impact du développement socio-économique et du changement climatique sur l'élevage au Bénin

Ina Gruber

L'élevage est un secteur qui change très rapidement dans les pays en développement à cause de l'accroissement de la demande des produits animaux et de la variation de la disponibilité des ressources communes. En outre, l'amélioration de la performance de l'élevage est importante pour accélérer l'atteinte des Objectifs du Millénaire pour le Développement notamment la réduction de la pauvreté, l'amélioration de la santé et la durabilité écologique. Dans cette thèse, on analyse l'impact de trois forces motrices majeures (la croissance démographique, la croissance du revenu et le changement climatique) sur l'élevage au Bénin. Cette recherche a pour objectif de contribuer à une meilleure compréhension de l'élevage au Bénin et des trajectoires possibles de son développement dans le futur, d'approfondir les connaissances sur ce secteur, afin d'utiliser au mieux son potentiel.

L'approche méthodologique employée pour analyser le statu quo et les trajectoires de développement dans le futur est la triangulation. Pour apprécier le statu quo, deux enquêtes avec les éleveurs et les experts locaux ont été conduites en complément aux données secondaires. L'identification des trajectoires de développement dans le futur a été effectuée en se basant sur les théories du développement agricole, les expériences déjà vécues dans d'autres pays en développement et les résultats de l'enquête auprès des experts sur les tendances dans le futur. Les résultats de cette analyse ont été intégrés au modèle BenIMPACT, un modèle développé pour l'analyse quantitative du secteur agricole au Bénin ; ceci a permis d'améliorer sensiblement ce modèle et il a été appliqué pour effectuer des analyses de scénarios dans le secteur de l'élevage.

La recherche a permis de constater qu'actuellement l'élevage au Bénin est caractérisé par l'utilisation de méthodes de production extensives, qui sont très dépendantes des ressources communes en eau et en zones de pâturage. La productivité est faible et l'activité est pratiquée non seulement pour garantir des revenus monétaires grâce à la vente directe des animaux mais ils lui assignent aussi divers autres objectifs. L'enquête montre que le problème majeur de la production est l'approvisionnement en fourrage aussi bien sur le plan quantitatif que qualitatif ; elle indique aussi que le comportement des éleveurs vis-à-vis du marché diffère selon les régions.

Les résultats de la recherche, pour ce qui concerne les trajectoires de développement dans le futur, montrent que la croissance démographique a un impact plus élevé sur le secteur de l'élevage au Bénin que la croissance du revenu. Dans le futur, il faudra probablement s'attendre à des changements dans les itinéraires techniques de production et le choix des espèces, la distribution spatiale de la production, l'intensité d'utilisation des intrants et une ouverture au marché plus élevée chez les éleveurs. Les résultats de BenIMPACT confirment le rôle prépondérant que jouent les ressources naturelles dans le secteur de l'élevage au Bénin, ce qui est en adéquation avec les constats révélés par les données des enquêtes de terrain ; ils soulignent aussi l'importance du problème de la pénurie croissante des terres. Bien que le dernier aspect pourrait constituer un attrait pour établir une production animale semi-intensive, le modèle indique que des coûts inconnus empêchent actuellement la production semi-intensive. De plus, le modèle du secteur agricole révèle que les différentes mesures de protection des forêts auront des conséquences différentes selon les régions aussi bien pour la distribution spatiale de la production animale que le revenu. En général, l'élevage sera plus nuancé à l'avenir concernant la région et l'intensité des intrants, en raison des avantages comparatifs régionaux.

Mots clés: l'élevage, Bénin (Afrique de l'Ouest), triangulation, modèle du secteur agricole, développement, changement climatique, agriculture

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Glossary

ACP-states	States of Africa, Caribbean, and Pacific which signed the Lomé Convention
BAU	Business As Usual scenario
BenIMPACT	Benin Integrated Modelling System for Policy Analysis, Climate and Technology Change
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung
BSE	Bovine spongiform encephalopathy
CARDER	Centre d'Action Régional pour le Développement Rural
CeRPA	Centre Régionaux pour la Promotion Agricole
CET	Common External Tariffs
CGE	Computational General Equilibrium Model
COMO	Consulting für Projektmanagement und Organisation GmbH
COS	Conservation scenario
CW	Carcass Weight
DdE	Direction de l'Elevage
DM	Dry mass
ECOWAS	Economic Community of West African States
EMUWA	Economic and Monetary Union of West Africa
EPIC	Erosion Productivity Impact Calculator
FAO	Food and Agriculture Organization of the United Nations
FCFA	Franc Communauté Financière Africaine
GAMS	General Algebraic Modeling System
GDP	Gross Domestic Product

GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
h	Hour
ha	Hectare
HDI	Human Development Index
HIPC	Heavily Indebted Poor Countries
HVO	Haute Vallée Ouémé
ICRA	Centre International pour la Recherche Agricole orientée vers le développement
IFPRI	International Food Policy Research Institute
IMF	International Monetary Fund
IMPETUS	Integratives Management-Projekt für einen Effizienten und Tragfähigen Umgang mit Süßwasser in Westafrika
INO	Innovation scenario
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Intertropical convergence zone
LW	Live Weight
MAEP	Ministère de l'Agriculture, de l'Elevage et de la Pêche
MASM	Mali Agricultural Sector Model
MBA	Marches à bétail autogérés
MCP	Mixed Complementary Problem
MDG	Millennium Development Goals
MDR	Ministère du Développement Rural
MFEP	Ministère des Fermes d'Etat, de l'Elevage et de la Pêche
MFN	Most Favourite Nation
n.s.	Not specified
NCD	Newcastle disease
NIE	New Institutional Economics
NUTBAL	Nutrition Balance Model
ONASA	L'Office National d'Appui à la Sécurité Alimentaire
p.a.	Per annum
PADEB	Projet d'Appui au Développement de l'Elevage dans le Borgou
PAMF	Projet d'aménagement des massifs forestiers

PDDAA	Programme détaillé pour le développement de l'agriculture africaine
PDE III	Projet de Développement de l'Elevage Phase III
PGFTR	Projet de Gestion des Forêts et Terroirs Riverains
PHEWS	Pastoral Household and Economic Welfare Simulator
PHYGROW	Phytomous Plant Growth Model
PMP	Positive Mathematical Programming
PPCB	Péripneumonie contagieuse bovine
PPR	Peste des petits ruminants
SONAPRA	State-owned National Agricultural Promotion Company
t	Metric tonne
TAC	Transaction costs
TLU	Tropical Livestock Unit (250 kg live weight)
UDOPER	Union Départementale des Organisations Professionnelles d'Eleveurs de Ruminants
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WHO	World Health Organisation
WTO	World Trade Organisation

Chapter 1

Introduction

> Rapid growth of livestock production in recent years has fueled hopes for accelerated economic development, fears of increased social inequity and environmental degradation, and recognition that comprehensive and effective policies are required to ensure that continued expansion of the livestock sector contributes to poverty alleviation, environmental sustainability and public health. (FAO, 2005)

1.1 Motivation of the study

The role of the livestock sector in developing processes, environmental problems, and the keyword climate change characterises the framework where livestock management is recognised by the public. In recent public discussions, particularly in industrialised countries, livestock has been acknowledged as one cause of climate change contributing to the green house effect. Additionally, other problematic aspects of livestock management, such as the environmental destruction or the excessive consumption of meat, which leads to health problems, have been identified.

In such discussions the positive effects associated with livestock keeping are disregarded. Especially in developing countries, livestock management can help to improve the economic situation of the poor, lead to better health status as a result of improved nutrition, and even contribute to environmental protection. These three aspects can be recognised in the Millennium Development Goals (MDG), which have been established to meet the needs of the poorest people, in particular with regard to poverty alleviation, health improvement, and environmental sustainability. This shows the high potential of livestock husbandry

to contribute to the realisation of these development goals.
Particularly, the poor population in developing countries keeps some livestock, often some poultry or small ruminants. This livestock is kept for their own consumption and for a small but regular additional income. As diets of poor people are based on starchy food, the consumption of some animal products, such as meat or milk, improves their nutrition significantly. However, keeping livestock not only provides income and health benefits for the poor: the integration of crop and livestock production may help to improve soil fertility as compared to the other prevalent methods of agriculture which are environmentally unsustainable and therefore lead to soil exploitation.

In Benin, one of the poorest countries of the world, agriculture plays an important role in the country's economy and in daily life. Agricultural income is the most important source of income as the majority of the population is engaged in agriculture. The livestock sector is not yet a priority of agricultural policy and its relevance has been largely neglected. Policy and research still concentrate on crop production, particularly on the cash crop cotton. However, this study focuses on livestock management and provides an analysis of the potential opportunities and challenges of the livestock sector, in particular with regard to climatic as well as socio-economic driving forces.
Extensive livestock keeping not only contributes to climate change but is, in turn, also affected by climate change due to its dependence on climate-sensitive natural resources. Looking at the socio-economic aspects, several driving forces which are affecting livestock management in Benin can be observed. The two most important driving forces for livestock husbandry are population growth and increasing income. Population growth increases the total demand for animal products because more people will require more food. Shifts in preferences and diets, as food habits differ according to location and also change over time, lead to more consumption of animal products. But these are not the only causes of this phenomenon. An increase of income, which is expected for Benin due to the steady economic growth in the last ten years, leads to higher demand for animal products.
This increasing demand – which is apparent in all developing countries – is an indication that livestock management in these countries will remain a very dy-

namic sector. The limited attention given to the livestock sector results in an uncontrolled development. More advertence is needed in order to benefit from this sector and take advantage of its potential. Referring to the livestock sector in developing countries, DELGADO et al. (1999, p.65) state that "failing to act risks throwing away one of the few dynamic economic trends that can be used to improve the lives of poor rural people in developing countries."

1.2 Objectives and methodological approach

Against this background, this study aims to contribute to and deepen the general understanding of current livestock management and possible developments of this sector in Benin. Not only failing to act is a risk, but also acting without a detailed understanding of interactions of this sector jeopardises the attainment of important development goals.

The general goal of a better understanding can be separated into two parts: first, the understanding of the status quo and second, the analysis of possible developments of livestock husbandry in Benin with respect to the selected driving forces.

First of all, it is crucial to have an exact appreciation of the system as it is now practised. So far, no general study of Benin's livestock management from the agricultural-economic perspective has been conducted. This study tries to fill this gap: in the first chapters, reliable data about production methods and economics in livestock husbandry are compiled and systematically analysed. This precise and substantial data collection as well as the understanding of the interactions are also the basis for the subsequent economic modelling.

As the comprehension of the livestock sector is also essential to assign the impacts of the driving forces, the development of the sector can be tackled after regarding and understanding the system. In the second part, the study examines how the livestock sector reacts to selected driving forces which cannot be influenced within the sector. The study provides a long-term analysis of the effects of climate change, population growth, and increasing income. The analysis is made for the long-term, as the implications of changes in the aspects of population as well as of climate arise more in the long-term than in short-term consideration. In doing so, special attention is paid to the implications

of increasing demand for animal products and the consequences of resource availability on livestock husbandry.
Compared to other studies, the present study takes the most relevant productive livestock species into consideration instead of concentrating on only one species. Cropping is incorporated whenever the same resources are used for production. Thus the interactions between different animal production branches as well as between crop and animal production can be better understood. Moreover, the study meets the challenge to look ahead to a changing environment.

The study limits its focus to three driving forces – climate change, population growth, and increasing income – which are seen as the most important factors influencing the livestock sector. Climate change has a direct impact on production methods, and the two selected socio-economic driving factors are the major trends which affect demand. This increasing demand again is the most important factor shaping the livestock sectors in developing countries.
A second aspect should be mentioned which is related to the driving force of climate change in combination with the extensive livestock keeping in Benin. Climate change affects mainly ruminants, as these species depend on natural pasture and grazing possibilities. Thus, in the sections of the study which deal with the climatic aspect, focus is more on ruminants than monogastric animals. However, the study intentionally includes the monogastric animals in the overall context. This is done as the effects of climate change on ruminants influence the monogastric animals in so far as causing a replacement of one species by the other. Secondly, the analysis of the socio-economic effects cannot be limited to ruminants, as there exist productive as well as economic interrelations between the different livestock species.

A last note should be given to the long-term analysis of the development of the livestock sector. Regarding future developments, theoretical considerations and model results are always more a plausible idea of the future than the eventuating reality. Notwithstanding, these ideas are helpful for the policy dialogue and policy making, as problems can be identified and addressed in advance. Moreover, by showing the possibilities and reactions of the livestock sector, the most challenging problems might be avoided.

The limited availability of information as well as the generally existing uncertainty of impact analysis are counteracted by the choice of the methodology. For the analysis of the status quo as well as of the future development the methodological approach of triangulation is used. More precisely, data triangulation and between method triangulation according to a definition of DENZIN (1970, cited in DOWNWARD and MEARMAN, 2007) are applied. Data triangulation uses different sources and types to collect required data (here applied for the status quo). The methodological approach of between method triangulation uses different methods to analyse an object of research. In this study qualitative and quantitative methods come into operation for the analysis of possible developments. Different methodological approaches are applied as this results in a more global picture than a single method. The research object is examined from varying perspectives in order to capture different characteristics and to come to a better understanding of the topic.

The status quo is analysed by means of two methods: literature review and surveys. On the one hand, the general understanding of livestock management in Benin is based on literature. On the other hand, since literature on the use of resources in Benin's livestock sector is limited, two surveys were conducted among livestock keepers and local experts. The two surveys are later referred to as the producer survey and the expert survey.

For the analysis of possible developments four methods are applied. The first three employed methods constitute a qualitative analyse: first, possible development paths of the livestock sector are considered and explained on the basis of agricultural development theories. Then, the study looks at experiences in other developing countries to detect parallels and analogies. Third, the evaluation of the local experts in the expert survey concerning development is analysed. After further developing the general understanding of the climatic and socio-economic impact on the livestock sector, a simulation model as the fourth method quantifies these effects. The agricultural sector model BenIMPACT has been expanded by the livestock sector in this study. The model simulates the situation until the year 2025. With the help of three scenarios, a likely frame is spanned in which livestock husbandry might develop. Moreover, the scenarios illustrate the impacts of the selected driving forces on livestock management in Benin.

1.3 Structure of the study

This study contains eight chapters starting with the motivation and an overview of the study in chapter one. The following six chapters present the current situation and possible developments, which are tackled with several different approaches to get a comprehensive understanding. Each of these six chapters ends with a summary and some preliminary conclusions. These conclusions are summarised and brought together to provide an overall picture of the study in chapter eight.

After the introduction, chapter two presents the natural and socio-economic conditions in Benin in order to understand the overall framework of the livestock sector. This description starts with the geographical location, climatic conditions, and the endowment of natural resources. Followed by the description of the overall socio-economic situation and a rough insight into agriculture, particularly cropping, the general framework of the livestock sector is provided.

The third chapter is devoted to the production methods in livestock management for the most relevant productive livestock species, namely cattle, sheep, goats, pigs, and chickens. Therefore, the literature and two field surveys, which were conducted in the study, are exploited. A special emphasis is put on the natural resources water and natural forage as these input factors are climate-dependent.

The fourth chapter deals with the political and economic aspects in livestock husbandry. A detailed literature review and primary data of the surveys illustrate the situation and the decision processes. In this part, the production costs to the extent they are known, the market system as well as the international relations and connections are described to provide a better understanding of the manifold determinants and constraints of the livestock sector.

Chapter five centres around theoretical development paths, the explanations of these possibilities, and empirical evidence of development in the livestock sector. This consideration starts with the challenges which have been already betokened in the previous chapters. With the help of agricultural development theories the different development paths of the livestock sector in Benin are examined. This is completed by some observations in other (African) developing countries, the assumptions of Benin's livestock experts concerning development possibilities and the reflection of hindering and supporting aspects for a particular direction of development.

Chapter six addresses the modelling background. According to the previous analysis of the sector, the relevant aspects for constructing an economic model are specified, followed by a literature review. The literature review presents several models comprising some of the crucial factors. Then the agricultural sector model BenIMPACT is described with a special emphasis on the livestock module, as this module was added within the study.

Chapter seven provides the modelling results. The model BenIMPACT is run for the base year and three scenarios are calculated until the year 2025. The first scenario, "business as usual", presents the situation if current production methods were applied in the same way until 2025. The second scenario, called "innovation", introduces an optional semi-intensive production method accessory to the traditional one. The third scenario, called "conservation", shows the role of conservation measures and additional conservation areas for the livestock sector.

The eighth and final chapter summarises the study based on the individual conclusions of each chapter.

Chapter 2

Natural and socio-economic conditions in Benin

This chapter provides an overview of Benin focusing on those aspects relevant for the study on livestock management. It begins with a description of the natural and climatic conditions, then provides information about population and the economy, and finally, discusses agriculture.

2.1 Climate and natural resources

Benin is located in West Africa at the Atlantic coast between 6° and 12° northern latitude and 1° to 4° eastern longitude. As figure 2.1 shows, Benin borders Togo in the west and Nigeria in the east. Burkina Faso and Niger are the northern neighbouring countries of Benin.

The country has an area of 112,600 km^2, the distance from south to north extends for 650 km. The small coastal line of 120 km width at the Gulf of Guinea consists of sand and is interspersed with lagoons. From here 110 km long lowlands span into the inland and pass into a mesa. In the north-west of Benin, the Atacora Mountains rise up to 700 metres. The northern lowlands are formed by the Beninese part of the Pendjari-Otilowland in the west of the Atacora and by the lowland of Niger in the east.

The Ouémé, fed by the rivers Okpara and Zou, empties into the Atlantic. With its length of 510 km, the Ouémé is the longest stream in Benin. The rivers Mékrou, Alibori, and Sota flow into the Niger. The Niger marks the border for 120 km between the states of Niger and Benin in the north.

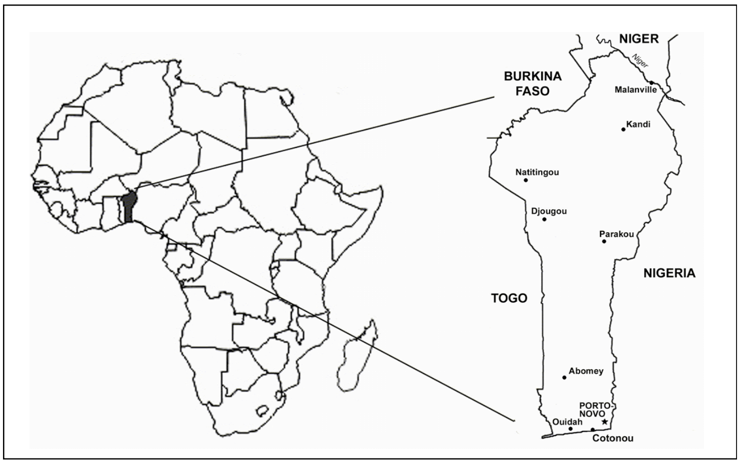


Figure 2.1: Location of Benin in West Africa
Source: Author's illustration, 2006

Situated in the tropics, Benin's climate is controlled by the annual shift of the intertropical convergence zone (ITCZ). In this zone the humid air from the northern and the southern hemispheres meets at the equatorial low pressure band. The ITCZ follows the zenith of the sun with a small temporal lag. This seasonal oscillation of the ITCZ causes the different disposition of the seasons (STAHR, 2000). In South Benin, two rainy seasons exist; the first starts in April and continues until July, the second shorter one lasts from October to November. This bimodal distribution of precipitation changes into a unimodal distribution north of 8° latitude. North of this latitude the one rainy season lasts from May to October.

The precipitation declines from south to north with average rainfalls of about 1200 mm per year in the southern area and 800 mm in the north (see figure 2.2).

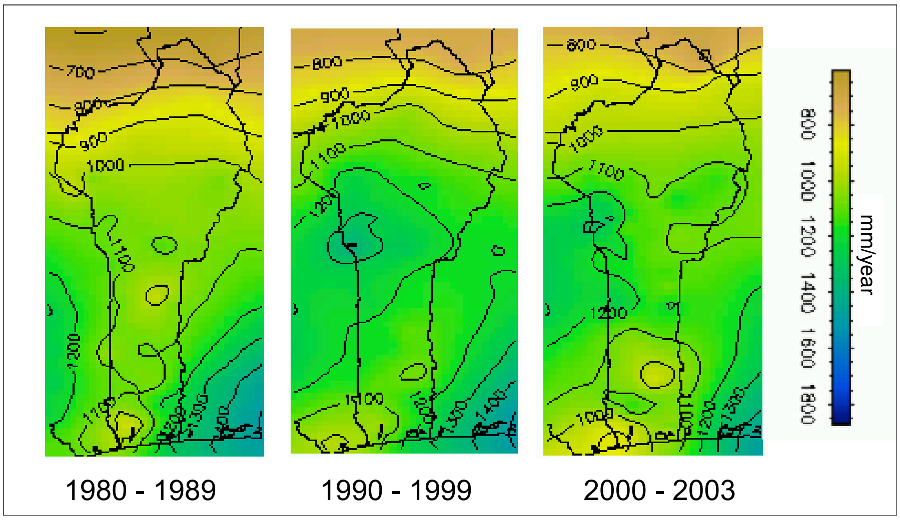


Figure 2.2: Average regional rainfall in Benin
Source: IMPETUS, 2005

The three images in figure 2.2 indicate that significant differences in the average precipitation occurred between the given decades. This supports the observation that in West Africa high climate variations between decades appeared in the 20th century.
In the south, temperatures range only from 22 to 26°C, whereas in the north temperatures fluctuate between 15 and 42°C. Another climatic characteristic is the Harmattan, a dry and hot wind coming from the Sahara, blowing from north to south in dry seasons.

In Benin, a savannah corridor interrupts the zonal West African rain forest. Air streams cooled by the cold currents in the Bight of Benin raise precipitation over the sea, and reduce it overland at the same time. This depression of precipitation causes the vegetation in Benin to differ from that in other West African countries. This savannah corridor, an interruption of the Guinea-Congo rainforest, is called Dahomey Gap (ADAMS, GOUDIE and ORME, 1996). The main vegetation types are savannah woodland covering 9 percent, and tree savannah and shrub covering 56 percent of the total land area (FAO, 2001). Forests currently amount to 23 percent or 2.65 million hectare (ha) of the vegetation in Benin, but at the beginning of the 1990s forests still covered more than 30 percent of the land area. Two National Parks extend over 780,000 ha which is equivalent to 7 percent of the land area. Furthermore, a biosphere reserve consisting of 620,000 ha and two wet areas with a total of 140,000 ha are protected (WORLD BANK, 2003). The endowment with other resources such as rain forests or natural resources (oil, limestone, marble) is marginal in Benin.

2.2 Population and economy

History

Until the end of the 19th century, the three kingdoms of Dahomey, Porto-Novo, and Nikki dominated the peoples of today's Benin. Between the 16th and 19th century the region was mostly known for its slave trade. The French established their power at the end of the 19th century and Dahomey became part of French-West Africa. In 1958, Dahomey achieved the status of an "autonomous republic" inside the France Communauté. Less than two years later, on 1 August 1960, the "Republic of Dahomey" became independent. The following years were characterised by economic instability, numerous governmental changes and military coups. In 1974, Marxism-Leninism was declared national ideology, and one year later the "Republic of Dahomey" became the "People's Republic of Benin". As a result of unrest in 1989/90, new guidelines for democratisation and economic reorientation were defined. Since then, the government has been a parliamentarian presidential democracy led by the prime minister. In the "République du Bénin", the first free democratic parliamentary elections were held in 1991 (BMZ, 1999).

Administrative organisation and living standard

The capital of Benin is Porto-Novo with about 200,000 inhabitants. However, the seat of government is Cotonou, the economic metropolis of the country which has a population approximately three times that of Porto-Novo. Nowadays Benin is politically and administratively organised in 12 departments, which comprise 77 communes, as shown in figure 2.3. The splitting of the former six departments into 12 was decided in 1990 by the national conference. The official implementation of the decentralisation was realised in 2002 by the local elections (DOEVENSPECK, 2004).

In 2002, about 6.6 million people lived in Benin (WORLD BANK, 2003). Al-

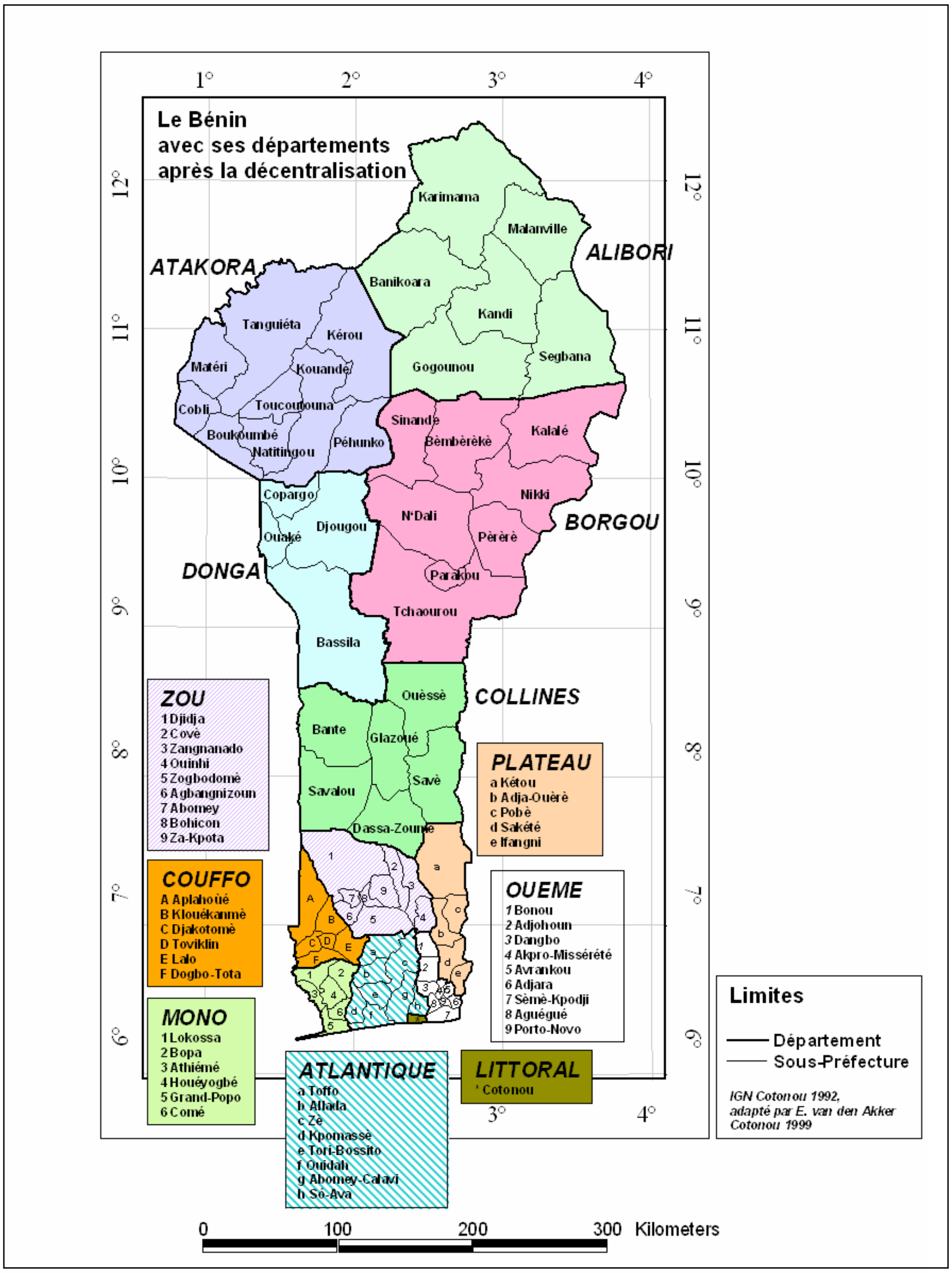


Figure 2.3: Administrative organisation in Benin
Source: VAN DEN AKKER, 2000

though the birth rate per woman decreased from 6.8 children in 1992 to 5.7 in 2002 (WHO, 2007), the population growth of 2.8 percent per annum (DO-EVENSPECK, 2004) still has a major impact on society in Benin. Average life

expectancy is with 51 years and differs between women and men by two years. The population density averages 60 inhabitants per square kilometre (WORLD BANK, 2004), but there are significant differences between regions. With about 240 people per square kilometre in the southern part, more than half of the total population live on 10 percent of country area, whereas in the north there are fewer than 14 persons per square kilometre (ONASA, 1999).
Urbanisation has constantly advanced and this development is expected to continue in the coming years. In 2000, approximately 58 percent of the total population lived in rural regions. For the year 2016 it is assumed that more people will live in Beninese cities than in the country, while for 2030 the percentage of urban inhabitants is estimated at 62 percent (FAO, 2003). In addition to this rural-urban migration, a second internal migration can be observed. Small and subsistence farmers are migrating from the north-west and the south, both regions with above average population density, into central Benin where agricultural land is still available (DOEVENSPECK, 2004).
The official language is French, but there are numerous tribal languages as up to 60 different ethnic groups exist in Benin. In the south, the Fon and the Yoruba are the largest ethnic groups constituting one fourth of the total population. The Bariba, Somba, Dendi, and Fulani[1] are important ethnic groups in the north. Especially the Fulani are engaged in livestock management.

Benin is among the least developed countries in the world. According to the Human Development Index (HDI)[2] the 2003 Human Development Report of the United Nations Development Programme (UNDP) ranks Benin in place 159 of a total of 175 countries. The HDI considers three levels of development: life expectancy (at birth), education (literate people older than 15 years and average duration of school attendance) and income. Since the beginning of the 1990s, the HDI in Benin has advanced from 0.352 to 0.411[3]. Although schooling is compulsory for children between six and eleven years of age, the illiterate rate is 61 percent, however differs significantly between genders. About 47 percent of men and even 75 percent of women older than 15 years are not able to read and write (WORLD BANK, 2003).

[1] Peulh in French.
[2] Minimal and worst value = 0, maximum and best value = 1.
[3] Compared to 0.921 for Germany.

Nutrition

Diets vary by region and season and are based on crop products like cereals, roots, and tubers. In the south, maize and cassava are the main food, whereas people in the north prefer millet, sorghum, and yams (FAO, 2003). Animal products are not that important in the daily Beninese diet compared to plant products. In 2003, the average intake of meat only amounted to 8.2 kg per capita and year (TOIGBE, 2004), which covers less than 5 percent of the daily energy requirement. The average protein intake ranges slightly between 65 and 78 g per person and day, depending on the season (FAO, 2003). In areas near the sea and close to rivers, seafood is an inherent part of the diet.

Economy

Benin is a member of various regional economic alliances such as the Economic Community of West African States (ECOWAS), which was founded in 1975 with the objective to elevate the standard of living, stabilise the economy, and promote political relations between the member states. Benin is also member of the Economic and Monetary Union of West Africa (EMUWA) which has similar objectives to ECOWAS, but a different membership. The monetary union has liberalised trade between the member states and established a joint custom regime in 2000 (MAIR, 2001).

For developing countries like Benin, special concessions exist in order to facilitate and support development. Benin is one of the ACP-states[4] that are allowed to export a specific amount of agricultural products to the European Union without tariffs. The credit convention from 2000 until 2004, with the International Monetary Fund (IMF), enabled Benin to participate in the debt relief programme of the IMF and the World Bank for Heavily Indebted Poor Countries (HIPC). In 2003, Benin reached the completion point, where Benin's total debt was reduced by 31 percent in net present value terms. The national budget is financed mainly by taxes, supplemented by donations of development aid organisations. In 2002, Benin received 220 million US Dollar in developmental aid (KÖRNER, 2004).

The country's currency is the Franc Communauté Financiaire Africaine (FCFA). Since its introduction, it has been DC coupled with the French Franc or rather

[4] 79 developing countries from the region Africa, Caribbean and Pacific.

with the Euro[5]. In 1994, the currency was devalued in order to counteract the overestimation of the FCFA. Since 2002 the inflation rate has been at a low level of about 2.4 percent per annum. In 2002, Benin produced a Gross Domestic Product (GDP) of 2.7 billion US Dollar with the corresponding growth rate of 4.6 percent. The GDP of 2002 corresponds to an average income of 380 US Dollar per capita and year (WORLD BANK, 2003). In the following two years the growth rate of the Beninese GDP in real terms increased up to 6 percent (KÖRNER, 2004). About 30 percent of the Beninese population is affected by poverty: in rural areas, poverty is estimated at 31 percent compared to 25 percent in urban regions. Despite a generally positive economic development, a slight rise in the number of poverty-stricken people has been observed since the mid-1990s (FAO, 2003).

The economic relevance of the three sectors agriculture, industry, and services is illustrated in figure 2.4. The highest contribution (50 percent) comes from the tertiary sector, whereas the industrial sector is little developed and just slowly increasing in size. It is mainly situated in Cotonou and its surroundings, and consists of some cotton manufacturing, food processing, and textile or building material production (KÖRNER, 2004).

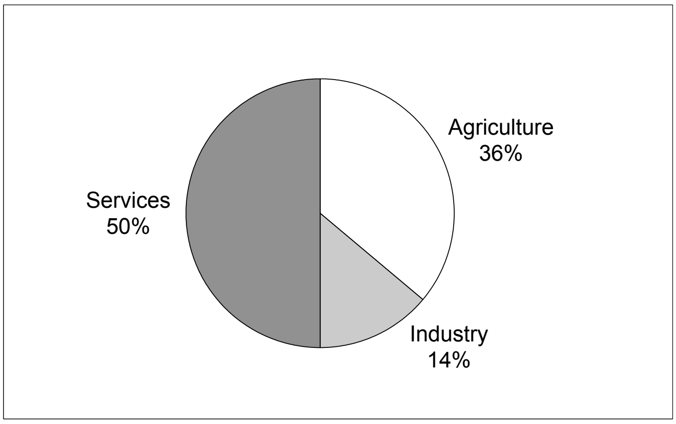


Figure 2.4: Sector's share of GDP
Source: WORLD BANK, 2003

The agricultural sector contributes considerably more than one third to the GDP and therefore serves as a basis for the economy in Benin. Crop cultivation

[5] One Euro corresponds to 655 Franc CFA in 2007.

amounts to 78 percent of the agricultural sector's input into the GDP while the livestock's contribution is 22 percent. But it needs to be taken into consideration that there is no agreement regarding the amount of livestock contribution to the total GDP. Information from BenInfo (2003), an official information tool of the Beninese government, suggests that the contribution has been fairly constant over the last 5 years at about 7.7 percent of the total GDP. One year later a report of the agricultural department specifies the percentage was decreasing in the same time period from 4.3 to 3.5 percent of total GDP (Direction de l'Elevage, 2004a). Other literature concludes that the importance of livestock production in the Beninese economy has increased from 6 to 10 percent (TOUTAIN et al. 2001; ABIASSI, 2002). Regardless of the ambiguous numbers, it can be concluded with reasonable certainty that within the last years the total amount of livestock GDP has increased and the annual growth rate is higher than the inflation (BenInfo, 2003; Direction de l'Elevage, 2004a).

Another sector in Benin that needs to be taken into account is the so-called "informal sector" which consists of all economic activities, but primarily commerce in urban areas. MALDONADO (1998) argues that this sector is spreading as increasing urbanisation demands more services in cities. Moreover, the increasing urban population puts pressure on the urban labour market, which is already characterised by underemployment. Monetary and barter revenues derived from informal activities contribute significantly to the household income. Foreign trade is dominated by the export of cotton and the import of energy and manufactured goods. In the last few years, imports in monetary values exceeded export values. Earnings from the export of agricultural commodities contribute over 95 percent to the total export revenue, of which 77 percent comes from cotton exports alone (WTO, 2004). The gap between import and export is widened by the dependency on cotton, as the expansion of Beninese cotton production is not able to bolster the consequences of fluctuating and decreasing global cotton prices. In 2002, the main destinations for exports were within Africa (39.3 percent), Asian countries (25.5 percent) and India (14.2 percent). The largest importer in the same year was France (24 percent), followed by African countries (22.4 percent) as well as Asia and other EU countries (each around 20 percent) (WTO, 2004). Reexport to neighbouring countries, for example of frozen chickens, is a distinctive feature of trade patterns in Benin, just

as the not officially recorded trade across the borders.
In agricultural trade policy, ad valorem tariffs are the main instrument with an average MFN rate of 16.9 percent in 2003. Custom duties for some herbal products like mangoes, pineapple, coffee, cassava, and cowpea, as well as for animal products such as cattle, sheep, poultry, pigs, milk, and eggs amount to 20 percent, whereas for rice they are fixed at 5 percent (WTO, 2004).

2.3 Agriculture

Employment and income

In Benin, agriculture takes an important position both in the overall economy and everyday life. This importance is illustrated by its dominating role in exports and the high rate of subsistence farming which contributes significantly to daily life with respect to nutrition or employment. Abound 65 percent of the active working population is engaged in the agricultural sector including both subsistence farming and marketable production (UNDP, 2004). On average, labour input in agriculture, without considering time for animal management, ranges from 900 to 1,200 hours per annum and person. This amount corresponds to around two thirds of total working hours. However, this average value varies decisively with regard to gender, ethnic groups, age classes, and regional characteristics. Women, particularly those occupied with household duties, childcare, and water carrying, spend about one third to half of the mentioned agricultural working time. Although family labour is in generally sufficient, additional labour is hired during peak periods such as harvest or land preparation, and for disliked activities such as insecticide application in the cotton production (BRÜNTRUP, 1997). Benin's farmers derive their income particularly from cropping activities across all regions with a mean of 57 percent, whereas 7 percent of revenue comes from (small) livestock management. In more important livestock keeping regions like Atacora the highest contribution is 13 percent in contrast to 3 percent in Zou (IFPRI, 2004).

Agricultural policy

The agricultural sector and its policy are managed by the Ministry of Agriculture, Livestock, and Fish (Ministère de l'Agriculture, de l'Elevage et de la Pêche, MAEP). The modernisation and development of agriculture by improving production methods as well as increasing diversification, conservation and processing of agricultural products are the main objectives (WTO, 2004). Emphasis of agricultural policy is put on cropping rather than on livestock because of the high importance of cropping in development policy, poverty alleviation programmes, and economic issues such as exports, revenues, and employment. Policy for livestock is described in greater detail in chapter 4.1.

Important Beninese state organisations in the agricultural sector are CeRPA, ONASA, and SONAPRA. The function of the Centre Régionaux de Promotion Agricole CeRPA (former Centre d'Action Régional pour le Développement Rural, CARDER), which are located in each of the former six old departments, is to advance rural development and share knowledge. L'Office National d'Appui à la Sécurité Alimentaire (ONASA) observes the regional food markets and establishes some storage facilities for maize and rice with governmental support. The state-owned Societé Nationale pour la Promotion Agricole (SONAPRA) promotes Beninese cotton on international markets, encouraging the use of inputs and providing inputs for cotton production for farmers. Recently, more and more tasks have been outsourced to private business. Furthermore, it is planned to encourage product diversification and to completely privatise processing and commercialisation.

Crop production

Benin's estimated cultivable area ranges from 4.8 to 8.3 million ha (ABIASSI, 2002; WTO, 2004), whereof about 1 to 2.5 million ha were cultivated in 2002 (WTO, 2004; FAOSTAT, 2005). The main crops, such as cotton, maize, cassava, pulses, groundnuts, sorghum and millet, yam, and rice, are cultivated using extensive production methods. These cultures cover approximately 80 percent of the agriculturally used area in 2002 as figure 2.5 shows.

Irrigating cultivated areas is hardly practiced in Benin as precipitation is usually sufficient for rainfed cropping. Some rice fields and horticultural areas in the south of the country are sporadically irrigated with watering cans, but large-area irrigation systems are lacking.

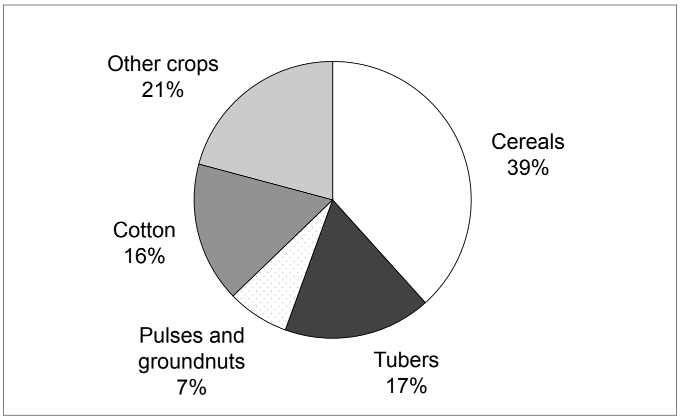


Figure 2.5: Crop shares of land use in 2002
Source: FAOSTAT, 2005

In Benin, agricultural production has been raised in the last few years by extending arable land rather than by increasing productivity per hectare. Mostly non-agricultural areas are taken into cultivation, or fallow periods are shortened (COMO, 1994b). In the southern departments, in Mono, Atlantique, and Ouémé, additional utilisable agricultural land has become scarce. The output per unit of land is decreasing due to the lack of fertilisation, and occasionally soil degradation has already been observed (BECK, 1995). Until the mid-1990s, food production kept pace with the rise in population, but the extension of areas for staple foods were larger than the increase in production (ABIASSI, 2002).

The most significant extension of production has not occurred in food production, but in cotton production (ABIASSI, 2002). Its production has been supported by the organised, state-run production and processing chain SONAPRA. SONAPRA makes production inputs available and regulates sales. In Benin, the largest extension in cotton production took place in the early 1990s with a growth of more than 300 percent within six years. But like in other West African countries, this notable extension started several decades ago and the harvested area of cotton has increased more than 40-fold in Benin since 1965. In 2003, Benin, with its main cotton producing region in North Benin, was the third largest West African cotton producer behind Mali and Burkina Faso (FAOSTAT, 2005). The average yield is around 1,100 kg per ha, the cottonseed cake is used for feeding livestock. Endeavours exist to liberalise the so-called “filiére agroalimentaire” and to privatise SONAPRA (WTO, 2004).

Cassava is the most widespread tuber in Benin. It belongs to the spurge plants and is cultivated for human consumption although all blossoms contain hydrogen cyanide. Therefore, some kind of processing is necessary before consumption, and leaves cannot be fed directly to livestock. The cultivation period varies between 6 and 24 months with the highest starch yield per hectare after 12 to 15 months. After harvesting, decay starts promptly, which explains why cassava is often harvested only on demand. Cassava roots remain edible for months when the plant is left in the soil. In Benin, cassava is cultivated on a larger scale in the south than in the north. A yield of about 13,300 kg per ha is achieved and it is often cultivated in combination with maize. Leaving cassava in the fields, however, hampers access to tilled areas, curbs the utilisation of the crop residues (COMO, 1994a), and is sometimes done in order to claim arable land in areas with high land pressure.
Another important tuber is yam. It is cultivated particularly in central and northern Benin with an average yield of approximately 13,500 kg per ha (FAOSTAT, 2005). This tuber requires a well-drained, rich, and loamy soil as well as a warm and humid climate. Yam is harvested twelve months after planting, contains 15 to 40 percent starch, and the leaves can be fed to livestock. It is firmly established in local consumption habits. In contrast to cassava, yam is directly edible (VAN DEN AKKER, 2000).

Cereals such as maize, sorghum/millet, and rice are the other staple foods in Benin besides tubers. The many varieties of maize allow production both in sub-humid and in semi-arid climates. Maize is cultivated throughout Benin. But, due to consumption habits and alternatives in production (VAN DEN AKKER, 2000), with higher shares in the southern regions than in the north. Two different varieties of maize are grown; the local variety with an average yield of around 1,000 kg per ha and the improved maize with 1,500 kg per ha. Especially maize in central and northern Benin is cultivated after cotton in order to benefit from residues of mineral fertilisers. Sometimes mineral fertilisers meant for cotton are directly applied to maize, as the acquisition of fertilisers is more

or less only possible through cotton production. Maize is exported mainly to neighbouring countries (WTO, 2004).
Sorghum and millet can be cultivated in regions with lower precipitation than that required for maize. For this reason, it is grown particularly in northern and central Benin. According to MULINDABIGWI (2006) sorghum is being replaced by other cultivations due to increasing scarcity of land and to the competition of tubers, which produce more calories per hectare. Moreover, the demand for sorghum by urban inhabitants is decreasing. The average yield of sorghum is about 950 kg per ha, whereas an average of 800 kg per ha of millet were produced in 2004 (FAOSTAT, 2005).
Today rice is becoming more and more important for consumption, particularly in urban regions, although it is not a traditional ingredient of the Beninese diet. Cultivated area and produced quantities are still marginal. Currently about 33,000 hectares are cultivated mainly in dips and inland-valleys[6]. The average yield was 2,100 kg per ha in 2004 (FAOSTAT, 2005). However, the largest amount of rice for consumption is imported as an important component of Japanese food aid (WTO, 2004).

Herbal protein in nutrition mainly comes from pulses and groundnuts. Different types of pulses are cultivated on around 180,000 hectares with an average yield of about 720 kg per ha (FAOSTAT, 2005). Pulses are particularly cultivated for the families' own consumption as staple food. Some national trade takes place, but trade of pulses does not play an important role in foreign trade.
In contrast, groundnuts are cultivated both for domestic consumption and for national and international marketing. Groundnuts for marketing are sold fresh or as sauté in the south whereas in northern Benin groundnuts are processed to oil (VAN DEN AKKER, 2000). The acreage of groundnuts accounts for 160,000 hectares with an average yield of about 800 kg per ha in 2004 (FAOSTAT, 2005).

[6] Bas-fonds in French.

2.4 Conclusions of the chapter

This chapter has given a brief account of the general situation in Benin, its climatic and natural settings, the economic situation and agriculture, which together build the framework for livestock management in Benin.
Benin is one of the poorest countries with a simultaneously high population growth. The country is characterised by natural differences on a small scale, numerous ethnic groups, and several political and administrative changes in the last few decades. Agriculture plays an important role in Benin's economy as the most important source of income. Benin's agriculture is characterised by subsistence farming, low yields, and also a low growth in productivity. Until now, agricultural policy has concentrated on cotton production as the most important cash crop.
These features indicate that the economic sectors are changing and there are signs of new developments. The livestock sector is one of the sectors which has to deal with changing circumstances. In the following chapter we will have a look at production methods in livestock management to provide a better understanding of the system.

Chapter 3

Production methods in livestock management

In this chapter, the production methods of the Beninese livestock sector are presented, and the most important animal species and their production methods are described in detail. In this study, the terms “livestock management” and “animal production” both refer to the keeping of cattle, sheep, goats, pigs, and chickens as these animal species are the most important agricultural productive livestock in Benin.

3.1 Survey description and secondary data

Information and figures related to Beninese livestock management given in the following sections are derived from different sources, such as literature (masters and doctoral theses, local experts, reports of organisations), and two surveys conducted by the author. These data serve as the basis for modelling the livestock sector described in chapter 7.

Data availability in livestock management is generally poor in Benin for several reasons: a high proportion of animals is kept in small herds for various purposes as they are not the major concern of the farmers. Furthermore, livestock keepers of large cattle herds are not well integrated in local administrations due to their mobile style of life. Additionally, high foreign currency revenues from export do not exist or rather are not expected, which leads to a lack of interest at the state level. As a result there is only a small representation of animal keeper in-

terests in official issues. However, over the last few years an increasing number of case studies and surveys have been drawn up, providing a better overview of Benin's livestock husbandry. This literature has been analysed with respect to production methods, and questionable data have been discussed with local experts. In particular, much time was invested in discussing the official animal statistics with the experts. All experts are engaged in livestock management at the University of Abomey, the Direction de l'Elevage, the CeRPA, the national farms or development and private organisations.
The experts were also consulted in order to obtain general understanding of the sector. In numerous open expert interviews during different stages of the study, qualitative data on the background of livestock management and its mechanisms were provided.

In addition, two formal surveys were conducted during six weeks in October and November 2005 in order to complement data and identify trends in this sector. Both surveys can be found in the appendix. For the first survey, local experts were consulted, while for the second survey local animal keepers in three different regions were interviewed (see figure 3.1).
The standardised expert survey comprised closed and open questions as well as hybrid questions where the questioned person had the possibility to add aspects which are relevant in their opinion. The written expert survey was divided into two parts: the first was about the current situation in livestock management and its problems, such as increase of performance, innovations in production methods or commercialisation of animal products. The second part dealt with the development of the sector until 2025, as trends cannot be easily deviated from statistics. Special attention was given to the development of production methods and to possible ways of responding to the increasing demand for animal products. Due to great varieties in land availability and production systems, some of the questions concerning land aspects were regionalised according to the three regions North (Atacora, Alibori), Central (Collines, Donga, Borgou) and South (departments Atlantique, Littoral, Ouémé, Plateau, Mono, Couffo, Zou).
The expert survey was carried out as a complete inventory count. Finally, 34 of the 37 experts, who were evaluated in a previous field survey, participated.

As mentioned before, these livestock experts are engaged at the University of Abomey, the Direction de l'Elevage, the CeRPA, the national farms or development and private organisations.

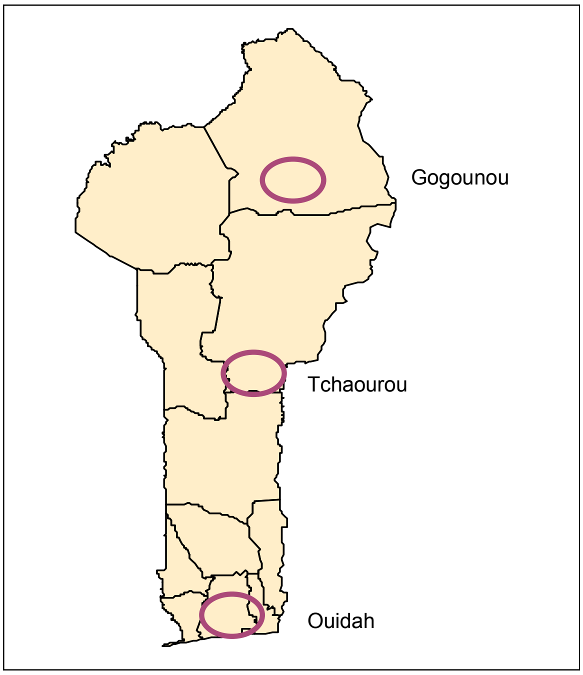


Figure 3.1: Location of the field research
Source: Author's illustration, 2005

Corresponding to the three regions in the expert survey, one commune for each region was chosen for the producer survey. The survey was realised in the three communes Ouidah, Tchaourou, and Gogounou. The selected communes are typical of each region representing the local production structure and methods as well as the endowment of natural resources. In the south, Ouidah stands for the periurban production systems near the conurbations of Cotonou, Abomey, and Porto-Novo. The research site of Tchaourou in Central Benin represents a region where large areas are still available for pasturing, but where also conflicts over resources occur regularly between farmers and livestock keepers. The third region, Gogounou in the north, has less precipitation compared to the other two regions, and is known for its efficient organisation and innovations in marketing. In order to see the differences in location and access to the local and interregional road network, 25 animal keepers in four to five different villages in each chosen commune were selected. The samples of finally 75 animal keepers were taken with the help of local producer organisations due to the generally guarded or even wary attitude of animal keepers towards national officials or strangers. As the survey was authorised by the local chiefs, even questions concerning taboos like number of animals were answered reasonably. The animal keepers were asked about their production methods and commercialisation. In particular, questions on aspects concerning the resources of water and natural forage were conducted in detail. Some of the questions were exactly the same as the ones handed out to the experts in order to find out whether their respective assessments of the situation concur (or not). Both surveys were evaluated with the programme system SPSS 12.0.

A workshop was carried out at the end of the field research in order to analyse the results. All experts who participated in the survey were invited to discuss the results and the development of livestock husbandry in Benin. The workshop was attended by 18 out of 34 participants of the survey, who discussed the initial results of the expert survey.

3.2 General outline

Livestock population and distribution

In 2004, about 1.8 million cattle, 0.7 million sheep, 1.35 million goats, 0.3 million pigs, and 13 million chickens were kept in Benin (FAOSTAT, 2005). As figure 3.2 shows, numbers of kept animals ascended continuously during the last few years. Deviants from the long-term trend are caused by the political uncertainty at the end of the 1980s and from epizootic diseases which decimated stocks.

Beninese experts confirm that, since 1990, statistics for cattle, sheep, goats, and pigs have been reliable. The official figures for chickens, however, can only be taken as an estimation, since almost every household keeps poultry. The exact number of chickens is often not known even at the household level, therefore these numbers are not included in the figure.

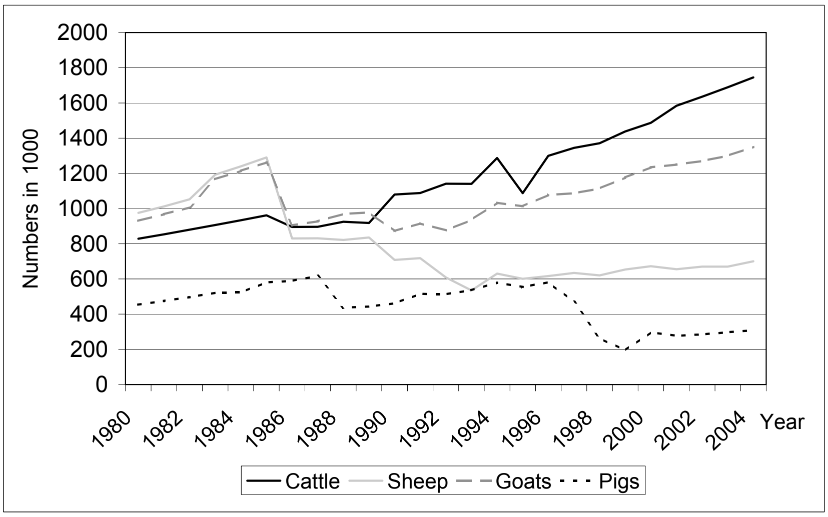


Figure 3.2: Development of animal numbers between 1980 and 2004
Source: FAOSTAT, 2005

Due to the need for different adaptations to the given natural landscapes and cultural backgrounds, productive livestock is not evenly distributed across Benin. Figure 3.3 reveals that cattle are kept predominantly in the north of the country, while pigs are kept mainly in the southern part. According to JAHNKE (1982) the distribution of cattle stock depends significantly on the existence of disease vectors. In Benin, cattle production is constricted in some regions by the African trypanosomiasis, which is passed on by tsetse flies. Other factors are availability of land and water places.
Religion is a notable factor for the distribution of pig production. Only marginal pig production can be found in predominantly Muslim regions, which is the case in northern Benin. For two reasons, pigs are often produced in more humid regions (KING, 1983), where cropping and sedentary farming is established. In the first place, sedentary farming produces surpluses or residues from cropping that facilitate pig keeping, and secondly, pigs are not adapted to nomadism (LEGEL, 1993).
The distribution of poultry stock is closely related to settlements. Poultry keeping is more determined by proximity to people than by natural conditions (JAHNKE, 1982).

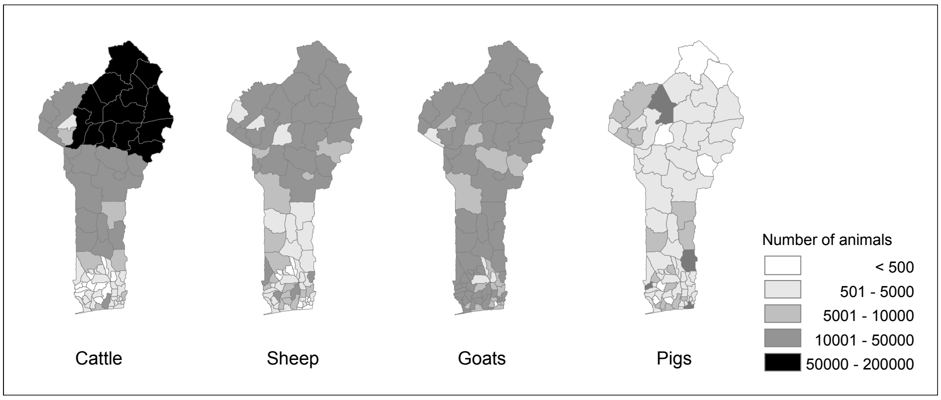
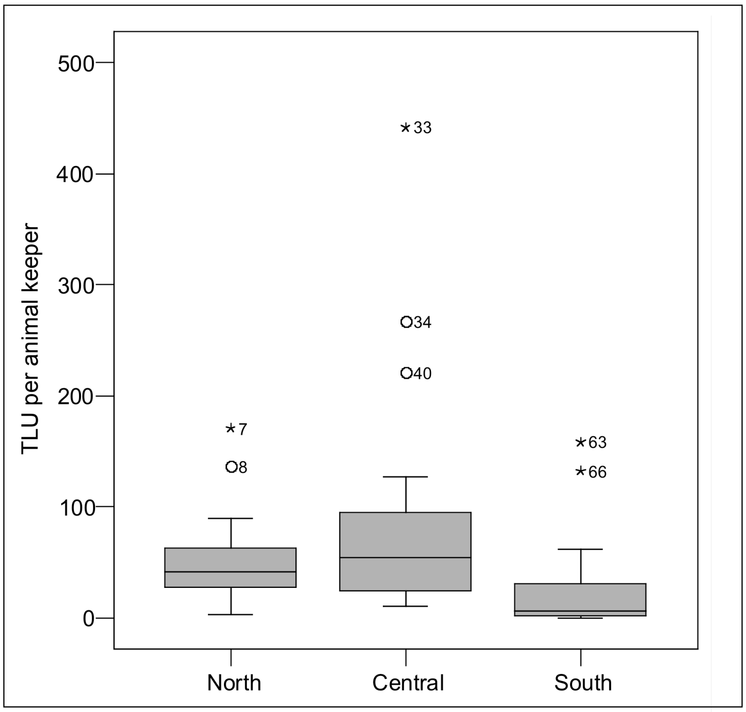


Figure 3.3: Distribution of productive livestock in 2002
Source: Author's illustration, 2004; Data: Direction de l'Elevage, 2003

The small ruminants, sheep and goats, are kept both in northern and southern Benin. While the number of goats is about equivalent to the number of sheep in the north, more goats than sheep are kept in the south. According to DOSSA (2002), farmers in southern Benin prefer keeping goats rather than sheep despite the higher monetary benefit of sheep keeping. Given reasons are a lower risk and fewer difficulties in keeping goats, which do not need high forage quality and stay near the settlements. Lower capital expenditure of goat keeping in contrast to sheep keeping as well as higher productivity are other potential explanations (EL AICH and WATERHOUSE, 1999). A study of the south-west of Nigeria by OKALI and UPTON (1985, cited in DOSSA, 2002) reveals that more goats than sheep are kept due to the potential destructiveness of sheep, and due to religious reasons.
The distribution of animal species is reflected in the dimensions of animal stock per animal keeper as figure 3.4 reveals. As demonstrated by data of the producer survey, livestock per animal keeper is aggregated through the Tropical Livestock Unit (TLU), which corresponds to 250 kg live weight (LW). The two non-parametric tests, H-Test of Kruskal-Wallis (global test, testing that several independent samples do not differ in mean rank) and the U-Test of Mann and Whitney (test for comparing two independent samples), are used to analyse the distribution of TLU (BÜNING and TRENKLER, 1994). The H-Test of Kruskal-Wallis[1] shows a significant difference among the three regions with the p-value

[1] The H-Test is used as homoscedasticity does not exist.

smaller than 0.001. A closer inspection of respectively two regions with the U-Test of Mann and Whitney identifies a significant difference between the northern and the southern regions as well as between the central and the southern regions. In contrast, a non-significant difference has been identified between the northern and central regions.



rings° and stars* are outliers

Figure 3.4: Regional animal stock per animal keeper in TLU
Source: Author's producer survey, 2005

The majority of outliers (rings[2] and stars[3] in the figure) seem to be reasonable values. Particularly in the south, the two outliers show the heterogeneity of production systems in livestock management, as both outlying values belong to cattle keepers. Cattle are therefore not the most typical production system but are nevertheless present in the southern region.

[2] Rings represent values which are more than 1.5 lengths of the box above the 75. percentile.
[3] Stars represent values which are more than 3 lengths of the box above the 75. percentile.

Ethnic groups and conflicts

Traditionally there is a strong specialisation of farms and ethnic groups in either livestock management or cropping. Although all ethnic groups are represented in livestock keeping, the Fulani are known as the specialists in livestock management (TOUTAIN et al., 2001). This specific strict and spatial separation of ethnic groups prevailed until about 1960. Cropping was conducted near the villages, whereas animal keepers settled on the edge of fields. Agreements existed between animal keepers and farmers. In particular, economic agreements were made such as the exchange of animal and cropping products, contracts for herding cattle or the protection of the Fulani (COMO, 1994b).
Due to the growing population and the expansion of arable land and of animal stocks, the close correspondence of production systems to population groups has been declining. For the keeping of ruminants in Benin COMO (1994a) defined seven agricultural farm systems with different main focuses (see table 3.1).

Farms focusing on
- Livestock management and transhumant animal keeping
- Livestock management and sedentary animal keeping
- Cropping and cattle stock with herding contracts
- Cropping and cattle stock with herd management
- Exclusive keeping of small ruminants
- Owners of livestock without any other agricultural activity
- Transhumant animal keepers from neighbouring countries, dry season

Table 3.1: Farm types with ruminants
Source: COMO, 1994a

As a result of the growing diversification in agriculture, the expansion of arable land and the higher demand for pasture, conflicts may develop among ethnic groups. AKPAKI (2002) described several such violent conflicts in a study, which is strongly biased in favour of the Fulani. But the occurrence of violent conflicts between farmers and livestock keepers cannot be denied, and the marginal position of transhumant animal keepers in society is recorded frequently (COMO, 1994b; Direction de l'Elevage, 1997; VAN DRIEL, 2001; SOUNKERE, 2003; HOUINATO, 2004). As in other West African countries, pastoralists are often seen as foreigners, many of them are poorly educated and they are not established in the political system due to their seasonal wandering (COMO, 1994b).

Motives for livestock keeping

The reasons for livestock husbandry are diverse, which is why specific animal species are kept for different intentions and various purposes. In addition to this differentiation the dedication may slightly vary between ethnic groups. The essential motives for productive livestock keeping are income and capital formation, procurance of food, and manure, draught power, gifts, religious festivities as well as ceremonies.

Cattle are used for the production of meat and milk and as draught animals, especially for the cotton production (Direction de l'Elevage, 2004a). The resulting manure is sometimes bartered for forage, which is organised in manure contracts. The consumption of beef is not really customary according to a survey of KADEL (2001). However, cattle are important components of funeral ceremonies, obsequies, and weddings. Among the Fulani, the bride receives one or several heifers or cows on her marriage. Also among the Betamadibe cattle are given as bride presents. But with the latter ethnic group, cows are not milked (COMO, 1994a), whereas milk production is an important income source of the Fulani (KEES, 1996a).

As a result of bad conditions in banking and credit business, cattle are often used as long-term capital formation. Farmers invest their monetary surplus from cropping in cattle in order to build up reserves. Such cattle stock often features a lower productivity, because the limited number of animals does not justify the input of capital or labour in this division. Most of these animals are given into the care of shepherds, who have more expertise in this field than the farmers. Cattle are sold if a large amount of money is needed (COMO, 1994a).

In contrast, small ruminants are kept for short-term capital formation. Sometimes sheep are sold in order to rebuild cattle herds after epidemics (KADEL, 2001). The decision for keeping sheep or goats is based less upon economic considerations than upon tradition, gender, and risk behaviour. Additionally, switching from cropping to keeping small ruminants is observed among older people, for example, if field work is becoming physically too difficult for them (DOSSA, 2002).

Sheep are important for religious festivities such as the Tabaski-festivity[4], for births and baptisms as well as for gifts for important guests as a sign of hospi-

[4] Important Muslim festivity.

tality. Basically, the species and the number of the given animals demonstrate the social position and the reputation of the owner (KADEL, 2001). As sacrificial animals, e.g. sacrifices to ghosts, almost exclusively sheep of the indigenous species Djallonké are used, whereas crossbreeds or sheep of the species Sahelian are rarely sacrificed (DOSSA, 2002). Goats are kept less for social and religious aspects than for short-term capital formation (KADEL, 2001).
Pigs, like small ruminants, are kept for short-term capital formation, liquidity improvement, and for weddings and other festivities. Regular income and procural of food are minor reasons for pig raising (KPADONOU, 1990).
Unlike other productive livestock, poultry are mainly kept for consumption as well as for gifts, which hosts give to distinguished guests. Poultry are considered as cash in order to balance smaller short-term expenditures, but serve less for capital formation like ruminants (KADEL, 2001). Laying hens, which are mainly found on intensive farms in the south, are kept for economic reasons only and not for social events (ICRA, 2001).

3.3 Production methods

In this section a review of production methods for each productive livestock species in Benin will be provided, starting with cattle, followed by small ruminants sheep and goats, and closing with the non-ruminants pigs and chickens.

3.3.1 Cattle

Production
The 1.8 million cattle are kept mainly in North Benin and all species are triple purpose breeds (meat, milk, and draught). The cattle stock is composed of the four local species Borgou (75 percent of all cattle), Zebu (15 percent), Somba (4 percent), and Lagunaire (6 percent). They are all well adapted to geographical and climatic conditions. The Borgou species resides in the north-east, the Zebu species is in the north, the Somba species is located in the north-west, and the Lagunaire species can be found in the south (Direction de l'Elevage, 2004a). Some production figures are listed in table 3.2, with the subject in the first column. The studies carried out on a special breed or a special region are listed in the column "Specification" or rather in "Region".

Cattle						
	Specification	**Unit**	**Parameter**	**Region**	**Year**	**Source**
Age at first calving	Borgou, extensive	Months	39	North Benin	2003	Adamou-N.
	Borgou, semi-intensive	Months	30	North Benin	2003	Adamou-N.
Reproduction rate	Borgou	%	84	Okpara[1)]	2004c	DdE[2)]
	Borgou	%	62	Borgou	2004b	DdE
Dry period	Borgou	Days	105	Borgou	1991	Otchoun O.
Calving interval	Borgou	Year	2 to 3	Benin	2004	Senou
	Somba	Year	1	Benin	2004	Senou
	Borgou	Year	1.3	Borgou	2001	Codjia
Lactation period	Borgou	Days	250	Borgou	2001	Codjia
	Borgou, calving dry season	Days	90 to 150	Bétécoucou[1)]	1995	Nonfon
	Borgou, calving rainy season	Days	300 to 360	Bétécoucou[1)]	1995	Nonfon
Milk performance	Borgou	kg/lactation	300	Benin	2004	Senou
	Borgou	kg/lactation	320	Borgou	2004b	DdE
	Borgou	kg/lactation	200	Borgou	2001	Codjia
	Borgou	kg/lactation	200	Borgou	1991	Otchoun O.
Replacement	Cattle	Age in years	10	Benin	2004	Senou
Birth weight	Borgou	kg	18.4	Borgou	2001	Codjia
	Borgou	kg	25.6	Bétécoucou[1)]	1995	Nonfon
Daily weight gain	Cattle, dry season	g/day	150	Kpinnou[1)]	1993	DdE
	Cattle, rainy season	g/day	511	Kpinnou[1)]	1993	DdE
Live weight (LW)	Borgou	kg	212	Borgou	2004b	DdE
	Borgou	kg	239	Borgou	2004b	DdE
Weight loss	Dry season	% of LW	14	Bétécoucou[1)]	2006	Tondji
	Dry season	% of LW	30	Benin	1992	DdE
Carcass yield	Borgou	% of LW	52	Benin	2003	Adamou-N.
	Borgou	% of LW	49.2	Borgou	2003a	DdE
	Zebu	% of LW	42.3	Borgou	2003a	DdE
Slaughtering weight	Borgou	kg	117	Borgou	2004b	DdE
Feeding requirement	Cattle	kg DM/animal and day	6.25	Benin	2004	Senou
Global mortality	Borgou	%	1.54	Okpara[1)]	2003b	DdE
	Borgou	%	7.5	Borgou	2001	Codjia
	Cattle	%	8	Benin	1994a	COMO
	Borgou	%	2.9	Bétécoucou[1)]	1993	DdE

[1)] National farm [2)] Direction de l'Elevage

Table 3.2: Production figures of cattle

Source: Compiled by the author, 2006

As these figures point out, productivity and keeping of cattle are at a low level. All parameters associated with dairy production show an extensive production, and in general no great development over the years can be noticed. Although milk performance is low at 1 to 2 kg per cow and day, milk is not only fed to calves, but is also used for human consumption and processing. Milking is generally done manually, once a day and mainly in the morning, but some ethnic groups milk in the evening.
Regarding meat productivity, only marginal or no change is observable. This pattern can be found all over the world, as the partial productivity of cattle measured in kg meat per animal has slow growth rates due to long production cycles. But in Benin, as figure 3.5 illustrates, the produced beef per animal and year in absolute terms is less than one third of the world's average, and even the African average is recognizably higher.

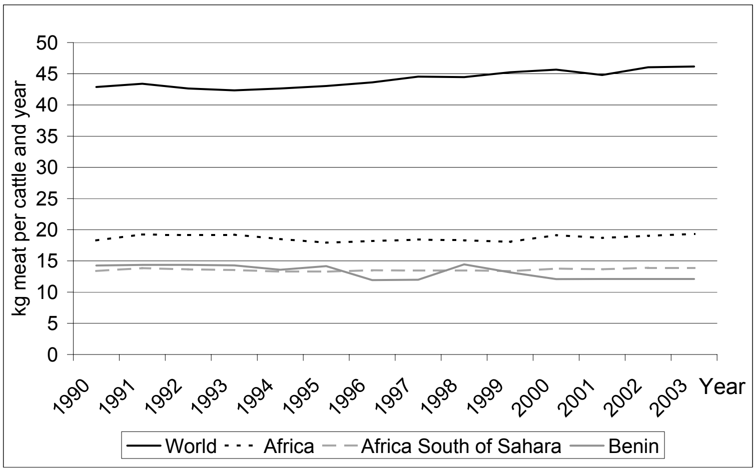


Figure 3.5: Partial productivity of cattle between 1990 and 2003
Source: Author's illustration, 2005; Data: FAOSTAT, 2005

The genetic disposition of the local species with low live weights of about 220 kg per animal might be one reason. However, higher productivity is feasible also in Benin, as national farms like Okpara or Bétécoucou show. These farms are improving and enhancing production methods and meat productivity of local breeds. The improvement of mortality and reproduction rates clearly indicates an increase in partial productivity measures of local species just by slight intensification.

About 80 percent of Benin's cattle are kept without stables in an extensive housing system, just fastened for the night, with hardly any planning of feeding, and marginal veterinary care (Direction de l'Elevage, 2004a). Currently, widespread diseases include cattle pasteurellosis, dermatophilose, bovine contagious pleuropneumonia, and African trypanosomiasis (FAGBOHOUN, 2004). Some of the local cattle species like the Somba are immune to the tsetse fly or at least less infected (Direction de l'Elevage, 1994). Treatments are theoretically available, but there is only an incomplete network of veterinarians. Producers often consider the costs to be too high and a general understanding of the advantage of vaccination is sometimes lacking. If, for example, cattle die from pasteurellosis after being given just the first of two vaccinations against pasteurellosis, local farmers often think that the death of the animal was caused by the first vaccination. As a consequence, they no longer have any animal vaccinated. In addition to or instead of conventional medicine, traditional medicine is also used. But vaccination rates are highest for cattle compared to other productive livestock as cattle are the most precious livestock, and the death of just one animal is a great loss for cattle keepers.

Feeding and transhumance

Feeding is significantly determined by the availability of natural forage as feed cropping is traditionally unknown. Cultivating forage is still mainly done on national farms. Statistics disclose that only 20 hectares are cultivated with forage outside of the national farms in the whole of Benin (Direction de l'Elevage, 2001). Many initiatives are trying to give animal keepers an understanding of feed cropping and conservation of feedstuff in order to establish a more productive livestock management and to guarantee sufficient forage throughout the year.

Natural vegetation is the main fodder; therefore, feeding systems, rations, and contents differ according to seasons. Main forage sources are natural pasture, fallow land, crop residues after harvests, cut forage from forests, and some additional mineral fodder, particularly salt. Between dry and rainy seasons, seasonal livestock migration, the so-called transhumance, is a widespread strategy to enlarge the forage supply and to ensure sufficient feeding. This means that pastoralists wander with their herds to find better conditions of feeding and watering. In Benin, as in Burkina Faso, transhumance does not begin on a specific date but depend on weather conditions and forage availability (TOUTAIN et al., 2001). The routes taken for transhumance are more or less the same each year. However, they are chosen depending on the conditions experienced in the previous year. The decision for a particular route is based on rain, forage, conditions of the route, population and settlements, diseases, and security for animals and herdsmen. As a consequence of the rise in population, overgrazing, and fewer animal diseases, it can be observed the transhumant migrations are moving further towards the south (TOUTAIN et al., 2001).

In Benin, normally two kinds of transhumance can be distinguished: the great transhumance in the dry season and the small one in the rainy season. In some regions and in some ethnic groups, however, four livestock migrations occur during one year. In these cases an additional interim migration is carried out between the major migrations (AKPAKI, 2002).

The great transhumance is particularly necessitated by the shortage of forage and water supply in the dry season with a period of three to five months (HOUINATO, 2004). The herds of 40 to 100 cattle, mainly of the Borgou species belonging to the Fulani and the Gando, wander long distances. The specification of the distance differs according to sources: distances up to 200 km are reported (COMO, 1994a; Direction de l'Elevage, 2004a) as well as distances between 200 and 450 km depending on herd size and the planned destination (AKPAKI, 2002). However, neither the entire household nor the complete herd take part in the migration, as is the case in nomadism. Some milking cows remain in the village, and the elderly persons and the children of a household, who stay at home, look after them. This strategy, that is one part participating in the transhumance and the other keeping near or in the village, is employed not only to take care of the family members who stay behind, but also to support the family if animal diseases break out and a new herd has to be built up (MEURER, 1992; KADEL, 2001; AKPAKI, 2002).

The main reason for the small transhumance in the rainy season is that animal keepers want to avoid damages in cropping fields and the resulting conflicts (TOUTAIN et al., 2001). Another motivation is to release farm hands from guarding both animals and crops in order to provide more manpower for cultivation. Further away from the cropping areas fewer persons are needed to herd livestock than in the surroundings of the cultivations (MEURER, 1992). The small transhumance within a radius of 1 to 30 km from the settlement is conducted by mobile and sedentary animal keepers and even farmers (KEES, 1996b; AKPAKI, 2002).

The interim migrations keep close to settlements. Contracts between farmers and animal keepers regulate the exchange of services: farmers allow the livestock to feed on crop residues and, at the same time, benefit from the manure left from livestock, the assistance of some of the herdsmen during harvest, or from the barter with milk or chickens (AKPAKI, 2002).

International transhumance and difficulties

In the dry season, herdsmen from neighbouring countries migrate with their herds to Benin, also due to the shortage of forage and water. Estimating international movements of animals is difficult, because counting transhumant animals is not considered to be of great importance at the borders. In addition, official border crossings are often avoided in order to circumvent taxes and/or customs duties (KIPPER, KRÖGER and AHOMLANTO, 1993; AKPAKI, 2002). In literature opinions differ about fees, both the kind and the amount are not clear. Some records mention fees for border crossing ranging from a hundred to several thousands of FCFA, others mention amounts up to 50,000 FCFA per herd. VAN UFFORD (2000) noticed that the level of taxes is not known, not even to officials. In 2005, the attempt to clarify taxes with the expert survey failed again.

Apart from some small disagreements, the migration of herds and the setting up of temporary camps normally goes smoothly. Unwritten traditional rules lay down that no pastoralist may be refused access to water and forage by another pastoralist (COMO, 1994b). Relations between farmers and animal keepers are more stable when they enter into herd-keeping contracts because of the resultant advantages on both sides. Farmers and animal keepers make private contracts, by which the herdsman take care of the cattle and are paid for it, whereas the farmers have the advantage of handing over their animals to experts (AKPAKI, 2002).

However, the expansion of the agricultural area with the simultaneously growing number of animals depending on natural pasture, the sharing of the same water sources, and the relaxation of inter-ethnic relations because of changing production systems causes conflicts. Moreover, mobile animal keepers and farmers increasingly ignore the traditional transhumance routes, thus augmenting disagreements and armed conflicts between these groups (COMO, 1994b). Not only social difficulties arise from mobile livestock management, but also ecological and production problems become apparent when watering points are gathering places of many herds in the dry season. The concentration of many herds at the same spot can cause an over-use of grazing areas around these places as well as soil degradation. Furthermore, an increasing risk of infections exists at such gathering points.

Opinions differ as to whether transhumance in Benin is exclusively determined by production methods or also by cultural background. According to a survey on transhumance, animal keepers regard transhumance solely as a production method without feeling constrained to follow a tradition (TOUTAIN et al., 2001). In contrast, according to MENSAH (2004), transhumance is part of the culture; for instance, a Fulani man must go on transhumance before he can marry and have a family. In 2005, this latter opinion was confirmed in another expert talk with the President of the Union Départementale des Organisations Professionnelles d'Eleveurs de Ruminants (UDOPER), who explained that the need for forage and water is one of the reasons for transhumance, but that it is also part of the Fulani culture.

Draught power

The tradition of using animals as draught power is relatively new in West Africa: this technique was unknown until the second half of the 20th century (DELGADO et al., 1999). In Benin, draught power, which is nearly exclusively provided by cattle, was promoted in the 1960s to stimulate cotton production in the north and palm oil production in the south. But this technique did not prevail in the south and, according to a study of COMO (1994a), it can be assumed that the importance of draught animals in the south will continue only on a marginal level because of scarce cultivable area and small fields. In comparison, a considerable number of draught animals are used in the north mainly for cotton production (IMF, 2003). The intensive use of draught power in recent years has occurred in regions with cotton production, which rose by 158 percent between 1996 and 2000 (CODIJA, 2001). By introducing animal power in crop cultivation, an expansion of the agricultural area and an increase in working productivity are possible. Draught power simplifies soil preparation and saves cultivation time. This time can be used for additional farming. The rainy season as the period for soil preparation and sowing can be used more efficiently and time pressure will decline. The time and man power gained by using draught animals is particularly used for the cotton harvest (BRÜNTRUP, 1997). Animal keepers also benefit from the employment of draught power in crop production by adding 50,000 to 100,000 FCFA per animal to normal market prices[5] when selling cattle for draught purposes (Direction de l'Elevage, 2004a).

As a consequence of the use of draught power, agricultural areas are cleared of trees to remove obstructions to ploughing. Although farmers are obliged to plant compensatory trees, there is first a need for an arrangement with the land owners, as in the traditional land law planting a tree often means claiming the land. This additional planting of trees is sometimes carried out more to cultivate marketable trees than to replace the cut ones (SCHRECKENBERG, 2000). Generally speaking, Benin's draught animals are mainly used for crop cultivation, especially in the cotton production, but rarely for transportation.

3.3.2 Small ruminants

The approximately two million small ruminants, sheep and goats are found throughout Benin. As production methods for sheep and goats are very similar in Benin and there is hardly any distinction in surveys and literature, they are subsumed under one description. Djallonké, the traditional indigenous species in South Benin, as well as Sahelian are breed names for both sheep and goats. In table 3.3 production figures for sheep are listed and where data are valid for both sheep and goats, the second column in "Specification" marks this with "s & g".

The Djallonké sheep is a hair sheep and well adapted to humid and semi-humid climates (KADEL, 2001; DOSSA, 2002). The Djallonké sheep are valued for their high fertility, which is higher than that of the Sahelian sheep. Moreover, Djallonké sheep are favoured due to the better understanding of how to keep

[5] Price of bull or ox between 150,000 FCFA and 340,000 FCFA depending on market in 2004.

them. Compared to them, the Sahelian sheep and crossbreedings are larger and preferred to Djallonké due to faster growth and their meekness.

Sheep							
	Specification		**Unit**	**Parameter**	**Region**	**Year**	**Source**
Age at first lambing	Sheep Djallonké	s&g s&g	Months Months	12 15 to 24	Bétécoucou[1)] Atacora	1996 1984	PPEA Auer
Duration of gestation	Djallonké		Months	5	Foun-Foun[1)]	1993	Almeida
Reproduction rate	Djallonké		%	112	Bétécoucou[1)]	2000	Senou
Lambing interval	Sheep Sheep Djallonké	s&g	Months Months Months	6 8 to 9 8	Bétécoucou[1)] Benin Foun-Foun[1)]	1996 1994a 1993	PPEA COMO Almeida
Replacement	Sheep		Year	7	Atacora	2001	Kadel
Birth weight	Djallonké Djallonké Sheep Djallonké		kg kg kg kg	2.5 2 1.5 2.1	Bétécoucou[1)] Bétécoucou[1)] Benin Foun-Foun[1)]	2006 2000 1994a 1993	Tondji Senou COMO Almeida
Weight gain	Djallonké Djallonké		kg at 1 year	14.1 13.6 to 14.1	Benin South Benin	2000 2002	Senou Dossa
Live weight	Djallonké Djallonké Djallonké Djallonké Sahelian		kg kg kg kg kg	40 to 45 15 to 30 20 to 25 30 to 46 40 to 55	Bétécoucou[1)] Atacora Benin Bétécoucou[1)] Atacora	2006 2001 2000 2000 2001	Tondji Kadel Senou Senou Kadel
Slaughtering weight	Sheep		kg	5 to 14	Cotonou	1986	Baptist
Mortality, globally	Sheep Sheep Sheep	s&g	% % %	6 21.2 9.1	Bétécoucou[1)] Benin Bétécoucou[1)]	1996 1994a 1993	PPEA COMO DdE

[1)] National farm

Table 3.3: Production figures of sheep
Source: Compiled by the author, 2006

The production figures of goats are presented in table 3.4. More than 90 percent of the goat population are Djallonké (DOSSA, 2002). Productivity of keeping small ruminants is at a low level, but national farms are slightly better off. Mortality rates on the national farms are considerably lower than the national mean value. However, the average value has obviously been improving both for sheep and goats since the 1990s.

Goats							
	Specification		Unit	Parameter	Region	Year	Source
Age at first kidding	Goat	s&g	Months	12	Bétécoucou[1)]	1996	PPEA
	Goat		Months	14 to 18	Benin	1994a	COMO
	Djallonké	s&g	Months	15 to 24	Atacora	1984	Auer
Fertility	Goat	s&g	%	162	North Benin	1996	PPEA
	Goat	s&g	%	135	Bétécoucou[1)]	1996	PPEA
	Djallonké		Farrow/year	1.4 to 2.2	South Benin	2002	Dossa
Farrowing interval	Goat	s&g	Days	180	Bétécoucou[1)]	1996	PPEA
	Goat		Days	251	Benin	1994a	COMO
	Djallonké		Days	230 to 274	South Benin	2002	Dossa
	Djallonké	s&g	Days	300	Atacora	1984	Auer
Birth weight	Goat		kg	1.4	Benin	1994a	COMO
	Djallonké		kg	1.2 to 1.3	South Benin	2002	Dossa
Weight gain	Djallonké		kg at 1 year	9.5 to 11.1	South Benin	2002	Dossa
Live weight	Sahelian		kg	80	Benin	2004	Mensah
	Djallonké		kg	15 to 30	Atacora	2001	Kadel
	Goat		kg	21	Benin	1994a	COMO
	Djallonké	s&g	kg	15 to 30	Atacora	1984	Auer
Carcass yield	Goat	s&g	kg	5 to 14	Cotonou	1986	Baptist
Mortality, globally	Goat	s&g	%	6	Bétécoucou[1)]	1996	PPEA
	Goat		%	17.6	Benin	1994a	COMO
	Djallonké		%	30 to 40	Atacora	1984	Auer

[1)] National farm

Table 3.4: Production figures of goats
Source: Compiled by the author, 2005

Productivity of small ruminants depends on fertility and mortality rates, number of offspring, weight of the offspring, health care, and general management. Therefore, low mortality rates are important for productivity. Another important aspect is genetic disposition, which is often considered to be too low. For this reason, programmes have been established in order to promote crossbreeding and a replacement of Djallonké by Sahelian (DOSSA, 2002). Regarding the development of partial productivity in figure 3.6, the same situation as with cattle is observable, there is no positive shift in performance. The main reasons for the low productivity in Benin are high mortality and very low input (KADEL, 2001).

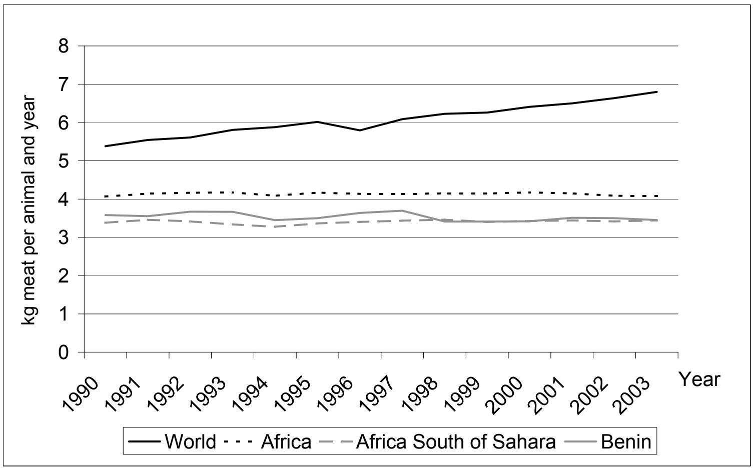


Figure 3.6: Partial productivity of small ruminants between 1990 and 2003
Source: Author's illustration, 2005; Data: FAOSTAT, 2005

The high mortality rates and low fertility rates are caused by several factors such as undernourishment, parasites, and diseases of the respiratory and gastric organs. The most widespread disease is the pest (FAGBOHOUN, 2004), which causes, inter alia, sudden fever, nasal discharge, or diarrhoea. Although veterinary treatment might improve the situation, only 20 percent of the small ruminants are given basic veterinary care (DOSSA, 2002). According to local farmers an estimated 60 percent of the losses are due to diseases, whereas another 28 percent of losses are caused by theft, accidents, wild animals, and poisoning (KADEL, 2001). DOSSA (2005) considers the explanation of "disease is reason for death" to be overstated, as farmers only know of diseases as the cause of death in the case of ruminants. He suggests that inbreeding is the main reason for the high mortality rate in some villages.

Most small ruminant keepers demonstrate a low level of knowledge of the subject and provide little care for their animals. Some neither know why their animals have died nor at what age their sheep might be lambing (about 24 percent) or their goats might be kidding (about 42 percent) for the first time. Moreover, there is no selection of male animals for reproduction. Instead, the best performing ones, the faster growing male animals, are sold first due to better prices

obtained. The remaining weaker animals are responsible for reproduction, and they reproduce in a particularly uncontrolled way (DOSSA, 2002).
Small ruminants, which are traditionally kept in herds of two to ten animals, are often left to their own resources, which means roaming around the camp searching for fodder. If available, kitchen scraps or crop residues are provided as additional feeding, but not regularly. During harvest time and at night the small animals are tied up in order to avoid or, at least, reduce damages or thefts. Stables or sheds for rainy seasons hardly exist, and if they do exist, their construction is of poor and inadequate quality (KADEL, 2001; DOSSA, 2002). Surprisingly, KADEL's study (2001) shows that the mortality rate in herds that are kept exclusively in stables is higher, perhaps due to irregular feeding and higher proneness to diseases. This might be one reason why animal keepers are suspicious about new housing systems.

3.3.3 Pigs and chickens

Pigs

The last group discussed in this section includes the roughly three hundred thousand pigs and the approximately 13 million chickens. The predominant pig breed, race local or also called porc ibérique, was imported by Portuguese and Spanish traders (MDR, 1997). It is well adapted to the local climate. Although they are fertile with good mothering characteristics, their growth is quite slow as can be seen in table 3.5. The non-native breeds are only spreading slowly because they are considered both too fat and too big, thus causing problems for processors who have not enough cooling capacity for storage after slaughtering (ADEGBIDI, 1996).

Pigs						
	Specification	**Unit**	**Parameter**	**Region**	**Year**	**Source**
Age at first litter		Months	6	Ouémé	1995	Kottin
Duration of gestation		Days	118	Ouémé	1995	Kottin
Farrowing interval		Days	183	Benin	1995	Kottin
Litter size		Piglet/litter	10	Kpinnou[1)]	2006	Lokossou
	Alive	Piglet/litter	6	Benin	1996	Codjo
		Piglet/litter	7	Ouémé	1995	Kottin
		Piglet/year	8	Benin	1990	Kpadonou
Number of nursed piglets		Piglets/sow	5	Benin	1996	Codjo
		Piglets/sow	5	Ouémé	1995	Kottin
Age at weaning of piglets		Days	44	Ouémé	1995	Kottin
Weight at weaning of piglets		kg	4.9	Benin	1996	Codjo
		kg	5	Ouémé	1995	Kottin
Weight of sow at first litter		kg	28	Benin	1996	Codjo
		kg	19	Ouémé	1995	Kottin
Birth weight of piglet		kg	0.96	Benin	1997	MDR
		kg	0.96	Ouémé	1995	Kottin
Daily weight gain	Between 7 to 22 kg LW	g/day	182 to 200	Benin	2003	Codjo
		g/day	77.5	Benin	1997	MDR
		g/day	155	Benin	1996	Codjo
		g/day	53	Ouémé	1995	Kottin
	Female	g/day	118	Ouémé	1995	Kottin
	Male	g/day	168	Ouémé	1995	Kottin
		g/day	74	Benin	1995	Kottin
	Race importé	g/day	118	Benin	1995	Kottin
		g/day	60	Benin	1995	Kottin
Live weight		kg	34 to 45	Benin	1997	MDR
		kg	21	Benin	1996	Codjo
		kg	27	Benin	1995	Kottin
		kg	30 to 60	Benin	1990	Kpadonou
Carcass yield	Between 7 to 22 kg LW	%	71.5	Benin	2003	Codjo
Mortality	Until weaning	%	29.1	Ouémé	1995	Kottin
	After weaning	%	5.9	Ouémé	1995	Kottin

1) National farm

Table 3.5: Production figures of pigs

Source: Compiled by the author, 2006

Low input and semi-intensive systems are predominant with regard to the management of pigs, particularly the local race. Only three percent of the national pig stock is kept in modern farming systems, often using the races Large White and Land race (Direction de l'Elevage, 2004a). The constant level of productivity in pork production during the last decade is illustrated in figure 3.7.

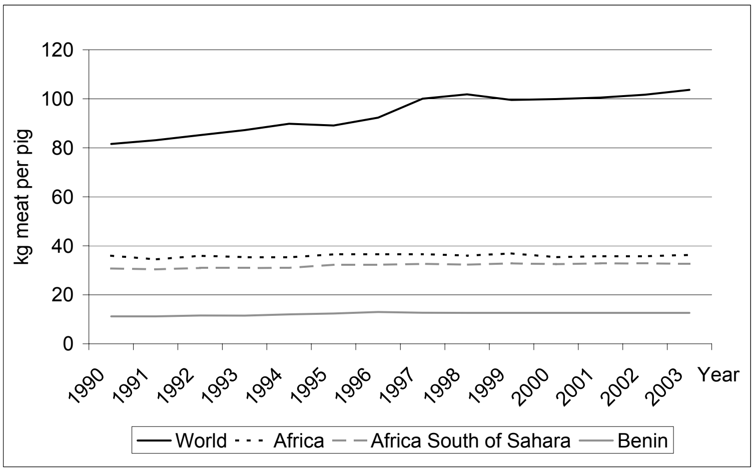


Figure 3.7: Partial productivity of pigs between 1990 and 2003
Source: Author's illustration, 2005; Data: FAOSTAT, 2005

The non-existence of a development in partial productivity measures is definitely a consequence of the bad housing conditions. Another reason might be the outbreak of the African swine fever in 1997, which reduced the national pig stock to one third of the original pig stock and placed containment strategies into the foreground. The genetic characteristics of the local race might be another cause, but in conclusion, its potential is hard to research under these circumstances (LEGEL, 1993). However, as the figures for the world average show, a greater productivity in pig production could be relatively easily achieved, as reproduction cycles are short and a good genetic potential could be passed on quickly.

The African swine fever, which is the most important disease, is more or less under control at the moment. But diseases can spread uncontrollably fast in Benin because pigs as small ruminants are often left to their own resources and are in constant contact with the other pigs in the village. Stables are rarely built and feeding is a flexible combination of available feeding products. Maize and cassava are the traditional fodder for pigs, complemented by household scraps and what pigs are able to find (CODJO, 1996). A typical ration feeding in the department Ouémé is composed of three-quarters of maize and one quarter of a combination of residues of the mill, cassava, and potatoes (KOTTIN, 1995).

Chickens

Poultry production is very heterogeneous both with regard to animals and techniques. Therefore, a description of production methods is bound with some difficulties. Beside chickens, particularly of the local breed, other poultry are kept such as turkey, guinea fowl, pigeon, duck, quail, and goose (N'NOUME, 2000). Guinea fowl and turkey are kept mainly in northern villages, while ducks are more common in southern Benin (Direction de l'Elevage, 2004a). Concentration in this synopsis is explicitly on chickens, because this poultry species forms the largest part of poultry stock. Traditionally mixed fowl keeping is practiced with egg and meat production. In intensive housing systems where imported races are kept, laying hen or meat poultry are differentiated, whereof about 80 percent are laying hen and 20 percent broiler (N'NOUME, 2000; Direction de l'Elevage, 2004a). Although intensive production is expanding, chickens on modern farms still represent only a maximum of 5 percent of the national chicken stock (Direction de l'Elevage, 2004a).

Table 3.6 presents production figures of the local breed, traditional and modern housing systems. As with all the previously discussed livestock species, the table shows low productivity levels in traditional chicken keeping. But it also highlights the significant differences between traditional and modern systems. The latter is located preferentially near larger cities such as Cotonou, Porto-Novo, or Parakou (PDDAA, 2004).

Chickens						
	Specification	**Unit**	**Parameter**	**Region**	**Year**	**Source**
First laying	Traditional	Months	6 to 8	Benin	2002	Houndje
Laying season	Modern	Weeks	52	South Benin	2000	Ayena
Laying performance	Traditional	Eggs/year	32 to 44	Benin	2004	Mensah
	Traditional	Eggs/year	32	Mono	2002	Houndje
	Traditional	Eggs/year	18 to 36	Benin	2002	Houndje
	Modern	Eggs/year	250	Benin	2003	MAEP
	Modern	Eggs/year	220	South Benin	2000	Ayena
	Modern	Eggs/year	270	South Benin	2000	Ayena
Weight of eggs	Traditional	g/egg	31	Mono	2002	Houndje
	Traditional	g/egg	35	Benin	2002	Houndje
	Modern	g/egg	60	South Benin	2000	Ayena
Number of chickens	Traditional	Chickens/hen and year	18	Mono	2002	Houndje
Birth weight	Hen, local	kg	0.3	Mono	2002	Houndje
Growing period		Weeks	20	South Benin	2000	Ayena
Feed requirement	Laying hen	g/day	125	Benin	2003	MAEP
		g/day	115	South Benin	2000	Ayena
	Until 2 kg LW	kg	4	South Benin	2000	N'Noume
Daily weight gain		g/day	29.6	Benin	2004	PDDAA
Live weight	Cock, local	kg	1.57	Benin	2001	ICRA
	Hen, local	kg	1.06	Benin	2001	ICRA
	Hen, local	kg	1 to 1.5	Benin	2002	Houndje
	Modern	kg	1.9	Benin	2000	N'Noume
Replacement laying hen	Modern	Year	1	Benin	2003	MAEP
Carcass yield		% of LW	67	Benin	2000	N'Noume
Mortality	Traditional	%	11	South Benin	2002	Houndje
	Dep. on farm	%	2 to 63	South Benin	1997	MDR
	Modern	%	10	South Benin	2000	Ayena
	Modern	%	5	South Benin	2000	Ayena

Table 3.6: Production figures of chickens

Source: Compiled by the author, 2005

The heaviest losses of chickens are caused by the following diseases: chronic respiratory problems, coccidiose, and Newcastle disease (NCD), which together contribute to 49 to 78 percent of all deaths (ICRA, 2001). Farmers in traditional poultry keeping are advised of vaccination (such as against Newcastle) to diminish outbreaks of diseases and thus, reduce mortality. For imported chicken breeds, however, there is a sanitary calendar, according to which the poultry keepers are obliged to administer standardised treatments to their animals (Direction de l'Elevage, 2004a; FAGBOHOUN, 2004). In a survey in the department of Mono, HOUNDJE (2002) showed that the mortality of chickens is lowest between January and April while between May and August the mortality rate is highest. He concluded that the tight time schedule of the animal keepers, who care little or not at all for their chicken stock during sowing time, might be one reason for his results. However, the supply of water and forage for local chickens is generally not sufficient (HOUNDJE, 2002; PDDAA, 2004). Water and fodder are inadequately provided or at sporadic intervals, although the chickens mostly roam about searching for their own fodder. Thereby the potential risk of eating parasites and poisoning is high. If supplementary feeding is provided, it consists mostly of mashed maize, grains, or sometimes termites. Termites, with their high protein content, are added in order to accelerate growth (HOUNDJE, 2002). In contrast, for chickens kept in intensive housing systems a balanced fodder plan exists, which is based on maize (PDDAA, 2004).

3.4 Input of climate dependent resources

It follows from the above described production methods that the Beninese animal production, in particular concerning ruminants, is heavily adapted to the natural conditions and is mainly dependent on natural resources. Additionally, competition and conflicts in the use of these natural resources already occur. Hence the following section focuses on water and forage as important and limited production input factors.

3.4.1 Demand for water

Agricultural production is dependent on natural resources, and water is one of the most essential and crucial ones. In rainfed crop production, water is required during cultivation only at certain periods. However, in livestock keeping, water is required the whole year round to ensure production. This continuous need for water combined with the intricacy of gaining access to watering places, often causes difficulties in the countries south of the Sahara during dry seasons.

These numerous problems are aggravated due to the different ethnic affiliation of farmers and livestock keepers.
In order to adequately supply the livestock with water, many different sources such as natural rivers and waters, seasonal waters like “marigots” and puddles as well as storage reservoirs, wells, and trucks are used. The natural waterways and waters have traditionally been and still remain the predominant watering places for cattle, whereas small ruminants mostly have to find the water they need themselves around the house. If small ruminants are watered at all, sheep usually get more than goats (DOSSA, 2002). In the dry season the puddles, some marigots, and many small stream courses dry up, therefore other water sources are required. The fact that different water sources according to season are used is corroborated by the producer survey, as figure 3.8 shows. Puddles and marigots are the main water sources in the rainy season, whereas rivers and wells become more important in the dry season.

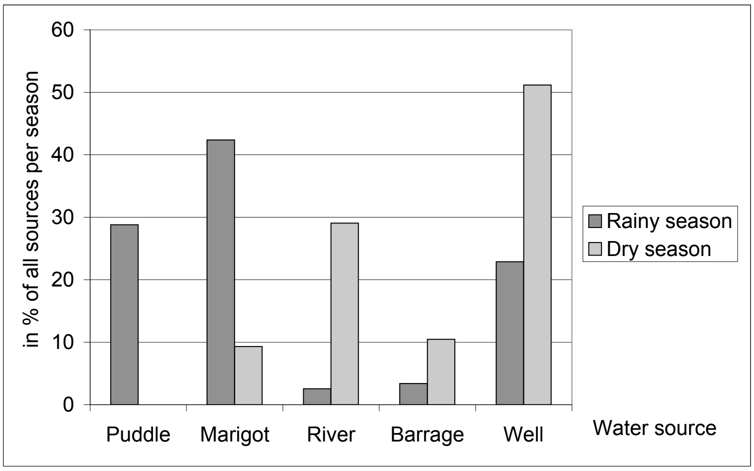


Figure 3.8: Used water sources depending on season
Source: GRUBER, KLOOS, and SCHOPP, forthcoming

A more differentiated view, according to sources that depend on the season and region is given in figure 3.9. Wells take up an exceptional position in the southern investigation area, where they are almost the sole water source and used the year-round. In this region, no significant difference in the use of water sources depending on the season has been established. But in the northern and central regions, seasonal differences of high significance have been confirmed (a p-value smaller than 0.001). For the northern and central regions the corrected coefficients of contingency between season and water source show a medium contingency of 0.57 and 0.51, respectively.

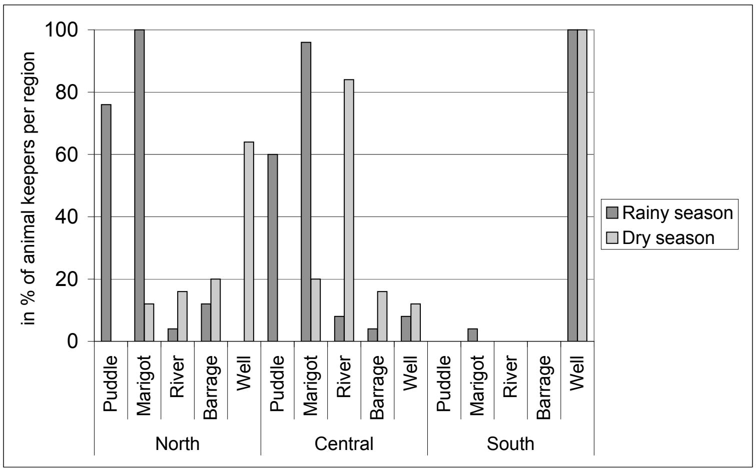


Figure 3.9: Used water sources depending on regions and seasons
Source: GRUBER et al., forthcoming

In the northern region of Gogounou wells do exist, but are used only in the dry season. A special feature of the central region is that there are large rivers which are water-bearing even in dry seasons. But in the rainy season puddles and marigots predominate as a water supply, because these sources are closer to villages and camps.

Barrages, which are often focused on by development aid for livestock management, are not of great importance to any of the three regions. It is extremely probable that either none of these regions lies in an area of barrages, or other water sources are more easily reached. Although not explicitly mentioned in the producer survey, water content in feedstuffs is another source of water, which reduces the absolute quantity of water required. Water content in plants is high if humidity is high, of which livestock keepers avail themselves in the rainy season. Additionally, small waters are water-bearing in the rainy season, and thus animal keepers are able to reduce distances to the water sources, inter alia, in order to avoid damages in cultivations.
In the northern and the central regions, all interviewed animal keepers conduct

their (large) livestock to the water sources and wait there until the watering is finished. In the dry season some additional water comes from wells. The minimal and maximal distances to the water sources are illustrated in figure 3.10.

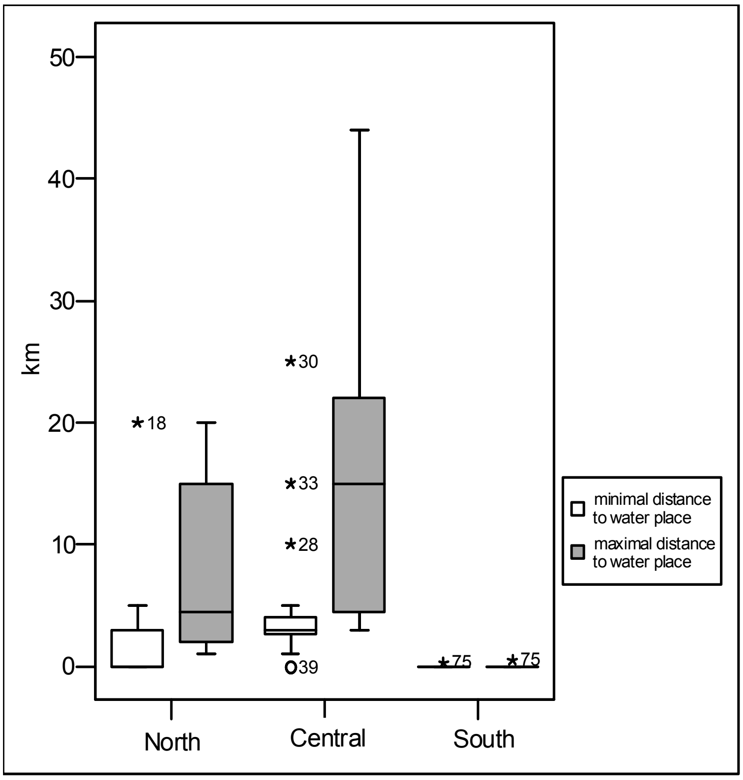


Figure 3.10: Distances to water sources
Source: GRUBER et al., forthcoming

The minimal and maximal distances differ among the three regions. They are not homogenous statistically, the chi-square after Pearson has a p-value smaller than 0.001. The animal keepers in the central region have to conduct their livestock the farthest distance. Due to 100 percent supply of wells on the interviewed farms in the south, animals are tended directly at the farms. In the north more wells exist than in the central region, therefore the minimal and maximal distances are shorter than in the central region. These varying distances in the three regions indicate differences in the watering infrastructure, and probably in water availability as well.

Water requirements for livestock have been calculated in order to evaluate regional relevance. Equation 3.1 has been compiled according to different literature. The term in the brackets calculates the water requirements of ruminants per year according to live weight and temperature. Water requirements for ruminants depend on the daily intake of dry mass (DM), temperature, race, and the current level of performance. The higher the water content in feedstuffs, the less additional water is required. Intake of dry mass again depends on the live weight of livestock. In addition, temperature affects water requirements per animal and day. At higher temperatures, livestock has to absorb more water per kg dry mass, which is considered in the estimation of water requirements. Equation 3.2 is a result of a non-linear fitting of water needs in dependence of temperature (data given in LEGEL, 1989). The second summand contains the water needs emerging during lactation. In the tropics, three litres of water are determined for one further litre of milk (LEGEL, 1989).
The third summand incorporates the water requirements of monogastric animals. For pigs, the moisture content of the feedstuffs defines the water requirements per animal and day. However, the moisture content in fodder rations is unknown, as pigs are often fed with varying products including waste and no feed analysis is available. Therefore, only a constant water requirement can be assumed per pig and day. The same goes for chickens, whose daily water needs are given with 0.3 litres per animal (KIRCHGESSNER, 1997).
Water quality is at least as important as quantity, and therefore adequate water quality is assumed as it is not possible to include the aspect of water quality in this estimation. If, for example, water is highly saline, the amount of required water rises. Although the risk of animal diseases being spread by water is low, parasites may sometimes be distributed in this way (KING, 1983).
The water requirements for all productive livestock in Benin are compiled and assessed, differentiated between regions, in the following:

$$\begin{aligned} WQ_r = & \sum_{rum} \left(\frac{N_{r,rum} \cdot LW_{rum}}{TLU} \cdot 6.25 \cdot w\,(temp) \right) + N_{r,cows} \cdot 3M \\ & + \sum_{mon} \left(N_{r,mon} \cdot n_{mon} \cdot 365 \right) \quad \text{, and} \end{aligned} \tag{3.1}$$

$$w(temp) = \left(4.303 + 0.0906\, e^{0.115 \cdot temp} \right) \quad , \tag{3.2}$$

where	WQ: water quantity [m^{-3}]	temp: temperature [°C]
	N: animal numbers	r: region
	LW: Live weight [kg]	M: milk performance [kg $year^{-1}$]
	TLU: Tropical Livestock Unit [250 kg]	rum: ruminants
	w(temp): water needs in	mon: monogastric animals
	dependence of temperature	n: water requirements [kg day^{-1}] .

Following the distribution of livestock, the northern departments of Alibori, Borgou, and Atacora show the highest requirements of water in absolute terms. Compared to total precipitation, the required water for productive livestock is quite small. However, local officials often point out in discussions that water requirements of animals must not be disregarded in water balances. Especially in dry seasons livestock is an obvious user of water and could be in competition with human beings. If the average human water consumption is constituted at 20 litres per day and capita, which is the target quantity for an individual in Benin, the situation turns out to be as figure 3.11 shows.

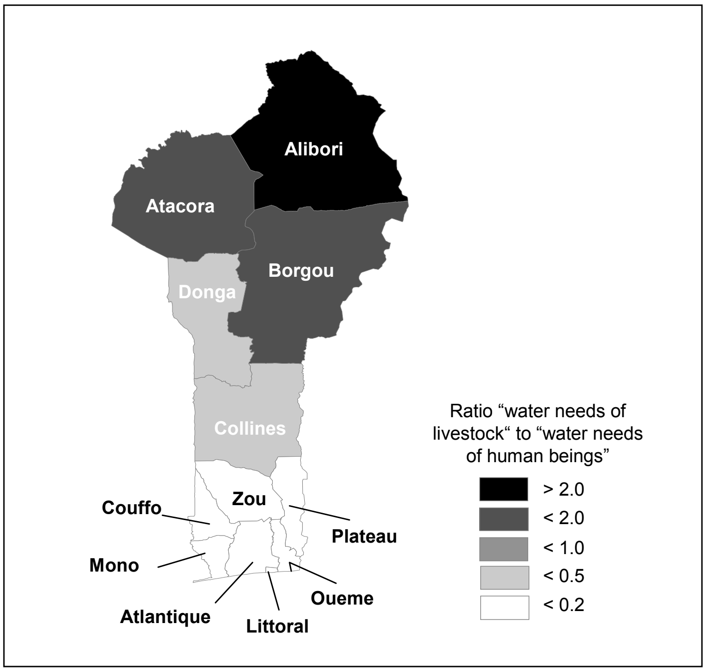


Figure 3.11: Water needs of livestock compared to human needs in 2002
Source: GRUBER et al., forthcoming

In the southern departments the water required for livestock is less than 20 percent of the water amount needed for human beings due to the high population density and less livestock. In the two departments of Collines and Donga, less than half the amount of water is consumed by livestock compared to people. In the northern departments, productive livestock can be competitors in water consumption. In Borgou and Atacora, animals need slightly more water than people, and in Alibori twice the water quantity is consumed by livestock.

Conflicts between farmers and animal keepers sometimes arise, if water resources become low in the dry season. In contrast, conflicts among animal keepers are rare, as the traditional law states that pastoralists among themselves must not refuse one another access to water and pasture (COMO, 1994b). In former times, water scarcity occurred only in years with low precipitation, because the dense vegetation ensured a slow surface run-off (COMO, 1994b). According to the survey, which was held in the mid-1990s, water scarcity and conflicts arise between farmers and animal keepers due to growing population, increasing animal numbers, ebbing of sources, blockading of access paths to fountains, forest clearances, and the prohibition against watering at public fountains. Watering at wells was traditionally one way to deal with water scarcity beside digging holes that fill up with groundwater, or seasonal herd peregrination. To reduce seasonal deficits, more and more water storage basins are being built: for example, between 1975 and 1995, the World Bank and the European Union funded a huge water project (MENSAH, 2004). However, considerable difficulties arise in constructing water storage basins. Size, location, and spatial distribution have to be considered and the integration of the local people into the planning and maintenance should be guaranteed. Otherwise water storage basins are ignored and long-term utilisation is doubtful. New water storage basins are able to reduce water deficits, but according to COMO (1994b) they can pose new problems if they are designed larger than 60,000 cubic metres. Such problems might be high costs of construction, high equity contribution of the local population, difficulties in controlling and administration, or the imbalance of water and corresponding pasture area in the surroundings. In times of general water scarcity, the availability of water attracts additional pastoralists with their herds. This causes an excessive demand for pasture, which is not available, and overgrazing and erosion are the consequences (JAHNKE, 1982).

3.4.2 Demand for natural forage

The existence of water or rather precipitation determines the spatial and temporal distribution of livestock directly by watering and watering points, and indirectly through natural forage production caused by precipitation. The forage productivity in regions with low precipitation and, therefore, the availability of natural forage, like pasture or forest, is a function of rainfall (JAHNKE, 1982; FAFCHAMPS and GAVIAN, 1996). In Benin, intra-annual fluctuations are larger than inter-annual ones. This means that differences between two seasons are more pronounced than between different years (HOUINATO, 2001). Table 3.7 presents exemplarily some biomass measurements for different years. Most of these biomass measurements are conducted at the end of the rainy season, as biomass is highest at this moment, which facilitates comparing results with other years.

Region	Type	kg DM/ha	Date of study	Source
North	Savannah	3807	Oct. 00	Sogbohossou, 2000
North	Average	5880	Oct. 03	Sinsin, 2004
Central	Savannah	2100	Jul. 97	Houinato, 2003
Central	Savannah	5600	Oct. 97	Houinato, 2003
Central	Savannah	6100	Nov. 97	Houinato, 2003
Central	Forest	1100	Jul. 97	Houinato, 2003
Central	Forest	2200	Oct. 97	Houinato, 2003
Central	Forest	2800	Nov. 97	Houinato, 2003
Central	Average	4900	Oct. 97	Houinato, 2003
Central	Average	5510	2001	Sinsin, 2003
Central	Average	5580	2002	Sinsin, 2003
South	Savannah	5880	2000	Teka, 2000
South	Savannah and fallow	7930	2000	Teka, 2000
South	Forest	6060	2000	Teka, 2000
South	Feed cropping	8900	2000	Teka, 2000
South	Average	5640	2001	Sinsin, 2003
South	Average	5250	2002	Sinsin, 2003

Table 3.7: Biomass in different regions and years in Benin
Source: Compiled by the author, 2005

The availability of biomass is particularly relevant for ruminants, as their main forage source is natural pasture. The main grazing period is in the rainy season, between April and October. The optimum of pasture, in quality as well as in quantity, is reached at the end of the rainy season (KADADJI et al., 1992). In the following months the quality declines continuously, pasture turns into straw, and the nutritional content becomes insufficient.

In the extensive production system for ruminants, strategies to deal with these conditions are transhumance (described in chapter 3.3.1), and feeding of complementary fodder from crop residues and forests, the latter called "pâturage aérien". In the dry season, both the water content and the general nutritional value in forage cut from trees are higher than in grass. However, the feeding of this fodder is limited because of ingredients like tannin or saponine (SIMBAYA, 2002).

Crop residues are mainly fed after harvesting, in November and December (KADADJI et al., 1992). The feeding of crop residues such as maize, sorghum, groundnuts, pulses, or cotton is a widespread method and a relevant element of feeding rations (COMO, 1994a). But the remains of the harvest cannot be entirely used for feeding. There are losses through dirt and trampling, as residues are not collected, but livestock is trekked through the fields. The exploitation rates of crop residues range, for example, between 40 - 50 percent for sorghum, between 50 - 80 percent for maize, and between 75 - 95 percent for cotton, depending on region and source (KADADJI et al., 1992; SERO, 1997). On a small scale, processing residues and feed cropping are also employed in Benin. Fodder conservation in the form of hay is found with animal keepers who use their animals for draught purposes (PADEB, 2003). The making of silage is rarely applied and can be seen nearly exclusively at national farms, where the development of this production technique for these regions has only just started.

Considering the three regions of the producer survey, the following strategies of managing scarcity in forage, emerge as figure 3.12 illustrates. Crop residues are most relevant if forage is in short supply, followed by aerial pasture from forests and transhumance in dry seasons.

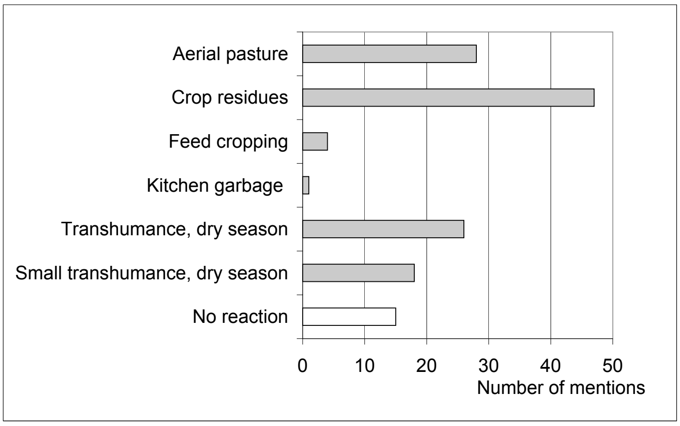


Figure 3.12: Reaction if forage is missing
Source: Author's producer survey, 2005

As for transhumance, a difference has to be made between great and small transhumance as some animal keepers trek far distances and others just trek to nearby inland-valleys and along rivers. Animal keepers going on a great transhumance mentioned that they first use aerial pasture or crop residues before trekking. This leads to the conclusion that nearby forage sources are preferred, and long distance trekking is the last employed method of compensating for scarcity of fodder.

Going more in detail one can observe that the strategies vary among the different regions as table 3.8 specifies. Aerial pasture is a typical phenomenon of central Benin, where forests and tree savannah are common. Nearly all animal keepers in the northern and central regions use crop residues, whereas in the south just a few use it as complementary fodder. The great transhumance is mainly practised in the north, while the small transhumance is quite common in central Benin. This can be put down to the existence of large rivers in the central region, where year-round natural pasture grows. Those interviewed animal keepers in the south going on the small transhumance head for inland-valleys, where also forage is always available.

	North [1)]	**Central** [1)]	**South** [1)]
Aerial pasture	7	18	3
Crop residues	21	23	3
Feed cropping	2	2	0
Kitchen scraps	0	0	1
Great transhumance, dry season	22	4	0
Small transhumance, dry season	0	14	4
No reaction	0	0	15

1) 25 Animal keepers, multiple mentions possible

Table 3.8: Strategies dealing with forage scarcity in different regions
Source: Author's producer survey, 2005

As in many other livestock-related aspects, the south takes up an exceptional position. Crop residues, aerial pasture, and small transhumance are used only by some of the animal keepers. Moreover, more than 50 percent do not have any strategy if forage runs short, although 10 of the 15 animal keepers stated that they have problems with forage acquisition and forage in general.

Those animal keepers who respond actively to forage scarcity, combine up to four different strategies to be able to adequately supply their livestock with fodder. Four animal keepers stated that they cultivate forage if fodder is missing. But independent of the forage situation, a total of eleven animal keepers in the north and in the central region, that is around 15 percent of all persons questioned, cultivate forage. They cultivate "Leuceana" in the north (5 mentions), while in the central area it is "Panicum" (4 mentions), and two do not remember what kind of plants they cultivate. The complete area of forage cultivation is 0.5 ha, normally with parcels of 20 x 20 metres.

This shows that the production of cultivated fodder is still negligible, but that attempts are being undertaken. Animal keepers who do not cultivate forage, as well as the experts, were asked about the obstacles to cultivating forage. Table 3.9 presents the given statements of the animal keepers and the expert opinions in a more differentiated way. The answer "no need" includes both "(they) do not see a reason for cultivating" and "pasture is for free in access and availability". Another reason against forage cultivation is the limitation of time as the cultivating times for crops and forage overlap and crop cultivation is preferred.

	Animal keeper in % [1]	**Experts in %** [2]
No seeds	22.2	13.7
Don't know how	17.5	13.7
No need	11.1	19.2
No land	6.3	13.7
No water	4.8	1.4
No time	4.8	2.7
Problems n.s.	3.2	—
Costs-funding	—	9.6
Production method	—	19.2
Missing support	—	4.1
Negligbile	—	2.7
No reason	30.2	—

1) N = 63, multiple mentions possible
2) N = 73, multiple mentions possible

Table 3.9: Reasons against forage cultivation
Source: Author's producer and expert survey, 2005

The aspect "production methods" in table 3.9 refers to the fact that the practised housing systems for livestock are counter-productive of feed cropping. For example, feed crops might get damaged due to missing fences around crop areas combined with the normally free-roaming livestock. Bushfires, which might destroy the cultivated areas, are another danger to forage crops.

Additionally, experts stated that livestock keepers do not consider feed cropping as an activity leading to monetary income. Comparing the two evaluations, experts underestimate the availability in place and time for forage seeds. To a certain yet not great extent, missing water and access to or rather availability of land for forage cultivation prevent the shift from natural pasture management to a controlled feeding method. On that account it is notable that almost a third of the livestock keepers have never thought of feed cropping as a possibility of compensating for the forage deficits in order to provide sufficient fodder for at least part of their livestock.

3.5 Conclusions of the chapter

This chapter has focused on the general characteristics and production methods in livestock management. In general, it can be observed that livestock management is a separate production system with merely loose connections to cultivation. Productivity in livestock management is at a low level, sometimes even lower than the Sub-Saharan average.

Production is extensive with low input of production factors, labour and capital, and is based on natural resources. Risk is reduced to a minimum, although livestock is used as a source of income, but also as risk protection and for diversification of production. Different strategies to deal with seasonal shortages of input factors have been developed. One strategy to deal with scarcity of input factors is the variation in the use of water sources depending on season and region. Animal keepers use the nearest water sources first, and later on the more distant ones. Thus distances to water sources are longer in the dry season, except in the south where animal keepers usually have their own wells. Infrastructure and the possibility of watering obviously vary within the country. Wells are widespread in the south, whereas in the central region year-round water-bearing rivers are located. Although the total water consumption of productive livestock is marginal compared to precipitation quantities, animals are regarded as rivals to human beings for water.

As with watering, the nearest adequate fodder is taken for feeding. Several sources of forage such as pasture, cuts from trees, or harvest residues are used, whereas fodder cultivation is still more an idea than a fact. Hindrances for establishing fodder cultivation are, inter alia, high costs for clearing as well as lack of seeds, knowledge or time. The introduction of forage cultivation would require both fundamental changes in the production system and more capital, which conflict with the current motivation in livestock husbandry.

Another obvious strategy of dealing with scarcity is transhumance, the seasonal migration of livestock following the supply of both forage and water. However, transhumance is often considered as an impediment to the integration of livestock husbandry into cropping and, therefore, also as a hindrance to sustainable agriculture and land use. But as long as animal numbers are compatible with the natural availability and carrying capacity of natural resources such as land or water, transhumance is a production system well adapted to natural and climatic conditions. Transhumance is flexible enough to react for short terms to changes by displacement or elongation of trekking routes. But this sustainability is lost when increasing stocking rates disturb the fragile balance. Additionally, production is endangered when general conditions change and only a slowly eroding traditional common law guarantees the basis of production.

These aspects of input of natural forage in production concern mainly the ruminants and to a lesser degree the non-ruminants, pigs and chickens. Pigs and chickens do not depend on natural forage, as their fodder comes from other sources. Especially in the south the fodder for pigs is purchased in the market. Pigs and chickens are very important for small animal keepers for income and risk reduction due to the diversification of agricultural production. On the basis of the motivation of these animal keepers, they also produce at an extensive level.

In general, improvements in productivity are possible by slight intensification, as the national farms and some projects indicate. In order to achieve this, some capital and knowledge have to be invested. Single intensive livestock farms exist, but they still contribute only marginally to the total production.

Chapter 4

Political and economic situation in livestock husbandry

In combination with climatic conditions and natural resources, human interactions govern the structure of livestock husbandry and have effects on livestock production and productivity. Thus this chapter focuses on agricultural policy in livestock management, the livestock markets, prices, and trade of animal products in Benin.

4.1 Agricultural policy in the livestock sector

The agricultural policy for livestock management in Benin is determined by the department of livestock (Direction de l'Elevage), which is subordinated to the Ministère de l'Agriculture, de l'Elevage et de la Pêche (MAEP). Although the agricultural policy of the country is predominantly concerned with crop cultivation, especially with cotton production (compare chapter 2.3), there also exist some public strategies for livestock management.

Until the end of the 1980s, the state's interest was focused on the keeping of large livestock. The productivity in large animal keeping was to be raised through different measures, such as supporting the formation of farmers' and traders' organisations or advisory committees for animal health and feeding. But goals were far from being achieved, inter alia, due to ineffective production methods and socio-economic problems. In order to resolve the national undersupply in animal products, the promotion of keeping small animals was introduced in 1990 (GNIMADI, 1998). The strategy was specified four years later, with the target to diversify livestock management and to raise productivity, especially in productive livestock with short reproduction cycles. This aim was to be achieved by intensifying research in the integration of livestock management into cropping systems in order to farm sustainably and conserve natural pastures and watering points. Another target was to improve feeding, first through an increase in the use of crop residues and processing remains in feeding. Second, feed growing was to be spread and intensified to provide forage in all seasons, particularly for reproduction and milk production. Access to veterinary care was to be simplified by promoting the establishment of private veterinarians in production areas. Veterinary care, access to medication, and an intensified vaccination programme against the major animal diseases was to improve the animals' state of health. The profitability for animal keepers was to be improved by the consolidation of commercialisation of animal products, a price policy in favour of livestock management[1], and an establishment of a processing chain for meat and dairy products. Finally, the government wanted to reduce its influence in the livestock sector where capable organisations were already working (GNIMADI, 1998).

In 2000, this political orientation and strategy in livestock management for the following years were affirmed, that is the concentration on the containment of animal diseases, an ongoing intensification and simultaneous diversification of animal products, the integration of cropping and livestock, and a new strategy of promoting livestock according to regional conditions and regional potential in livestock keeping (MAEP, 2000).

According to the expert survey, the diversification of animal products shifts production to livestock with short reproduction cycles and to unconventional livestock. These shifts show a medium to strong potential of improving the domestic supply of animal products as well as increasing the income of animal keepers. The evaluation for the influence of diversification on income is slightly more optimistic than for improving the supply of animal products in Beninese diets (Author's expert survey, 2005).

[1] Not more specified.

Livestock management is particularly regulated by the laws of “la vaine pature” and “la transhumance”. The first one regulates the usage of the commons, but remains at a very general level. Inter alia, it prohibits the uncontrolled roaming of productive livestock without shepherds and regulates the proceedings in the case of damaged crop cultivations. The second law concerning transhumance establishes the general duty of care in trekking animals. Moreover, it requires herds coming from neighbouring countries to pass one of the official veterinary posts at the border to have the livestocks’ good state of health certified. In addition, the absolute number of foreign livestock permitted can be determined every two years[2]. However, compliance with this law is likely to be limited, as border crossings to a large extent cannot be controlled. The restriction which limits the time of transhumance for foreign herds in Benin’s departments is just as hard to fulfil. The herds in the northern departments officially have to leave by the end of April, and in the southern departments by the end of March at the latest (ATCHADE, 1994).

Although it also supports the development of markets and processing, the main focus of livestock policy is strengthening production methods, veterinary inspection, and standards. Concerning classical agricultural policy instruments, one notices that no premiums, subsidies, or quotas exist. Some prices of input factors such as costs for vaccination are fixed. At the international level, import tariffs exist for animal products such as bovine animals, sheep, poultry, pigs, milk, and eggs. The introduction of the Common External Tariffs (CET) in 2000 fixed the import tariffs at 20 percent for animal products (WTO, 2004).

4.2 Production costs and factor demand

To define production costs in livestock management, input factors for the extensive production system in Benin have to be identified first. The producer survey helped to establish different input factors, which are listed in table 4.1. Thus, the matter of expense has to be adapted to the regional characteristics, the different regional production systems, and infrastructure.

[2] In 1992 a complete ban on the entry of foreign livestock from Nigeria was imposed due to previous conflicts between farmers and transhumant livestock keepers (COMO, 1994b).

Production costs
- Additional bought livestock for replacement
- Forage, mineral fodder, salt
- Veterinarian and medical care costs
- Water costs
- Non-family labour

Table 4.1: Identified production costs
Source: Author's producer survey, 2005

These identified production costs are incorporated into the calculation of the gross margins in the model simulations. The interest costs of invested and floating capital have been intentionally omitted in the gross margins, as this economic consideration does not reflect reality in a production system which is not exclusively aligned to profit maximisation. Moreover, access to credits is difficult in rural areas in Benin[3]. In the producer survey, costs for forage arise particularly in the south, where animal keepers provide their livestock with purchased fodder like wheat bran, manioc, or maize. This is due to the lack of land for ruminants and higher shares of pigs and chickens which are fed with crop plants or crop residues instead of pasture. In the central and northern parts, fodder costs are composed of expenses for salt, mineral fodder, payments for using the crop residues of farmers, and sometimes of additional fodder like cotton cake. Salt is sold in 25 kg bags for 2,500 to 3,200 FCFA. Prices of mineral licks range between 2,000 and 5,000 FCFA per stone, a stone corresponding to 5 kg.

Costs of veterinary care are mainly outlays on vaccinations. In the north and the central region, where the interviewed animal keepers are strongly and professionally organised, nearly all livestock is vaccinated. In the southern region vaccination is not so common, probably due to the lower degree of organisation and a different livestock composition. The latter aspect is relevant to cattle of a valuable species and for which health care is highest, while vaccination for chickens is often not available. The two obligatory vaccinations for cattle against Pasteurellosis cost 130 FCFA per year, and against Péripneumonie contagieuse bovine (PPCB) 65 FCFA per year have to be paid. The costs of the vaccina-

[3] See also DOSSA (2002), including interests in gross margins is not appropriate for livestock husbandry in Benin.

tion against Peste des petits ruminants (PPR) for small ruminants amount to 100 FCFA per year.
Costs of water appear in the southern investigation area only. There, these expenses are often not considered as production costs, because the animal keepers do not pay for the water itself, but for pumping it.
The production costs of chickens are not quantifiable in non-intensive farming systems, as most animal keepers do not provide forage, water, or health care for chickens. More often than not, they do not even know the number of chickens they own.

In the producer survey, costs of hired labour have been observed as the sole factor demand. As none of the interviewed animal keepers make use of stables or hurdling, no costs of places in stables, land, or storage have been mentioned. The other housing systems which are employed are listed in table 4.2. At night nearly all cattle keepers tie up their animals, whereas all pigs are kept in sheds, which are often built of gratuitous materials. Sheds are also used for chickens. But as all chickens roam about freely, sheds are not used for permanent housing, only for the nights. Some animal keepers have constructed sheds for ruminants for the nights.

	Number of herds	**Free roaming of herds**	**Herds tied up during night**	**Herds tied up all day**	**Herds kept in sheds**
Cattle	59	33	58	0	1
Sheep	47	23	32	5	1
Goats	48	25	32	6	8
Pigs	8	0	0	0	8
Chickens	50	50	0	0	21

Table 4.2: Housing systems for livestock
Source: Author's producer survey, 2005

DOSSA (2002) showed in his study that stables for small ruminants are mostly constructed without any costs, whereas KADEL (2001) claimed that 50 percent of the animal keepers of small ruminants pay for stable construction. His survey also revealed that farmers with some livestock are more willing to invest into stable construction than pastoralists, who are not used to stables.

Labour is provided by family members and hired persons. The time – in absolute terms – during which animal keepers are engaged in livestock care varies between 0.5 h and 13 h per day and stock. In figure 4.1, the average working time in livestock management is referred to TLU according to region.

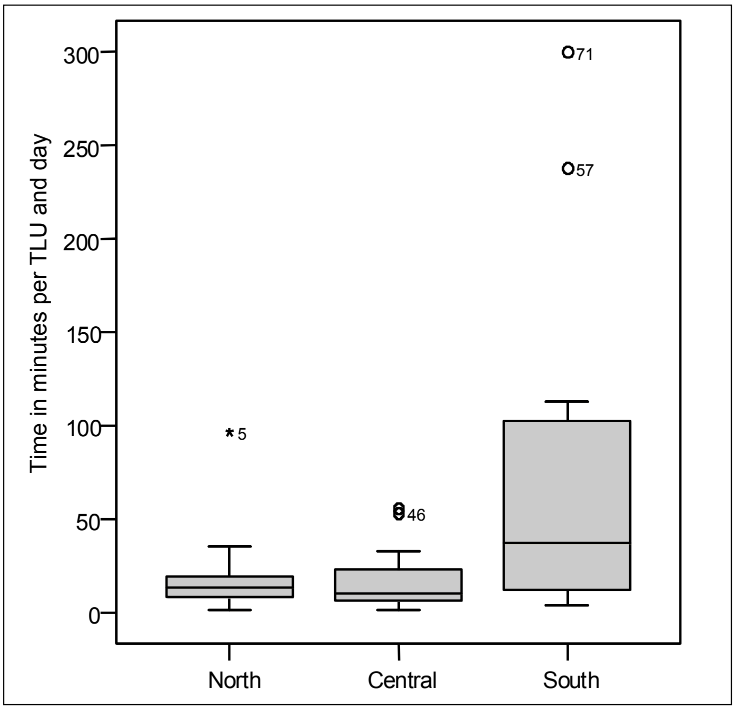


Figure 4.1: Average working time per TLU and day in minutes according to region

Source: Author's producer survey, 2005

The Mann-Whitney-Test shows that in the northern and the central regions the equality of the time per TLU and day per livestock keeper in minutes cannot be rejected, a p-value of 0.523. The south is significantly different to the north (south-north: p-value 0.006) and the central region (south-central: p-value 0.003). Due to its large variation in production systems, the range is wider in the south than in the two other regions. An exact calculation of working hours per TLU from these figures is not possible, as herdsman receive assistance from children or women. However, animal keepers have clearly laid down periods of time for animal care, and some of them distinguish between working time in rainy and dry seasons. In the latter, the time has to be extended due to the fact

that it takes longer to find sufficient water and forage.
Additional labour is hired both in livestock management and in cropping as illustrated in figure 4.2. In cropping labour is hired seasonally and is paid for in cash, while in livestock management it is engaged throughout the year and paid for in cash or barter.

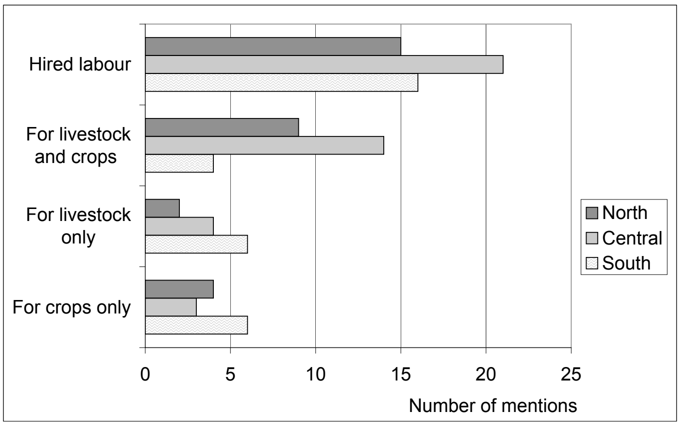


Figure 4.2: Hired labour of livestock keepers according to region
Source: Author's producer survey, 2005

Typical wages in the northern and central regions are either a one-year-old calf after 6 months of work, or if the worker prefers cash, 5,000 to 7,500 FCFA per month and person. In the south, wages are paid in cash and range between 12,000 and 22,000 FCFA per month and person.
Furthermore, animal keepers in the south hire labour for pumping water. Eight out of the nine animal keepers questioned who pay for pumping water keep cattle, and the ninth has a large pig stock. The wages for providing 10 to 60 TLU with water range between 3,000 and 8,000 FCFA per month.

4.3 Market system and trade

Particularly the animal markets are the interface between producers and consumers, where either directly or via intermediaries livestock is sold and bought. The market system and the characteristics of livestock trade are described in the following section.

4.3.1 Livestock markets and transportation

In addition to the above mentioned production costs, the animal keeper incurs marketing costs for transportation and market taxes. Livestock change hands mainly at animal markets. Another possibility of marketing is for traders to travel to villages and camps, where they buy the animals which are up for sale. Either traders take the livestock immediately with them or the livestock remains in the herds, sometimes for weeks after the price has been negotiated between livestock keeper and trader. The trader pays the amount on the spot and the animals stay in the herd until the trader has assorted a herd and engaged a herdsman to trek the animals to further distant markets (BAPTIST and SAKA-SALEY, 1986). A third alternative is that trade takes place directly between neighbours and/or animal keepers. For example, in Niger this kind of direct trade is estimated to amount to 20 to 40 percent of the total animal trade (FAFCHAMPS and GAVIAN, 1996). The following shares of the different points of sale in figure 4.3 were evaluated in the producer survey. These shares do not display the sold livestock quantities at each sales point. In the northern and central regions most animal keepers sell their livestock at markets, whereas the market as a sales point is less relevant for the southern region.

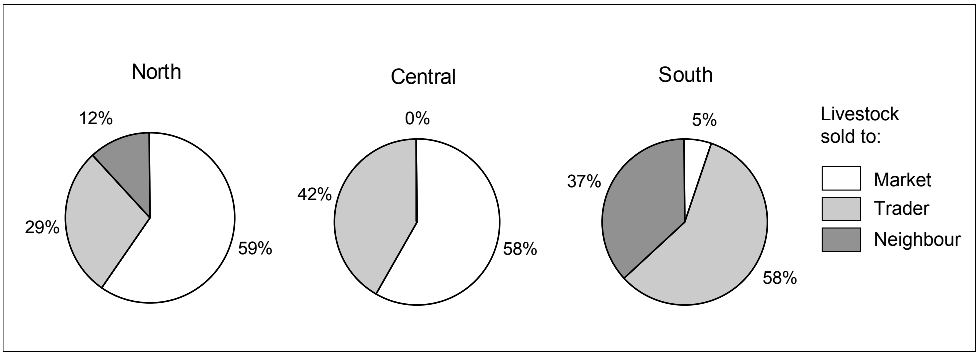
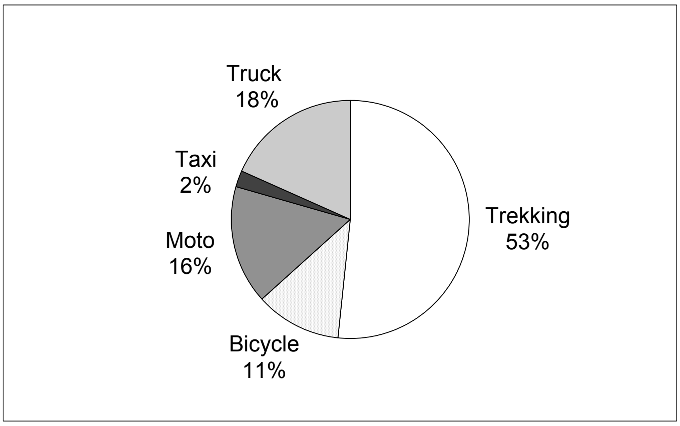


Figure 4.3: Sales points according to region
Source: Author's producer survey, 2005

In the south, more animal keepers are within the area of a trader who comes to the house, or livestock is sold to neighbours. Distances and transportation to markets are not in the animal keepers' line of action as nearly all of them sell their livestock at the door. In the south, most animal keepers are regularly

visited by traders, albeit not more often than once a year, at the time of ceremonies. The animal keepers do not seem to mind this, as they do not attach much importance to keeping and selling animals. In the two other regions fewer animal keepers are visited by traders than in the south, but then more frequently. KADEL (2001) found that in Atacora/Donga great distances to markets lead to a larger number of sales ex farm.
More than 25 percent of the animal keepers in the producer survey never come into contact with livestock traders in their villages. If traders never or seldom come to the villages and camps, or if markets seem the better alternative, the animal keepers have to transport the livestock they want to sell to the markets.

There are three types of livestock markets in Benin: local, regional, and international markets, which are provided with local, regional, and international transportation flows. Trekking livestock on the hoof is the traditional way of transportation to all markets. Despite trekking risks such as animal mortality, disease, thefts, and crop damage, livestock is trekked even long distances in order to reduce transportation costs, including bribes en route. On this account Sahelian sheep and goats, for example, are trekked from Niger to Beninese markets (DOSSA, 2002). In the same way even pigs reach the market of Adjarra (ADEGBIDI, 1996) although trekking is not the foremost means of transportation for pigs. Bicycles and mopeds are often used to transport small animals especially if the distances are short. Bicycles and mopeds are in wide use for all livestock transportation, which is illustrated in figure 4.4. Around 52 percent of the animal keepers in the producer survey who sell their livestock at markets use trekking as the means of transportation. Trekking livestock to the market is often the task of the children or other family members (VAN UFFORD, 2000; Author's producer survey, 2005). If shepherds are hired for trekking, their pay ranges between 1,000 and 5,000 FCFA per cattle and 500 to 1,000 FCFA per small ruminant. Trucks are used in 18.4 percent, followed by mopeds, particularly for small livestock (about 16 percent) and bicycles in 11.5 percent of all means of transportation used. For greater distances cars and trucks are employed more often, and sometimes the train between Parakou and Cotonou is taken.



N = 87, multiple mentions possible

Figure 4.4: Means of transportation to livestock markets
Source: Author's producer survey, 2005

In 1996, transportation costs amounted to 3,000 FCFA per animal for the train between Parakou and Cotonou, and 5,000 FCFA for truck transportation. For longer distances prices up to 8,200 FCFA per animal were charged (VAN UFFORD, 2000). In 2005, costs of cattle transport in trucks ranged between 2,000 and 10,000 FCFA per animal, depending on the distance.
Since the 1970s and 1980s, trucks have become more and more common in comparison to trekking and the train. Truck transportation is time saving and cheaper than engaging herdsmen for the animals. Besides, particularly in the south, trekking routes have become scarce due to paucity of land. However, combinations of trucks and trekking are still used in order to profit from the advantages of both transportation systems (VAN UFFORD, 2000).

Often a large diversity of livestock in small amounts are traded at the local markets. In comparison, at the regional or international markets, a specialisation in one or two livestock types takes place, and larger amounts of animals are on offer. Both the local markets and the regional markets have the additional function of being collection points and places for intermediate trade, from where livestock is distributed further. Hence, some market places or regions are known for their specialisation in one kind of livestock. The well-known cattle markets, open also to small ruminants, are located in the north, for example, in Malanville, Gogounou, or Parakou. Normally, intermediaries are a charac-

teristic of animal markets, but due to their strict and well-run organisation, the animal keepers in the above mentioned places reformed their markets and organise them now on their own. In 1999, the first three self-governing markets (marches à bétail autogérés, MBA) were established, and within two years another six markets of this kind were opened up. The organisation includes, inter alia, market secretaries, witnesses for the transactions, controllers, notification, and market taxes for the officials. The main objectives of these self-governing markets are to increase transparency in livestock trading, improve the producer prices by reducing the trade margins, and create more confidence for livestock keepers (ONIBON, 2004). In 2005 in Gogounou, for example, the market tax was 500 FCFA per piece of cattle and 100 FCFA per small ruminants for both the animal keeper and the purchaser.
The best-known and largest swine market is in Adjarra, in the south-east of Benin. It is held every four days, and per market day, depending on the source, up to 300 or 500 pigs, nearly exclusively of the local race, are offered (ADEGBIDI, 1996; DEKA, 2004). In 2005, during visit to the market in the rainy season when the supply is generally low, about 150 pigs were up for sale. Chickens are offered mainly at the local markets all over the country.

4.3.2 Price formation and price fluctuation

In the literature many determinants are mentioned which generate producer and consumer prices for animal products, as production is not exclusively market-orientated in Benin. But the major price determinant is the interplay between supply and demand (BAPTIST and SAKA-SALEY, 1986; VAN UFFORD, 2000), which the following studies point out exemplarily. The Direction de l'Elevage (1999) observed that prices fluctuate regularly depending on season, festivities, and transhumance. In a transhumant destination area, the additional herds cause prices to decline during transhumance, due to a higher supply. In Colline and Zou, which are destination areas for transhumance, prices are negatively correlated to the northern departments from where the transhumant herds originate (MDR, 1992). Another seasonal phenomenon is that prices for fresh milk in rainy seasons are about two thirds of the prices in dry seasons when low milking performance limits the supply (KEES, 1996b). In 1999, an especially high price for pork was generated when the African swine fever reduced the supply

(Direction de l'Elevage, 1999).

In the context of supply and demand, further factors determine prices. As weighing is not common, prices are normally not fixed per kg LW or carcass weight (CW). Nevertheless, price decisions are reached and depend, inter alia, on the bargaining of the two trading partners. Only producers of improved pig or chicken races[4] have an organised commercialisation, by which, for example, pigs are sold at fixed prices per kg LW to meat processors (ICRA, 2001). The otherwise common arrangement of consumer prices is a non-transparent business which ADEGBIDI (1996) describes in a study of swine markets: The farmer enters the market with his pig(s), looks for an agent of his choice, sells his pig(s) and pays a commission – for example, 200 FCFA were paid per pig at Adjarra in 1996 – and leaves the business to the agent. Now the agent can negotiate a much higher price when selling it to processors or consumers. The number of agents is determined by the distance to the end market and the organisation of the markets (ICRA, 2001). In the end, the agents and the last salesman often gain the largest profits without producing or processing. However, the self-governing markets show that pricing need not be so complicated, nor are the small margins for producers and by far larger margins for traders necessary. Although the organisation of these markets is well-run and efficient, the agents' trading skills are still important price determinants. Other price determinants besides trading abilities are race, sex, and the condition of livestock. The prices of animal products in Benin are also influenced by the prices in Nigeria and the exchange rate of the Niara and the FCFA. However, it is remarkable that differences in meat quality do not lead to different prices (COMO, 1994a).

The fact that some livestock markets are specialised in a particular species, was the basis for a detailed monthly price study in a project carried out by MAEP. The "Projet de Développement de l'Elevage Phase III" (PDE III) started in 2000 and lasted until the end of 2005. The major aims of this project were to enhance transparency and inform producers about prices. Data was collected on 15 markets, not only for the five species of productive livestock, but also for different breeds including crossbreeds and different animal types such as bullocks, cows, or heifers. Four of the 15 markets are principal markets, and eleven are

[4] Normally these species are equated with imported species.

secondary markets. The distinguishing characteristics of the principal markets of Cotonou, Parakou, Bohicon, and Gogounou are firstly that they are situated in or near large cities and secondly that they function as distribution centres.
To demonstrate price levels and price fluctuations on livestock markets, figure 4.5 illustrates seasonal price trends for cattle. One can observe that prices in the south are higher than in the north or the central region. Prices decrease in the rainy season and start going up at the beginning of the dry season. For northern cattle markets, according to VAN UFFORD (2000), this drop in rainy seasons is due to a reduced trading activity during cropping and a release of draught animals after the harvest.

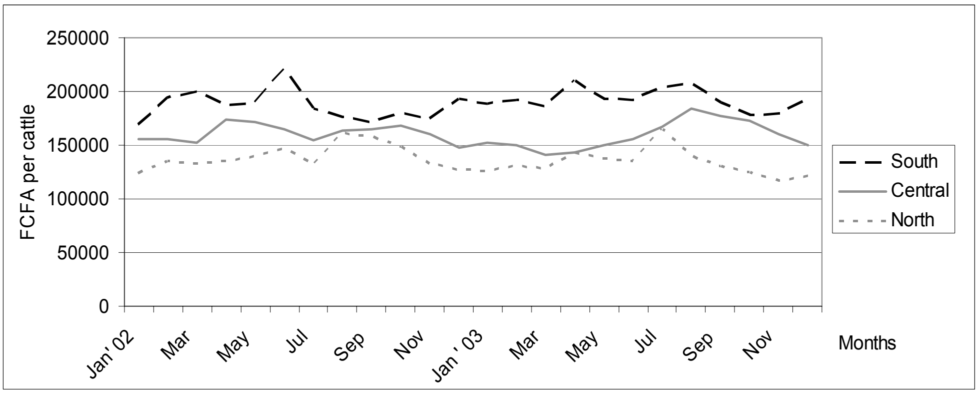


Figure 4.5: Seasonal price development for cattle in 2002 and 2003
Source: Author's illustration, 2005; Data: PDE III, 2002-2003

The prices on the secondary markets are generally lower than on the principle livestock markets. The cattle market in Materi in the north-west of Benin is, for example, a typical secondary market where prices for all cattle types are noticeably lower than at the principle markets. For instance, when comparing prices of reformé cows at the market in Bohicon with the same breed in Materi, one finds that prices in Materi reach only around 50 percent of the price in the south in 2002 (PDE III, 2004).

Animal keepers are aware of price differences, but high prices are not the main and only incentive for selling. Figure 4.6 pictures the reasons why, and at what time, the interviewed animal keepers sell their livestock. Although prices are not the decisive factor for sales, satisfying the monetary need is a major reason for selling livestock. In almost the same frequency, animals are sold if they are old, diseased, or without breeding use for the owner.

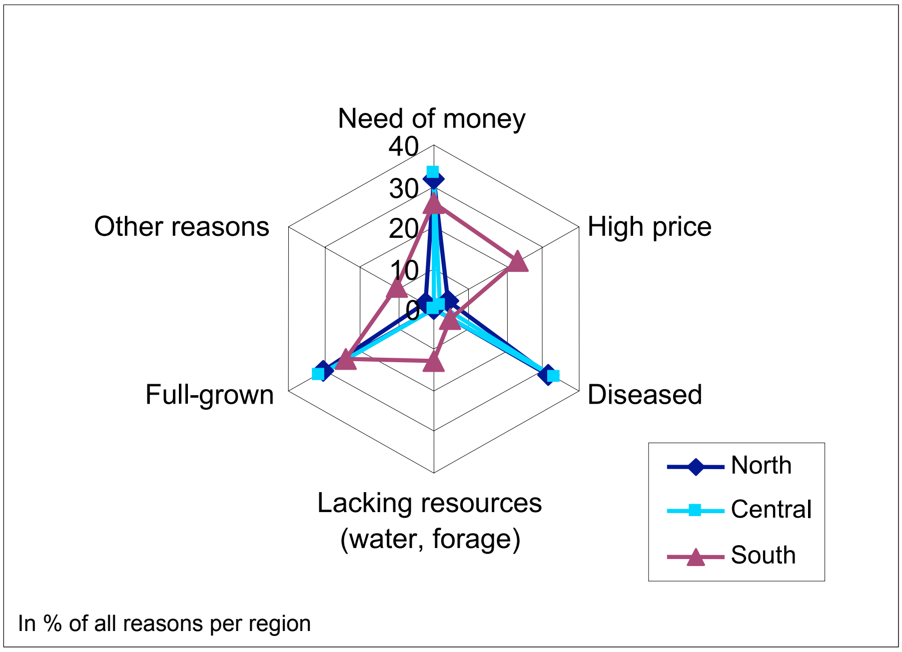


Figure 4.6: Reasons and time for selling livestock
Source: Author's producer survey, 2005

The share of livestock which is sold when diseased is remarkably high. This explains why livestock in bad physical condition can often be seen on markets. Interestingly, this motive for selling old and sick animals emerges predominantly in the north and the central region. In these areas, animal keepers often corroborate this argument of selling diseased animals only if the veterinary diagnosis gives no hope of recovery. There is an obvious concordance of vending causes in the northern and the central regions, whereas the south shows a quite different pattern. In the south, monetary needs and good prices are more often the reasons for selling livestock. An ICRA study (2001) found that in the south modern livestock husbandry is increasingly combined with market orientation. Although only average, that is non-industrial animal keepers, were interviewed in the producer survey, under "other reasons" for selling activities, an explicit demand for livestock was also listed.

4.3.3 Regional and international trade

The classical reason for trading is the difference in disposability of goods, where demand in one region cannot be permanently or temporarily satisfied and a surplus is produced in another region. Another crucial cause for trading is that production costs differ in several regions, thus causing varying regional price levels. Finally, differences in quality lead to trading, which is less relevant for animal products in Benin however. In order to determine where production takes place and where the general trade flows are heading, the livestock species are aggregated by the TLU. In figure 4.7, the annual meat production per capita is shown. It can be seen that the meat production per capita is higher in the northern and central regions than in the south. There, just one to three kg meat of productive livestock per capita and year are produced.

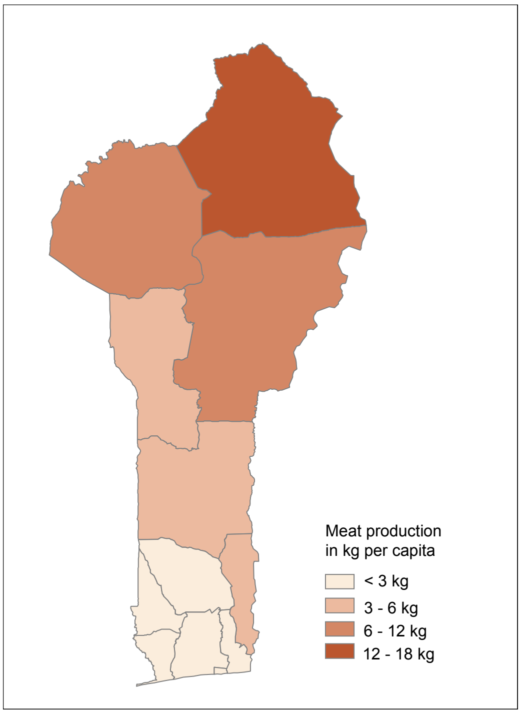


Figure 4.7: Meat production per capita and year
Source: Author's illustration, 2005; Data: FAOSTAT, 2005

The higher meat production per capita in the north is the consequence of livestock and population distribution in this region. Cattle, with their high live weight in comparison to pigs or small ruminants, are located in northern Benin. The distribution of the meat production per capita supports the statement that production and consumption take place in different regions, as the population density is highest near the coast. This regional discrepancy in supply and demand for animal products leads to regional trade within Benin (VAN UFFORD, 2000).

While the local trade flows head for the nearest villages and urban areas in all cardinal points, regional trade tends to be directed principally southwards, to the markets of Bohicon and Cotonou respectively. The IMPETUS-Catchment Haute Vallée Ouémé (HVO)[5] with its livestock trading movements, which is shown in figure 4.8, can be taken as an example for the regional trading pattern. All livestock head directly, or with intermediate stops, for the nearest regional market. In this case the nearest market is Parakou, which is both a destination market and a distribution market.

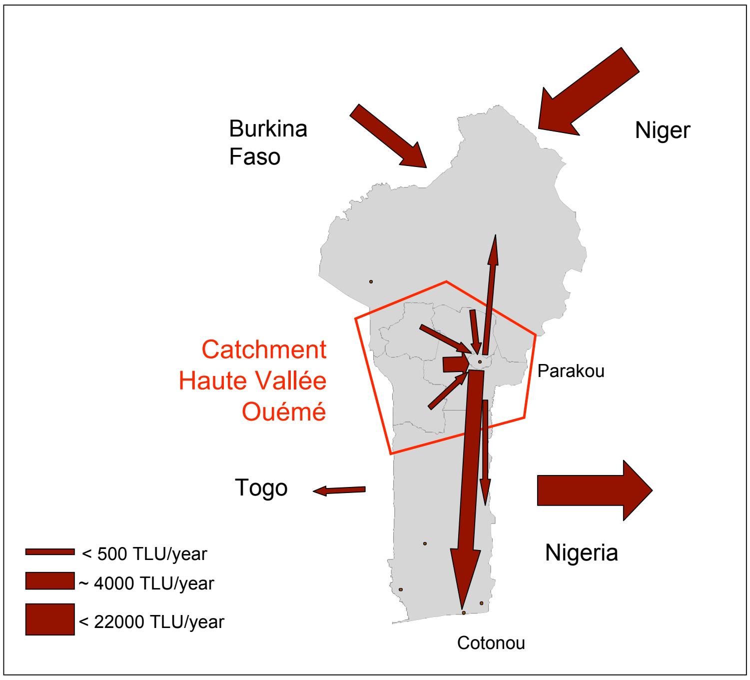


Figure 4.8: Livestock trade in the HVO and international transportation flows in 2002

Source: GRUBER and M'BAREK, 2004

[5] The main research side within the IMPETUS Project.

From there, the livestock to be distributed further is transported in great quantities towards the south, particularly to Cotonou and, to a smaller extent, to Bohicon. The one arrow pointing to the north represents transportation flows heading for the next submarket in Malanville, a bordering market and interstation for international trade towards Niger. But the principle international trade flows southwards to the neighbouring states of Togo and Nigeria (VAN UFFORD, 2000; ONIBON, 2004). The large coastal cities such as Lomé (Togo), Ibadan (Nigeria), or Lagos (Nigeria) are reached directly or with an additional trade stop in Cotonou.

Figure 4.8 indicates that Benin is exporting particularly to its eastern neighbouring country Nigeria. Moreover, it becomes apparent that the Sahelian countries, Niger and Burkina Faso, which are known for their production of red meat, export livestock into Benin. International trade is conducted also with European countries and other non-neighbouring countries. Figure 4.9 reveals the imports and exports of meat in the years 1998 to 2003, according to official data. Meat imported by far exceeds the quantity of exported products. Exports to the world market (all non-neighbouring countries) play a minor role in all exports of animal products.

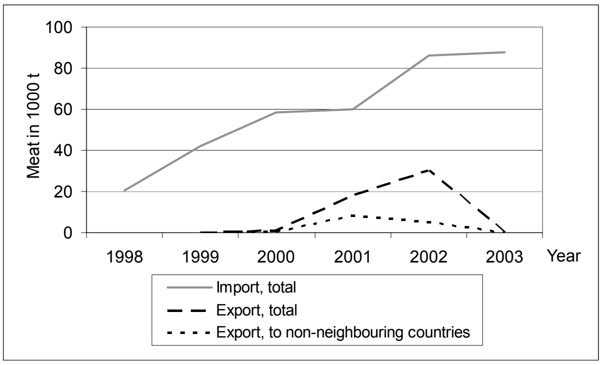


Figure 4.9: Import and export of meat between 1998 and 2003
Source: Author's illustration, 2006; Data: INSAE, 2004

The situation for imports is just the opposite: the officially confirmed quantities from the world market dominate imports. Meat imports from neighbouring countries are relatively modest compared to the total imports. The imported quantities of meat are composed nearly exclusively of chickens[6]. This peculiarity of imports – that large quantities of frozen chickens from Europe (around 90 percent) or other non-neighbouring countries (around 10 percent) arrive in Benin[7] – seems to improve the supply situation of meat. But legal and illegal reexports, particularly to Nigeria, reduce the amount of animal products offered on Beninese markets. Pursuant to local experts, up to 90 percent of imported chickens are reexported (BIADJA and GBAGUIDI, 2004). In general it is difficult to estimate trade activities as numerous illegal border crossings are not registered, and imported and exported animals which are in transit are not listed separately.

4.4 Conclusions of the chapter

This chapter has analysed the political and economical situation in livestock husbandry. At present, livestock policy in Benin regulates few aspects and concentrates on improving and supporting production methods. Classical agricultural policy instruments are not employed. The issues emphasised in policy, such as vaccination or reduction of diseases, are necessary targets for improving livestock management. But it seems that no general strategy for developing the livestock sector exists, and that livestock policy is not proactive. Instead, policy acts as crisis intervention, or reacts to changes induced in other political or administrative fields. This is, partly due to the fact that representatives of the stakeholders are lacking, because livestock husbandry is mainly practised by marginally integrated groups, such as transhumant animal keepers or small (peri-)urban animal keepers.

Compared to structures in cropping, especially cotton, structures for the livestock sector are, apart from some specifically local projects, still in the process of being developed. The nearly non-existing organisation and the absence of an infrastructure for commercialisation account for the difficulties in implementation. However, these structures are necessary for integrating livestock pro-

[6] In 1997, an embargo for beef imports was established due to the outbreak of BSE in Europe (VAN UFFORD, 2000).

[7] At the end of 2005, a ban on chicken imports was imposed due to the avian influenza.

duction into the market economy, as the demand for animal products is steadily increasing. At present, interventions in the design of the agricultural sector are possible only at bottlenecks, such as the cotton factories in crop production. Currently, in livestock management the only bottleneck is found at the border, and attempts are being undertaken to make state interventions feasible for imported and exported products. Thus, the realisation of any political decision-making is difficult due to the low organisational structure in livestock management.

The majority of animal products are produced in the northern and central regions, whereas the large consumption centres are located in the urban agglomerations in the south. As production areas are not congruous with consumption areas, transportation flows are generated, which have to be organised. This trade leads to transport of live animals, as cooling capacities are just marginally distributed.

This regional south-north distinction might be aggravated by the increase in population and has implications on the production method and commercialisation system. Currently, input and organisation are at a low level; both aspects, however, depend significantly on the region. Although production and commercialisation are adapted to the restricted resources in Benin, a higher structure and organisational level, such as higher input and more active commercialisation, can be observed in regions with strong producer organisations.

Despite the high population growth, labour is hired in all regions and is temporarily scarce. Notwithstanding that prices are determined by the interaction of supply and demand, the regional producer organisations influence the producer prices. In regions with producer organisations the margins for trade or intermediaries are reduced, which benefits the producers.

Interestingly, the chiefly small (peri-)urban animal keepers in the south are more market-orientated than the animal keepers in the other two regions. Due to the increasing demand and higher prices compared to the northern regions, an opportunity is provided to produce animals for the market. What is just as important, is the growing awareness of explicit demand, so that production for the market and not just for one's own consumption and prestige is worthwhile.

Having analysed the livestock sector in Benin, the next chapter focuses on the challenges of livestock management and its possible development paths. The repercussions of the driving forces on the livestock sector, population growth, increasing income, and changes in resource availability, are dealt with in the following.

Chapter 5

Current problems and theoretical development paths

The following chapter identifies the challenges of the livestock sector and reveals possible consequences of the selected driving forces and development paths of livestock husbandry. This is done, inter alia, with the help of agricultural development theories. Subsequently, the experiences in some other countries and the results of the expert survey are discussed.

5.1 Challenges in livestock management

With regard to the current situation in the Benin's livestock sector, it appears that difficulties and challenges occur, which are regionally differentiated. First, the difficulties in production are investigated before we look at commercialisation problems.

5.1.1 Production and commercialisation

In the producer survey, the animal keepers were asked, without specification so as not to influence their answers from the start, to identify their most relevant problems and difficulties in production. Experts were also asked about the aspects which hamper production of animal products for the animal keepers in Benin. The appraisals of the animal keepers and experts, with respect to production difficulties, are listed in table 5.1. Interestingly, the first three aspects:

forage, diseases, and problems with the supply of water are in the same order and of the same significance for animal keepers and experts. With a distinct lead and an unexpectedly high percentage, problems in feeding rank first. This is surprising, as official programmes still concentrate on the abatement of diseases. Diseases still limit production, but according to the information of the surveys they are better under control than feeding.

Problems	**Animal keeper in %** 1)	**Experts in %** 2)
Forage – pasture	33.9	25.6
Diseases	24.0	14.7
Water	19.3	10.9
Conflicts between farmers and animal keepers	7.0	1.6
Theft of animals	5.3	—
Health care for livestock – input factors	4.7	3.1
Land availability	2.3	3.1
Other problems	3.5	—
Commercialisation and organisation	—	10.9
Extensive production	—	8.5
Missing consulting and research	—	7.8
Access to credits	—	3.1
Genetics – breeding	—	4.7
Missing knowledge of the animal keepers	—	6.2

1) N = 169, multiple mentions possible
2) N = 129, multiple mentions possible

Table 5.1: Difficulties in livestock management
Source: GRUBER et al., forthcoming

Feeding problems result from high costs of forage in the south and are associated with natural pasture in the two northern regions. There, animal keepers depend on the quantity and quality of natural pasture and are therefore not able to influence supply to a great extent. Moreover, areas for natural pasture are usually common property belonging to the state, which provokes the classical problem of public goods. Every person has the same right to exploit the resources at no or low costs. However, if livestock overgrazes the land, the pasture loses its regeneration potential in non-grazing periods.
While the animal keepers and experts were in agreement regarding the importance of the first three problems, their opinion differed on the remaining issues.

For example, the animal keepers consider thefts to be a more important production problem than the experts do. In contrast, experts call attention to additional and more far-ranging aspects such as ignorance or lack of consultation, which are not mentioned by animal keepers. However, the lack of knowledge of forage cultivation was acknowledged by the animal keepers, when they were questioned a second time as to why they do not cultivate forage. Interestingly enough, cultivation knowledge is at hand, as 85 percent of the animal keepers cultivate crops for their own consumption and sometimes even for marketing. One possible explanation for this might be the lack of awareness and specific knowledge of forage cultivation. Another explanation might be that forage cultivation requires labour at a specific time, which is not available as working time is first expended on cultivating crops.

To evaluate the difficulties in commercialisation, the animal keepers and the experts were given a list of possible reasons for problems, which they were asked to consider as to whether the respective aspects relate to existing commercialisation problems or not. The difficulties in commercialisation are rated in the following way as table 5.2 shows. The assessments are not as consistent as in production. Moreover, there is no major problem recognisable in the experts' evaluation.

Problems	**Animal keeper in %** 1)	**Experts in %** 2)
Distance	19.7	13.2
Transport costs	23.0	13.8
Means of transportation	—	17.0
Cooling	—	14.5
Intermediary	1.6	14.5
Access to markets	2.5	9.4
Low prices	41.0	—
Veterinary standard	4.1	4.4
Other problems	8.2	1.9
Lack of possibilities	—	5.7
Competition	—	5.7

1) N = 122, multiple mentions possible

2) N = 159, multiple mentions possible

Table 5.2: Problems in commercialisation

Source: Author's producer and expert survey, 2005

Both in production and commercialisation, availability of credits is another difficulty mentioned. This point is also referred to in other studies. Even if animal keepers are willing to invest in production and improve their production methods, the implementation is hampered by the difficulty in obtaining credits (Direction de l'Elevage, 1997; ICRA, 2001).

5.1.2 Regional differences

The regional distribution of the mentioned production problems shows significant differences. While the northern and the central regions are similar in several aspects, the south differs from both regions, as figure 5.1 illustrates. In the south, for example, water supply is not a problem, and forage problems are less relevant than in the other two regions. This seems to be owing to the well-developed infrastructure, as wells are normal components of daily life. Other reasons might be better access to ground water, a higher precipitation, and/or higher level of supporting measures in the specific regions.

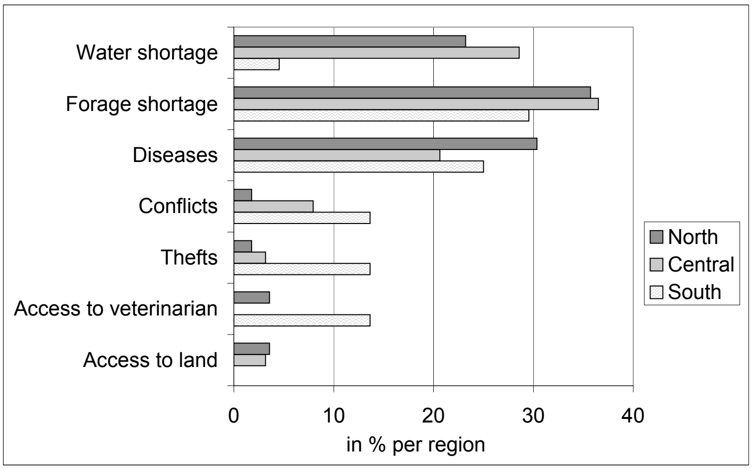


Figure 5.1: Production problems of animal keepers according to region
Source: Author's producer survey, 2005

This regional heterogeneity in perceived problems originates to some extent from differences in natural conditions. As a consequence of good adaptation to and great dependence on natural resources, different production systems have been developed. Several differences in production methods can be found, inter alia, in species, herd size, watering places, and strategies to deal with scarcity of water and forage.

It is evident that not only natural conditions are responsible for regional distinctions. Socio-economic conditions, infrastructure such as distances to markets, market or producer organisations also exert a strong influence on the sector. Although thefts of livestock, for example, occur in all parts, the south is affected most. Thefts exert a considerable impact on the housing systems, as animal keepers in the south have to hire extra guards to protect their herds, or have to lock up the animals in sheds during the night.

The observed regional differences in vaccination, for instance, can be put down to the different organisational statuses of the three investigated areas. In the northern region, it is common for pastoralists to be a member of a producer organisation, which requires its members to have their livestock vaccinated. For several reasons, however, vaccination is not so widely spread in the south: income from livestock management is often not the only source of income. Herds are smaller and large animals are rare, therefore less importance is attached to vaccination. Moreover, producer organisations for pigs and chickens are often more engaged in modern livestock systems. These production methods are not practised by small livestock keepers, who are, therefore, less aware of the benefits from vaccination.

In connection with the vaccination issue, veterinary standards are more problematic in the south than in the two northern regions. This aspect and the regional heterogeneity of the problems of commercialisation are illustrated in figure 5.2. In contrast to vaccination, distances and transportation costs are more a problem in the two northern regions where transportation infrastructure is less developed and large markets are not nearby. These two aspects as well as market access are not considered to be problematic in the south due to the proximity to urban regions and, therefore, to several markets.

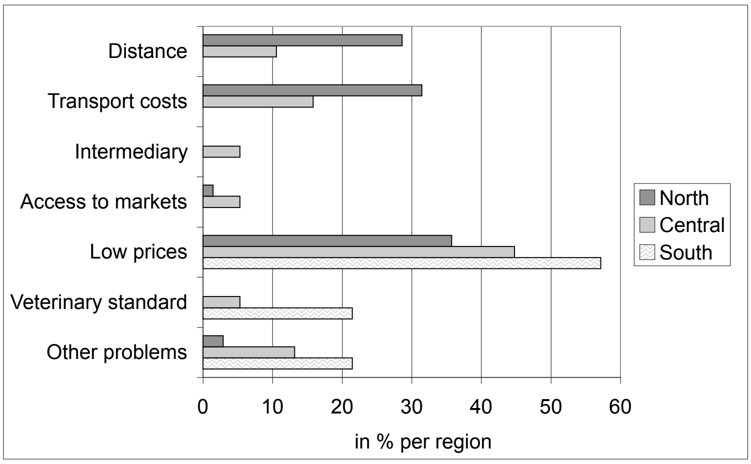


Figure 5.2: Commercialisation problems of animal keepers according to region
Source: Author's producer survey, 2005

Low prices are seen as a problem in each region. While in the north low prices are one problem among others (distances and transportation costs), low prices are regarded as an outstanding problem in the central and southern regions. Other commercialisation hindrances are related to temporal lack of buyers in the north, to border fees and selling on credits in the central region, and to marketing difficulties in the south. As discussed in chapter 4.3.2, a regional difference in marketing comportment is also observed. In this aspect, the north bears resemblance to the central region. In contrast, the south differs in selling livestock and is significantly more market-orientated than the other two regions.

5.2 Theoretical development paths in livestock management

The description of the current situation and challenges has indicated that Benin's livestock sector will face some changes in the coming years. In the first part, the following section deals with the theoretical possibilities of further development based on the current situation. Agricultural development theories try to explain these paths and specific causes of a development direction. In the second part, some experiences of other developing countries and the opinions of local experts add information on possible development directions. In the following section, the starting point is the traditional animal production, in which the majority of livestock is kept in Benin.

5.2.1 Definition of development and starting point

First of all, it is useful to define the term “development” in order to reach a consensus on its meaning. There are numerous definitions of development, and in each discipline the term has a special meaning and background. In general, development is understood as a process of change, of growth and decline, of speeding up and falling back. In this broad definition, development is without any attachment to value, as all directions in changes are possible and allowed. Development is often associated with improvement, with changes for the better. The next two definitions of development emanate from this connotation. First, economic development often refers to economic growth, in the sense of increasing income per capita. The second definition with the connotation of improvement includes economic as well as social components: “development is the improvement of the living standard of the total population in a specified region” (NORTON and ALWANG, 1993, p.12). A more abstract definition refers to development as “expanding freedom of choice and action” (MEIER and STIGLITZ, 2001, p. viii). In this study, development refers to the general definition, that is the word is used without a specific value judgement describing the changes in the system.

As we have seen in chapter 2, Benin faces an ongoing high population growth, and an optimistic view of the economic situation can be expected. In the next few years, the high population growth and the prospect of economic growth, combined with high income elasticities for animal products, will lead to an increasing demand for animal products. The market of animal products will develop as illustrated in figure 5.3. Benin is seen as a “small country” which is not able to considerably influence world market prices. The aggregated supply curve S° is composed of the up to now domestic inelastic supply and the elastic supply coming from imports. The elastic demand curve D will experience a shift to the right, due to population growth and high income elasticities greater than or equal to one for animal products. As a result, an additional demand for animal products will emerge.

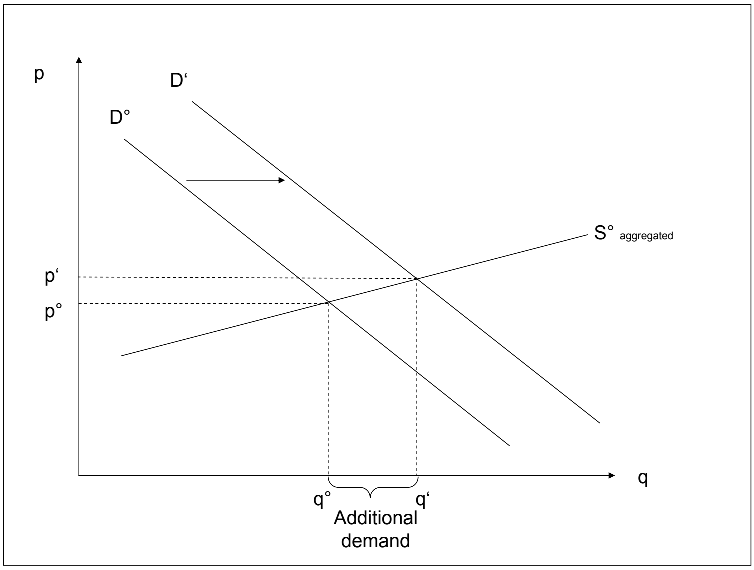


Figure 5.3: Supply and demand of animal products
Source: Author's illustration, 2006

Regarding this point two questions arise: firstly, how the expected increase in demand can be satisfied in the next few years, and secondly, how the livestock sector will respond to the changing situation and what the development in this sector will look like.

We start the analysis of the development from the perspective of the consumer. It is assumed that in the coming years the overall demand for animal products will increase drastically. In order to see the dimension and the relevance of the changes in consumption, the growth rate in demand for food *d* in percent can be estimated (NORTON and ALWANG, 1993). The main influencing values are the driving forces population growth *p* in percent, the income elasticity in demand for food ϵ_y and income growth per capita *g* in percent:

$$d = p + \epsilon_y \cdot g \quad . \tag{5.1}$$

The population growth of 2.8 percent per year, the observed income growth of 1.2 percent per capita and year, and an average income elasticity of 1.0 for animal products, result in a yearly increasing demand for animal products of 4.0

percent for Benin. Equation 5.1 reveals that the main part of the increasing demand is driven by the population growth in Benin. Population growth at 70 percent contributes to the increasing demand whereas the remaining 30 percent stem from income growth. This growth rate of demand for animal products means that in 2025 demand will be higher by a factor of 2.2 compared to 2005.

The situation turns out to be as follows: demand is shifted to the right due to population growth and income growth combined with high income elasticities, as illustrated in figure 5.4. If the supply is not adjusted to the quantity demanded, prices will rise considerably. Prices may remain constant or increase less if the additional demand is met. In general, the additional demand can be met by imports or increased domestic production. The increase in domestic production can be achieved by increasing the number of animals, the productivity, or a combination of both.

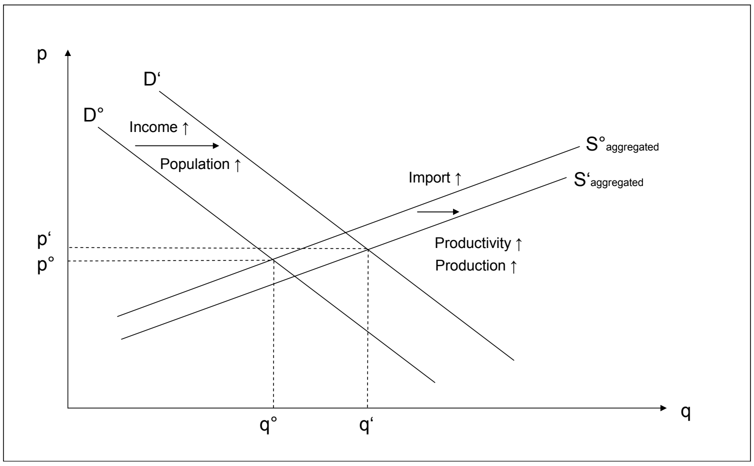


Figure 5.4: General possibilities to meet increasing demand
Source: Author’s illustration, 2006

This means for the consumer that either prices will rise or the additional demand is satisfied one way or another. In the first situation, consumers may buy animal products to the extent they can afford them. In the second situation, it is not relevant for the consumer where the additionally needed supply comes from and who manages the production as long as they have no preferences between domestic and imported products.

For the producer the whole issue is more complex, as the question whether the supply is provided by imports or domestic production is an essential point. In the following, we will have a closer look at what this situation means for the producer in Benin. What possibilities of reacting and developing are imaginable here? If the complete additional demand is satisfied through imports, the livestock keepers may stick to their production system to the extent that the production factors are available. However, if some of the additional demand is met by livestock husbandry in Benin, the question arises as to how production will react and which producer group will respond in what extent to the new situation. This decision considerably influences the economic status of the producer in question. As the study investigates the impact on livestock management, the following analysis concentrate on the producer side and the possible developments of livestock husbandry.

Currently, the increasing demand and changes in prices caused by population growth and increasing income are the strongest driving forces boosting the production of productive livestock. However, for area-dependent ruminants, a second impact of population growth can be noticed. For the keeping of ruminants the availability of input factors such as land or water will become additionally relevant. One can currently observe that, due to population growth and stagnating crop yields, the agricultural area for crops is being expanded. At the same time, the available land for pasturing livestock is being reduced, thus influencing the traditional production system. Therefore, in the present system, the available grazing area for animal keepers who are dependent on pasture is the total agricultural land minus the cropping area. The present observation of increasing demand for animal products and decreasing pasture area is shown in figure 5.5.

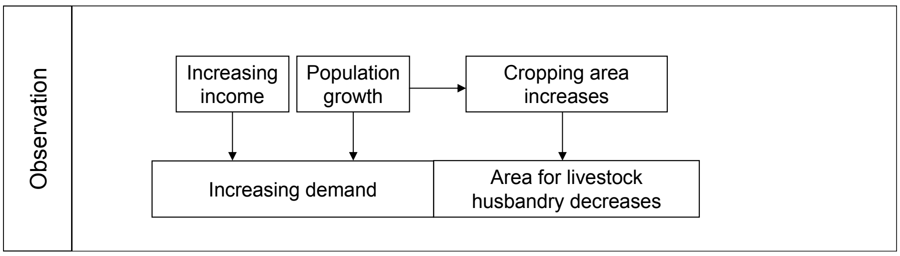


Figure 5.5: Current observation in agriculture
Source: Author's illustration, 2006

The latter aspect is, on the one hand, a result of the stronger position of crop farmers, as compared to migrating pastoralists, to enforce use and property rights in the traditional land use system. On the other hand, it is the consequence of the fact that more calories per hectare can be produced by cropping than by livestock husbandry. Disagreements and conflicts between farmers and livestock keepers have already been observed, but in some areas the simultaneous expansion of cropping areas and herds is still possible. However, it is only a question of time that more land is required than "free" land is available.

As illustrated in figure 5.6, there are two main reactions on the part of the animal keepers to the increasing demand and to the more or less (depending on their production system) serious decrease in available pasture areas. One reaction might be continuing the well-known and well-established production system. In order to maintain sustainability – this is the prerequisite for long-term development strategies – the animal keepers have to look for regions where they can keep livestock in the traditionally established ways. Therefore, the transhumant animal keepers have to search for new pasturing areas in more remote and marginal areas and increase the number of animals to the extent possible. Another reaction might be to change the composition of livestock, that is to switch to productive livestock which is less dependent on pasture areas. The animal keepers of extensively kept monogastric animals may continue to produce for their own needs. Maintaining exclusively the extensive production system will not meet the increasing demand.

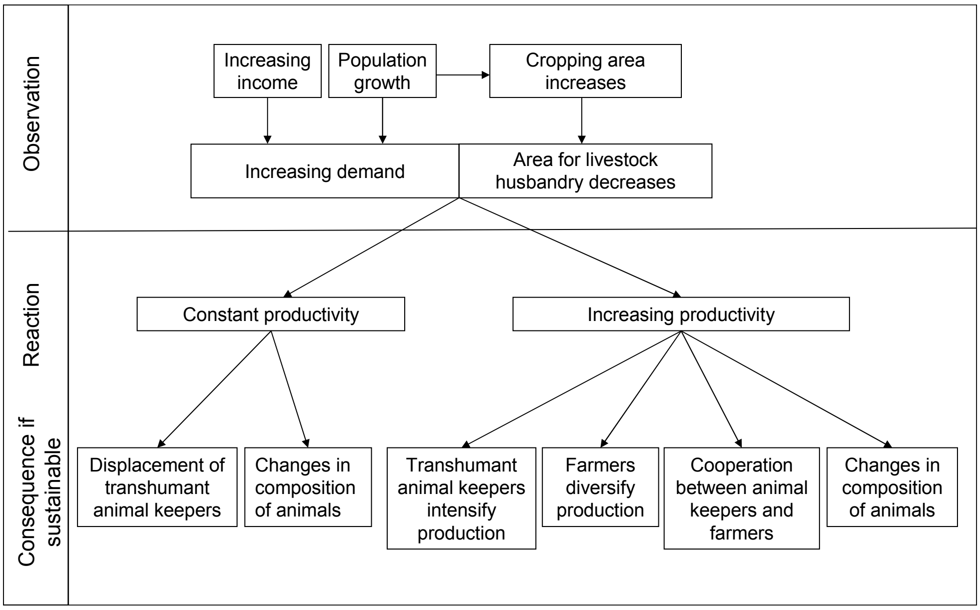


Figure 5.6: Possible long-term development paths
Source: Author's illustration, 2006

Another reaction might be to increase the productivity, in particular the land productivity in livestock keeping. Land productivity seems to be the most important aspect, but at certain times labour is scarce, hence labour productivity may also play a major role. An increase in productivity is rarely achieved when using the extensive or transhumant production method, by which variable production conditions determine the output. If livestock keepers want to increase productivity, they have to change their production system. This means, for example, that they have to deal with forage cultivation.

But the farmers also have to deal with new production methods when they take over the production of animal products. Today they often invest in livestock, especially in cattle, when they have extra money at their disposal. At first, the cattle of the farmers are cared for by the livestock keepers, but if the stock expands, farmers do their own keeping. By adapting methods of forage cultivation or livestock keeping, a more intensive interaction between crop production and livestock keeping might be possible.

A development path where both groups can use their specific knowledge involves the cooperation of the both groups. In this case the livestock keepers still care for the animals, and the farmers still produce crops complemented with forage crops, which are sold to the animal keepers.
Last but not least, also with a view to increasing productivity, the composition of the productive livestock can be changed from cattle towards a higher share of small ruminants and non-ruminants, such as pigs and poultry, which are less dependent on natural pasture.

5.2.2 Agricultural development theories explaining development paths

Development strategies and policy recommendation should be based on an analysis of the different paths. Have some first steps already been taken, is there one or another path which is more plausible, or are there signs or incentives that a certain path has been chosen? It is fascinating to observe that, at the moment, nearly all possibilities can be seen in Benin. Spatial displacements of mobile animal keepers occur in certain regions, while other transhumant livestock keepers are starting small-scale forage cultivation. Moreover, farmers are starting to establish their own herds, and some (semi-)intensive production of monogastric animals can be seen. Cooperation is also increasing, but not in the traditional ways, such as fertiliser contracts or contract herding, but more in an indirect way through the market. At the markets animal keepers buy by-products and wheat, which can be found mainly for monogastric livestock in the south. Hence, the question remains which development will prevail.

The question as to which development path will be taken and which driving forces lead to a special direction is dealt with in economic development theories. These theories are engaged in analysing the causes of development and in explaining development paths. These theories are, of course, embedded in the specific period of evolving. The political systems, the experiences in history, and the economic understanding are only three of the many backgrounds which influence the design of the theories, or rather are the bases on which the theories are built. Existing development theories are also a base for new theories, which are derived from the existing ones. Some theories were developed further or were the reason for creating a counter-theory. The following analysis takes agricultural development theories into account in order to see which arguments and causes can be found for the one or the other development path within the livestock sector.

According to a widely-used classification for agricultural development theories by HAYAMI and RUTTAN (1985), there are six different categories of development theories. The six groups of theories are: the resource exploitation model (also called frontier model), the conservation model, the location model, the diffusion model, the high-payoff input model, and the induced innovation model. For both authors it is important to mention that they

> [...] do not regard these models as stages in the agricultural growth process. Rather, they [the models] are designed to capture the changing sources of growth during the process of agricultural development. In most countries agricultural growth draws on all of the sources identified in each of the several models (HAYAMI and RUTTAN, 1985, p.42).

This citation includes two major statements: first, that the different sources need not be used in a chronological order, and second, that changes emerge from using different sources of development. Certainly some sources can be applied chronologically as well as separately, but multiple causes for development are more likely.
There is another theory of agricultural development which cannot be easily classified within this group of six: the theory of BOSERUP (1965). In the following explanation of different development paths in the livestock sector in Benin, several of the seven development theories are employed, as neither a single theory is able to explain all possibilities, nor are all theories necessary and helpful to understand the processes in Benin.

At present, mainly the maintaining of existing production methods and the expansion and relocation of pasture areas can be observed, which correspond to the resource exploitation model and is the first strategy to increase production. But as mentioned before, land resources are limited, changes will take place, and other answers have to be found for future development.
The location model is also related to geographical aspects, like the resource

exploitation model, and is based on the theory of von Thünen, which explains geographic variations in location and intensity of agricultural production. As shown in figure 5.7, the location model can help to explain both the path of constant productivity and of increasing productivity. Applied to Benin's situation, this would mean that near urban areas livestock production is intensified, and in more remote areas the extensive production methods are maintained. As no spatial regulation of livestock keeping exists, the establishment of intensive production near or in urban areas is likely to occur.

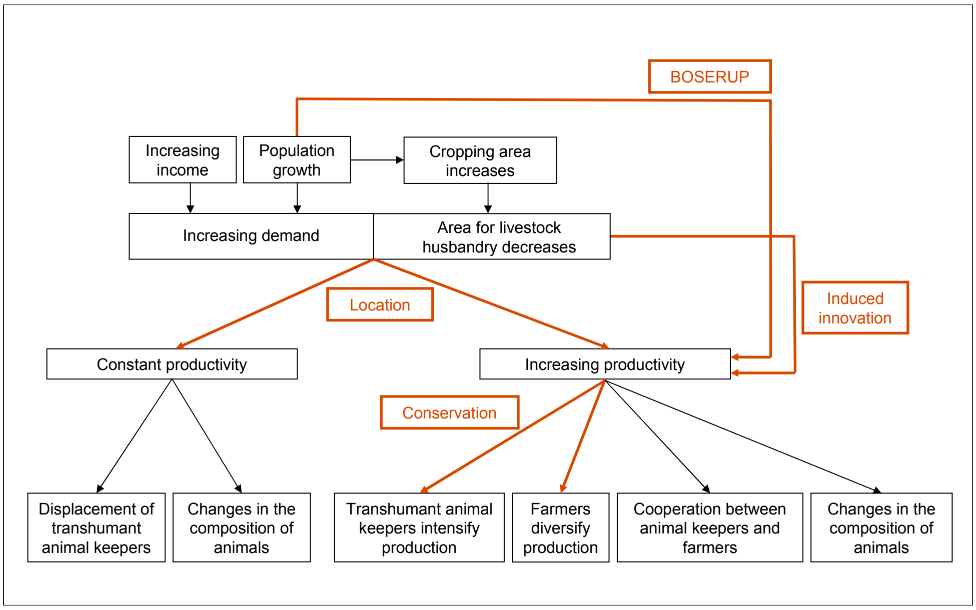


Figure 5.7: Development paths explained with development theories
Source: Author's illustration, 2006

An increase in productivity can be obtained by integrating crop and animal production, which is described within the conservation model. By dint of more intensive crop-rotation systems, the use of organic manure, drainage, irrigation, or other physical facilities, the limited resources of land and water can be used more effectively. These facilities are mainly provided by agriculture itself. This intensification of agriculture has shown sustainable growth rates in agricultural production in the range of 1.0 percent per year in the long-term (HAYAMI and RUTTAN, 1985). Although sustainable growth can be reached by this method, it cannot keep pace with the increasing demand for animal products of 4 percent

per annum in Benin.
BOSERUP (1965) has provided another theory regarding the developing of the agricultural sector. She argues that the main inducement to increase productivity is an increasing population. Population growth is seen as an exogenous variable for agriculture, as, for example, in many developing countries the high population growth cannot be explained by an increasing food supply. Hence, her theory is opposed to Malthus's, who says that inelastic food supply regulates population numbers. Instead of exploiting new land, she emphasises the importance of land use frequency. When land resources are limited, the frequency of cultivating land increases and shorter periods of fallow occur. The change between different types of fallow, from forest-fallow cultivation to bush-fallow cultivation, short-fallow cultivation and to annual and multi-cropping, induces the use of different tools for cultivation. In a forest-fallow system it is not practical to use ploughs as remains of burnt trees hamper the ploughing, whereas in a short-fallow cultivation system ploughs are needed to get rid of the weeds, since burning does not destroy the roots (BOSERUP, 1965).
The third model, which explains increasing productivity in the agricultural development process in figure 5.7, is the theory of induced innovation, put forward by HAYAMI and RUTTAN (1985). This theory is based on the theory of wages developed by J.R. Hicks and is applied here to agricultural development. In this theory, technical changes are endogenous to development, as technical change is a response to changes in resource endowment and increasing demand. The newly developed or applied technologies facilitate the substitution of relatively abundant and cheap input factors for the relatively scarce and expensive ones. Hence, according to the relatively scarce factors and the possibilities of substitutes, different development paths are adopted according to country, region, or to respective starting point. In figure 5.8, the impact of changes in relative factor prices of resource endowments on the technical change is illustrated.
The innovation possibility curve I_0 stands for the range of possible technologies which can be used in period t_0. The line P_0 represents the relative price relation of the input factors, labour L_0 and land A_0. The least-cost combination occurs at point a, where the isoquant i_0 is tangent to P_0 and I_0.

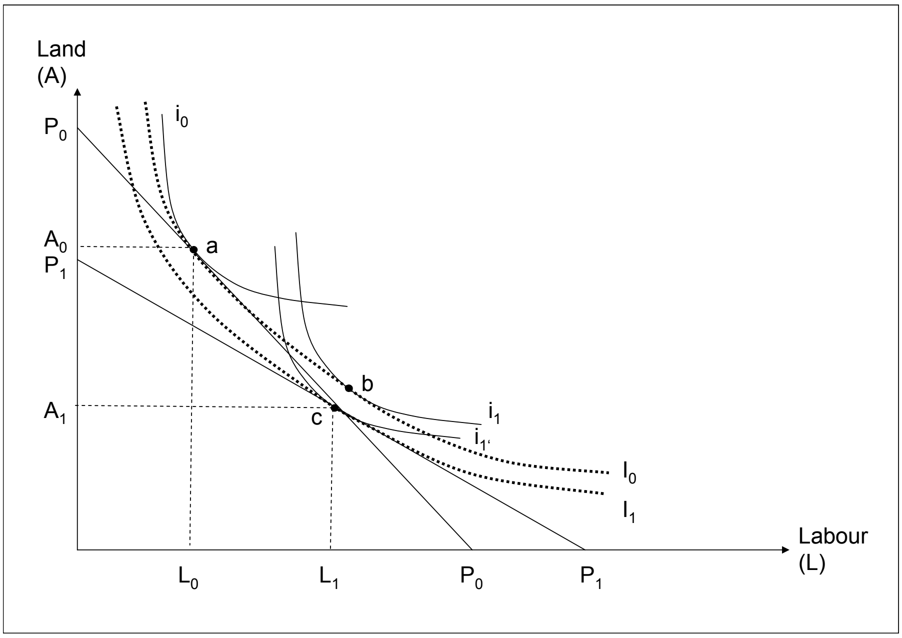


Figure 5.8: Induced innovation
Source: Adapted from HAYAMI and RUTTAN, 1985, p.91; NORTON and ALWANG, 1993, p.175

Then, in the course of time, relatively more labour is available than land, the price of labour is reduced compared to the price of land, which means that the price relation line turns to become P_1. Hence, relative prices create incentives to develop and use more labour-intensive technology. Without any technical progress the production takes place at point *b*. But the theory of induced innovation says that new technologies have been developed to save scarce resources, meaning that I_0 moves closer towards the origin, creating the new innovation possibility curve I_1. Consequently the isoquant i_1 moves to point *c*, where L_1 and A_1 is used for production in period t_1. Akin to induced innovation in the private sector, HAYAMI and RUTTAN (1985) describe the mechanism for the induced innovation in the public sector. An adjustment of relative prices of input factors creates technical innovation, which saves the relatively scarce factor. Consequently, the producers might prompt the public research institutions to develop the new technical innovations, as long as producers are organised and have contact persons in the public sector to express their demands. However, the overall innovations in the field of technology outside the agricultural sector are also a helpful tool in the progress of agricultural innovations.

Two theories – the diffusion model and the high-payoff input model – are intentionally left out as they are not seen as helpful tools to explain the possible development paths. Agricultural growth in the diffusion model comes from the diffusion of (more) productive practices. Since communication between producers' communities are still marginal (local level), the advice of national farms is limited recognised (national level), and the conditions for the techniques/varieties used in industrialised countries are far from the conditions in Benin (international level), diffusion might not be an explanation for development in the current situation. The second model which does not come into operation is the high-payoff input model. This model sees investments in developing and promoting new inputs as an origin of increasing productivity. However, the model does not comment on how (economic) conditions induce the processes of developing and promoting the new adapted inputs.

Not all development paths can be explained by one of the used agricultural development models. Especially the location model as a sole theory to explain constant productivity in the livestock sector followed by a displacement of transhumant animal keepers does not adequately portray reality.
Thus, the New Institutional Economics (NIE) is used, which is an economical concept explaining economic activities embedded in social and legal institutions. There exist several strands of NIE, such as the transaction costs, property rights approach, or the principal agent theory (RICHTER and FURUBOTN, 2003). The property rights approach is helpful in explaining the occurrence of displacement (see figure 5.9). As different groups with different land rights are involved in the land allocation process, the institutional background – in this case access to land and the land use rights – determines the further development. Without the same institutional right as farmers have to claim and cultivate land, animal keepers have limited possibilities to react properly. They are allocated land only if land is available, which means not before the farmers' needs have been met. This leads to a local displacement of animal keepers or to changes in the composition of livestock as the animal keepers replace their livestock and acquire herds which are less resource dependent.

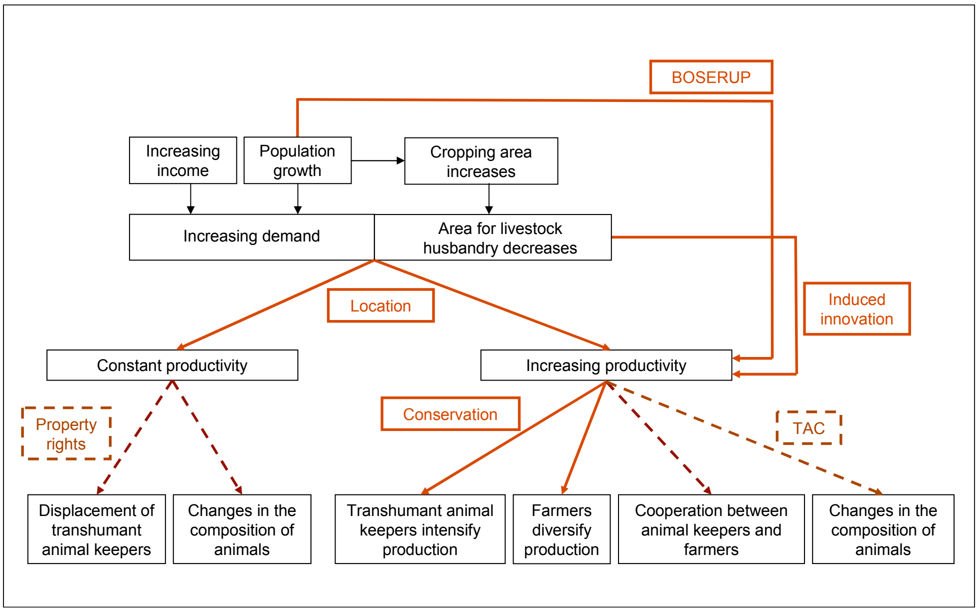


Figure 5.9: Development paths explained by NIE
Source: Author's illustration, 2006

The same change in the composition of species can also occur on the assumption of increasing productivity. This change, which is normally the change from large ruminants to small ruminants, can occur due to adjustments in relative prices of the input factors, or, to stay closer to the NIE environment, due to transaction costs (TAC). In this case maintaining the natural pasture-dependent livestock would require higher transaction costs, e.g. for obtaining land rights, than changing the composition of animals.

Transaction costs also become relevant in case animal keepers and farmers cooperate in animal production. Each producer group concentrates on their special knowledge and production. Farmers produce forage whereas animal keepers use this forage and keep the productive livestock. Thus each group is able to reduce transaction costs by gaining and using additional knowledge and experience of production and trade organisation, of fields they have, so far, not been acquainted with. However, transaction costs may accrue if a trustful relationship between farmers and animal keepers is missing and has to be established first.

5.3 Empirical evidence in developing countries

Beside the theoretical considerations as to which development path might be taken, looking at typical (expected) developments in the livestock sector or in other African developing countries which have recently been confronted with more or less the same situation may also help to identify pathways in Benin. Therefore, general observations regarding livestock development and some examples of similar situations may help to better understand the situation in Benin.

Not only Benin is confronted with the increasing demand for animal products: between 1995 and 2025, the global demand for animal products is expected to increase by 70 percent, whereof more than 4/5 will occur in developing countries. This means that the demand in developing countries will more than double within this period of 30 years (ROSEGRANT, CAI and CLINE, 2002).
The changes already underway and forthcoming in livestock management are induced from the demand side, in contrast to the Green Revolution, which was supply-driven. DELGADO et al. (1999) call this process the “Livestock Revolution” in the style of the Green Revolution. The Livestock Revolution is characterised by seven processes which are listed in table 5.3.

The Livestock Revolution
- Rapid global increase in consumption and production of animal products
- Major increase in the share of developing countries in consumption and production of livestock products
- Shift from multi-purpose use to food and feed production
- Increased substitution of meat and milk for grain in the human diet
- Rapid increase in cereal-based feeding
- Greater stress on pasturing areas and more land-intensive production near cities
- Emerging technological change of production methods

Table 5.3: The processes of the Livestock Revolution
Source: DELGADO et al., 1999

Several characteristics of this global tendency are also mentioned by SCHNEIDER (1999) regarding the process of the development in livestock management. He arranges the detected shifts and changes in three large groups, which are shown in table 5.4. During the development of the livestock sector the function

and species of livestock change, and displacements in geographical location as well as structural and technological shifts take place.
The first adjustment to the increasing demand for animal products can be perceived in an augmentation of animal numbers. In general, in Benin as well as in other developing countries, little or no increase in efficiency per animal has been noticed in the last decades. But instead, a consistent augmentation of animal numbers can be perceived, which results from the adjustment to the increasing demand for animal products (JAHNKE, 1982; MFEP, 1982; DELGADO et al., 1999).

Shifts	**Time** t_0	**Time** t_1
Shifts in function and species	Non-food	Food function
	Multi-purpose	Single-purpose
	Ruminants	Non-ruminants
Geographical shifts	Marginal areas	(Sub)humid areas
	Rural areas	Urban areas
Structural and technological shifts	Resource-driven	Demand-driven
	Small scale	Large scale
	Horizontal integration	Vertical integration
	Low input	High input

Table 5.4: Shifts in livestock production
Source: SCHNEIDER, 1999

The enlargement of animal numbers in developing countries occurs, above all, in regions with increasing demand. Thus, industrial livestock management is set up preferentially in the closer surroundings of cities, owing to a weak state-run regulation of production locations and the inadequate infrastructure far from cities (DELGADO et al., 1999).
In Benin, some of these shifts have started and can now be observed in some regions. The increasing number of animals is noticed in the whole of Benin. Furthermore, the shift from (large) ruminants to small and non-ruminants, higher response to demand as well as urban livestock keeping is seen in southern Benin.
At the same time as livestock production is shifting to urban areas, natural resources are becoming less and less important, which can be also found in a very general description of REISCH and ZEDDIES (1992) concerning the develop-

ment in the livestock sector. They mention three stages of livestock management: at the beginning, livestock husbandry normally corresponds to grazing management, where large stretches of land are used without any technology. In the next step, livestock keeping supports cropping and conserves the potential yield of soil with manure until mineral fertilizer is broadly available and replaces manure. Then, livestock enlarges production in a given agricultural area. Fodder still comes from pasture, but additional forage is cultivated and/or bought.

Although the number of ruminants depend on pasture area and grazing systems are the main production method globally, the number of ranging ruminants is expected to be reduced. This is shown in figure 5.10, where the share of landless-kept ruminants is illustrated for the end of the 1990s and for 2030, according to a study of the FAO (2000). In this figure, landless systems stand for systems without ranging which use stalls, pens, or feedlots.

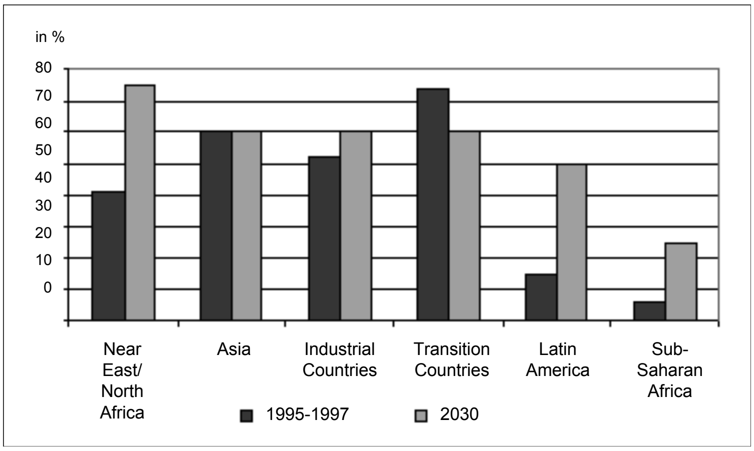


Figure 5.10: Cattle and sheep produced on landless systems
Source: FAO, 2000

Besides in Latin America, the increase of ruminants kept in landless systems will be mainly found in the Near East/North Africa and Sub-Saharan Africa. The use and/or the existence of natural pasture is not the determining factor for livestock management according to ALEXANDRATOS (1995). In his point of view, just a weak interrelation exists between livestock keeping and natural pasture resources. On the contrary, he maintains that livestock management in developing countries depends mainly on population and cropping activities.

In the Sidama Region in southern Ethiopia, the preference for cultivating crops to breeding livestock was already mentioned in the mid-1970s. The coexistence of cropping and livestock changed when land resources became scarce. As a result, the dominating cropping activities (partially) crowded out livestock husbandry (GHIROTTI, 1998).
This phenomenon can also be seen in West Africa, for instance in south-eastern Burkina Faso, where REENBERG, OKSEN and SVENDSEN (2003) investigated land use changes. They have found out that the changes in the land use pattern – meaning the expansion of agricultural land – has led to regional migration of transhumant animal keepers due to the distribution of land tenure. At the same time, the tendency to bring the plough into use can be seen, on the one hand, as the reason for the expansion of agricultural area as well as for the deterioration of traditional relations between farmers and animal keepers. On the other hand, this tendency is the consequence of both the expanded agricultural area and the relaxed traditional relations. Following the arguments of the authors, the trust of the two groups in each other is dwindling and cooperation is becoming more and more unpopular.
The same tendencies to expand agricultural land at the expense of natural pasture as well as to loosen the ties between farmers and animal keepers, and a decrease in specialisation are reported for Niger (BARBIER and HAZELL, 2000) and for Mali (KABORE et al., 2000; KRINGS, 2002). For both regions conflicts between different stakeholders and dynamics within the system of land use are covered. Population growth and climate change are important driving forces, for instance in Mali, where farmers expand their agricultural area to keep pace with the population growth, and to compensate for yield declines, since precipitation is low and not very reliable (KABORE et al., 2000).

In West Africa, deforestation carried out explicitly for livestock keeping – to compensate for the lack of pasturing area and to keep up the current production system – is not practised to such a great extent as in South America. In Africa, the environmental hazard of livestock keeping is overgrazing. This overgrazing is not an everlasting destruction of resources per definition, but it depends on the soil characteristics (BARBIER and HAZELL, 2000; TURNER, 2000). The declining prevalence of transhumance leads more to overgrazing than the traditional seasonal migrating. This decline and displacement of transhumance occurs due to despecialisation of livestock management, shifts in ownership, and agricultural expansion in transhumance paths. These changes cause a deterioration of traditional pasture-use regulations and lead therefore, to scarcity and overuse of resources (TURNER, 2000; KRINGS, 2002).
Traditionally, there are two main complementing strategies to deal with non-temporary resource scarcity in the West African classical extensive production system: firstly, the herd is divided into two groups, and a new household is established where resources are available. Secondly, animal keepers settle down and intensify the smaller herd in the original establishment (COMO, 1994a).

This migration of large ruminants to regions where natural pasture is still available changes the composition of livestock in the original production region. Fewer cattle are kept, the remaining cattle are kept more intensively, and the proportion of small ruminants, which are less demanding, increases. Although, in the last 15 years, the growth of cattle kept pace with the population growth in Mali, Cote d'Ivoire, and particularly in Burkina Faso, the growth of small ruminants was more marked than that of cattle in the whole of West Africa. This shift in the composition of livestock from large ruminants towards small ruminants can be seen in figure 5.11, in which the proportion of small ruminants to cattle is illustrated. Small ruminants are increasingly kept when natural resources are limited as these animals are more frugal than cattle.

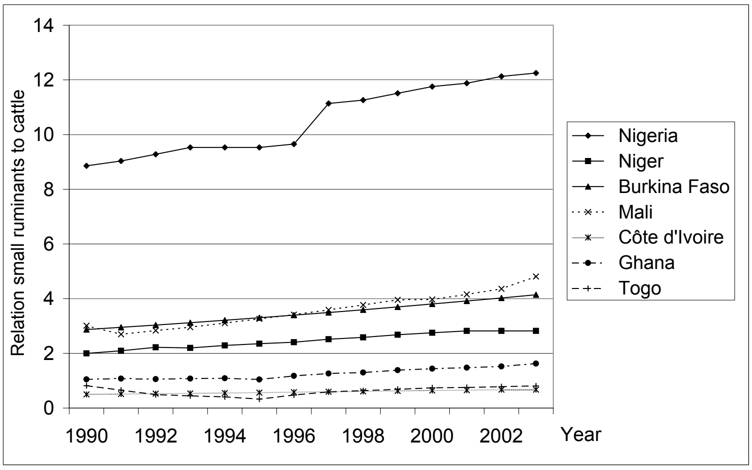


Figure 5.11: Development of small ruminants compared to cattle stock
Source: Author's illustration, 2006; Data: FAOSTAT, 2006

Additionally, in regions where mainly subsistence farming is practised, cattle for meat and milk production are kept in areas with easy market access. In more remote areas small ruminants are kept, because they pose no major problems concerning transport (PENDER and HAZELL, 2000). This might be the reason why in coastal countries (in figure 5.11) the differences in growth are not as pronounced as in the countries closer to the Sahelian zone.

5.4 Assumptions for Benin

In principle the future trends should be developed from statistical data, but the data are filled with imaginary figures or gaps. Moreover, literature based on survey data, especially for partial productivity, does not show any changes in the past twenty years. These are the reasons why experts have been consulted about the future development to supplement the information found in literature, to create plausible statements, assumptions, and scenarios.

5.4.1 Estimations of local experts

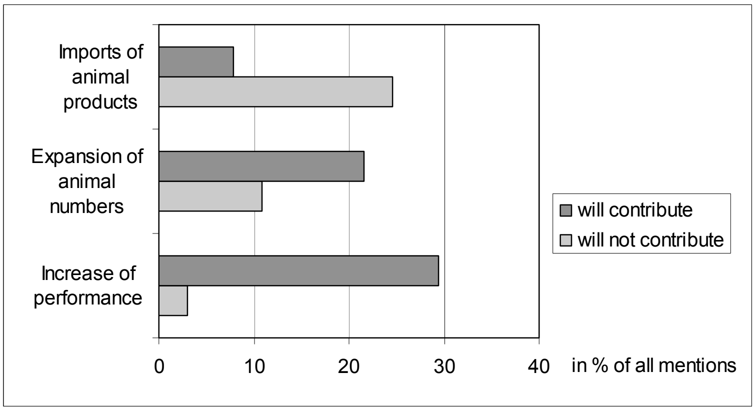
The second part of the expert survey concentrated on the development of the livestock sector in general, the future demand for animal products for human consumption, and some special features like transhumance. In the survey the experts were asked how they would estimate the quantity of meat (in kg) consumed per person and year for 2015, and further on for 2025. All experts but one assume that the consumption per capita will drastically increase until 2025 (see table 5.5). The experts' opinions are supported by literature such as by JAHNKE (1982), ALEXANDRATOS (1995), DELGADO et al. (1999), or SCHNEIDER (1999), who also state that supply will be demand- and not resource-driven.

	Unit	Year 2005	Year 2015	Year 2025
Average consumption of meat	kg/capita and year	7 - 8	9.8	13.8
Min. statement	kg/capita and year	—	6.5	5.5
Max. statement	kg/capita and year	—	15	30
Standard deviation	kg/capita and year	—	1.8	5.6

Table 5.5: Current and estimated consumption of meat for 2015 and 2025
Source: Author's expert survey, 2005

On average the experts assume a slight increase until 2015, and for the following years they presume that Benin's people will be able to afford more meat. The one expert who stated a negative trend in the consumption of meat, explained his view with his observation that the rural population earns little and cannot, therefore, afford animal products. He thinks that this situation will not change in the near and the more distant future. The experts estimated on average a lower increase of 3 percent per year than the estimated growth rate of 4 percent per annum calculated according to population growth and income elasticities (equation 5.1).

If this increase is brought about, the next question arises as to how the additional demand can be satisfied. When asked about this issue, most of the experts were of the same opinion, which can be seen in figure 5.12. They presume that imports will not make the main contribution to satisfying the additional demand. The traditional method, that is, increasing the animal numbers to increase supply, is still seen as an appropriate method in the next few years. But according to the experts the most likely answer will be the increase of performance per animal.



N = 102, multiple mentions possible

Figure 5.12: How future demand in Benin will be satisfied
Source: Author's expert survey, 2005

One argument of the experts contra the increase of imports is that animal diseases, like BSE or the avian influenza, lead to a decrease in imports, as imports are more and more hampered or even forbidden. However, an increase in imports of frozen chickens from Europe and live imports coming from the Sahelian countries can be observed.

According to the Ministry of Agriculture, the animal numbers in Benin depend on the demographic development (MFEP, 1982). This more than 20-year-old statement is still valid. GNIMADI (1998) also observed, for example, that the increase in egg production is equivalent to population growth. This aspect of interconnection between the animal numbers and population is supported by the low production level and simultaneous availability of arable land. As long as free pasture is available and no incentives exist to increase performance, the expansion of animal numbers is the easiest way for livestock keepers to respond to increasing demand. Therefore, the development of animal numbers in Benin is compared with population growth in figure 5.13. The comparison of the development of animal numbers for each productive livestock and population growth is illustrated according to the assumptions of the interviewed experts.

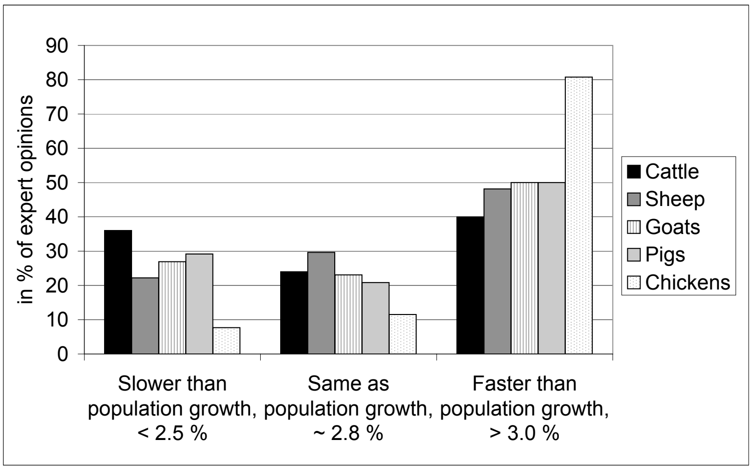


Figure 5.13: Assumed growth of animal numbers per year until 2025

Source: Author's expert survey, 2005

The most unambiguous position exists for chickens. The majority of the experts assume that the chicken stock will grow faster than the population, probably due to low costs and easy handling of chickens. This over-proportional increase is also expected by half of the experts for the pig stock and small ruminants. Especially small ruminants are frugal and can also be kept near houses. For cattle the expectations are much more uncertain because the production method would have to change.

One expert stated that the politically based incentives for improving animal health promote more the expansion of animal numbers than the increase in performance.

At present, the performance per animal is typically low, and has not developed in the last few years. Hence, an increase in performance per animal is presumed to be the most effective method to satisfy the increasing demand. But comparing this answer with the estimated gains in productivity per animal, an increase in performance cannot taken for granted. As table 5.6 shows, gains in productivity are difficult to imagine for the coming years. The lowest statements for 2025 still represent the values of 2005 without any change, whereas some experts predicted a doubling and even a tripling of performance. Some indicated maximal values could be obtained by replacing the current species. Particularly the 120 kg/meat per pig indicate a complete change from the local species to species like Large White or Land race. But also local small ruminants, such as Djallonké, would have to be substituted by larger sheep and goats like Sahelian to realise this increase, or an all-embracing intensification programme would have to be started.

Product	Unit	Average 2005	Estimated for 2025 Average	Min.	Max.	Standard deviation
Milk	kg/cow and year	200	337	200	700	141.2
Beef	kg/animal	117	163	117	300	54.5
Mutton	kg/animal	10	16	12	27.5	4.3
Goat meat	kg/animal	10	16	12	27.5	4.5
Pork	kg/animal	20	35	20	120	23.8

Table 5.6: Assumed development in performance
Source: Author's expert survey, 2005

The average value for 2025 of all the expert assumptions is a possible and realistic estimate without a complete replacement of the currently used species. But taking this average, the increase corresponds to a growth ranging from 1.7 percent per annum (for beef) to 2.9 percent p.a. (for pork). These figures are lower than the assumed average increases of meat production by 4.0 percent p.a. and of milk production by 3.4 percent p.a. for Sub-Saharan countries (DELGADO et al., 1999).
The realisation of an increase in performance is faster and more easily achieved with species with short reproduction cycles, which is why special political emphasis in livestock management is put on the enhancement of small livestock. This strategy is supported by the assumption that by 2020 two thirds of the consumed meat will be pork or chicken in Benin (BIADJA and GBAGUIDI, 2004). The use of species with short reproduction cycles will contribute to a medium degree (44.1 percent of experts) or to a high degree (47.1 percent of experts), to a rise in the supply of animal products. Although the experts see the advantages and profitable use of pigs and chickens to satisfy demand, they also declare that production methods for all species will or must change, which might be a challenge. Exemplarily for changes in production methods, the expected changes in transhumance, forage cultivation, and water consumption are shown.

Transhumance moulds the current picture of ruminant keeping in Benin, but its continued existence in the coming years is in question due to changes in production resources. The experts are not in unison with the year 2015, as can be seen in the first graph in figure 5.14. About half the experts assume a decline of the number of animals going on transhumance. But even for the densely populated south an increase is presumed by some experts.

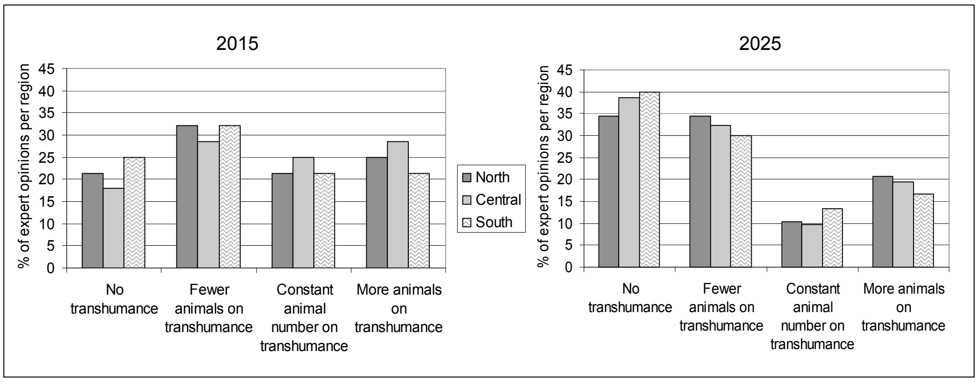


Figure 5.14: Development of transhumance
Source: Author's expert survey, 2005

The assumed situation for the year 2025 turns out to be more clear: here the experts' views tend unambiguously towards a reduction of the number of animals on transhumance. This time span is probably long enough for a change within the production system.

Hand in hand with a partial or total abandonment of transhumance comes the procurement of fodder for cattle. An abandonment of transhumance necessitates establishing forage cultivation or pasture rotation in order to ensure and improve the quantity and quality of forage. But pigs and intensively kept chickens are also dependent on consistently high-quality fodder, which is not being cultivated at present. Forage cultivation has been considered as negligible up to now, but the experts predict a real explosion of forage cultivation by 2015 and 2025. The estimated percentage of forage cultivation ranges from 10 percent up to 15 percent of the agriculturally used area, which is illustrated in figure 5.15. These percentages correspond to around 445,000 ha (for 2015) or 670,000 ha (for 2025) compared to the official 20 ha of forage cultivation in 2004. In comparison, in Europe the area cultivated with fodder crops accounts for around 50 percent of the used arable land. Establishing forage cultivations or pasture rotations requires capital and investments for fences, legal security, and knowledge. A realisation of all these aspects is, in the short-term, rather unrealistic (COMO, 1994a).

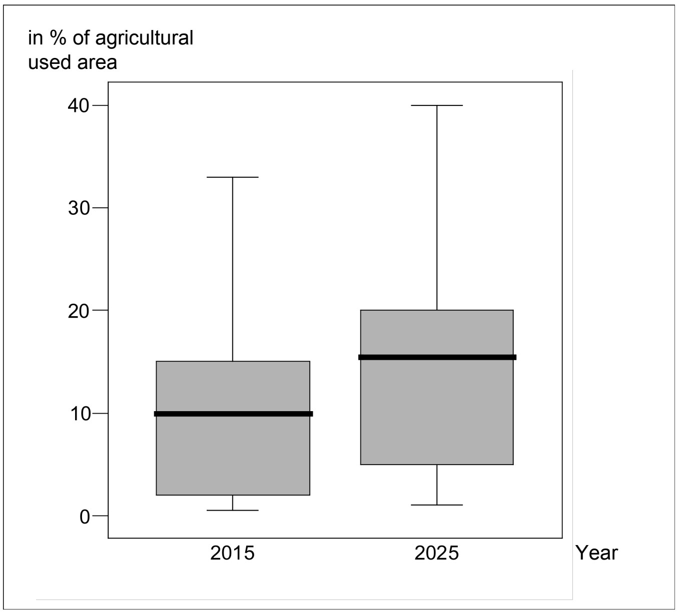


Figure 5.15: Share of cultivated forage area
Source: Author's expert survey, 2005

The third aspect, the required water supply for livestock, is derived from literature. It can be inferred from a study of the International Food Policy Research Institute (IFPRI) (ROSEGRANT et al., 2002) that the total water consumption for livestock management will increase noticeably in the next 20 years. Globally, the water consumption of livestock was marginal with 2 percent of the total water consumption in 1995. This amount seems small, and even an expected increase of up to 3 percent in livestock management by 2025 would appear marginal. But on closer examination it is apparent that this seemingly marginal increase will have extensive effects. This increase of one percent of the total water consumption will result in a doubling of the absolute amount of water consumed by livestock in developing countries. Moreover, it has to be considered that the availability of these apparently small water amounts could be problematic, both regionally and temporarily (ROSEGRANT et al., 2002). It can therefore be assumed that for Benin the water demand of livestock will increase as well and aggravate the temporal water competition with human beings. How the situation will turn out exactly for Benin will be simulated and studied in the model runs.

5.4.2 Determinants for changes in productivity

So far we have looked at some theoretical considerations, empirical evidence from other countries, and expert assumptions for the development of Benin's livestock sector. In the following section, the aspects and arguments which may lead to a constant or increasing productivity are examined. In this context, productivity refers to land or labour productivity respectively as land and labour are the important production factors at present. As capital is lacking and access to credits is difficult, the lack of capital can be described as a general hindrance to intensification in Benin.

The arguments for and against the improvement of productivity are listed in table 5.7. On the left side, the reasons for constant productivity and against an improvement in productivity are listed. On the right side, the arguments for an improvement and against maintaining the current production methods are given.

Arguments	
for constant productivity	**for increasing productivity**
Lack of credits	Scarcity of land
Tradition of transhumance	Opportunity for income generation
Integration into society and linkages of ethnic groups	Changing infrastructure
Low organisation of the sector	Beginnings of intensification in the production systems of animal keepers
Current property rights	Beginnings of diversification in the production systems of animal farmers
Temporal missing labour	(Traditional) cooperation between animal keepers and farmers

Table 5.7: Arguments for and against increasing productivity
Source: Compiled by the author, 2006

The traditional production system of transhumance argues for constant land and labour productivity in cattle keeping. The advantage of this system is the adaptation to natural conditions with a simultaneous risk reduction, which implies the extensive use of resources. This system has developed over several generations and is, therefore, strongly associated with the cultural background. According to the President of UDOPER (2005), transhumance will continue in the foreseeable future due to this cultural relevance.

As mentioned before pastoralists are not strongly integrated into society thus the exchange of information with officials about production and problems is restricted. Without the information flow in both directions, new experiences, knowledge, incentives, or needs are distributed slowly. Likewise the strong bonds within the ethnic groups slow down the spreading of knowledge between different groups. Moreover, these close-knit communities limit the cooperation of animal keepers and farmers, as trust is higher within grown structures. The state farms and some projects try to improve productivity and to introduce new production methods. But from the point of view of KADEL (2001), the animal keepers do not accept state farms as an example. KOHNERT (1998) supports this argument, because in his opinion the recommended innovations often do not correspond to natural conditions or specific difficulties of people. He mentions the unsuccessful attempt at implementing draught animals in South Benin since colonial times.

Although the arguments mentioned so far concern particularly transhumant animal keepers, the same arguments can be found for the sedentary livestock keepers using the extensive production system. For most of the animal keepers with some sheep, goats, or pigs, the keeping of animals is an additional income rather than the sole income source. Since livestock keeping is one of several diversification strategies to boost income, the animal keepers show limited interest in investing time to learn about other production methods, or capital to improve their production. Additionally, as is the case of transhumant livestock keepers these sedentary small livestock producers are not well integrated into decision processes and also receive limited information.

Another important argument for constant productivity in livestock husbandry is the practised land property right. The traditional pasture areas with high nutritional value, such as gallery forests and inland-valleys, are used more and

more by farmers for cropping. The transhumant animal keepers without land property rights have to shift their pasture areas to more remote and marginal areas (COMO, 1994b). NEEF (1999) classifies transhumant animal keepers, along with tenants and women, as the group of people most affected by legal uncertainty and serious limitations in land use. The aspect of land rights, under the conditions of population growth and the expansion of cropping area, represents the first critical phase in livestock management, according to BIRNER (1999). This phase is described critical, as the result of the land allocation to farmers and animal keepers determines the further development in livestock management. The non-transhumant and extensive small animal keepers have, like pastoralists, limited access to land or, if they maintain their extensive production method on a small scale, are not able to invest into land titles.
This above argument concerns just land productivity, but BIRNER (1999) clearly shows that also labour productivity has to be addressed, as, especially during crop production, labour is scarce. In certain time spans no free labour is available to care for intensive livestock keeping or additional cultivation activities for forage crops. As capital is generally lacking, the increase in land productivity through labour might not be as easy as assumed, because cultivation activities of crops and forage coincide.

Just as there are arguments for constant productivity in the coming years, there are, of course, other factors which support the increase of productivity in livestock keeping.
In regions where land reserves exist, beef production is obviously higher than in densely populated regions (see figure 5.16), as the transhumant production mode requires land reserves, such as fallow land or pasture. In the southern regions, most agricultural land is used for crop production, and little natural pasture is left for large ruminants.

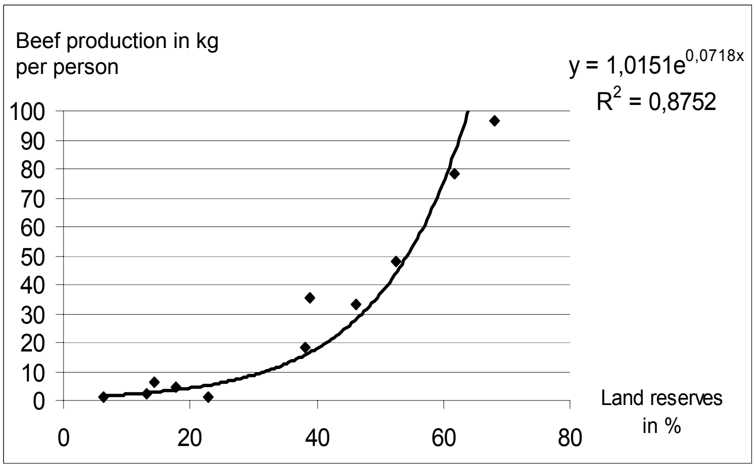


Figure 5.16: Beef production per person depending on land reserves
Source: KUHN and GRUBER, 2006

If pastoralists continue to rely on the transhumant production mode, the production of beef will inevitably go down. The reduction of available pasture might be an incentive to change the production method in order to continue large livestock keeping.

The changes in relative prices of input factors are generally a strong incentive to substitute the relatively abundant factor for the scarce factor. This argument is closely connected with the possibility of income generation for producers. Demand surplus leads to increasing prices, thus being an interesting field for production. In Benin, an increase in meat prices can be observed, which might be an incentive to intensify animal production particularly as more expensive production factors can be afforded.

Changes in infrastructure, planned for animal production as well as for an overall improvement, are assumed to produce additional changes in other areas. For example, the following tendencies were observed in some villages after constructing water basins: large herds were still on transhumance, but more animals stayed in the villages. As animal keepers with small herds tend to dismiss peregrination and intensify cropping, crop residues can be used more intensively and sometimes even forage cultivation is established (COMO, 1994b). Here the construction of water basins or, in general, the building up of an infrastructure influences production methods in the long-term.

This example underlines again that the distinction between animal keepers and farmers is not so clear-cut, that the combination of the two production systems does exist, and that further interactions are possible. The mutual takeover of production methods by animal keepers and farmers is practised for their own consumption of crops (by animal keepers) and animal products (by farmers). Once started, this interaction and integration of crop and animal production might contribute, in terms of the conservation model, to an increase of productivity.

The (traditional) cooperation between animal keepers and farmers leads in a similar direction: the division of labour permits each group to concentrate on their specific skills. For permanent cooperation, however, high trust must exist between the groups, and many details have to be arranged. As it is seen in the investigated southern area, these kinds of transaction costs are avoided by buying input factors not from farmers directly, but at the market. When organised markets, transparent structures, and capital exist, this indirect cooperation also allows specialisation and division of labour. As a consequence of lasting specialisation an intensified production can take place.

5.5 Conclusions of the chapter

This chapter has analysed current challenges in livestock management in view of the regional differences and a possible further development of the livestock sector in Benin. For the latter aspect it has been drawn on development theories, experiences in other developing countries as well as the opinion of local experts.

With respect to the regional differences it can be stated that between the south and the other two regions, central and northern Benin, not only quantitative production differences exist. The south also differs in the selection of livestock species, production systems including the use of natural resources, organisational structure, and marketing strategies. These given conditions and different regional structures of livestock husbandry complicate development strategies. It has been demonstrated that the three larger regions are inhomogeneous with regard to their present production and commercialisation problems.

Regional differences in a sector are always a challenge for politics and, in a developing country such as Benin, for the development cooperation. If differing preconditions, like resources, infrastructure, or market behaviour of producers exist in the different regions, one single strategy is not adequate or helpful. Therefore, regional approaches have to be considered and elaborated.

However, as the producer survey shows, it turns out that one problem – the adequate supply of forage – ranks first in all three regions and takes the same ranking in the expert survey. This result is startling since agricultural policy has not given high priority to this topic in current field research.

Although, the current system is able to adapt to small challenges, it becomes apparent that the existing internal difficulties are aggravated by external driving forces, which are becoming more and more significant for the sector.

The exogenous aspects of population growth, increasing income, climate change, and the expansion of cultivation areas including the increasing frequency of cultivation, influence the livestock sector by forcing modified production and marketing patterns in the long-term. Especially the expected increase in demand of around 4 percent per annum is considered to be the most important driving force in the livestock sector, just like in other developing countries. Climate change and the continuous reduction in natural pasture decrease the general availability of natural forage, the most important input factor, and the possibilities of using fallow land for grazing. The latter arguments influence particularly the area-dependent ruminants. However, the production of the monogastric livestock species is also affected as a result of higher prices of animal products due to demand surplus, the possibility to react more rapidly because of their shorter reproduction cycles, and their independency to area aspects.

It should be mentioned that the additional demand may be met by imports. Increasing imports of animal products can be observed in other developing countries and especially in West Africa (FAO, 2006a; FAO, 2006b). However, if some extra demand is to be met by domestic production, the livestock sector has to react to the changing circumstances. Several reactions to the driving forces and development paths are theoretically possible on the assumption of sustainability. Destocking, migration to regions where resources are still available, a shift in the composition of livestock species, the intensification of production as well as the cooperation between different producer groups could be the answer(s) to the changing environment.

These possibilities have been analysed with the help of selected agricultural development theories according to which there are six different sources of change which are able to explain different development paths – without political intervention, additional support, or development cooperation. There are the two geographical or technical sources of change leading to development such as the location of production (location model) and the integration of cropping and livestock management (conservation model). The other four points are geared to socio-economic sources and sectoral organisation, like population growth (theory of Boserup), shifting factor prices (induced innovation model), land rights (property rights approach), and organisation structures supporting cooperation (approach of transaction costs).

It can be presumed that one source of change alone will not lead to development, and that the answers and reactions to the driving forces will differ. The different regional starting points and the several different strategies to deal with changes in exogenous factors will lead to a more regionally diversified production structure. In the livestock sector larger differences in the range of applied methods will be found. There will be extensive as well as intensive production, as each region has its respective comparative advantage.

The experiences in other developing countries show that livestock management changes during the development process. There are shifts from ruminant to non-ruminant keeping, production is relocated from rural to urban regions, and resources become less important whereas demand gains more importance and influences production. Moreover, multi-purpose livestock keeping is given up in favour of single-purpose use combined with higher inputs. Generally, more and more animals are kept in landless systems and large ruminants are driven out when grazing areas become scarce.

This means for Benin that in regions where natural forage is free of charge, the extensive transhumant keeping of cattle based on large areas and natural resources, is retained as long as pasture and water are adequately available (COMO, 1994a). Therefore, one can presume that extensive production methods will be kept up in Benin, and that the adjustment to the growing demand by the expansion of animal numbers will be continued as long as possible. But, the hitherto freely available input factors will not be provided gratuitously in sufficient quantity in the future. Thus, the problem of a sufficient year-round forage supply will become even more crucial.

The local experts expect a strong increase in performance per animal and that more monogastric animals will contribute to meat production. Parallel to increasing performance, they predict a significant decrease in transhumance with a simultaneous increase in forage cultivation. The expected increase in performance for each productive livestock is smaller than the expected increase in demand. Although the often promoted integration of crop and livestock production is an useful approach to increasing production and maintaining environmental sustainability, these endeavours will not be sufficient to match the whole additional demand. On that account, production methods will probably change to more intensive methods, as it has been observed in cropping in recent years. In regions with a dense population where arable land for cropping has become scarce, cultivation has switched from a semi-permanent to a permanent farming system. This means that cropping intensity has been increased and fallow periods have been shortened (ABIASSI, 2002).

Beside the comparison with the development of crop production in the south, the current livestock keeping in the south may serve as example pointing the way to a possible further development of livestock management in the whole of Benin. In the south, fewer large ruminants are kept, inter alia, due to scarce land. However, the land scarcity in the south does not mean that no areas are left for grazing, but the remaining pastures are not suitable for extensive cattle keeping as these areas are scattered over the country and disconnected from one another.

This demonstrates that land use decisions are of great importance. Land use rights need not necessarily be private land titles. But also the legally laid down land use right for a group or the dedication of an area to special purposes would be helpful to maintain sustainability and to use the existing resources efficiently. The committees regulating transhumant paths and damages are already working in this direction, but they are not established in all regions and have limited influence.

The comparative advantage of the more densely populated regions can be found, inter alia, in the low transportation costs, in contrast to more remote regions. Considering the experiences in other developing countries and the statements of the local experts, it can be assumed that production is also relocated to periurban and urban areas where more non-ruminants will be kept, and that production will be intensified. Following these arguments, the number of monogastric animals, in periurban production systems as well as in general, will more and more increase. The periurban systems can, due to short transport distances, easily provide the urban markets with animal products. These markets are also the ones where the main increase in demand is assumed to take place. The periurban production in the south is supported by easy feasibility of cereal imports through ports, or by transit coming from Nigeria or Togo. But also milk production near major urban markets can become more important like in other developing countries, especially because of initiated plans for programmes supporting milk production in urban regions.

For the political decisions concerning livestock management it is to note that without political interventions the increasing demand and the simultaneous crumbling of the production basis will lead to a shortage in animal products, and thus prices will increase (without unlimited access to the world market). This might be a sufficient incentive for local producers to change their production systems. Otherwise the market will be supplied by international markets.

Therefore, the most important conclusion and strategy for policy is that the politicians will have to ascertain which goals in agricultural and in the livestock sector should be achieved. Is the constant development of the sector or the saving of local producers of animal products in Benin a matter of public concern? Or are maintaining tradition, holding up culture, and environmental sustainability the aspects to be considered first? Should the supply of sufficient and reasonably priced animal products for the consumers be guaranteed, or should poverty among agricultural producers be alleviated and the reduction of poverty among livestock keepers (which group?) be aspired?

Although the development of the livestock sector is not an useful aim in itself, one can see the livestock development “as a means to contribute to development goals of overriding importance such as economic growth, equity, poverty alleviation and environmental sustainability” (BIRNER, 1999, p.285), a means which should be made use of.

For completeness one further aspect should be addressed shortly. For countries with real or potential risks of undernourishment, land scarcity, and resource problems, the question arises if such countries would not be better off concentrating on a vegetarian diet. There may be an argument for cultivating cereals for human consumption instead of using the area for grazing or producing cereals for livestock feeding in industrialised countries, where diets are balanced and more than sufficient. In our case, however, this argument does not hold, as in Benin animal products improve diets significantly and also provide (necessary) income to rural regions.

Chapter 6

Modelling background

In this chapter, a numeric simulation model, which is based on the theoretical considerations of the development discussed in the previous chapter, is further developed to quantify the impacts of the driving forces on the livestock sector. The requirements for such a model are briefly outlined, and a review of models, related to the field of research, is given. Then the structure and the main features of the agricultural sector model BenIMPACT are provided. Subsequently, the livestock module in BenIMPACT is described in detail.

6.1 Requirements for simulating livestock husbandry

In order to develop a model reflecting the impact of socio-economic development and climate change on the livestock sector, several aspects have to be taken into account. Such a model has to include the agronomic aspects of the livestock sector, economic behaviour, climate and climate change, as well as a time perspective. Although the focus of this study is on livestock keeping, the interactions between cropping and livestock make it necessary to consider the entire agricultural sector. In particular, cropping and livestock management use the same (limited) resources for production with regard to land use and labour. Thus, the model has to reflect the agricultural sector as well as the interactions of the two main production branches to provide an alternative utilisation of land and labour between farmers and livestock keepers.

Land, or rather natural pasture, is also the point where climate and climate change come into the picture. Reflecting the analysis of the livestock sector in

Benin, the interaction between climate, particularly precipitation, and the input factor pasture for production needs to be considered. The changes of this obviously exogenous driving force lead to changes of the natural factor endowment which is the basis for ruminant production. As there are high cross price elasticities between different kinds of meat on the demand side, which means that substitution is likely to occur, the production of monogastric animals has to be included into the model as well.

Furthermore, the economic behaviour of the different actors is based on economic theory in order to provide a consistent and comprehensible analysis and interpretation of the model results. As subsistence farming is widespread in Benin, the economics of subsistence farming needs to be taken into consideration. The decision-making of subsistence farming takes place at the household level where consumption and production are interrelated. But as farmers and livestock keepers also produce for local, regional, and international markets, this production and the markets must be integrated into the model as well.

Since the model should not only reflect the status quo, the changes of the driving forces have to be included in the model. Therefore, exogenous trends of the most important driving forces are imposed on the model. The simulation of the future economic processes and resource availability are designed, as far as possible, on endogenously formulated processes.

To recapitulate, the model covers the agricultural sector, reflecting the complex interactions of bio-physical, agronomic, and economic processes over time. The following literature review compiles a few bio-economic models which consider the above mentioned aspects.

6.2 Literature review of bio-economic models in developing countries

Several quantitative models concentrating on the agricultural sector of Benin have been developed in recent years. VAN DEN AKKER (2000), SENAHOUN (2001), and ABIASSI (2002) analyse the impact of changes in socio-economic and political conditions.

VAN DEN AKKER (2000) makes projections of the impact of technical and institutional innovations in Benin's agricultural sector at the national level up to

the year 2010. The macro-economic impact of innovation on crop production is simulated with an interregional and intertemporal sector model. SENAHOUN (2001) examines the impact of the structural adjustment programmes on the development of food production, consumption, and prices, by means of an agricultural sector model for the whole country. In contrast, the agricultural household model of ABIASSI (2002) investigates the farm household behaviour in southern Benin, focusing on the impact of the FCFA devaluation in 1994.
These studies focus particularly on crop production but do not consider the impact on the livestock sector, nor do they model explicitly climatic impacts on production. Therefore, the literature review is carried out on a larger geographical scale and does not concentrate on models for Benin only, but on the thematic aspect of bio-economic livestock models for developing countries.

6.2.1 Overview of bio-economic models

In the last few decades, more and more bio-economic models have been developed and applied in agricultural economics. These models are able to convey a more realistic picture than purely economic models for agriculture, because the complex interactions of agro-ecological and socio-economic features are integrated.
KING et al. (1993, p. 389) characterise bio-economic models as models that

> [...] describe biological processes and predict the effects management decision have on those processes. Bio-economic models are used to improve understanding of complex production systems, to assess the effects of policies and new technologies, and to support farm-level decisions.

According to a definition of the FAO (1998) bio-economic models are seen as "an analytical tool to facilitate management decisions". This is done by establishing functional relationships between certain characteristics of the natural resource and the activities of the population using this resource. However, limitations and difficulties in formalising bio-economic models and interpreting the findings of the highly interdependent systems are also mentioned in the FAO statement.
Both definitions mention the function as an analytical tool for management decisions and describe the bio-economic models as an integrated model combining the two aspects of bio-physical feature and economic behaviour. As the aspect

of integration can take form in different specifications this can be called for classifying bio-economic models.
According to a classification of BROWN (2000), the categories of bio-economic models are characterised by the share of the bio-physical and economic components. He distinguishes between three large model types in the overall combinations:

1. Bio-physical process models with an economic component;
2. Integrated bio-economic models including socio-economic attributes of the economic optimisation models as well as the process simulation of the biological model; and
3. Economic optimisation models with bio-physical components.

This classification of BROWN (2000) is further used in the literature review. Two other criteria for the classification of bio-economic models are possible as well: the applied time scale or the level of aggregation used in the model. Models for one year or several years can be constructed in a comparative-static or recursive-dynamic way. For the spatial level different designs are suitable, depending on the research question: the field plot is appropriate for bio-physical processes, the household level for modelling subsistence farming, villages when the interest is focused on the commonly used resources, watersheds are appropriate in the case of water supply or water demand questions, or for the analysis of the macro-economic impact of policy decisions the administrative level is appropriate.
The economically and politically orientated models which analyse the whole agricultural sector move from the household and village level to a higher aggregated (administrative) region. On a larger scale, temporal and spatial information losses in the biological process have to be accepted in general, and in developing countries in particular, due to the heterogeneous situation and the limited number of biological studies.

Climate change and pressure on natural resources and the food supply due to population growth are important topics in bio-economic models for developing countries which are frequently simulated. Several bio-economic simulation models have been developed for the purpose of analysing tropical resource management and (subsistence) farming. This is done due to the fact that, especially in developing countries, subsistence farming is practised which is based on natural resources, since compensation strategies for missing resources are too costly to apply.

Widespread bio-economic models with emphasis on biological processes, which belong to the first group according to BROWN (2000), include, for example, EPIC (WILLIMANS, JONES and DYKE, 1987) or SAVANNA (COUGENHOUR, REID and THORNTON, 2000). Both models are applied both in industrialised and in developing countries. EPIC stands for Erosion Productivity Impact Calculator and was originally developed to assess the effect of soil erosion on soil productivity. Over the years several additional biological and some individual economic components were added. In addition to the plants, soil, weather, and nutrient cycling, animals are integrated in the SAVANNA model. The SAVANNA model was developed to model wildlife-human-livestock dynamics in conservation areas in eastern Africa and the western United States. Now it is employed in several different areas around the world.

Normally, these models concentrate on biological processes and are applied on a small scale. But in a more generalised form, some of these biologically emphasised models are also included as the biological component in the second or third classification category. BARBIER and BERGERON (2001) integrated EPIC into their recursive-dynamic bio-economic model for a microwatershed in Honduras for simulating changes of yields depending mainly on weather and soil conditions.

Bio-economic models of the second or third classification category concentrating on subsistence farming and on the consequences of population growth have, for example, been developed for an Ethiopian watershed (OKUMU et al., 2004) or for analysing land degradation, drought, and food security (HOLDEN and SHIFERAW, 2004). The latter model finds that indirect price effects due to drought on the welfare of the population are stronger than direct impacts of drought on production. A bio-economic village model for Burkina Faso drawn up by BARBIER (1998) shows that resource scarcity due to population pressure leads to an intensification of agricultural production and a higher expenditure on land conservation, but without positive effects on income.

6.2.2 Bio-economic livestock models

The literature review for livestock models is based on bio-economic agricultural simulation models where livestock husbandry is explicitly included as an activity. Geographically, the chosen models are set in developing countries, starting with farm-household models at the village and local level and leading up to models at the national and international level. Special emphasis is given to models containing the following three aspects: the impact of population growth, the interrelation of crop and livestock activities in extensive production systems competing for the same resources, and effects of climate change on livestock husbandry.

Farm-household models, also known as agricultural household models, are a widely used method for simulating economic behaviour in subsistence farming. Farm-household models are applied frequently to analyse a large variation of topics and aspects within agriculture in developing countries. The main characteristic of a farm-household model is that production and consumption decisions are made simultaneously. Production and consumption decisions are often non-separable in farm-households due to market imperfections, and due to the fact that the household is responsible for both areas (BARDHAN and UDRY, 1999). The following five farm-household models show in an exemplary fashion how livestock management and resource use can be modelled at the local level. The review of household models starts with a more biologically orientated model, goes on to primarily economic models, and ends with a bio-economic model where a policy intervention is integrated.

The first model discussed is an agro-pastoral household model referred to as PHEWS (Pastoral Household and Economic Welfare Simulator) of THORNTON, GALVIN and BOONE (2003) conceived for East Africa. According to the bio-economic model classification of BROWN (2000), the model belongs to the group of the bio-physical process models with an economic component, since the main component of the spatial and dynamic model is built on SAVANNA. PHEWS simulates the interaction of productive livestock, wildlife, increasing population, and growth in agriculture.

In PHEWS it is assumed that a household wants to achieve different goals. The different objectives have a hierarchical order. First, food security has to be ensured, then an apriori defined number of TLU per person is targeted, and third, additional consumption is possible if sufficient cash is available. These rules represent the management decisions that are made to reach the target TLU per person. The decision as to whether livestock is traded or not is modelled by a matrix which is defined with the help of two indices. This matrix specifies trading activities depending on the value of the two indices. These two indices are built of the actual TLU divided by the target TLU or rather actual income divided to the target income.

The model is calibrated for the Ngorongora Conservation Area in northern Tanzania. The monthly iterations update several aspects such as calorie requirements, pastoralists' welfare as well as herd sizes of the households. The activity levels in livestock management are calculated with SAVANNA and corrected with the aid of the indices. For the impact analysis of population growth, two scenarios are defined at 3 percent and 6 percent growth per year for a time horizon of 15 years. The outcome of the model indicates that all households rely on additional calories from the market. Even if just a small agricultural area is permitted in the Conservation Area, the pastoralists' welfare is not sustainable. With ongoing population growth, the number of animals is reduced due to limited resources. As a consequence, the poverty of the poor households increases.

The bio-economic household model of ARAYA (2005) is a more economically orientated model. The linear programming model has been designed for the Central Highlands of Eritrea. In this dynamic household model, the year is divided into 18 periods. The agriculturally productive time between June and November is divided into two-week steps; the other months are modelled in monthly steps.

The objective function maximises the net benefits of farming and other activities of the household. At the same time, the constraints on the resources of land and labour, as well as on the budget, the minimum food requirements for human beings, and forage for livestock have to be fulfilled.

Income can be generated by cropping, livestock husbandry, tree planting, and off-farm employment. Since the quantities produced or rather required by the

households do not influence the markets, the prices of agricultural products as well as non-farm products are exogenously determined and fixed. However, there is a differentiation between the buying and selling prices of agricultural products, as subsistence farmers often sell their products after harvests when prices are low, and then have to buy food when prices are high.
The bio-physical components considered in the model are soil erosion, nitrogen balances, and vegetation cover. Crop production depends on the size of the area cultivated, the yield, which in turn depends on soil types, the quantity of fertiliser used, and the applied conservation methods. Livestock is represented in the model by the species of oxen, cows, donkeys, and small ruminants. The number of livestock grows at an exogenous annual rate determined by the birth and mortality rates of livestock. The minimum number of livestock is defined by the requirements of oxen and donkeys for ploughing and transportation. The maximum number of livestock is determined by the availability of forage.

The next model presented is a bio-economic model for Burkina Faso, constructed also as a linear programming model (BARBIER, 1996). The model analyses the effect of population and market pressure on the welfare of the village. The recursive-dynamic model is calibrated for two villages and simulates the development until the year 2030. The objective function maximises farmers' net income under the consideration of several constraints such as risk aversion, food consumption, land area, soil fertility, labour, and cash availability.
The yield functions of the crops of cotton, maize, sorghum, and irrigated rice are provided by EPIC. For livestock husbandry, transhumant cattle, intensively kept cattle, oxen, and donkeys are integrated into the model. Input factors in livestock keeping are labour, veterinary care, and forage. Forage is composed of cuts from trees, crop residues, fallow and grazing areas, and cultivated forage. The main exogenously determined factors in the model are population growth, the market demand for surplus food, and prices of inputs and outputs.
The model projects that, in the long-term, the transhumant cattle will be reduced and replaced by farm livestock. The pressure on livestock management, caused by population growth, leads to an intensification of the livestock production system in the form of fences, forage cultivation, and shifts in property rights. Moreover, better access to markets, improvements in infrastructure as well as

political interventions give rise to intensification. However, the model also reveals that the intensive production will not be entailed by higher income. Additionally, with respect to the returns on labour, the extensive production method achieves higher returns than the intensive one.

The bio-economic model of BARBIER and HAZELL (2000) concentrates on modelling the interactions of farmers and transhumant animal keepers at the village level. The model is designed for a village typical of the Sahelian region in Niger. In this model again, population growth and greater commercialisation in agriculture are crucial determinants, which shape farming and livestock keeping. For simulating long-term interactions, a dynamical and discrete stochastic programming model has been chosen. Special emphasis has been placed on the specification of drought risks. Concerning their decision making, farmers and livestock keepers are graded as risk-averse actors. The majority of the decisions have to be taken at the beginning of rainy seasons. However, some decisions, especially those dealing with buying or selling livestock, can be made throughout the whole year. The model splits each year into three periods: the rainy season, the harvest season, and the dry season. Each planning horizon covers four years, and finally the model is run for 100 years. The objective function of the model maximises the aggregated welfare of the community. Inter alia, population growth, livestock growth potential as well as prices are set in advance, whereas livestock and farming activities are endogenous to the model. Droughts are introduced by exogenously reduced crop yields, reduced livestock prices, and increased millet prices.
The model shows that transhumant livestock husbandry makes a crucial contribution to the preservation of livestock herds, especially in drought years. The use of cultivated forage could drastically increase the herd sizes and reduce the need for transhumance. Although transhumance is an important strategy to handle risk, its contribution to income is modest.

A bio-economic household model for southern Mali has been constructed by DALTON and MASTERS (1998). The model simulates changes of crop-livestock management for a time horizon of 15 years. This model explicitly takes into consideration a political intervention to induce changes of production methods. The intervention introduced into the model is a pasture tax, the impact of which is identified.

The objective function maximises the discounted utility of the household subject to several constraints such as land, labour, and capital. The costs of livestock keeping are composed of veterinary care, feeding, and pasture tax. There are three production methods in livestock husbandry introduced into the model: extensive grazing on common land and using crop residues after harvest, the slightly more intensive method of tying up the animals during the night and collecting some of the manure, and the third method is to put livestock into so-called parcs améliorés. The last method provides more manure but also requires more labour and capital.

The model determines the minimally needed pasture tax, about 3 US Dollar per TLU and year, to induce the more intensive production method of the parc amélioré. At this price, the costs of reducing livestock on common grazing areas are lower than the social gains from reduced grazing pressure. Moreover, the model shows that as long as common pasture is available without tax, the intensive production method will not be applied. This results from the high investment costs despite the increase in gross farm income.

The above presented models concentrating on livestock are just a small selection of farm household models in developing countries, since the number of models constructed for this level is constantly growing. At the next higher aggregated level, the agricultural sector, models including the livestock sector are rare for developing countries. Probably due to data being unavailable, these partial equilibrium models are seldom designed. Notwithstanding, two agricultural sector models including livestock management – one for Mali and another for Burkina Faso – are presented.

The Mali Agricultural Sector Model (MASM) is a bio-economic multi-market model including risk behaviour (BUTT, 2002). The model analyses the impact of population growth, climate change, and technological change until 2015. The mathematical programming model simulates the market equilibrium for seven crops (maize, rice, cotton, groundnuts, millet, sorghum, and cowpeas), three livestock species (cattle, sheep, and goats) and five processed products. The objective function maximises agricultural welfare, assuming that producers maximise profits and consumers utility. The model comprises seven supply regions and eight demand regions, since the major city has been declared to be a demand region only. Risk is considered in terms of yield uncertainty, food insecurity, aversion to revenue variations, and social and institutional sources of risk. The implications of climate change on crop yields are calculated with EPIC. For the climatic consequences for grazing areas the Phytomous Plant Growth model (PHYGROW), and for the daily feed requirements the Nutrition Balance model (NUTBAL) is used. The model is calibrated against prices, crop choice date, and demand and supply conditions in 1996. The overall constraints are the input factors of land and labour, which are required for crop production and livestock husbandry. The MASM indicates that the impact of climate change has a strong negative effect on economic welfare. This negative effect could be reduced by developing heat-resistant varieties, changes of crop patterns, and changes of trade.

The second relevant partial equilibrium model was developed for Burkina Faso (WEISSLEDER, 1998). The Yatenga-model explores the impact of exogenous factors on the cereal and livestock markets in the Yatenga region and rebuilds the interactions of the cereal-livestock and finance market. The normative optimisation model maximises in its objective function the net welfare of all market participants. The model contains millet and the three livestock species of cattle, sheep, and goats. Each livestock species is represented in three subgroups. The Yatenga-model is a spatial and regional model, where trade and storage are allowed. The model is conceived for one year, with 12 periods pursuant to the months. For the flow of goods, two supply regions, one trade sector, and three demand regions are constructed. For the flow of funds just the Yatenga region, where supply and demand are modelled, is defined. The budget restriction guarantees that the flow of all goods is monetarily feasible. Climate change, such as droughts, are introduced into the model as exogenous factors. One climatic scenario simulating such a drought reveals that producers benefit from high prices due to reduced supply, though consumers are afflicted with high prices of cereals.

As the aggregation level increases, the production processes are more and more simplified, which can be seen, for example, in the FAO World Food Model, which simulates on a global scale. In this model the contribution of natural resources to feeding is neglected as well as the land requirements for fodder cultivation (BOUWMAN, 1997). Today, establishing large and detailed models is hampered by difficulties which lie less in a lack of technical possibilities, but rather in the complications of collecting and building up a consistent and reliable data set for all countries included.

Thus, research in developing countries has mainly focused either on the village level, where subsistence farming is practicable and micro data are available, or on the (inter-)national level concentrating on trade, financial flows, or influence of taxes on an aggregated level.

However, some attempts were made to combine these two modelling levels. This results from the importance of subsistence behaviour in developing countries and the influence of the markets and politics on the subsistence production. Such a model combing micro and macro levels, for example, was developed by LÖFGREN and ROBINSON (1999). They constructed a non-separable micro household model which they coupled with a CGE model (Computational General Equilibrium Model). The model shows that small-farm households respond discontinuously to price changes. In a certain range of price changes, production is kept constant and only the amount of sold labour varies. However, at a certain price threshold, production patterns are changed and the farm household shifts production towards the high-value crop.

6.3 BenIMPACT and the components of the livestock module

The name of the modelling system BenIMPACT, which has been further developed in this study, stands for Benin Integrated Modelling System for Policy Analysis, Climate and Technology Change. The name indicates very concisely the main aims of this tool.
In the following chapter the model is first described in an overview. Then a closer look at the economic modelling of the livestock management is taken. Subsequently, the presentation of the bio-physical component of the livestock module is provided.
The main abbreviations in the model are introduced and named in the following chapter in *italic* letters. Variables calculated within the model are written in CAPITAL letters, whereas parameters and indices are printed in small letters. A complete list of the abbreviations in the mathematical formulations and the full model documentation are included in the appendix.

6.3.1 BenIMPACT at a glance

BenIMPACT is a bio-economic agricultural sector model analysing the economic interrelation of the agricultural production in respect to supply, demand, prices, factor input, and income, and considering also the regional endowment of natural resources. The focus of the quantitative model is on the economic aspect. But as bio-physical aspects strongly influence agricultural production, especially in a low-input country like Benin, BenIMPACT also has a bio-physical component.
In the coming years, Benin will face some ongoing fundamental developments, particularly in demography and economy. Additionally, climate change will have relevant impacts on the agricultural sector. The consequences and the repercussion on agriculture are analysed with BenIMPACT.

The agricultural model is a partial equilibrium model for the regions of Benin. Altogether, the model covers 17 regions *r,s*: the twelve administrative departments in Benin *rdom*, the neighbouring countries *rnc* (Nigeria, Niger, Burkina Faso, and Togo), and a constructed country *row* called “Rest of the World”, representing the world market. The decision-making for agricultural production orients itself by the farm-household level, which means that production and rural food consumption decisions are made simultaneously. Therefore agricultural production influences agricultural income, which, in turn, determines rural consumption, as figure 6.1 illustrates. This idea reflects the principal decision process in subsistence farming.

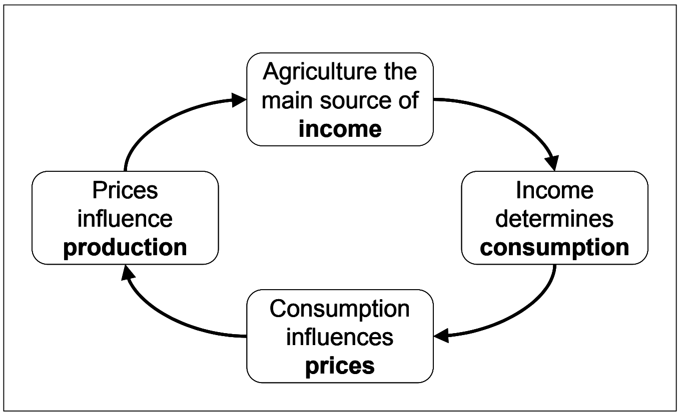


Figure 6.1: Decision processes in BenIMPACT
Source: GRUBER, JANNSON, and KUHN, 2006

Each of the twelve departments – Atacora, Alibori, Borgou, Donga, Collines, Zou, Couffo, Mono, Plateau, Ouémé, Atlantique, and Littoral – stands for a representative agricultural household in the specific region. Consequently, each department represents consumption of all households and agricultural production as well as the trade patterns of the farm households in the region.

The agricultural activities *j* are composed of cropping and livestock activities. In cropping *jc* the production of cotton, maize, yam, cassava, sorghum and millet, groundnuts, pulses, and rice is considered. In livestock husbandry *jl* the keeping of cattle, sheep, goats, pigs, and chickens is simulated. The crops include several varieties, for example, local maize and maize ameliorė, or early and late season, according to seedtime. The model commodities *i* relating to livestock husbandry are beef, mutton, goat meat, pork, and chicken meat.

Each simulation year *sim* is divided into four periods *t* in order to capture the differences between rainy and dry seasons as well as multiple harvests per year for some crops.

Storage of food is possible as well as trade. As not all products are traded on the world market, trade is not allowed for all products in all regions. The inclusion of explicit trade and storage implies that regional and seasonal prices differ by price spans which induces that trade takes place. The different price spans are also the basis for the simulation of agricultural imports and exports.

Crop supply is modelled by regional aggregate farm models with a calibrated quadratic profit function. Costs of commodity supply comprise costs of input use in cropping, transportation costs, storage costs, as well as costs of labour and shadow prices of land, once available land is used up. The supply of extensively kept livestock is determined by prices, non-economic reasons (birth and mortality rates), and the restricting resource availability.

Food demand is determined by commodity prices and household income, which is, in turn, generated by agricultural activities to a major part, depending on the income structure of the population in a particular region. Commodity demand is algebraically represented by a Generalised Leontief expenditure system (DIEWERT and WALES, 1987; RYAN and WALES, 1996) with time separability. The latter means that products consumed in different time periods are considered as different goods with no cross price effects except over income.

The base year *bas* in BenIMPACT is the average of the years 2001 and 2002. The scenarios are calculated in a recursive-dynamic fashion in five-year steps until 2025. Between these five-year-steps the driving factors are shifted according to the expected trends. The exogenous driving forces are climate (change), population development, and increasing non-agricultural income.

The (economic) interrelations of the different aspects and the influence of the driving forces are shown in figure 6.2. The grey aspects are the exogenous driving forces, while the black aspects are endogenously calculated in the model. A plus sign [+] indicates that a change in the first variable induces a change in the same direction for the second variable. A negative sign [-] means that the change in the second variable goes in the opposite direction. The positive sign, for example, between population and labour pool means that an increase in population give rise to an increase in available labour.

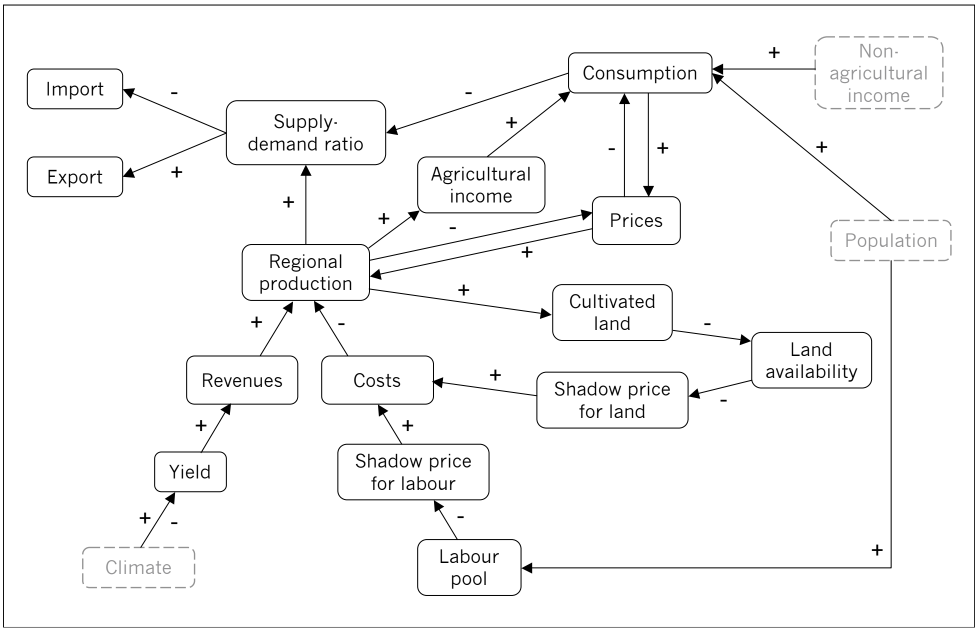


Figure 6.2: Flow diagram of BenIMPACT
Source: Author's illustration, 2007

The scenarios are to be understood as possible realistic developments and not as the exact projection of the future. The three scenarios evaluated in this work are: the business as usual scenario (BAU) with ongoing current trends, the innovation scenario including semi-intensive livestock keeping (INO), and third, the conservation scenario (COS).

BenIMPACT is programmed in the modelling language GAMS (General Algebraic Modeling System) and is solved by PATH 4.6.07. The model is built of several files which are presented in figure 6.3. There are three main file characteristics: data, storage places where the raw data or the simulated data are stored and provided for the next modelling step, and the simulation modules containing the calculations. The first module "MODCOM" collects raw data and calculates the required data with estimation methods and heuristic calculation methods. The results of the module "CROPWAT" where the availability of natural biomass is simulated enter "MODCOM" as base data. As far as possible all data are transformed to the departmental level and stored in the data file "PARBAL" and "PARCOM".

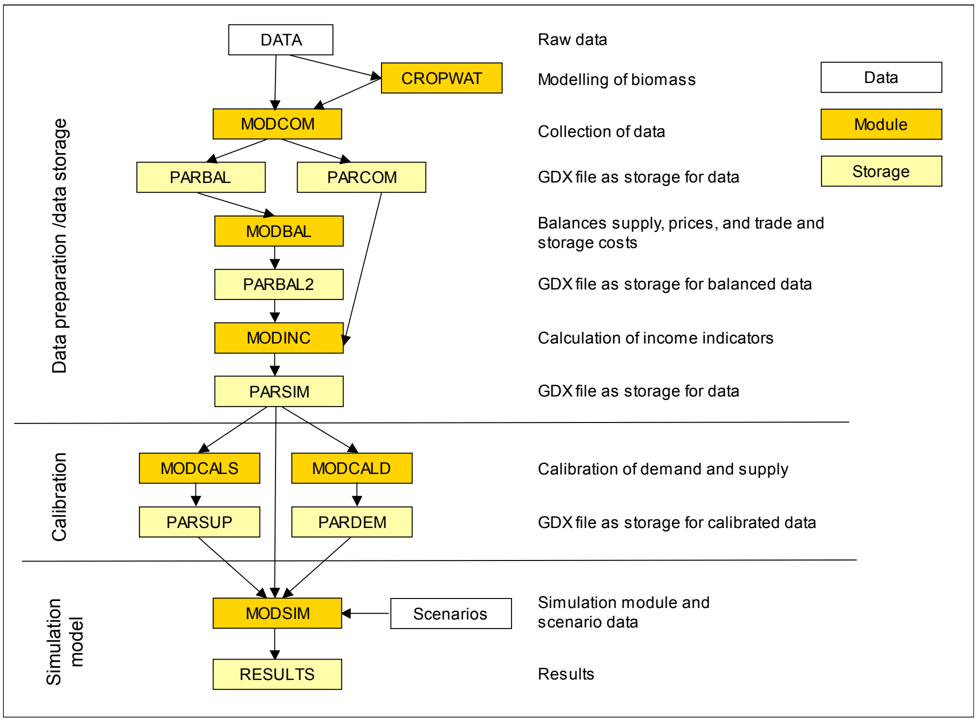


Figure 6.3: Construction of BenIMPACT
Source: Author's illustration, 2006

These data of “PARBAL” enter “MODBAL”, where supply, prices, and trade and storage costs are balanced. The trade and storage costs are estimated by minimising deviations from an assumed trade cost function and of prices from observed prices, taking into account the market balance and arbitrage conditions (JANSSON, 2005a).
Then some income indicators are calculated in “MODINC” before the quadratic supply function for crops is calibrated. The calibration is accomplished by minimising the squared deviation of estimated elasticities of supply from given own-price elasticities and squared deviation of total land use elasticity from a given amount (JANSSON, 2005b). For the supply function of livestock an explicit calibration is not needed, because of the specific assumptions of the supply function (see chapter 6.3.2) and the non-binding restrictions in the base year. The demand system is calibrated at base year demand and prices to represent, as closely as possible, demand elasticities derived from regional studies and the FAO World Model.

The calibrated data enter into the simulation module “MODSIM”, into which the assumptions for the scenarios also flow. The data and trends until the year 2025 for the three scenario simulations are stored in the scenario data file and enter directly the simulation module. The simulation model is designed as a mixed complementary problem (MCP) where the equations can be a mixture of inequalities and strict equalities. The formulation of the equations does not contain an explicit objective function, but the system of equations is solved simultaneously (RUTHERFORD, 1995).

6.3.2 The economic modelling related to livestock management

The description of the livestock module is based on the model construction of the business as usual scenario. Further (mathematical) extensions which are necessary in the two other scenario simulations, are described in the respective scenario assumptions. Moreover, the numerical choice of the parameters is described in the respective scenarios.

Furthermore, the description zooms in on the newly emerged livestock module and those equations which are used for both crop and livestock activities. Thus, some of the presented equations are valid for livestock management as well as for cropping. In the course of constructing the livestock module attention has been paid to designing the new module closely to the existing one. This was done in order to include the interactions of the two sectors, as both resort to the same main production factors, labour and land.

The model description starts with the general spatial and temporal equilibrium conditions. Then the production processes, the use of input factors for production, and the output are presented before the modelling of income and demand is described. In order to keep the model description concise, the index *sim* is only written down in equations where it is explicitly needed.

Spatial and temporal market equilibrium

The sectoral market equilibrium is simulated subject to three conditions. The first one is the zero profit condition for traders, meaning that the supply price *VPRIS* [in 1,000 FCFA per ton] in region *r* plus the transportation costs *tc* [in 1,000 FCFA per ton] must be greater than or equal to the supply price in region *s* for trading

$$\mathsf{VPRIS}_{r,i,t} + \mathsf{tc}_{r,s,pgrp} \geq \mathsf{VPRIS}_{s,i,t} \quad . \tag{6.1}$$

The second condition is the zero profit condition for storage being the temporal equivalent to the spatial condition in equation 6.1 above. In the storage equation it is guaranteed that the supply prices in a period *t* plus the storage costs *sc* [in 1,000 FCFA per ton] for the period *t* must be greater than or equal to the supply prices in period *t+1*

$$\mathsf{VPRIS}_{r,i,t} + \mathsf{sc}_{r,pgrp} \geq \mathsf{VPRIS}_{r,i,t+1} \quad . \tag{6.2}$$

Otherwise the temporal equilibrium has not been reached. The third condition is the market clearing condition for all agricultural markets in the model except the world market, where all quantities are given in 1,000 tons. The market production *VMAPR* plus the released storage quantities *VSTIN* minus transported quantities *VTRAN* from region *r* to *s*, has to equal the consumed quantities *VHCON* plus the processed products *VPROC* (only for cotton products) minus the transported quantities *VTRAN* from region *s* to *r*

$$\begin{aligned} &\mathsf{VMAPR}_{r,i,t} + \left(\sum_{t+1} \mathsf{VSTIN}_{r,i,t+1} - \mathsf{VSTIN}_{r,i,t} \right) - \sum_{T} \mathsf{VTRAN}_{r,s,i,t} \\ &= \mathsf{VHCON}_{r,i,t} + \mathsf{VPROC}_{r,i,t} - \sum_{T} \mathsf{VTRAN}_{s,r,i,t} \quad . \end{aligned} \tag{6.3}$$

The variable *VTRAN* includes local trade within Benin, regional trade between Benin and the neighbouring countries as well as trade between Benin and the “Rest of the World”.

Production input

As seen in the previous chapters, the livestock production in Benin is characterised by extensive production methods which is why only a few input factors come into operation. The major input factors – land including forage availability, labour, and water – are implemented into the model.

The input factor land for grazing of ruminants including fodder availability is restricting the extensive ruminant keeping in two ways. Firstly, it is assumed that farmers have the right to claim and cultivate land. The usable agricultural area *landbound* [in 1,000 ha] has to be greater than or equal to the cultivated land. The cultivated land is calculated by the activity level of cropping *VLEVL* [in 1,000 ha] multiplied by the respective temporal land requirements per activity *plevf* [in percent]

$$\mathrm{landbound}_r \geq \sum_{jc} \mathrm{VLEVL}_{r,jc} \cdot \mathrm{plevf}_{r,jc,t} \quad . \tag{6.4}$$

This reflects the situation in Benin that the extensive livestock keepers do not possess land titles and may only use the remaining land for their livestock husbandry.

The second restriction emerging from land aspects is the fodder restriction for ruminants *jrum*. The sum of the available fodder resources in each region has to be greater than or equal to the feed requirements of ruminants. Forage which can be fed to ruminants is composed of pasture on the remaining land and of fodder from forests (first summand) as well as of crop residues left on the cultivated land (second summand)

$$\begin{aligned} &\mathrm{yield}_{r,bio,sim,t} \cdot \left(\left(\mathrm{landbound}_r - \sum_{jc} \mathrm{VLEVL}_{r,jc} \cdot \mathrm{plevf}_{jc,t} \right) + \mathrm{pfore}_r \right) \\ &+ \mathrm{VLEVL}_{r,jc} \cdot \mathrm{pcres}_{r,jc,t} \\ &\geq \sum_{jrum} \mathrm{VLEVL}_{r,jrum} \cdot \mathrm{pfodi}_{jrum,t} \quad . \end{aligned} \tag{6.5}$$

The calculation of the available yield of pasture and forest *yield* [in tons] is presented in the bio-physical component of the livestock module in chapter 6.3.3. The available biomass of pasture is calculated by multiplying the yield of pasture by the area of pasture and savannah [in 1,000 ha]. The available biomass

of forests is obtained by multiplying the yield of forests by the regional forest area *pfore* [in 1,000 ha]. The quantity of crop residues amount of the product of cultivated area and the useable crop residues *pcres* [in tons per 1 ha crop]. The feed requirements of ruminants is calculated by multiplying the regional activity level of ruminants by the feed requirements per animal and period *t*. In the extensive housing system, which is assumed for the BAU scenario, the monogastric animals *jmon* are fed with household garbage and do not demand extra forage or land.
As deforestation is currently a crucial factor in land use, the regional forest area *pfore* [in 1,000 ha] is updated in each simulation step. The adjusted regional forest area depends on the ratio of forest area to regional land, on the regional population pressure *poppres* which is definded as the regional growth rate of total population *ppopt* between two simulations $\mathsf{poppres} = \mathsf{ppopt}_{\mathsf{sim}}/\mathsf{ppopt}_{\mathsf{sim}-1}$, and it depends on a constant K.

$$\mathsf{pfore}_{\mathsf{r,sim}+1} = \mathsf{pfore}_{\mathsf{r,sim}} \cdot \left(1 - \frac{\mathsf{pfore}_{\mathsf{r,sim}}}{\mathsf{landbound}_{\mathsf{r}}} \cdot \mathsf{poppres}_{\mathsf{r,sim}} \cdot \mathsf{K}\right) \quad . \tag{6.6}$$

The constant K is calculated for each simulation step and guarantees that the sum of the regional deforested areas meet the overall deforestation in Benin quantified by the overall yearly deforestation rate *pdefo* [in percent]

$$\mathsf{K} = \frac{\sum\limits_{\mathsf{r}} \left(\mathsf{pfore}_{\mathsf{r,sim}} \cdot \left((1+\mathsf{pdefo})^5 - 1\right)\right)}{\sum\limits_{\mathsf{r}} \left(\mathsf{pfore}_{\mathsf{r,sim}} \cdot \frac{\mathsf{pfore}_{\mathsf{r,sim}}}{\mathsf{landbound}_{\mathsf{r}}} \cdot \mathsf{poppres}_{\mathsf{r,sim}}\right)} \quad . \tag{6.7}$$

Despite low input into livestock production, some labour input is needed for the monogastric animals as well as for the ruminants. All labour is given in million hours. The overall labour on-hand at farm households *plabi* consists of family labour used in agriculture *VLABF*, labour sold *VLABS*, and the “consumption of leisure” $\mathit{VHCON}_{'\mathsf{leis}'}$

$$\mathsf{plabi}_{\mathsf{r,t}} \geq \mathsf{VLABF}_{\mathsf{r,t}} + \mathsf{VLABS}_{\mathsf{r,t}} + \mathsf{VHCON}_{\mathsf{r,'leis',t}} \quad . \tag{6.8}$$

The amount of family labour is defined as the total required labour for agriculture *VLABT* minus the additionally hired labour *VLABH* applied in agricultural production

$$\mathsf{VLABF}_{r,t} = \mathsf{VLABT}_{r,t} - \mathsf{VLABH}_{r,t} \quad . \tag{6.9}$$

The restriction of available labour in equation 6.8 specifies the shadow price of labour *VSPLB* [in FCFA per hour], which is used to distinguish between *VLABS* and *VLABH*. As the change between selling or buying labour does not occur at a specific wage rate, a corridor of response has been established.

The water requirements are calculated, because the use of this input factor for livestock is competing with requirements of human beings. The equation 6.10 for the total water requirements *VAWAT* [in 1,000 tons], depending on region, temperature *ptems*, and the modelled activity levels, is written within the modelling notation

$$\begin{aligned} \mathsf{VAWAT}_{r,sim,t} = & \sum_{jrum} \mathsf{VLEVL}_{r,jrum} \cdot \mathsf{pawat}_{r,jrum,t} \cdot \left(4.303 + 0.0906\, e^{0.115 \cdot \mathsf{ptems}_{r,sim,t}}\right) \\ & + \mathsf{VLEVL}_{r,jcatt} \cdot 0.03 \cdot \mathsf{pyiel}_{r,milk,t} \\ & + \sum_{jmon} \mathsf{VLEVL}_{r,jmon} \cdot \mathsf{pawat}_{r,jmon,t} \quad , \end{aligned} \tag{6.10}$$

where *pawat* is the water requirement per animal [in tons] and *pyiel* is the milk performance [in tons]. Depending on regions, seasons, and climatic development, the requirements of water for livestock might lead to different degrees of competition.

Production output

The scale of the accomplished activities is determined for cropping by profit maximisation and for the extensive livestock sector by an iso-elastic supply function with low supply elasticity *pasel* and by exogenous growth factors. The growth rates of ruminants are corrected by the fodder restriction.
The number of animals are shifted by the factor *pagro* [in percent] according to the regional development of the population for non-ruminants and according to the rates of birth and mortality for ruminants. The relative change of the number of animals *VPRES* [in percent] due to price changes is defined as

$$\mathrm{VPRES}_{r,jl,t} = \left(\frac{\mathrm{VPRIS}_{r,i,t}}{\mathrm{ppris}_{r,i,t}}\right)^{\mathrm{pasel}_{r,jl}} \Big|_{j \rightarrow j(i)} \quad , \tag{6.11}$$

with given supply elasticities.
On these assumptions the activity level of livestock *VLEVL* is calculated by the supply function, which represents the behaviour of the producers

$$\begin{aligned}\mathrm{VLEVL}_{r,jl,sim} = \; & \left(\frac{\sum_t \mathrm{VPRES}_{r,jl,t}}{4}\right) \cdot \mathrm{pagro}_{jl} \cdot \\ & \left(\mathrm{VLEVL}_{r,jrum,sim-1} \cdot (1 - \mathrm{VMRED}_r) + \mathrm{VLEVL}_{r,jmon,sim-1}\right) \quad .\end{aligned} \tag{6.12}$$

The activity level of livestock is regionally corrected for ruminants by the fodder restriction (equation 6.5) with the help of *VMRED* [in percent]. If the fodder availability is regionally insufficient and cannot be fulfilled in a model period *t*, regional and seasonal reduction coefficients *VRRED* [in percent] are calculated, which reduce the number of ruminants to an amount where the fodder restrictions can be fulfilled. It is not reasonable, though, to reduce animal numbers in several consecutive periods *t* within one year, as the reproductive cycles, particularly of cattle, last several periods.

Hence, the largest reduction coefficient of one simulation year is taken to determine the reduction of ruminants in the respective year. As the formulation of the model as a mixed complementary problem does not allow the employment of the maximum function (among several arguments), the maximum norm is applied. The equation

$$\mathrm{VMRED}_r \geq \left(\sum_t \left(\mathrm{VRRED}^a_{r,t}\right)\right)^{\frac{1}{a}} \tag{6.13}$$

determines the approximated highest value *VMRED* of the four possible reduction coefficients *VRRED*. The determined maximal reduction coefficient reduces the number of ruminants to the level where fodder is sufficient. The coefficient *a* is set equal to eight due to numeric reasons.

The activity levels of cropping, which influence the available area left for grazing, are determined in equation 6.14 which is the first order condition of the corresponding quadratic profit maximisation problem solved for the activity levels

$$\begin{aligned}\mathrm{VLEVL}_{r,jc} = \quad (\mathrm{VGREV}_{r,jc} \quad & -\sum_{i,t} \mathrm{pinpu}_{r,i,j,t} \cdot \mathrm{VPRIS}_{r,i,t} \\ & -\sum_{t} \mathrm{plaba}_{r,jc,t} \cdot \mathrm{VSPLB}_{r,t} \\ & -\sum_{t} \mathrm{plevf}_{r,jc,t} \cdot \mathrm{VSPLD}_{r,t} \\ & -\mathrm{pmpa}_{r,jc}) \cdot \frac{1}{\mathrm{pmpb}_{r,jc}} \quad .\end{aligned} \tag{6.14}$$

The equation contains gross revenues *VGREV* [in 1,000 FCFA], costs for inputs, costs for resources such as labour (second subtrahend) and land (third subtrahend) and the coefficients *pmpa* and *pmpb* of the Positiv Mathematical Programming (PMP). The second subtrahend is composed of the labour used per activity *plaba* [in 1,000 hours per activity] and the shadow price of labour *VSPLB* [in FCFA per hour]. The third subtrahend is built of the area requirements per activity and period *plevf* [in percent] and the shadow price of land *VSPLD* [in 1,000 FCFA per ha].

The net yield in livestock management is an exogenously determined parameter *pyiel* [in tons] from literature, as in the last few decades no increase in performance per animal on average has taken place. Consequently, the gross production *VPROD* [in 1,000 tons] on the regional model farm is then

$$\mathrm{VPROD}_{r,i,t} = \quad \mathrm{VLEVL}_{r,j} \cdot \mathrm{pyiel}_{r,i,j,t} \mid_{j \to j(i)} \quad . \tag{6.15}$$

The production entering the market *VMAPR* [in 1,000 tons] for Benin equals the net production or use on farm considering a loss factor *plosf* [in percent]. For neighbouring countries, marketable production is determined by a linear supply function with the intercept *qpia* and the slope *qpib*

$$\mathrm{VMAPR}_{r,i,t} = \begin{cases} \mathrm{VPROD}_{r,i,t} \cdot \mathrm{plosf}_{r,i,t} & \text{if } r \in \mathrm{rdom} \\ \left(\mathrm{VPRIS}_{r,i,t} - \mathrm{qpia}_{r,i,t}\right) / \mathrm{qpib}_{r,i,t} & \text{if } r \in \mathrm{rnc} \quad . \end{cases} \tag{6.16}$$

Gross revenue and income

The gross revenues *VGREV* [in 1,000 FCFA] earned in agricultural production are determined by the supply prices and by the yields *VYIEL* [in tons] in agricultural production

$$\mathrm{VGREV}_{r,j} = \sum_{i,t} \mathrm{VYIEL}_{r,i,j,t} \cdot \mathrm{VPRIS}_{r,i,t} \cdot \mathrm{plosf}_{r,i,t} \quad . \tag{6.17}$$

The total income per capita *VINCC* [in 1,000 FCFA per capita] is composed of the agricultural income *VINCN* [in 1,000 FCFA] and the income coming from off-farm activities *VINCR* [in 1,000 FCFA] multiplied by share of rural population *ppopr* [in percent] and the population in the simulation region *ppopt* [in 1,000 persons]

$$\mathrm{VINCC}_r = \left(\mathrm{VINCN}_r + \mathrm{VINCR}_r\right) / \left(\mathrm{ppopr}_r \cdot \mathrm{ppopt}_r\right) \quad . \tag{6.18}$$

The agricultural income *VINCN* is formed by the production entering the market minus the costs of hired labour. As production costs have not been accounted for so far, it is assumed that only fifty percent of this surplus are available as income to rural households

$$\mathrm{VINCN}_r = 0.5 \cdot \left(\sum_{i,t} \mathrm{VMAPR}_{r,i,t} \cdot \mathrm{VPRIS}_{r,i,t} - \sum_{t} \mathrm{VLABH}_{r,t} \cdot \mathrm{VSPLB}_{r,t} \right) \quad . \tag{6.19}$$

The income from off-farm activities *VINCR* [in 1,000 FCFA] is generated by the amount of sold labour *VLABS* multiplied by the shadow price of labour *VSPLB*. The second summand *pincp* [in 1,000 FCFA] includes residual income of other income sources

$$\mathrm{VINCR_r} = \sum_{t} (\mathrm{VLABS_{r,t}} \cdot \mathrm{VSPLB_{r,t}}) + \mathrm{pincp_{r,t}} \quad . \tag{6.20}$$

Demand and consumption

The income and the prices of the activities on the supply side influence the demand side. The rural demand prices *VPRID* [in 1,000 FCFA per ton] for agricultural products equal the supply prices

$$\mathrm{VPRID_{r,i,t}} = \begin{cases} \mathrm{VPRIS_{r,i,t}} & \text{if } i \text{ is a consumer good} \\ \mathrm{VSPLB_{r,t}} & \text{if } i \text{ is leisure} \quad . \end{cases} \tag{6.21}$$

The price for leisure is given with the shadow price of labour *VSPLB* [in FCFA per hour] as the time spent for leisure corresponds to a renouncement of income.

The rural consumers are assumed to maximise their utility depending on consumer prices *VPRID*, total income *VINCC*, and income of leisure *VINCL* [in 1,000 FCFA per capita]. The consumption per capita *VHCPR* [in kg per capita] is defined as

$$\begin{aligned} \mathrm{VHCPR_{r,i,t}} = \; & \frac{\beta \cdot \sqrt{\frac{\mathrm{VPRID_{r,i,t}}}{\mathrm{VPRID_{r,i,t,}}}}}{\beta \cdot \sqrt{\mathrm{VPRID_{r,i,t}} \cdot \mathrm{VPRID_{r,i,t}}}} \\ & \cdot (\mathrm{VINCC_r} + \mathrm{VINCL_r} - (\mathrm{VPRID_{r,i,t}} \cdot \mathrm{ds_{r,i,t}})) \\ & + \mathrm{ds_{r,i,t}} \quad , \end{aligned} \tag{6.22}$$

where *ds* is the constant term of the Generalised Leontief Demand system.

6.3.3 Modelling the bio-physical component in the livestock module

To capture the climatic aspect in the model, an additional bio-physical component has been added in order to include the influence of climate on biomass, which is the main input factor for ruminant livestock husbandry.
To calculate the quantity of forage availability, and the seasonal trends of natural pasture, a model of the FAO is used. Normally, CROPWAT is applied for calculating evapotranspiration, crop water use, irrigation, or assessments of rainfed agriculture (ALLEN et al., 1998). By default the linear crop-production function is formulated as

$$\left(1 - \frac{Y_a}{y_m}\right) = k_y \cdot \left(1 - \frac{ET_a}{ET_m}\right) \quad , \tag{6.23}$$

where	Y_a	actual regional yield per month	[tons ha^{-1}]
	y_m	maximal regional yield	[tons ha^{-1}]
	k_y	yield response factor	
	ET_a	actual evapotranspiration	[mm month^{-1}]
	ET_m	maximal evapotranspiration	[mm month^{-1}] .

In BenIMPACT, the equation 6.23 is employed to calculate the changes of crop yields, natural forage, and forests due to climatic variations. For this study[1] the model CROPWAT has been modified and adjusted with respect to different parameters. With the modifications the model is able to calculate the yield of natural forage and forests subject to climatic conditions, especially to precipitation.
The values for y_m, the maximal regional yield, are net primary production values representing actual potential biomass production under the present land use system without any water restriction. The data for net primary production come from remote sensing and were arranged by RÖHRIG (2006) so that regions and current conditions match.
The yield response factor k_y quantifies the reaction of a crop to water shortages

[1]CROPWAT is also used in the crop module to calculate the climatic aspect, however in a different fashion than the form described in this chapter, since CROPWAT had to be adapted to the simulation of biomass here.

in the four different growth periods: vegetative, flowering, yield formation, or ripening period. The actual evapotranspiration ET_a has been derived from the latent heat of the simulation runs of the meteorological model REMO, which covers West Africa (PAETH and GIRMES, 2006; PAETH and HEUER, 2007). The maximal evapotranspiration ET_m is calculated by multiplying the crop coefficient k_c by the reference evapotranspiration ET_o. The k_c factor, yield response factor, differs in crop, development stage of the cultivated plant, and partly in wind speed and humidity. ET_o is determined by the FAO Penman-Monteith method (ALLEN et al., 1998, p. 24). The FAO Penman-Monteith equation 6.24 uses climate data such as air temperature, humidity, radiation, and wind speed data to establish ET_o:

$$\mathrm{ET_o} = \frac{0.408\Delta \cdot (\mathrm{R_n} - \mathrm{G}) + \gamma \cdot \frac{900}{\mathrm{T}+273} \cdot \mathrm{u_2} \cdot (\mathrm{e_s} - \mathrm{e_a})}{\Delta + \gamma \cdot (1 + 0.34\mathrm{u_2})} \quad , \tag{6.24}$$

where	Rn	net radiation at the crop surface	[MJ m^{-2} day $^{-1}$]
	G	soil heat flux density	[MJ m^{-2} day $^{-1}$]
	T	mean daily air temperature at 2 m height	[°C]
	u_2	wind speed at 2 m height	[m s^{-1}]
	e_s	saturation vapour pressure	[kPa]
	e_a	actual vapour pressure	[kPa]
	e_s-e_a	saturation vapour pressure deficit	[kPa]
	Δ	slope vapour pressure curve	[kPa $°C^{-1}$]
	γ	psychrometric constant	[kPa $°C^{-1}$] .

The climate data, the calculations of the regional ET_o and ET_a, were provided by REMO model simulations. The data were provided on the 0.5° grid, for the region between 6°-13° north and between 0°- 4° east, and for the period from 1960 until 2025.
It is assumed that the only limiting factor is water and that the growing season of pasture and forests starts as soon as enough precipitation has fallen. For this assumption the relation of precipitation to potential evapotranspiration is used as the decision criterion. The vegetation period starts when the precipitation is higher than half the potential evapotranspiration (BOUDET, 1978). Therefore, the beginning of the vegetation is possible in any month where this criterion is

fulfilled, subject to the condition that also in the following month this minimally required quantity of precipitation exists. Then vegetation starts to grow in the model and the produced biomass can be used for livestock feeding. The vegetation start *VVSTA* in month *t* is defined therefore as

$$\mathrm{VVSTA}_{r,pt,sim,t} = t_{r,pt,sim} \quad \text{if} \begin{cases} & \mathrm{rain}_{r,sim,t} & > 0.5 \cdot \mathrm{ET}_{o_{r,sim,t}} \\ \wedge & \mathrm{rain}_{r,sim,t+1} & > 0.5 \cdot \mathrm{ET}_{o_{r,sim,t}} \\ \wedge & \mathrm{rain}_{r,sim,t-1} & < 0.5 \cdot \mathrm{ET}_{o_{r,sim,t}} \end{cases} . \tag{6.25}$$

The criterion that precipitation has to fulfil the condition in two consecutive months is introduced in order to avoid a whole vegetation cycle getting started by a short but intensive rainfall-event. The vegetation ends in month *t* when in the following month *t+1* the first criterion is no longer fulfilled. Therewith a flexible criterion for starting and ending the vegetation period is established, and scenarios with varying climatic conditions, for example with different onsets of rainy seasons, can be calculated.

The equation 6.23 is solved to the actual yield[2] Y_a for natural pasture and forests, for each modelling region and period, for the years 1960 until 2025. The model runs for the years 1960 until 2000 with historical data were calculated to validate the model output with respect to the availability of forage. The years 2001 until 2025 are additionally solved for two simulated climatic scenarios. The climatic scenarios, which are abutted on the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), are provided by the meteorologist of the IMPETUS project. The data come from the climate simulations of the meteorological model REMO for West Africa. The projected consequences of climate change for 2025 are such that both average temperature and the variation in precipitation distribution will increase. The two climatic scenarios A1B (strong economic development based on fossil and non-fossil fuels) and B1 (sustainable use of resources) of the IPCC are calculated to receive the impact of different climatic developments. In order to catch the long-term trends in climate change and to avoid that, for example, an exceptional dry year represents the time-slice, the 5-year average of climatic development in each scenario is taken. For the interpretation of the results it should be kept in mind

[2] The variable Y_a from CROPWAT enters BenIMPACT as parameter *yield* in equation 6.5.

that the equation 6.23 is only valid for water deficits of up to around 50 percent (DOORENBOS and KASSAM, 1979).

The model is run for biomass, which is why the output Y_a is displayed in dry mass. The preferred method of simulating forage supply and requirements of productive livestock would be a forage balance which, based on energy and protein, takes into account the variable contents in plants and the growing season. But as model outputs depend on the quality of input data, the information conditions in Benin and the research aim do not allow such a detailed approach. Vegetation is composed of many different plants and not of one or two major herbals on cultivated pasture areas. With that extended composition one may be able to handle a small region, but the studied area covers more than eleven million hectares. Combined with only few investigations on herbal composition for livestock feeding, data availability is too low to create a more precise biophysical model for the whole of Benin.

Another simplification is that the crop specific factors are reduced to “pasture” and “forest”. These two groups are compositions of many different plant species, which react differently to climate change. But according to GOLDBACH (2005) biomass is an appropriate indicator for fodder in this region, as most pasture is eaten by livestock, although animals optimise intake and favour sapid plants if forage surplus exists.

To validate the model results, the estimated yield of biomass per ha was compared with several regional studies about biomass in Benin (see table 3.7) before scenarios were computed. The assessed biomass values reach the empirical data in the same order of magnitude. As soil condition and degradation cannot be considered in this calculation and as the value of an average hectare on the departmental level is compared with a specific hectare in a research site, the calculated values have been rated as coherent simulation results. The calculated values for regional and temporal availability of biomass in the base year as well as in the simulation years enter BenIMPACT as input data.

6.4 Conclusions of the chapter

This chapter has focused on the modelling background and the development of a quantitative model as analytical tool. This fourth method in the context of analysing the development of the livestock sector in Benin is applied in addition to the qualitative ones. The setting of the bio-economic model is based on the findings of and the analysis in the previous chapters. For the construction of the quantitative model, the requirements which have been identified in the previous chapters are summarised at the beginning.

The literature review provides a short overview of bio-economic models in developing countries in general, and in detail for models emphasising livestock management. Bio-economic models for developing countries have often been designed for the village level due to several reasons. In general, the availability of consistent and reliable data is low in developing countries, whereas it is possible to acquire the needed data at the household or village level by means of interviews. Moreover, natural resources play an important role in agricultural production, as mainly agriculture with low input is practised. Thus, bio-physical processes and changes in the endowment of resources influence production more heavily than in industrialised countries, where there are more possibilities for compensation through financial means. The better simulation of the exact bio-physical processes in a limited region as well as data availability and data collection favour the use of small scale models.

These two reasons are also the arguments why agricultural sector models are seldom used for developing countries. However, in this study an agricultural sector model is used to meet the challenge of modelling not only a small region but a larger one, and to provide a more general statement for the entire livestock sector. The bio-economic model BenIMPACT used in this study is such an agricultural sector model covering Benin (12 regions), four neighbouring countries, and the world market. Eight crops and five livestock activities are implemented into the model. The interactions between crop and animal production are found particularly in the areas of land use and labour. Modelled bio-physical processes influence the yields in crop production as well as natural biomass on grazing areas for ruminant livestock. The producers are assumed to maximise profits and consumers maximise utility. The time horizon is set for the year 2025, and simulations are carried out for several scenarios where changes in economic as well as climatic aspects occur.

The entire agricultural sector has to be taken into account in order to show that the ongoing socio-economic development and climate change influence the livestock management in general. These changes and their consequences are worth showing, so that agricultural policy in Benin may recognize that a (positive) development of the livestock sector might contribute to the overall aims of poverty reduction and food security. But as indicated before, by choosing a partial equilibrium model one has to accept some limitations which are found, inter alia, in the choice of the model type as well as in the specification in the model. However, each model is just a simplified imitation of the real situation. Following the statement of ROBINSON (1962, p. 33) “a model which took account of all the variegation of reality would be of no more use than a map at the scale of one to one”, the model has to concentrate on the most important aspects and driving forces. Nevertheless, one has to be aware of the model specifications to be able to rate the model results.

In some parts, the formulation of the livestock module at first sight seems to be a strong simplification of reality as in the case of processing which is not considered for livestock production. But this simplification meets the production facts quite well in Benin, as live animals are sold and processing of animal products is mainly practised at the household level.

Another limitation is that some developments or trends are difficult to capture, such as the input of fertilisers in crop production, which has not yet been modelled at all. A country wide application of fertiliser is assumed to increase crop yields. This, in return, would have effects on the extensive livestock keeping, as probably cultivated areas would be less expanded and more grazing areas would be available.

Another restraint might be that the great transhumance is not explicitly modelled. In BenIMPACT fodder is available at livestock keepers’ demand within the administrative boundaries, and balancing of forage availability is possible within these limits. This means that small transhumance is allowed, but not great transhumance. But as great transhumance in the southern region is already limited in the base year, and as for the other regions strong declines of livestock on transhumance are assumed until 2025, this simplification seems justified.

Another point which should be noted is the exposure to the variable costs of land. The land rent, which corresponds to the shadow price of land, enters the supply function just in the case that the land restriction is binding. It might be more realistic that an initially very low land rent increases parallel to the process of decreasing land availability. To get a plausible starting value as well as a tendency in land price changes, a master's thesis is being conducted, but has not yet been finished.

The specification of the labour market in the model should be also mentioned here. In BenIMPACT, labour is employed for agriculture and non-agricultural activities. When the shadow price of agricultural labour falls below a defined value then labour is sold and income is generated in the non-agricultural sectors. This assumption implies that non-agricultural sectors are able to absorb all free available labour at any time and at any place. This is, of course, not true in all cases and could be better approached in a CGE model. However, as most labour pass to the informal sector in Benin, the assumption is at least not so problematic as it would be in an economy without such a strong informal sector.

A last aspect which should be addressed here is the role of agricultural imports in BenIMPACT. Since Benin is seen as a small country in the model, supply deficits are easily cleared by the world market. As a consequence of the fully elastic imports, prices vary little within the simulations. In reality it is to assume that additional costs will rise with increasing import quantities and that barrier-free importing is possible for some but not all imports. Thus, the imported quantities in the model might be overestimated.

Having described the general assumptions and keeping in mind the limitations of the model, we can move on to the model results in the following chapter.

Chapter 7

Model simulations and results

In this chapter the results of the quantitative simulations are provided. To highlight some of the different possible developments, a selection of three scenarios is discussed. Each scenario starts with its motivation and a short set-up of the scenario-specific assumptions before the results are presented. The first scenario is the business as usual scenario, followed by the innovation scenario where semi-intensive production is introduced as a production option, and the last scenario looks at the consequences of conservation measures. An overview of some variables is given in the appendix.

7.1 The business as usual scenario

First, the model is run for the business as usual (BAU) scenario where present production methods, trends, and policies are maintained until 2025. Based on the analysis in chapter 5 it can be assumed that the extensive production method will be practised as long as possible due to, inter alia, the input factors, which cost little or nothing at all, the risk-averse behaviour of producers, and the lack of markets for different meat qualities.

7.1.1 Assumptions for the BAU scenario

The main assumption of the BAU scenario is that the extensive production methods remain constant in the long-term. This means that the model, as formulated in chapter 6.3, is run for the base year, calibrated to this year, and is then con-

fronted with the existing trends of exogenous determinants. The set-up for the BAU simulation assumes that the interaction of crop and livestock production consists in the use of the same resources, land and labour. Farmers own the land right titles, whereas the transhumant livestock keepers do not possess land rights and depend on available common land as a source for fodder. Livestock keeping is not an exclusively income-orientated activity; herd sizes are primarily driven by a predetermined growth rate as long as the natural resources of fodder do not impose restrictions on further expansion. The necessary input factors (water, natural pasture, and labour) are free of charge.
The exogenous driving forces in the BAU scenario are population growth, increasing non-agricultural income, and climate change. Generally, population growth and increasing income lead to increasing demand for animal products. Moreover, livestock husbandry is affected by population growth due to the expansion of agricultural area. This increase in agricultural area reduces the free accessible area, which is the production basis for extensive pastoral livestock keeping. Figure 7.1 illustrates the land use in the BAU scenario as well as in the innovation scenario (see chapter 7.2). The arrows indicate the expansion of cropping area into savannah and forests.

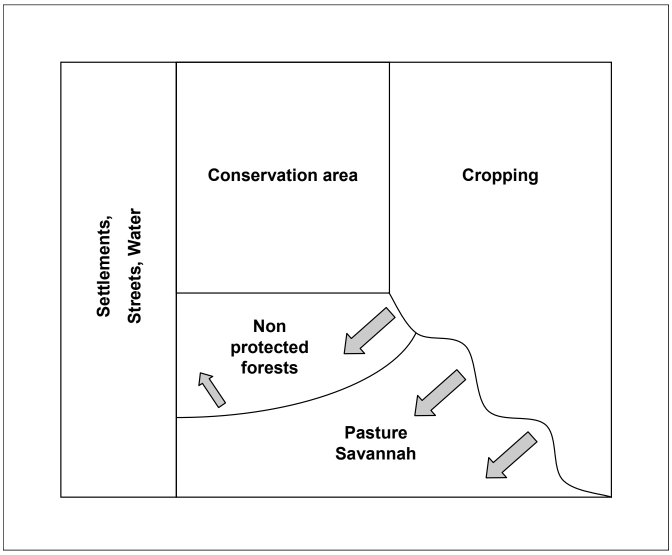


Figure 7.1: Land use in the BAU and innovation scenarios
Source: Author's illustration, 2007

Livestock is also affected by climate (change) which influences the availability of biomass on the grazing areas.

The applied production methods are kept constant in the BAU scenario and the same goes for the performance in livestock husbandry. Therefore, the extensive production method is the only used production method. The supply function is an iso-elastic non-linear supply curve determined by a low supply elasticity. The only possible (domestic) response to increasing demand is a rise in animal numbers. The exogenous growth rate for ruminants is established by the observed birth and mortality rates of ruminants in Benin. However, the fodder restriction (see equation 6.5) has to be fulfilled in each period for ruminants. This constraint does not need to be imposed on the monogastric animals. The numbers of pigs and chickens are assumed to increase according to an exogenous growth rate in compliance with the regional population growth. The monogastric livestock is provided with kitchen scraps, which is why no area and crop activities are required for them in the BAU scenario. All data for the base year – for example, performance, birth and mortality rates, or prices – are taken from the literature review and the surveys, which are described and listed in chapters 3 and 4.
The scenario data of the demographic development come from the IMPETUS project and are provided by DOEVENSPECK and HELDMANN (2005). They calculated the development of population using the expert model SPECTRUM DemProj[1] for Benin's departments until 2025. For population growth one specification across all scenarios is employed, as the demographic development is a very slow process which will not experience major changes until 2025. For the development of increasing income the specification of 1.2 percent per capita and year is employed according to WORLD BANK (2006). For the development of climate the two variations according to the IPCC are taken into consideration within the BAU scenario. In the IPCC scenario A1B land use, which is a relevant factor influencing local climate, is subject to great changes, whereas in the IPCC scenario B1 changes in land use are less pronounced. The climate data are provided by the meteorological model REMO (PAETH and GIRMES, 2006; PAETH and HEUER, 2007). Data concerning historical natural biomass was provided by the remote sensing group (RÖHRIG, 2006). The simulated

[1] This model is also the applied simulation tool in Benin's administration.

biomass for the years 2001 until 2025 and the two scenarios are calculated using CROPWAT (see chapter 6.3.3). The regional forest areas for the base year are also coming from the remote sensing group of the IMPETUS project (THAMM, 2007).

7.1.2 Results of the BAU scenario

The presentation of the model results of the reference scenario focuses on the two most interesting aspects. First, a look is taken at the development of supply, and second, at the impact of climate change on the natural resources which are used as input factors.

If there is no change in production methods and in the allocation of land use rights according to the assumption mentioned above, the animal numbers will increase as shown in figure 7.2, where livestock is measured in TLU per region.

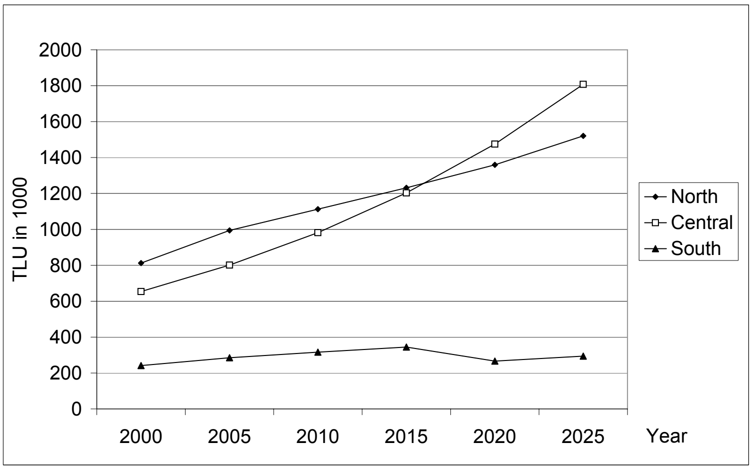


Figure 7.2: Simulation of livestock until 2025 (BAU scenario, A1B)
Source: Model result, 2007

The activity level in the BAU scenario is driven by three aspects: prices, growth rates of herds, and, for ruminants, forage availability. Regarding these three factors it can be said that the supply is little influenced by changes in prices due to the low price elasticity of supply and the more or less constant prices. Figure 7.3 illustrates that the gap between demand and domestic supply is drifting further apart.

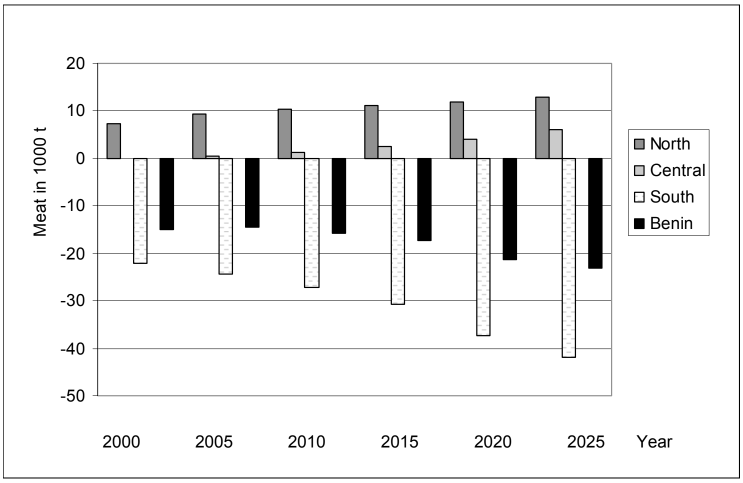


Figure 7.3: Domestic market balance until 2025 (BAU scenario, A1B)
Source: Model result, 2007

Although the domestic market balance becomes more negative, prices for animal products are little influenced. These nearly constant prices in the model are possible as world market prices dominate domestic prices for tradable goods. Therefore, the increasing demand does not drastically affect the domestic prices and imports absorb the supply deficit. This demonstrates the relevance of trade with respect to continuous supply of animal products. If trade is restricted to the amount of the base year trade, then prices for meat increase drastically. The average price of meat increases by 91.6 percent until 2025, with large differences in species. The largest increase is with chickens and the lowest for beef. However, the production of extensive animal products remains nearly unchanged (plus 1.6 percent) due to the assumed low supply elasticities. This low supply elasticity is extremely likely as good prices have not been identified in the producer survey as a reason for selling livestock in the northern and central regions (see chapter 4.3.2).

In contrast to the prices, the second aspect, that is the growth rates of the herds, significantly influences the activity level of livestock keeping in the model (see sensitivity analysis in the appendix). Depending on the assumed growth rates of animals, the levels vary to a large degree. An improvement in the health status of livestock might permit higher growth rates. But in this case the fodder

constraint for ruminants becomes more restricting in the simulated years.
For the monogastric animals the assumed growth rates might be considered as too low, since the experts stated that the number of monogastric animals will increase faster than the population growth. But, as the assumptions of the BAU scenario define that no resources of labour or cultivated fodder are required, a growth rate larger than the population growth does not seem appropriate. In the following chapter 7.2 where semi-intensive livestock keeping is simulated, higher growth rates are allowed.

The third potentially important aspect which influences the activity level of ruminants in the model is the availability of forage. For the overall availability of forage, land accounting and climatic conditions are most important. The land use statistics are of overriding importance as the areas used for settlements, the conservation areas, or the woodlands, determine the area which can be used for cropping and pastoral livestock keeping. Figure 7.4 presents how the results of the numbers of ruminants react with and without forage restriction in the simulation.

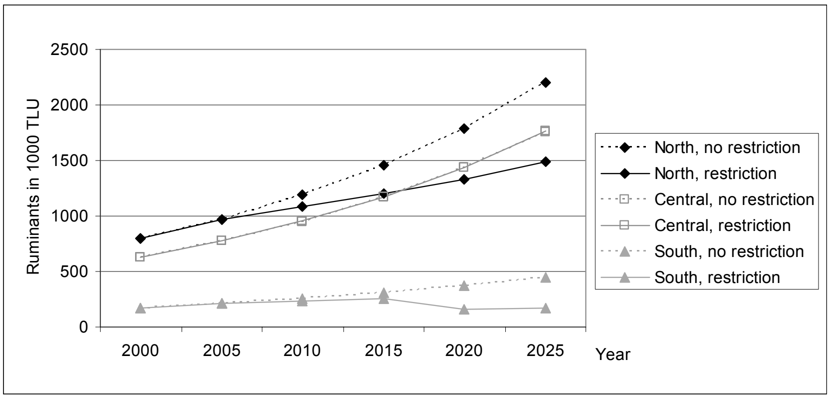


Figure 7.4: Number of ruminants with and without fodder restriction (BAU scenario, A1B)

Source: Model results, 2007

It becomes apparent that the fodder restriction constrains the number of ruminants in the northern and southern regions. The reduction factor reduces the number of animals, for example between 13 and 17 percent per simulation step in Alibori (North Benin) and up to 100 percent in Atlantique (South Benin). The land constraint becomes binding in the model simulation, and no land is left over for extensive ruminant keeping. In the central region no difference between the model results concerning numbers of ruminants emerge as the fodder restriction does not become binding. Two simulation runs with the different climatic scenarios A1B and B1 show only a marginal difference in animal numbers. More important than the climatic difference between the two scenarios is the numeric definition of forest areas and conservation areas as a sensitivity analysis reveals (see chapter 7.3). There, the influence and importance of forests are investigated more closely since tree cuts and crop residues are the fodder basis for ruminants in dry seasons.

Although the climatic differences between the two IPCC scenarios are too small to show great influence on the livestock supply, figure 7.5 reveals that the intra-annual distribution of precipitation notably influences the seasonal requirements of area per TLU. The area requirements per cattle normalised by an average of 35 years are shown for the three periods t2, t3, and t4, based on the assumption that pasture is the sole basis of feeding.

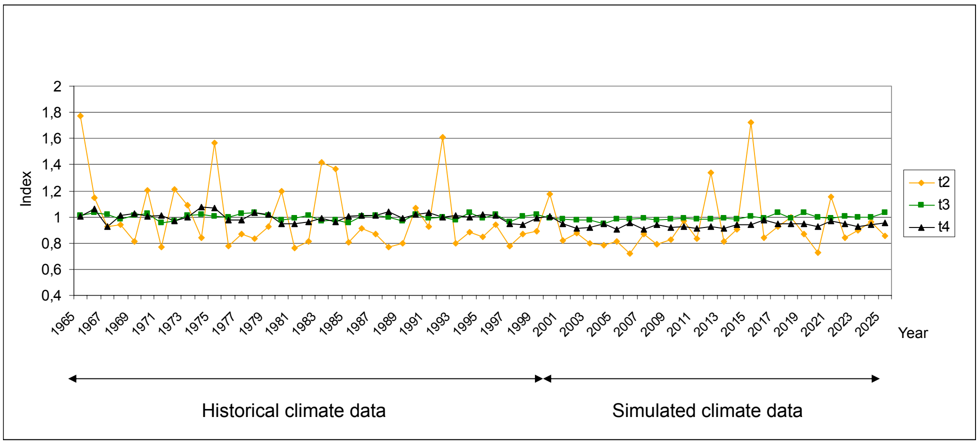


Figure 7.5: Area requirements of cattle in Alibori according to three periods (BAU scenario, A1B)

Source: Model result, 2007

These simulation results of the northern region of Alibori show the climatic influence on the supply of fodder. The area requirements vary significantly between the three periods as well as within the period t2 (months of April to June) over the simulated years. For period t3 (months of July to September) and t4 (months of October to December) the variances between the simulation years are low. The onset of the rainy season determines the area requirements in period t2. The later the onset occurs the higher is the area requirement in t2. The results in period t4 are influenced by the duration of the rainy season: the longer the rainy season lasts the smaller is the required area. For the southern regions the area requirements are more constant due to a generally higher precipitation in the south.

The second input factor of natural resources is the required water for watering livestock. Water is not embedded as a restriction in the model, but the use of this input factor also depends on the climatic development. Water requirements of livestock are compared, as in chapter 3.4, to the requirements of human beings to show potential situations of competition. The human requirements are set at the targeted amount of 20 litres per person and day. In absolute terms, in the whole of Benin, the requirements of human beings exceed the watering needs of livestock by a factor of 2.0 in the base year and decline to a factor of 1.7 in 2025. Figure 7.6 shows that the requirements for livestock increase faster than for human beings when regarding the requirements normalised by the base year.

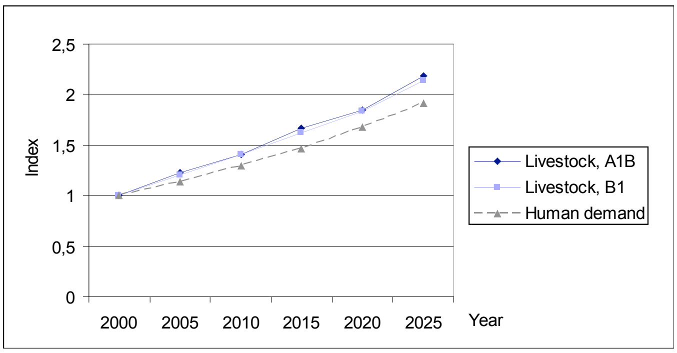


Figure 7.6: Water requirements normalised by the base year (BAU scenario, A1B and B1)

Source: Model result, 2007

This seems to indicate that situations of competition between human beings and productive livestock is rare in the base year and might increase only slightly. But the overall amount of required water in absolute terms of livestock will increase by a factor of 2.2 from the base year to 2025, which has to be considered when regarding potential situations of conflict.
Moreover, the regional details reveal great differences in competitive water usage due to inhomogeneous livestock distribution and population density within the country. Figure 7.7 presents how the regional situations in absolute terms turn out in the BAU scenario.

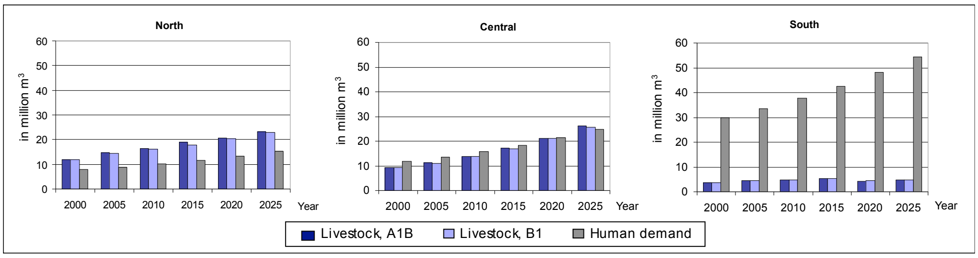


Figure 7.7: Regional water requirements of livestock and human beings (BAU scenario, A1B and B1)

Source: Model result, 2007

Similar to the forage availability it can be seen that the water requirements for livestock show no great difference relative to the climatic scenarios, although the different development of temperature in A1B and B1 has been considered. The development of the number of animals is again more important.

Although labour is required both in cropping and livestock keeping, the requirements of labour for livestock keeping do not compete with labour needs in cropping. This follows from the assumption that the labour for extensive livestock keeping does not cause any costs but is subtracted from the overall labour pool. Comparing the absolute amount of labour which is expended on livestock keeping, these labour requirements are 24.2 percent of the labour for cropping in the base year and increase to 27.7 percent in 2025. This small amount results from the modelling of a representative household which stands for a department. In real households the allocation of labour to cropping or livestock keeping can look quite different.

7.2 The innovation scenario

It is a very strong but not unrealistic assumption in the BAU scenario that for a 20-year period the extensive production methods will remain constant. To relax this assumption, the option to use a more intensive production method is introduced in the innovation scenario (INO), additionally to the extensive one, which can still be practised.
A mentioned motivation for subsistence producers to switch from extensive to more intensive production methods is the general monetarisation of life due to the need to pay in cash for taxes, school fees, or industrial goods (KNISSEL-WEBER, 1989; BRAUN, 1996). Other motivations are the proximity to urban areas, which means short distances to markets with corresponding low transportation costs, or the increase of population (BRAUN, 1996; UPTON, 1996). When a (semi-)intensive production is applied, a different exposure to resources is required as well as a year-round access to markets (BRAUN, 1996).

7.2.1 Assumptions for the innovation scenario

To characterise the innovation scenario, where optional keeping of semi-intensive livestock is possible, several additional assumptions have to be made. They are described as follows:

1. Producers maximise profits in semi-intensive livestock keeping.
2. No different prices for intensively or extensively produced products.
3. Purchasing of feed for intensively kept monogastric animals.
4. Local fodder production for ruminants.
5. Higher productivity per animal unit than by extensively kept livestock.

The main assumption for the innovation scenario is an optional semi-intensive production which can be conducted to increase revenues without using common land. Therefore, livestock keepers are assumed to maximise their profits. This behaviour is implemented in the equation

$$\begin{aligned} 0 \geq \quad & \mathsf{VGREV}_{\mathsf{r,jiani}} \\ & -(\mathsf{piaco}_{\mathsf{r,jiani}} + \mathsf{plaba}_{\mathsf{r,jiani,t}} \cdot \mathsf{VSPLB}_{\mathsf{r,t}} \\ & \quad + \mathsf{plevf}_{\mathsf{r,jirum,t}} \cdot \mathsf{VSPLD}_{\mathsf{r,t}} + \mathsf{pifed}_{\mathsf{jimon,i,t}} \cdot \mathsf{VPRIS}_{\mathsf{r,i,t}}) \quad , \end{aligned} \tag{7.1}$$

which is the first derivative of the linear profit function solved for the activity levels, where *piaco* [in 1,000 FCFA] correspond to variable costs other than labour, land, and fodder. The fodder costs for monogastric animals are the feed requirements *pifed* [in tons] multiplied by the producer price *VPRIS* [in 1,000 FCFA per ton].

To simulate the activity levels of semi-intensively kept livestock the complementary slackness is exploited. The equation 7.1 is paired with the activity levels of semi-intensively kept livestock *VILEV*. In order to obtain an optimal solution either the equation must hold, then there is an optimal solution and a positive activity level exists, or if the equation is not fulfilled, the activity level has to be zero. This means that the zero profit condition has to hold in order to get a positive *VILEV*. Otherwise, if the marginal costs do not correspond to the prices the activity level *VILEV* has to be zero. The gross revenue *VGREV* is computed by yields *pyiel* multiplied by the supply prices *VPRIS*. Since differentiated prices for different qualities of meat do not exist, the prices for meat which derive from semi-intensive production correspond to the prices for meat stemming from extensive production.
For the optional semi-intensive livestock keeping *jiani* several assumptions have to be made for the performance *pyiel* of semi-intensive livestock. The yield used in the semi-intensive production system is determined following the expert estimations. The values assumed for the semi-intensive production correspond to the estimated average values for the year 2025, which are listed in table 7.1. These values are assumed to represent the semi-intensive production which, approximately, can also be found at the national demonstration farms. The employed performances are between 30 percent (for chickens) and 75 percent (for pigs) higher than the observed average values in 2005.

Product	Unit	Average 2005	Assumed semi-intensive production
Beef	kg/animal	117	163
Mutton	kg/animal	10	16
Goat meat	kg/animal	10	16
Pork	kg/animal	20	35
Chicken meat	kg/animal	1	1.3

Table 7.1: Performance of the assumed semi-intensive production
Source: Author's expert survey, 2005

These values do not reflect a high performance of livestock, but they are considerably higher than the current performance in Benin. This level of performance has been chosen on account of the fact that the improved livestock species are usually less adapted to the tropical climate and local conditions.

The production costs in equation 7.1 (gathered within the parenthesis) are composed of input costs, labour costs, land costs, and costs of feeding. The input costs *piaco* include, inter alia, costs of vaccinations, mineral fodder, and water. The data for the production parameters come from the two surveys as well as literature. The labour costs amount to the labour needs for animal keeping and forage cultivation multiplied by the shadow price of labour *VSPLB*. The costs of land occur only for the keeping of ruminants, as it is assumed that the area-dependent ruminants demand land in the region where the production is located. The land requirements for semi-intensively kept ruminants are claimed from the agriculturally usable land which is used for cropping and not for extensive livestock keeping. This means that the regional land restriction must be greater than or equal to the area used for cropping (first summand) plus the area for fodder cultivation in the semi-intensive livestock production (second summand)

$$\mathsf{landbound}_{r,t} \geq \sum_{jc} \mathsf{VLEVL}_{r,jc} \cdot \mathsf{plevf}_{r,jc,t} + \sum_{jiani} \mathsf{VIEVL}_{r,jiani} \cdot \mathsf{plevf}_{r,jiani,t} \quad . \tag{7.2}$$

Therefore, if agriculturally usable land *landbound* becomes scarce, the costs of land for semi-intensive ruminants *jirum* are composed of the land requirements *plevf* multiplied by the shadow price of land *VSPLD*. The last item of expense

in equation 7.1 are the feeding costs for monogastric animals *jimon*. The fodder requirements *pifed* are bought at the producer price *VPRIS* at the market.
The total regional amount of fodder for semi-intensively kept livestock *VIFED* [in 1,000 tons] is calculated as $\mathsf{VIFED}_{r,i,t} = \sum_{jimon} \mathsf{pifed}_{jimon,i,t} \cdot \mathsf{VILEV}_{r,jimon}$. These feed requirements are considered in the commodity balance and are added as a further aspect on the demand side:

$$\begin{aligned} &\mathsf{VMAPR}_{r,i,t} + \left(\sum_{t+1} \mathsf{VSTIN}_{r,i,t+1} - \mathsf{VSTIN}_{r,i,t}\right) - \sum_{T} \mathsf{VTRAN}_{r,s,i,t} \\ &= \mathsf{VHCON}_{r,i,t} + \mathsf{VPROC}_{r,i,t} + \mathsf{VIFED}_{r,i,t} - \sum_{T} \mathsf{VTRAN}_{s,r,i,t} \quad . \end{aligned} \tag{7.3}$$

Furthermore, in modelling the innovation scenario it is taken for granted that a year-round market access is guaranteed, that knowledge of the semi-intensive production method exists, and that the required input factors are available. This scenario focuses on the decision as to whether production of intensively kept livestock is practised and to what extent. The semi-intensive production method is additionally applied to the extensive one. The extent of the semi-intensive production is endogenously determined in the model by the assumption of profit maximisation. Since the two IPCC scenarios have not shown great discrepancies in the results of the BAU scenario, the A1B scenario is applied as a climatic scenario.

7.2.2 Results of the innovation scenario

When the optional semi-intensive livestock production is introduced into the model, the general activity level of productive livestock increases nationally, at the most, by 3.3 percent in comparison to the business as usual scenario. Figure 7.8 presents the results of the model run with semi-intensive production.

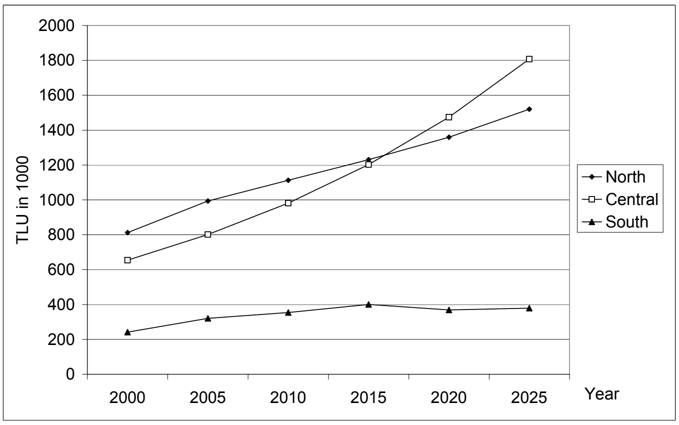


Figure 7.8: Simulation of livestock until 2025 (INO scenario)
Source: Model result, 2007

Considering the regional aspect it should be noted that the activity levels in the northern and central regions have not changed and only extensive livestock is still kept. In contrast, the optional semi-intensive production method is applied in the south. Regarding only the south, the level of TLU is 29.1 percent higher in 2025 than in the BAU scenario of the same year due to the introduction of semi-intensive production.
The decrease in TLU from 2015 onwards is still present, but it is moderate as compared to the BAU scenario. This results from the destocking of ruminants, which is, to some extent, compensated by the introduction of the semi-intensive production of livestock.

This development of the activity levels is also reflected in regional production. The production of meat is illustrated in figure 7.9. The production of meat increases in all regions, though in different ways. Due to limited natural resources in the north the increase in cattle, which is the largest contributor to meat production, is restricted. As a consequence, the production centre is relocated from the north to the central region, and also the south raises its share in the meat production in Benin.

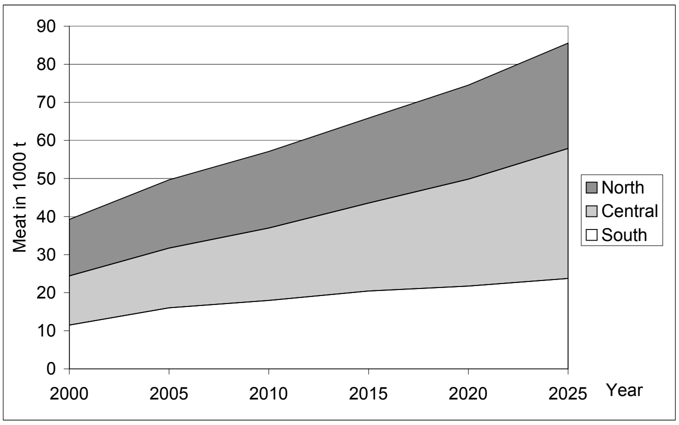


Figure 7.9: Simulation of meat supply in Benin until 2025 (INO scenario)
Source: Model result, 2007

Although the marketable production of meat reduplicates, the gap in domestic supply will remain even if semi-intensive production is simulated. Figure 7.10 illustrates the balance of regional supply and regional demand.

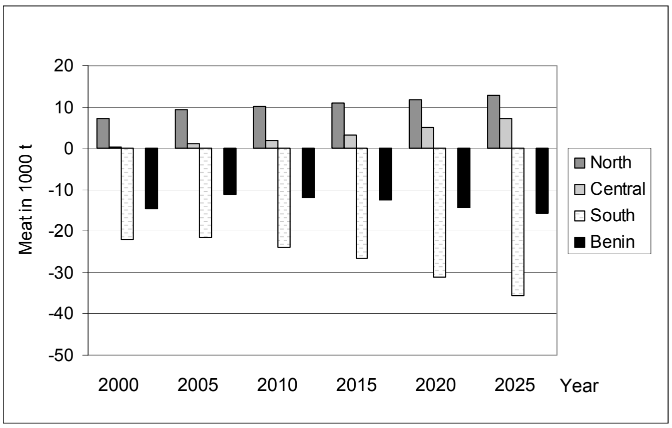


Figure 7.10: Domestic market balance until 2025 (INO scenario)
Source: Model result, 2007

The increasing demand cannot be satisfied by the optional semi-intensive production method, but the gap between domestic supply and demand can be reduced up to 48.5 percent at the most. Here again it becomes apparent that the central region becomes more and more a region of excess supply although it is the primary target for rural migration.

In addition to the aspect of supply, the question arises as to how far the agricultural income per capita may be affected. The simulation in the BAU scenario shows a slightly increasing income per capita earned by livestock keeping in the whole of Benin. In the innovation scenario this tendency is intensified by the optional production method. In figure 7.11 the development of income per capita gained by livestock keeping in the BAU scenario and the INO scenario is presented. In the northern and central regions nearly no changes in income earned by livestock keeping occur as compared to the BAU scenario. The small differences between the two scenarios result from small price deviations.

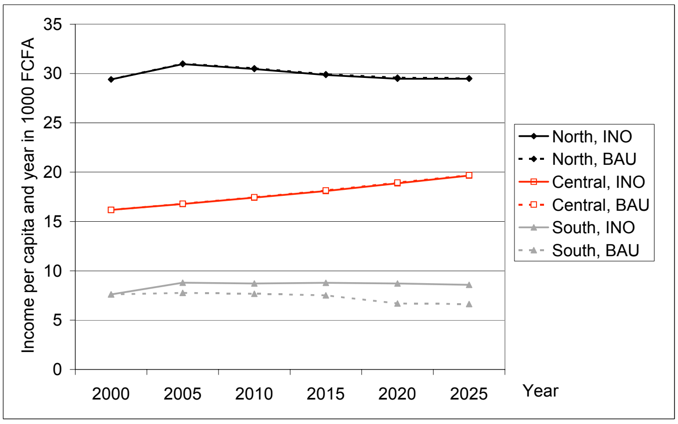


Figure 7.11: Income situation per capita and year (INO and BAU scenarios)
Source: Model result, 2007

In the south, the simulation shows a more positive development of income from livestock keeping. Here, the optional semi-intensive production leads to a considerably higher income derived from livestock production per capita than in the BAU scenario.

It is obvious that the described results of the semi-intensive production method strongly depend on the assumptions made in the scenario setting. The activity levels are influenced by the respectively assumed performances, the production parameters, the structure of costs, and matter of expenses. In table 7.2 the gross margins are exemplarily presented for semi-intensively kept cattle and pigs. In all regions the gross margins are positive for cattle as well as pig keeping.

	Cattle, semi-intensive			**Pigs, semi-intensive**		
	North	**Central**	**South**	**North**	**Central**	**South**
Yield per animal and year in kg	33	33	33			
Yield per year in kg				61.3	61.3	61.3
Prices in FCFA/kg	1500	1503	1509	894	897	899
Value of output	49500	49599	49797	54802	54986	55109
Hours	182	182	182	18	18	18
Labour wages	29.8	30.2	33.7	29.8	30.2	33.7
Labour costs	5424	5496	6133	536	544	607
Fodder costs	–	–	–	22600	22600	23700
Other variable costs	3050	3814	3785	1500	1500	1476
Costs of variable inputs	8474	9310	9918	24636	24644	25783
Gross margin						
in FCFA per animal and year	41026	40289	39879			
in FCFA per year				30166	30342	29326

Table 7.2: Gross margins for the semi-intensive keeping of cattle and pigs
Source: Model result, 2007

These positive gross margins for the base year are in contrast to the observed production systems, as nearly no (semi-)intensive livestock keeping is conducted in Benin. Therefore, the positive gross margins can be interpreted as unidentified costs which are not incorporated into the standard production costs in the beginning. To achieve a base year simulation without semi-intensive livestock production, these unidentified costs are added to the other production costs in the base year per model definition.

One component of the unidentified costs is doubtlessly the cost of land to cultivate fodder for ruminants, which turns up in the model only when the land bound is reached. Another kind of expense that has not been explicitly considered might be additional transportation costs for semi-intensive livestock, which have to be paid by the producers to reach the market. Beside these explicit costs there are also uncertainties, such as land use rights, uncertainties in the supply of input factors, or bushfires. These uncertainties lead to transaction costs, which are reflected in these unidentified costs.

As land costs do not emerge in the model until the land bound is reached, the impact of land rents on livestock management is analysed. Figure 7.12 reveals the consequences of the land rent for the semi-intensive livestock keeping in the south. Three (moderate) land rents – 1 FCFA per ha, 100 FCFA per ha, and 1,000 FCFA per ha – are added to the costs of semi-intensive ruminants keeping in equation 7.1. Supposing that just 1 FCFA per ha has to be paid, the semi-intensive livestock contributes 12 - 38 percent to all TLU in the south over the simulation years.

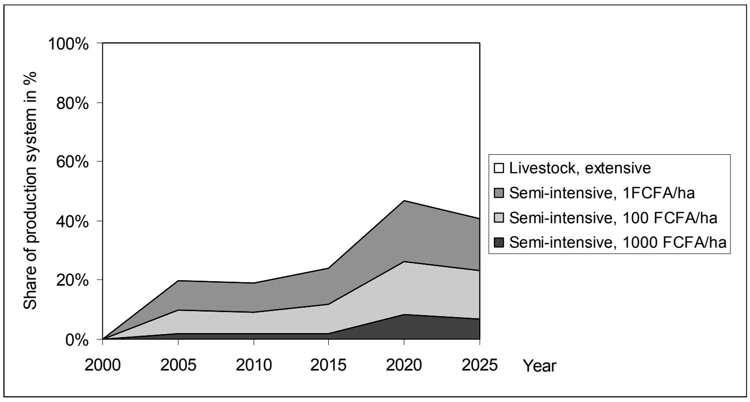


Figure 7.12: Influence of land rents on the level of livestock in the south (INO scenario)

Source: Model result, 2007

Already the introduction of costs of 100 FCFA per ha reduces the semi-intensive livestock. Land rents of 1,000 FCFA per ha eliminate semi-intensively kept ruminants from the simulation results until 2020 and just the semi-intensively kept monogastric animals remain. From 2020 on some intensively kept small ruminants are at hand in the simulation with 1,000 FCFA per ha. In comparison, the currently paid land rents in southern Benin reach 9 - 20 thousand FCFA per ha.

The aspect of missing labour for fodder cultivation, which has been mentioned in the two surveys, has not been classified as a great problem or seen as a scarce resource in the model. This might be the result of an underestimation of required labour as, for example, the time consuming work of land clearing has not been considered in the simulation.

7.3 The conservation scenario

We have seen the relevance of the available area for livestock keeping in the analysis in chapter 5 and it has been indicated in the business as usual scenario. The increase in population leads to an expansion of agriculturally used area and a reduction in grazing area, which currently impairs the extensive livestock keeping. Extensive livestock keeping depends on these non-cropping-used areas and on the right of access to forests and fallow lands. At the same time, forests contribute to soil conservation and a controlled water cycle. The continuous deforestation due to the expansion of agricultural areas is an important and up-to-date topic. OREKAN (2007) reveals in his study that even in his business as usual scenario an almost complete deforestation in the IMPETUS-catchment – a large timbered region – is possible until 2025. The tendency of continuous deforestation is not only limited to the IMPETUS-catchment, but can also be found in the whole of Benin where non-protected forests still exist.
The high pressure on this natural resource combined with the importance of forests for the local climate as well as for soil and water sustainability encourage the analysis of the consequences of different deforestation rates by means of agro-forestry projects and the consideration of marking off additional protected areas. Therefore, the conservation scenario (COS) includes reduced deforestation rates (in scenario COS-A) and introduces additional conservation areas (in scenario COS-B).

7.3.1 Assumptions for the conservation scenario

The main additional assumptions for the conservation scenario are the aspect of reduced deforestation and the idea of forest protection. The current deforestation rate is given at 2.2 percent per year (UNEP, 2007). In the model, this overall deforestation rate is regionally differentiated by the equations 6.6 and

6.7 (see chapter 6). If the deforestation rate remains at such a high level, the ecological system will face a major impact. In Benin, the question is raised as to how the remaining non-protected forests could be conserved, as such a deforestation rate is not ecological sustainable. There are two possibilities: first, the awareness has to develop that forests, used in a sustainable way, are more helpful in the long-term than short-term aspects, and second, that new additional forest conservation areas have to be established. In Benin, both conservation measures are being discussed and an attempt has been made to implement them within several forest management projects, for example, in the Projet d'aménagement des massifs forestiers (PAMF) or the Projet de Gestion des Forêts et Terroirs Riverains (PGFTR).
Therefore, the first possibility of protecting the existing forests is to reduce the amount of deforested areas in the conservation scenario A. The deforestation rates are set to 1.1 percent or to 0.1 percent per year. Then, in the conservation scenario B, additional conservation areas are introduced in northern and central Benin to protect some of the potentially cleared forest. These additional conservation areas equal 10 or 30 percent of the respective forest area in the base year. It is assumed that cropping as well as livestock keeping in the protected area are completely prohibited. However, the current yearly deforestation rate of 2.2 percent continues to be applied on the non-protected forests. Figure 7.13 illustrates the land use in the two conservation scenarios.

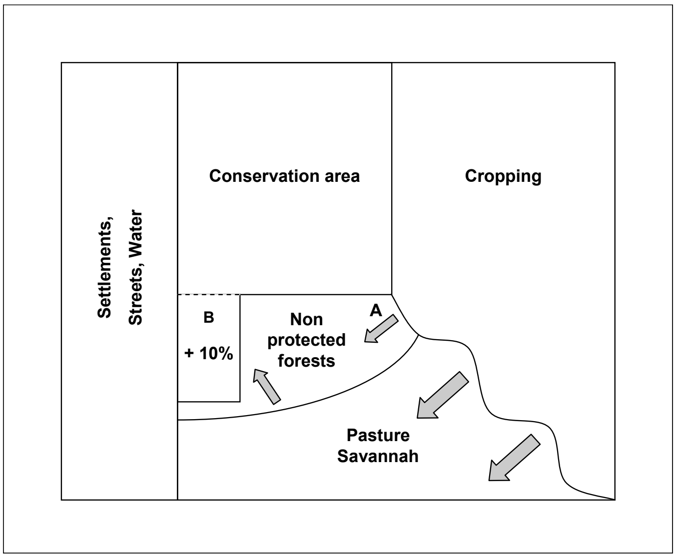


Figure 7.13: Land use in the conservation scenario
Source: Author's illustration, 2007

The cropping area is expanded due to population growth, reducing the pasture area at the same time. In the conservation scenario A the non-protected forests are cleared at different deforestation rates. In the deforestation scenario B the conservation area is added once. Consequently, the forest area for ruminants is reduced twice in the conservation scenario B. The general model construction of the innovation scenario remains constant in both conservation scenarios.

7.3.2 Results of the conservation scenario

The results start with the impact of reduced deforestation on livestock numbers. Besides the amount of livestock in the innovation scenario with a yearly deforestation rate of 2.2 percent, figure 7.14 presents the situation if a yearly deforestation of just 0.1 percent is assumed. This low deforestation rate can be taken as the lowest possible deforestation rate. It can be seen that the amount of livestock keeping augments in the northern region compared to the innovation scenario. However, further on solely extensive livestock keeping is simulated in the northern region, whereas the development of activity levels appears to be reversed in the south. Here, the levels in the conservation scenario

A are smaller than in the innovation scenario. The generally higher production of animal products in the northern region reduces the semi-intensive production in the south due to marginally lower prices.

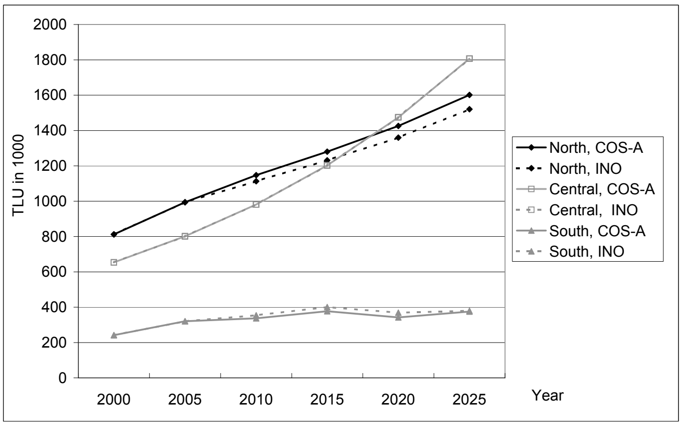


Figure 7.14: Simulation of livestock until 2025 considering different deforestation rates (COS-A and INO scenarios)
Source: Model result, 2007

The activity levels in the central region are nearly non-affected by the different deforestation rates. This should not lead to the assumption that the central region can ecologically easily compensate for the losses in forest area. This model result just indicates that the fodder availability is probably sufficient in the long-term as long as access to all pasture areas is guaranteed.
Although the semi-intensive production becomes economically more interesting if fewer forests are available for extensive ruminant keeping, the increasing semi-intensive production cannot compensate for the reduction in extensive ruminants, which is also reflected in the production of meat.

While the aspect of conservation is not relevant for the extensively kept monogastric animals, the extensively kept ruminants are directly affected. Therefore, figure 7.15 presents the consequences of this conservation measure on the level of ruminants in northern Benin with the corresponding forest area. Three overall different deforestation rates of 2.2 percent, 1.1 percent, and 0.1 percent per year are implemented which are regionalised.

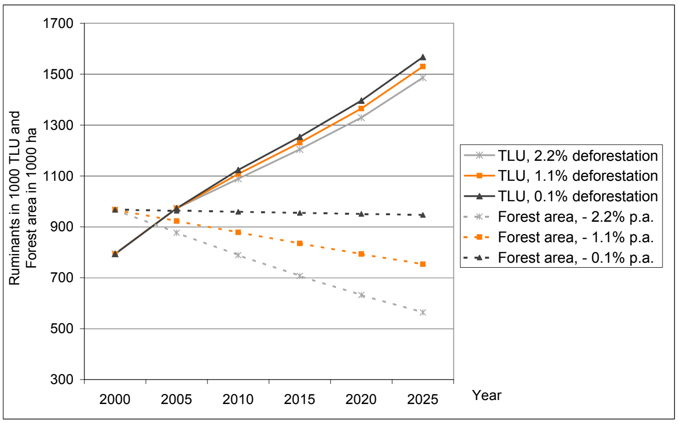


Figure 7.15: Levels of ruminants in the north considering different deforestation rates (COS-A scenario)

Source: Model result, 2007

In northern Benin, the reduction of livestock due to fodder restrictions still exists, but it is in both cases less pronounced after 2005 than compared to the high deforestation rate in the innovation scenario. Compared to the simulation with 2.2 percent of deforestation (INO), the deforestation of 1.1 percent per year leads to ruminant numbers that are 2.9 percent higher in 2025, and 5.5 percent higher in 2025 with a deforestation rate of 0.1 percent. However, the deforestation rate of 2.2 percent may even underestimate the effect of deforestation on transhumant ruminants until 2025 when the landscape becomes more fragmented and the remaining forests might be scattered over the country, disconnected from one another, and no longer suitable for transhumance as is already the case in the south.

The results of the conservation scenario A have been modelled so far just with the shadow prices of land, but without considering land rents as long as land is available. Recalling the strong influence of (small) land rents on semi-intensive ruminant keeping in chapter 7.2, the stocks of ruminants will change more if land rents are considered in the simulation. Figure 7.16 reveals the influence of conservation on ruminant stocks if land rents are included. The simulation where nearly no deforestation is modelled and no additional land rent is charged represents the 100 percent line. There, extensive and semi-intensive ruminants can be kept and no land rent is considered as long as there is no shadow price of land.

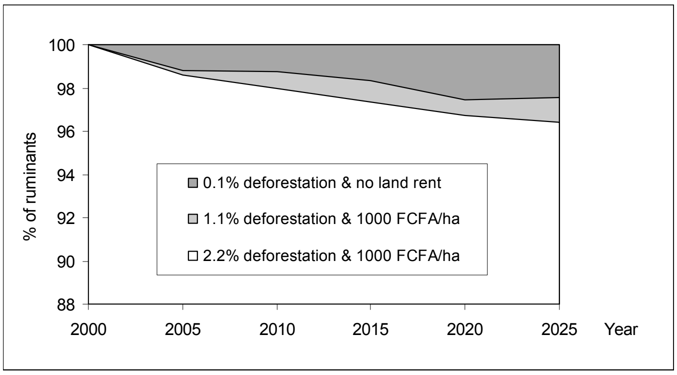


Figure 7.16: Levels of ruminants considering different deforestation rates and a land rent (COS-A scenario)
Source: Model result, 2007

Both aspects, deforestation and land rents, have an effect on the number of ruminants. Deforestation leads to a reduction of extensively kept ruminants in the northern and central regions. A further reduction of semi-intensively kept ruminants occurs in the south if land rents are introduced. Therefore, the relevance of the contribution of monogastric animals to the production of animal products varies according to assumed deforestation rates and opportunity costs of land. In the base year the non-ruminants contribute with 30.4 percent to meat production. In 2025 the non-ruminants contribute 28.5 percent to meat production in the BAU scenario. In the innovation scenario without land rent the contribution of non-ruminant meat reaches 30.7 percent and 31.3 percent with a land rent of 1,000 FCFA per ha. If the deforestation rate is set to 1.1 percent in the conservation scenario A, the meat production of monogastric animals amounts to 30.5 percent (without land rent) or to 31.0 percent (with a land rent of 1,000 FCFA per ha). However, the shift in the composition of meat production is not significant enough in any scenario to be considered a substantial change in kept species.

The second possibility of protecting existing forests and tree savannahs is to establish additional protected areas (conservation scenario B). This seems to be more controllable since the general prohibition of the manifold usage of forests is easier to realise than to raise the awareness of the need of forest protection measures. The establishment of protected areas with an interdiction of utilisation generally leads to higher shares of forests. In this case, for extensive ruminant keepers the available area providing forage in dry seasons is then further reduced. The introduction of additional conservation area (10 or 30 percent of the currently existing forest areas) leads to the following changes of activity levels as presented in figure 7.17. The shares of ruminants are compared to the simulation where nearly no deforestation and no additional conservation area are modelled representing the 100 percent line.

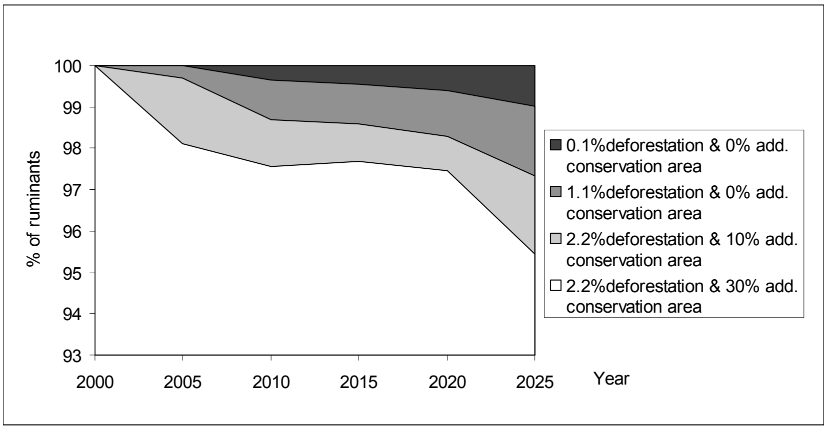


Figure 7.17: Shares of ruminants considering additional conservation areas (COS-B scenario)

Source: Model result, 2007

The percentage of the additional conservation areas is relatively high and might be difficult to implement. However, 30 percent of current forests must be converted into conservation areas in order to obtain the same amount of protected areas compared to the reduced deforestation rate of 1.1 percent per annum. The consequences for the keeping of ruminants differ depending on the conservation measure.

For the whole of Benin, the additional introduction of 30 percent conservation areas affects the ruminant stock more than the reduction of the deforestation rate to 1.1 percent per year, both leading to the same additional protected forest area. Even the introduction of only 10 percent conservation area instead of 30 percent leading to less forest area also affects the level of ruminants more than the reduction of the deforestation rate to 1.1 percent per year. This is a consequence of the additionally practised semi-intensive ruminant keeping in the southern region in the case of 30 percent additional conservation area. In this situation the access to extensive pasture areas is reduced from the beginning and fewer extensive ruminants are kept. This results in (marginal) higher prices in the model and the semi-intensive production method becomes economically more attractive.

The conservation measures affect not only the activity levels, but also the income gained by livestock keeping to a different degree. The effect of reduced deforestation and additional conservation area on the income per capita and year earned by livestock production differs according to the region, as figure 7.18 illustrates. Here, the income situation of the two conservation measures (deforestation rate 1.1 percent and an additional conservation area of 30 percent) are compared. Both conservation measures lead to the same area of protected forests.

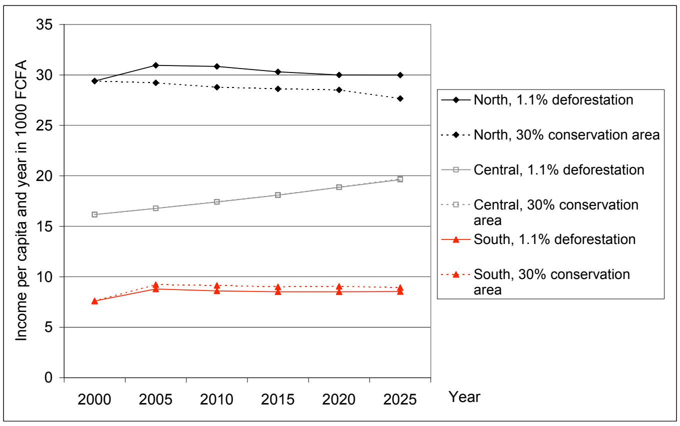


Figure 7.18: Development of income gained by livestock keeping (COS-A and COS-B scenarios)

Source: Model result, 2007

Although the development of the average income per capita from livestock keeping in Benin remains indifferent to the conservation measures taken, the three regions react differently to the chosen measures. Whereas the northern regions experience a reduction in per capita income of 8.4 percent due to the introduction of additional conservation areas compared to the simulation where the rate of deforestation rate is reduced, the income in the central region remains more or less constant (0.3 percent). For the south, a positive shift in income gained by livestock keeping is simulated in the case of additional conservation areas (4.4 percent). Moreover, the results show the increase of economic importance of (semi-intensive) livestock keeping in the south due to the relocation of livestock keeping to the south. This indicates the different regional potential and possibilities of reacting to changes.

7.4 Conclusions of the chapter

This chapter has presented the results of three different scenarios: the business as usual scenario, the innovation scenario, and the conservation scenario. The impacts of the selected driving forces, population growth, increasing non-agricultural income, and climate change, are quantitatively analysed using the agricultural sector model BenIMPACT for all three scenarios. In the business as usual scenario, the current production methods are kept constant and are challenged by all three driving forces. In the innovation scenario, an optional semi-intensive production method is introduced to increase the possibilities of reacting to the changes. In the conservation scenario the emphasis is placed on the consequences of conservation measures such as reduced deforestation and additional conservation areas.

One consequence of population growth and increasing income is the growing demand for animal products. Since extensive production cannot keep pace with the increasing demand, the demand excess will grow until 2025. However, imports and trade meet the excess demand and world market prices dominate domestic prices in the model. Therefore, activity levels of extensively kept livestock are less determined by prices than by the growth rates of herds and forage availability. Although the amount of available natural pasture and forest used by ruminants depends mainly on climate, the results have not been significantly influenced by the driving force of climate change. The differences between the base year and the simulated years as well as the differences between the two climatic scenarios are not as dramatic as might have been expected from non-quantitative arguments. The horizon marked by 2025 is too short a period of time to see the different consequences of climate change according to the two IPCC scenarios A1B and B1. But the intra-annual distribution of precipitation influences the area required by ruminants. However, land for grazing is becoming scarce in some regions due to expanded cropping areas caused by population growth. Besides natural forage, water is the second climate-dependent input factor. In absolute terms the amount needed for watering is small compared to total precipitation but the required water for livestock will have doubled by 2025. This simulation result is consistent with the result of DELGADO et al. (1999). These aspects lead to the conclusion that the competition for climate-dependent resources such as water and natural forage will increase with the growth of livestock and population. A reduction of conflicts over the needs of human beings and livestock for the resources of land and water is distant as long as two parallel existing regulations or laws, the traditional and the modern regulations, are applied to natural resources.

In the second scenario, the innovation scenario, where a more intensive production method is introduced into the model, the dependence on natural resources, at least on natural pasture, and the assumption of constant productivity are relaxed. Livestock keepers have the chance to respond to the increasing demand by the extensive as well as by the semi-intensive production method. The model results show that exclusively in the south some semi-intensive production is conducted. Therefore, production is relatively relocated to the southern and central regions as also the central region is becoming more important in (extensive) production. The domestic gap between supply and demand in Benin is reduced as compared to the business as usual scenario. In the model, a positive effect on the income of southern livestock keepers is noticed. Due to the construction of the representative regional farm-household no answer can be given as to which group is keeping livestock and which group benefits from the optional semi-intensive livestock keeping. Based on the current situation, the transhumant animal keepers, the small animal keepers in urban areas as well as farmers have the possibility of starting a semi-intensive livestock production.

Although the gross margins of the semi-intensive system are all clearly positive, this production method is hardly seen in reality. Thus, the model simulation reveals that there have to be (large) unidentified costs which currently inhibit semi-intensive production. The increasing demand is not a sufficient incentive to intensify domestic production as costs are too high and excess demand can be unproblematically met by imports in the model. The unidentified costs can be interpreted as uncertainties which arise due to the existing structure of markets, access to land and land use rights, or the acquisition of input factors. These aspects are also the areas where general improvements should be contemplated if more intensive livestock production methods are aspired. Besides these unidentified costs and uncertainties, one explicit problem in the realisation of semi-intensive livestock keeping is the cultivation of fodder. Until now, cultivating fodder is not seen as a profitable activity as seeds or labour have to be invested in advance and the economic benefit is not seen as long as other fodder sources are available. One possibility to facilitate the introduction of forage cultivation might be the cultivation of multi-purpose use crops which are also for consumption or helpful for soil conservation.
In the third scenario, the conservation scenario, two possibilities for the protection of forests are analysed. Population growth influences the livestock sector by increasing demand, by causing an expansion of cropping into savannah, and by creating a threat to forests. Forests are cleared due to the high population growth and, therefore, the reduction of the deforestation rate or establishing additional conservation areas are considered ways to protect the remaining forests. The model results indicate the importance of forests as a fodder source for extensively kept ruminants and reveal that the chosen conservation measures differently influence livestock management. Differences occur in the regional distribution of livestock, the composition of extensively and semi-intensively kept animals, and the regional income gained by livestock keeping. The introduction of additional conservation areas considerably reduces the number of extensively kept ruminants. Some production is relocated to the south in the form of semi-intensive ruminant production. The aspect of relocation towards the southern region can also be found regarding the income per capita gained by livestock. This leads to the conclusion that it is of great interest for the pastoralists to support the conservation of forests as long as they

have a guaranteed right of access. If access is completely barred to the conservation areas and a sustainable wood pasture is not available, the existing conflicts over resource use might be aggravated. However, the establishment of additional conservation areas might be difficult to realise, at least not before an increase in the productivity of crop production has been put into practise.
It has to be kept in mind – beside the general model limitation (see chapter 6) – that these results indicate only the potential behaviour of livestock keepers and possible trends and should not be taken as accurate projections of the future. Naturally, catastrophes, such as the African swine fever which struck in the 1990s, are not considered in the model simulation. Such a calamity, which is not studied here but could be subject matter of a “disaster scenario”, would considerably influence the results of all long-term simulations.
Another point which has not been modelled yet is the innovation and intensification in crop production. In subsistence farming without the opportunity to market surpluses, the increase in crop yields may, in sum, lead to a smaller cultivated area due to reduced tendencies to expand crop area. This would imply that more extensive area is available for extensive livestock keeping than is simulated in the presented scenarios. But at the same time it has to be considered that, as the harvest index of improved crop species increases, less biomass is left on the fields. Thus, the gained advantage of more pasture area for extensive livestock keeping may be outweighed by the introduction of improved crops. Moreover, crop production may become economically more attractive due to intensification if farmers have the chance to earn additional income by selling surpluses. In this case, the currently cultivated area remains in production and the production exceeding the families’ own consumption enter the markets. Then the competition between (extensive) livestock keeping and cropping will become more severe as compared to the situation of mainly subsistence farming.

Chapter 8

Summary and conclusions of the study

This chapter summarises the motivation, structure, and results of the respective chapters. At the end general conclusions of this work and some recommendations are made regarding livestock husbandry in Benin.

8.1 Summary

In the last decade there has been an increasing global awareness of livestock husbandry being in flux and of the profound changes, which will continue in the next decade(s). This dynamic process, the so-called Livestock Revolution, has enormous consequences for producers as well as consumers in all kinds of aspects such as health, livelihoods, and environment. The reason for the changes can be found, above all, in the worldwide increasing demand for animal products. Especially in developing countries, the driving forces of population growth, urbanisation, and rising income lead to this increasing demand. Since livestock keeping is often an important (additional) economic activity for the poor, these changes provide an opportunity to improve livelihoods in developing countries and alleviate poverty. Therefore, a real chance exists to benefit from the ongoing changes in the livestock sector.

This situation is also found in Benin (West Africa), one of the poorest countries of the world. Agriculture plays a dominant part in daily life, which is noticed,

inter alia, in employment or export earnings. About two-thirds of the population are engaged in (subsistence) farming, and 95 percent of the export revenues are provided by agriculture, mainly by cotton exports.
Despite the signs that changes are on the way and although livestock is kept in all regions and is a widespread activity, the interest in the livestock sector as well as research on livestock management in Benin is marginal.

Thus, the motivation and the aim of this study are first to establish an understanding of the livestock husbandry. The collected and provided data has been systematically analysed and will be a helpful information base for planning and policy. The status quo is described and investigated in chapters 2 to 4. The second objective of this work is to analyse possible developments of livestock husbandry in Benin in consideration of the driving forces of population growth, rising income, and climate change. This analysis of the situation and possible development paths provide some considerations on which up-coming decisions can be based. Moreover, it may give an idea about future development paths and shows relevant aspects which should be considered in the context of policy discussions. The possible future developments are discussed and illustrated in chapters 5 to 7. The applied method in this study is triangulation, that is different methods are used in order to obtain a more global picture of the research field than would be possible by investigating the topic with one single method. The status quo is analysed with the help of literature and two field surveys: the producer survey and the expert survey (data triangulation). Between method triangulation – three qualitative ones and one quantitative one – comes into operation for researching further development paths: agricultural development theories, experiences of other developing countries in a similar situation, interviews on the development of the livestock sector with Beninese experts and, last but not least, the quantitative analysis with the agricultural sector model BenIMPACT.

The status quo in livestock husbandry is characterised by extensive production methods and a multi-purpose motivation for livestock keeping that is not only income-orientated. The production input is mainly composed of natural resources such as water and pasture for grazing, or crop residues and kitchen scraps. The extensive production method results in low productivity per productive livestock. The well-adapted production method pursues several strategies to compensate for seasonal shortages of production factors such as the diversification of water sources according to season. Another strategy is transhumance, the seasonal migration of ruminants to water and fodder resources. The producer survey showed, however, if fodder is available nearby, the nearer resources are preferred. Non-ruminants, mainly uncontrolled, are kept near the house and fed with kitchen scraps. Pigs and chickens provide some additional income and are used as short-term capital formation or gifts.

Agricultural policy neither effectively intervenes in the livestock sector nor establishes structures to promote the marketing of animal products. This results, inter alia, from the fact that the majority of livestock keepers, the transhumant ones and the small subsistence producers, are not well integrated into political processes. On the other hand, it is evident that the realisation of political decisions is not easily implemented due to the lack of sectoral organisation and infrastructures. The non-existence of structures hampers the integration of livestock production into market economy. Since livestock keeping serves not only as a generation of income, and since prices are not only determined by supply and demand, the multi-functional relevance of livestock should not be underestimated.

However, the producer survey has shown that in the south awareness of livestock keeping as an economic activity and producing for the market is gradually increasing. The high demand in the agglomerations of Cotonou, Abomey, and Porto-Novo and the proximity to the markets are facilitating a change of the attitude in livestock keeping. Additionally, it should be noted that the producer organisations are already showing their potential to reshape the commercialisation of animal products and to benefit from their organised structure. Moreover, transportation flows from the north to the south show the mechanism of the market, which balances excess supply and excess demand between the northern production areas and the southern consumer regions.

This situation in livestock management is challenged by an increasing demand for animal products, and by changes in the availability of the natural resources of water and pasture due to the expansion of cropping area. These changes come across a heterogeneous production and commercialisation situation in southern, central, and northern Benin. However, despite these regional differences, the major problem in all regions is the inadequate and insufficient supply of fodder. This result of the producer survey, which has been confirmed by the expert survey, is striking as fodder supply has not been a commonly discussed topic until now. Diseases are the second problem, and the third major problem is the inadequate supply of water. This ranking indicates the importance of the natural resources and the corresponding challenges in using these resources.

There are, theoretically, several reactions possible in response to these challenges. On the assumption that sustainability is maintained and that demand is not exclusively satisfied by imports, six pathways are feasible which can be explained by (agricultural) development theories. The location model explains both the displacement of transhumant animal keepers to marginal regions and the intensification near agglomerations due to the location to markets. The induced innovation model assumes that the increasing prices of failing resources are incentives for producers to intensify their production. Boserup states in her theory that more intensive production methods are practised when the population growth requires higher production. The conservation model argues that intensification of production is possible by an integration of cropping and livestock keeping. The New Institutional Economics provide the property rights approach to explain the displacement of transhumant animal keepers, and the approach of transaction costs to explain the cooperation between different producer groups as well as changes in the composition of animals.

The experiences in other developing countries show that several shifts in livestock management occur during the development process. There are shifts from ruminant to non-ruminant keeping, from rural to urban areas, from resource-driven to demand-driven production, from multi-purpose use and low input intensity to single-purpose use and high input intensity. When natural resources are no longer available, there is a tendency to abandon the keeping of large ruminants and to keep more animals in landless systems. The Beninese experts assume that livestock producers will react by expanding of animal numbers and, in particular, increasing performance. According to their assumptions, the (great) transhumance will phase out over time, while forage cultivation will be a widespread activity by 2025.

Having analysed the theoretical development paths, the impact of socio-economic development and climate change is modelled by means of the agricultural sector model BenIMPACT. The choice has been made for a partial equilibrium model to illustrate the regional differences and the general development of the livestock sector. Only few models with a similar thematic, geographical, and methodological intention have been constructed as in developing countries household models are applied more often on a smaller scale, due to a better data availability. Before the results of the three selected scenarios – business as usual, innovation, and conservation – are presented, the bio-economic BenIMPACT is described in general, and a detailed description is given of the livestock module which has been developed in this study. Five livestock activities have been added to the eight crop activities. In the twelve representative farm-households, which correspond to the administrative regions in Benin, producers maximise profits and consumers maximise utility.

The business as usual scenario indicates that livestock activity will develop differently in the three regions of North, Central, and South Benin. Although the gap between domestic production and consumption increases, prices will stay more or less constant in the model, due to imports. The activity level of ruminants depends significantly on the available quantity of fodder and the assumed growth rates. The climatic impact on the biomass influences the activity levels only marginally. More important is the access to forests and crop residues in the dry season. Water requirements of livestock will double until 2025, but remain small compared to absolute precipitation. However, livestock has twice the needs in some regions than human beings, which (may) create a competitive situation in dry seasons.

The innovation scenario reveals that more semi-intensive livestock husbandry would have to be of economic interest if the standard costs were assumed. But as (semi-)intensive livestock keeping is still of peripheral importance, there are, obviously, additional costs and uncertainties which are so high that they inhibit this production system. Such costs might include those for land rent or transportation. There may also be uncertainties regarding land use rights, the supply of input factors or bushfires which might jeopardise infrastructure for semi-intensive livestock keeping. The extent to which semi-intensive livestock is practised as a result of model simulations is very sensitive to prices and costs.

The conservation scenario highlights the impact of deforestation and the consequences of additional forest conservation areas. The conservation of valuable natural areas is doubtlessly of general interest, however, different conservation measures have different regional impacts on livestock management regarding livestock distribution and income. Before establishing a particular conservation measure the regional impacts should be considered.

8.2 Conclusions of the study

Originating from IMPETUS, a project on regional impact research of global change, this study has been conducted with the overall objective to obtain a better understanding of livestock management and to identify possible and realistic developments of this sector in Benin but mainly under the assumption of limited policy interference. Moreover, the study aims at contributing to increasing the ability to benefit from the potentials of livestock keeping. The study concentrates on the major driving forces of population growth, increasing income, and climate change.

The impact of population growth and increasing income will lead to an increasing demand for animal products. Although income elasticities for animal products are high, the absolute effect of population growth on the demand side is more significant. The currently practised extensive livestock keeping will not be able to keep up with the demand as the basis of production withers and market orientation is limited. As a result of the population growth and the existing land rights, which stipulate that farmers have the right to claim and cultivate land before transhumant livestock keepers may use it, the available land for transhumant livestock keeping is reduced. Thereby the fodder base is reduced and the problem of adequate forage supply is aggravated. As the major production problem in all regions is already the inadequate and insufficient supply of forage, policy for livestock management should place this issue on the agenda.
Climate change also influences the production basis for forage and water requirements. The analysis is able to underline that precipitation and temperature exert a great influence on the seasonal availability of production factors, although the impact of climate change on livestock management for the chosen

time horizon has been found to be small. Nevertheless, regional and temporal differences in precipitation influence the availability of production factors considerably.

Depending on the season as well as on the region, the competition for and conflicts over natural resources are already at hand and will increase due to the growing demand of both people and livestock for natural resources and as a result of the ambiguous legal situation. Currently, two parallel regulations are applied, the traditional and the modern one, both regulating the use of the natural resources of water and land. Changed conditions such as the increasing scarcity of land, new and more users due to migration, new production systems, increasing population, and unknown or not accepted regulation mechanisms intensify the existing legal ambiguity in the use of resources and the problem of sustainable resource use.

In view of the trends regarding demand, there should be incentive enough to increase the supply by adopting a more intensive production method. However, high unidentified costs have been found, which is why such an (semi-)intensive livestock production seems to be economically unattractive to a large extent. One component of these unidentified costs is doubtless the low level of market structure developed for animal products, the (difficult) market access as well as uncertainties in land use rights and in the supply of input factors.

However, the study reveals that despite the high hidden costs some intensification will take place. The (semi-)intensive livestock production will be practised in the proximity of the southern agglomerations. Thus, it could be shown that the intensification of livestock production will take place in the (peri-)urban regions, as is the case in other developing countries. Due to the partial reduction of extensively kept ruminants and the intensification of area-independent monogastric animals, a slight tendency towards non-ruminant meat production has been identified. As a consequence of relocation of production towards the south the economic importance of livestock keeping is also increasing in the southern area. In general, a greater regional differentiation in livestock management will take place. This wider range of different production systems will develop and exist side by side due to regional comparative advantages.

The already existing regional comparative advantages emerge from the regional heterogeneity in given natural conditions and different regional structures. Regional differences in a sector are always a challenge for politics as one single strategy is not adequate and helpful to solve supra-regional difficulties. The study shows, for example, that the chosen conservation measure for protecting forests influences livestock management differently regarding the composition of extensively and semi-intensively kept animals and the regional income gained by livestock keeping. Therefore, regional approaches have to be considered and elaborated which take the regional situation into account.

Up to now, an intense process of differentiation regarding location and intensification of livestock keeping has not yet started. However, it is extremely likely that the driving forces will exercise their influence on the sector in the direction indicated in the study. Therefore, policy should develop concrete goals for the livestock sector and identify areas where regulations might be necessary to avoid conflicts over resource use. In particular, politicians have to deliberate on a general strategy concerning a constant development of the sector, supporting local producers of animal products in Benin, maintaining tradition, culture, and environmental sustainability. Even without an explicit policy, a direction will be chosen, and it may be one which does not make use of the potential of livestock management to achieve the Millennium Development Goals.

The non-use of natural resources and existing knowledge would be unwise. The establishment of a clear binding concept of land use would help to create long-term conditions in order to facilitate decision-making in the livestock sector. This concept does not necessarily have to be exclusive private land right titles but could also be area dedications for a group.

Another crucial approach to a greater benefit from livestock management is the improvement of market access and infrastructures as well as creating an awareness of market production. These aspects, which interact with each other, are a prerequisite for a more market-orientated production. The initiatives of livestock keepers to improve their market access and production methods are positive approaches to profit (more) from livestock husbandry.

Recapitulating the study, we can say that the analysed driving forces have a significant impact on the livestock sector in Benin. As a result of the driving forces this sector will face several changes and challenges. Generally, the livestock management will be more differentiated according to region and input intensity.

Therefore, it will be worthwhile for (inter-)national organisations and projects to continue their commitment to livestock husbandry and livestock research. Further research should identify possible policy measures to avoid unwanted developments. Another focus of future research could be to further investigate the conditions under which livestock keepers would choose to intensify their production. This study has hopefully contributed to promoting and extending the understanding and knowledge in order to benefit from available potential and the associated positive aspects of livestock management in Benin.

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Appendix

Indices, Variables, and Parameters in BenIMPACT

Indices	Description
r,s	Regions
j	Activity
jc	Crop activity
jl	Livestock activity
jmon	Keeping of monogastric animals
jrum	Keeping of ruminants
jcatt	Keeping of cattle
jiani	Intensively kept livestock
jimon	Intensively kept monogastric animals
jirum	Intensively kept ruminants
i	Product
pgrp	Production groups
t	Time - period
bas	Base year
sim	Simulation year
labo	Labour
leis	Leisure
rdom	Region in Benin
rnc	Neighbouring countries
row	"Rest of the World"
bio	Biomass
T	Transportation flows

Variables	Description	Unit
VAWAT(r,sim,t)	Total water requirements for all productive livestock	in 1,000 tons
VGREV(r,j)	Gross revenues	in 1,000 FCFA
VHCON(r,i,t)	Consumption of products	in 1,000 tons
VHCPC(r,i,t)	Per capita consumption	in kg per capita
VHCPR(r,i,t)	Rural per capita consumption	in kg per capita
VIFED(r,i,t)	Feed demand intensive livestock keeping	in 1,000 tons
VILEV(r,j)	Level of semi-intensive activities	in 1,000 heads
VINCC(r)	Total income	in 1,000 FCFA per capita
VINCL(r)	Income equivalent from leisure	in 1,000 FCFA per capita
VINCN(r)	Income from production plus other minus inputs	in 1000 FCFA
VINCR(r)	Income from off-farm activities	in 1,000 FCFA
VLABF(r,t)	Family labour in cropping	in million hours
VLABH(r,t)	Labour hired	in million hours
VLABS(r,t)	Family labour sold	in million hours
VLABT(r,t)	Total labour in agricultural production	in million hours
VLEVL(r,j)	Activity level	in 1,000 ha or 1,000 heads
VMAPR(r,i,t)	Marketable production	in 1,000 tons
VMRED(r)	Maximum value of VRRED over all periods	in percent
VPRES(r,j,t)	Supply responding to VPRIS in livestock husbandry	in percent
VPRID(r,i,t)	Demand price	in 1,000 FCFA per ton
VPRIS(r,i,t)	Supply price of products	in 1,000 FCFA per ton
VPROC(r,i,t)	Processing consumption	in 1,000 tons
VPROD(r,i,t)	Gross production or use	in 1,000 tons
VRRED(r,t)	Seasonal reduction factor for ruminants	in percent
VSPLB(r,t)	Wage rate (shadow price for labour)	in FCFA per hour
VSPLD(r,t)	Land rent (shadow price for land)	in 1,000 FCFA per ha
VSPPC(r,i,t)	Shadow price for processing capacity	in 1,000 FCFA per ton
VSTIN(r,i,t)	Stock in	in 1,000 tons
VTRAN(r,s,i,t)	Transportation flow	in 1,000 tons
VYIEL(r,i,j,t)	Crop yields and yields of livestock	in tons

Parameter	Description	Unit
bs(r,t,i,ii)	Terms in front of square roots in Generalised Leontief Expenditure Function	
ds(r,i,t)	Constant terms in Generalised Leontief Expenditure Function	
landbound(r)	Upper bound on land use	in 1,000 ha
K	Constant term for updating the regional forest area	
pagro(jl)	Yearly growth rate of animal numbers	in percent
pasel(r,jl)	Supply elasticity in livestock keeping	in percent
pawat(r,jl,t)	Water requirements of livestock	in tons per animal
pconu(r,i,t)	Urban consumption	in 1,000 tons
pcres(r,j,t)	Crop residues useable for livestock feeding	in tons per 1 ha crop
pdefo('ben')	Global deforestation rate in Benin	in percent
pfact(r,i)	Processing capacity	in 1,000 tons
pfodi(jrum,t)	Feed requirements of ruminants	in tons per head and period
pfore(r)	Regional forest areas	in 1,000 ha
phcon(r,i,t)	Consumption	in 1,000 tons
piaco(r,iani)	Input costs of intensive livestock keeping	in 1,000 FCFA per head
pifed(imon,i,t)	Feed requirements for monogastric animals	in tons per head
pincp(r,t)	Regional rural income from other sources (residual)	in 1,000 FCFA
pinpu(r,i,j,t)	Quantity of input factors	in kg per activity
plaba(r,j,t)	Labour used per activity	in 1,000 hours per activity
plabf(r,t)	Family labour in cropping	in million hours
plabh(r,t)	Labour hired	in million hours
plabi(r,t)	Labour pool of farm households	in million hours
plabr(r,t)	Total regional labour pool	in million hours
plabs(r,t)	Family labour sold	in million hours
plevf(r,j,t)	Area requirements per activity and period	in percent
plevl(r,j,t)	Activity levels	in 1,000 ha or 1,000 heads
plosf(r,i,t)	Production losses	in percent
pmpa(r,j,a)	PMP term intercept	
pmpb(r,j,j)	PMP term slope	
poppres(r)	Population pressure	in percent
ppopr(r)	Rural population share in simulation region	in percent
ppopt(r)	Population in simulation region	in 1,000
ppris(r,i,t)	Supply price	in 1,000 FCFA per ton
prpri(r,i,t)	Fixed supply price	in 1,000 FCFA per ton
ptems(r,sim,t)	Regional temperature	in °C
pyiel(r,i,j,t)	Crop yields and yields of livestock	in tons
qpia(r,i,t)	Quadratic Profit function - International linear	
qpib(r,i,t)	Quadratic Profit function - International quadratic	
sc(r,pgrp)	Storage cost derived from losses	in 1,000 FCFA per ton
tc(r,r,pgrp)	Trade cost between regions	in 1,000 FCFA per ton
yield(r,bio,sim,t)	Biomass of pasture and forests in dry mass	in tons

The BenIMPACT Documentation

UPPER CASE: VARIABLES

lower case: parameters and indices

I. Resource use

Land restriction

$$\mathsf{landbound_r} \geq \sum_{jc} \mathsf{VLEVL_{r,jc}} \cdot \mathsf{plevf_{r,jc,t}} \quad \perp \mathsf{VSPLD_{r,t}} \tag{1}$$

Family labour restriction

$$\mathsf{plabi_{r,t}} \geq \mathsf{VLABF_{r,t}} + \mathsf{VLABS_{r,t}} + \mathsf{VHCON_{r,'leis',t}} \quad \perp \mathsf{VSPLB_{r,t}} \tag{2}$$

Family labour

$$\mathsf{VLABF_{r,t}} = \mathsf{VLABT_{r,t}} - \mathsf{VLABH_{r,t}} \tag{3}$$

Condition for hiring labour

$$\begin{aligned}&\mathsf{VPRIS_{r,'labo',t}} \cdot \\ &\left(\frac{(\mathsf{plabr_{r,t}} - \mathsf{plabf_{r,t}} - \mathsf{phcon_{r,'leis',t}} - \mathsf{plabh_{r,t}} + \mathsf{plabs_{r,t}})}{(\mathsf{plabr_{r,t}} - \mathsf{VLABF_{r,t}} - \mathsf{VHCON_{r,'leis',t}} - \mathsf{VLABH_{r,t}} + \mathsf{VLABS_{r,t}})}\right)^{0.8} - \mathsf{VSPLB_{r,t}} \\ &\geq 0 \quad \perp \mathsf{VLABH_{r,t}}\end{aligned} \tag{4}$$

Condition for off-farm labour

$$\begin{aligned}&\mathsf{VSPLB_{r,t}} - \mathsf{VPRIS_{r,'labo',t}} \cdot \\ &\left(\frac{(\mathsf{plabr_{r,t}} - \mathsf{plabf_{r,t}} - \mathsf{phcon_{r,'leis',t}} - \mathsf{plabh_{r,t}} + \mathsf{plabs_{r,t}})}{(\mathsf{plabr_{r,t}} - \mathsf{VLABF_{r,t}} - \mathsf{VHCON_{r,'leis',t}} - \mathsf{VLABH_{r,t}} + \mathsf{VLABS_{r,t}})}\right)^{0.8} \\ &\geq 0 \quad \perp \mathsf{VLABS_{r,t}}\end{aligned} \tag{5}$$

Fodder restriction

$$\begin{aligned}&\mathsf{yield_{r,bio,sim,t}} \cdot \left(\left(\mathsf{landbound_r} - \sum_{jc} \mathsf{VLEVL_{r,jc}} \cdot \mathsf{plevf_{jc,t}}\right) + \mathsf{pfore_r}\right) \\ &+ \mathsf{VLEVL_{r,jc}} \cdot \mathsf{pcres_{r,jc,t}} \\ &\geq \sum_{jrum} \mathsf{VLEVL_{r,jrum}} \cdot \mathsf{pfodi_{jrum,t}} \quad \perp \mathsf{VRRED_{r,t}}\end{aligned} \tag{6}$$

Update of forest area

$$\mathsf{pfore_{r,sim+1}} = \mathsf{pfore_{r,sim}} \cdot \left(1 - \frac{\mathsf{pfore_{r,sim}}}{\mathsf{landbound_r}} \cdot \mathsf{poppres_{r,sim}} \cdot \mathsf{K}\right) \tag{7}$$

where

$$K = \frac{\sum\limits_{r} \left(\mathrm{pfore}_{r,sim} \cdot \left((1 + \mathrm{pdefo})^5 - 1 \right) \right)}{\sum\limits_{r} \left(\mathrm{pfore}_{r,sim} \cdot \frac{\mathrm{pfore}_{r,sim}}{\mathrm{landbound}_{r}} \cdot \mathrm{poppres}_{r,sim} \right)} \tag{8}$$

Water requirements

$$\begin{aligned} \mathrm{VAWAT}_{r,sim,t} = \; & \sum_{jrum} \mathrm{VLEVL}_{r,jrum} \cdot \mathrm{pawat}_{r,jrum,t} \cdot \left(4.303 + 0.0906\, e^{0.115 \cdot \mathrm{ptems}_{r,sim,t}} \right) \\ & + \mathrm{VLEVL}_{r,jcatt} \cdot 0.03 \cdot \mathrm{pyield}_{r,milk,t} \\ & + \sum_{jmon} \mathrm{VLEVL}_{r,jmon} \cdot \mathrm{pawat}_{r,jmon,t} \end{aligned} \tag{9}$$

II. Production output

Gross revenues

$$\mathrm{VGREV}_{r,j} = \sum_{i,t} \mathrm{VYIEL}_{r,i,j,t} \cdot \mathrm{VPRIS}_{r,i,t} \cdot \mathrm{plosf}_{r,i,t} \tag{10}$$

Crop areas

$$\begin{aligned} \mathrm{VLEVL}_{r,jc} = \; & (\mathrm{VGREV}_{r,jc} - \sum_{i,t} \mathrm{pinpu}_{r,i,j,t} \cdot \mathrm{VPRIS}_{r,i,t} \\ & - \sum_{t} \mathrm{plaba}_{r,jc,t} \cdot \mathrm{VSPLB}_{r,t} \\ & - \sum_{t} \mathrm{plevf}_{r,jc,t} \cdot \mathrm{VSPLD}_{r,t} \\ & - \mathrm{pmpa}_{r,jc}) \cdot \frac{1}{\mathrm{pmpb}_{r,jc}} \end{aligned} \tag{11}$$

Extensive livestock herd size

$$\begin{aligned} \mathrm{VLEVL}_{r,jl} = \; & \left(\frac{\sum\limits_{t} \mathrm{VPRES}_{r,jl,t}}{4} \right) \cdot \mathrm{pagro}_{jl} \cdot \\ & (\mathrm{VLEVL}_{r,jrum,sim-1} \cdot (1 - \mathrm{VMRED}_{r}) + \mathrm{VLEVL}_{r,jmon,sim-1}) \end{aligned} \tag{12}$$

Choosing the highest livestock reduction factor

$$\mathrm{VMRED}_{r} \geq \left(\sum_{t} \left(\mathrm{VRRED}_{r,t}^{8} \right) \right)^{\frac{1}{8}} \tag{13}$$

Price response in livestock management

$$\mathrm{VPRES}_{r,jl,t} = \left(\frac{\mathrm{VPRIS}_{r,i,t}}{\mathrm{ppris}_{r,i,t}} \right)^{\mathrm{pasel}_{r,jl}} \Big|_{j \to j(i)} \tag{14}$$

Semi-intensive livestock herd size

$$\begin{aligned} 0 \geq \quad & \mathsf{VGREV}_{r,iani} \\ & -(\mathsf{piaco}_{r,jiani} + \mathsf{plaba}_{r,jiani,t} \cdot \mathsf{VSPLB}_{r,t} \\ & \quad + \mathsf{plevf}_{r,jirum,t} \cdot \mathsf{VSPLD}_{r,t} + \mathsf{pifed}_{jimon,i,t} \cdot \mathsf{VPRIS}_{r,i,t}) \end{aligned} \tag{15}$$

Gross production or use on farm

$$\mathsf{VPROD}_{r,i,t} = \quad \mathsf{VLEVL}_{r,j} \cdot \mathsf{pyiel}_{r,i,j,t} \,|_{j \to j(i)} \tag{16}$$

Production entering markets

$$\mathsf{VMAPR}_{r,i,t} = \begin{cases} \mathsf{VPROD}_{r,i,t} \cdot \mathsf{plosf}_{r,i,t} & \text{if } r \in \mathsf{rdom} \\ (\mathsf{VPRIS}_{r,i,t} - \mathsf{qpia}_{r,i,t}) / \mathsf{qpib}_{r,i,t} & \text{if } r \in \mathsf{rnc} \end{cases} \tag{17}$$

Processing capacities

$$\mathsf{pfact}_{r,i} \geq \mathsf{VPROC}_{r,i,t} \quad \perp \mathsf{VSPPC}_{r,i,t} \tag{18}$$

Processing profitability

$$\mathsf{VPRIS}_{r,i,t} \geq \mathsf{prpri}_{r,i,t} - \mathsf{VSPPC}_{r,i,t} \quad \perp \mathsf{VPROC}_{r,i,t} \tag{19}$$

Market clearing condition

$$\begin{aligned} & \mathsf{VMAPR}_{r,i,t} + \left(\sum_{t+1} \mathsf{VSTIN}_{r,i,t+1} - \mathsf{VSTIN}_{r,i,t} \right) - \sum_{T} \mathsf{VTRAN}_{r,s,i,t} \\ & = \mathsf{VHCON}_{r,i,t} + \mathsf{VPROC}_{r,i,t} - \sum_{T} \mathsf{VTRAN}_{s,r,i,t} \end{aligned} \tag{20}$$

Spatial price transmission

$$\mathsf{VPRIS}_{r,i,t} + \mathsf{tc}_{r,s,pgrp} \geq \mathsf{VPRIS}_{s,i,t} \quad \perp \mathsf{VTRAN}_{r,s,i,t} \tag{21}$$

Temporal price transmission

$$\mathsf{VPRIS}_{r,i,t} + \mathsf{sc}_{r,pgrp} \geq \mathsf{VPRIS}_{r,i,t+1} \quad \perp \mathsf{VSTIN}_{r,i,t} \tag{22}$$

III. Income of rural households

Income from production minus input costs

$$\mathsf{VINCN}_r = 0.5 \cdot \left(\sum_{i,t} \mathsf{VMAPR}_{r,i,t} \cdot \mathsf{VPRIS}_{r,i,t} - \sum_{t} \mathsf{VLABH}_{r,t} \cdot \mathsf{VSPLB}_{r,t} \right) \tag{23}$$

Income from off-farm activities

$$\mathsf{VINCR_r} = \sum_{t} (\mathsf{VLABS_{r,t}} \cdot \mathsf{VSPLB_{r,t}}) + \mathsf{pincp_{r,t}} \quad (24)$$

Total income per capita

$$\mathsf{VINCC_r} = (\mathsf{VINCN_r} + \mathsf{VINCR_r}) \,/\, (\mathsf{ppopr_r} \cdot \mathsf{ppopt_r}) \quad (25)$$

Income equivalent from leisure per capita

$$\mathsf{VINCL_r} = \left(\sum_{t} \mathsf{VHCON_{r,'leis',t}} \cdot \mathsf{VSPLB_{r,t}} \right) / \, (\mathsf{ppopr_r} \cdot \mathsf{ppopt_r}) \quad (26)$$

IV. Commodity demand and consumption

Supply price determines rural consumer price

$$\mathsf{VPRID_{r,i,t}} = \begin{cases} \mathsf{VPRIS_{r,i,t}} & \text{if i is a consumer good} \\ \mathsf{VSPLB_{r,t}} & \text{if i is leisure} \end{cases} \quad (27)$$

Rural consumer demand per capita

$$\begin{aligned} \mathsf{VHCPR_{r,i,t}} = \; & \frac{\beta \cdot \sqrt{\frac{\mathsf{VPRID_{r,i,t}}}{\mathsf{VPRID_{r,i,t,}}}}}{\beta \cdot \sqrt{\mathsf{VPRID_{r,i,t}} \cdot \mathsf{VPRID_{r,i,t}}}} \\ & \cdot (\mathsf{VINCC_r} + \mathsf{VINCL_r} - (\mathsf{VPRID_{r,i,t}} \cdot \mathsf{ds_{r,i,t}})) \\ & + \mathsf{ds_{r,i,t}} \end{aligned} \quad (28)$$

Total consumer demand for commodities

$$\mathsf{VHCON_{r,i,t}} = \mathsf{VHCPR_{r,i,t}} \cdot \mathsf{ppopt_r} \cdot \mathsf{ppopt_r}/1,000 + \mathsf{pconu_{r,i,t}} \quad (29)$$

Total consumer demand per capita

$$\mathsf{VHCPC_{r,i,t}} = \mathsf{VHCON_{r,i,t}}/\mathsf{ppopt_r} \cdot 1,000 \quad (30)$$

Additional model results

Sensitivity analysis concerning different growth rates of livestock (BAU scenario)

Original growth rates	
Cattle:	4.2 percent per year
Small ruminants:	3.8 percent per year
Monogastric animals:	according to regional population growth

- Influence of growth rates on activity levels (BAU scenario)
- Regional distribution of livestock in 1,000 TLU

Growth rate multiplied by factor:	Region	2000	2005	2010	2015	2020	2025
0.5	North	812.3	899.5	996.2	1103.3	1163.8	1235.0
	Central	654.0	724.7	803.1	890.1	986.5	1093.3
	South	241.6	262.7	272.5	269.3	203.0	203.4
	Benin	1707.9	1886.9	2071.8	2262.7	2353.3	2531.8
0.8	North	812.3	955.2	1082.6	1177.1	1272.1	1389.8
	Central	654.0	769.9	906.5	1067.4	1257.1	1480.5
	South	241.6	276.1	297.9	312.4	238.6	253.5
	Benin	1707.9	2001.2	2287.0	2556.9	2767.7	3123.8
1.0	North	812.3	993.9	1112.7	1231.2	1359.6	1520.3
	Central	654.0	801.3	981.8	1203.1	1475.1	1807.7
	South	241.6	285.3	316.3	344.8	266.6	293.9
	Benin	1707.9	2080.5	2410.8	2779.1	3101.2	3621.9
1.2	North	812.3	1025.3	1144.8	1291.4	1460.7	1628.4
	Central	654.0	833.5	1062.2	1354.4	1727.9	2204.5
	South	241.6	294.7	335.8	380.7	298.2	341.1
	Benin	1707.9	2153.5	2542.8	3026.4	3486.8	4174.0
1.5	North	812.3	1045.6	1198.1	1396.0	1644.7	1637.3
	Central	654.0	883.6	1194.9	1616.6	2188.2	2505.5
	South	241.6	309.4	367.6	441.7	353.5	420.7
	Benin	1707.9	2238.5	2760.6	3454.2	4186.4	4563.6
2.0	North	812.3	1081.7	1300.3	1612.3	1686.2	1655.5
	Central	654.0	973.0	1449.9	2161.6	2702.4	2933.2
	South	241.6	335.3	427.7	565.6	455.2	583.0
	Benin	1707.9	2390.1	3177.9	4339.6	4843,8	5171,7

Source: Model results, 2007

Sensitivity analysis concerning different world market prices (INO scenario)

- Influence of world market prices (WMP) on livestock in 1,000 TLU
- Change of world market prices until 2025, yearly change is accordingly lower

Changes in WMP	Region	2000	2005	2010	2015	2020	2025
WMP -1%	Extensive ruminants	1601	1959	2274	2623	2925	3421
	Intensive ruminants	0	28	30	47	69	74
	Extensive monogastric animals	107	121	137	155	176	200
	Intensive monogastric animals	0	0	0	0	0	0
WMP constant	Extensive ruminants	1601	1959	2274	2624	2925	3421
	Intensive ruminants	0	28	30	46	92	73
	Extensive monogastric animals	107	121	137	155	176	200
	Intensive monogastric animals	0	7	8	9	11	13
WMP + 1%	Extensive ruminants	1601	1959	2274	2624	2925	3423
	Intensive ruminants	0	28	27	120	117	212
	Extensive monogastric animals	107	121	137	155	176	200
	Intensive monogastric animals	0	7	11	15	11	13
WMP + 2%	Extensive ruminants	1601	1959	2274	2625	2927	3426
	Intensive ruminants	0	28	92	282	445	599
	Extensive monogastric animals	107	121	137	155	176	200
	Intensive monogastric animals	0	7	8	10	12	20
WMP + 3.5%	Extensive ruminants	1601	1959	2274	2627	2930	3435
	Intensive ruminants	0	28	389	703	786	814
	Extensive monogastric animals	107	121	137	155	176	200
	Intensive monogastric animals	0	7	9	15	31	399

Source: Model results, 2007

Overview of some variables in the simulated scenarios

- Activity level: in 1,000 TLU
- Income: in 1,000 FCFA per capita and year
- Domestic market balance: in 1,000 tons

	Year	BAU	INO	COS-A (1.1% deforestation)	COS-B (30% conservation area)
Activity level	2000	1707.9	1707.9	1707.9	1707.9
	2005	2080.5	2115.5	2115.5	2078.1
	2010	2410.8	2448.5	2457.8	2409.5
	2015	2779.1	2834.3	2847.9	2797.5
	2020	3101.2	3202.9	3223.7	3164.8
	2025	3621.9	3707.1	3748.2	3621.2
Income - livestock keeping North	2000	29.4	29.4	29.4	29.4
	2005	31.0	31.0	31.0	29.2
	2010	30.5	30.5	30.8	28.8
	2015	29.9	29.9	30.3	28.6
	2020	29.6	29.6	30.0	28.5
	2025	29.5	29.5	30.0	27.7
Income - livestock keeping Central	2000	16.2	16.2	16.2	16.2
	2005	16.8	16.8	16.8	16.8
	2010	17.5	17.5	17.4	17.4
	2015	18.1	18.1	18.1	18.1
	2020	18.9	18.9	18.9	18.9
	2025	19.7	19.7	19.6	19.7
Income - livestock keeping South	2000	7.6	7.6	7.6	7.6
	2005	7.8	7.8	8.8	9.2
	2010	7.7	7.7	8.6	9.2
	2015	7.5	7.5	8.5	9.0
	2020	6.7	6.7	8.5	9.1
	2025	6.6	6.6	8.5	8.9
Domestic market balance	2000	-14.5	-14.5	-14.5	-14.5
	2005	-14.5	-11.1	-11.1	-11.5
	2010	-15.7	-11.8	-11.8	-12.1
	2015	-17.3	-12.4	-12.3	-12.6
	2020	-21.4	-14.4	-14.2	-14.9
	2025	-23.0	-15.7	-15.0	-16.9

Source: Model results, 2007

The Producer Survey – Questionnaire éleveurs d'animaux

Nom :	....	Commune :	....
Date :	....	Village:	....

I. Exploitation – Production

- *Est-ce que vous élevez des animaux domestiques ?*

Oui ☐ Non ☐

- *Quels animaux d'utilité élevez-vous ?*

Bœufs ☐
Moutons ☐
Chèvres ☐
Cochons ☐
Poules ☐
Autres ☐ ....

- *Est-ce que vous faites de l'agriculture ?*

Oui, pour les besoins propres ☐
Oui, pour les besoins propres et le marché ☐
Non ☐

Si oui, combien de pourcentage de votre temps de travail annuel employez-vous pour l'agriculture ? ....%

- *Combien d'heures vous vous occupez des animaux par jour ?* .... h/jour

- *Employez-vous du personnel saisonnier ?*

Oui ☐ Non ☐

Si oui, dans quelle branche employez-vous du personnel saisonnier ?
....

- *Existent-ils des séances de vulgarisation auxquels vous avez recours ?*

Oui ☐ Non ☐

Lesquels ? (Organisation, contenu)

....

- *Dans quels buts vous élevez vos animaux ? (Mentions multiples possibles)*

Animaux	Consom-mation personnelle	Marché	Attelage à la charrue	Transport	Cadeau	Cérémonie	Caisse d'épargne
Bovin	☐	☐	☐	☐	☐	☐	☐
Vache (Viande)	☐	☐	☐	☐	☐	☐	☐
Vache (Lait)	☐	☐	☐	☐	☐	☐	☐
Bœuf	☐	☐	☐	☐	☐	☐	☐
Taureau	☐	☐	☐	☐	☐	☐	☐
Chèvre	☐	☐	☐	☐	☐	☐	☐
Mouton	☐	☐	☐	☐	☐	☐	☐
Cochon	☐	☐	☐	☐	☐	☐	☐
Poule (Viande)	☐	☐	☐	☐	☐	☐	☐
Poule (Oeufs)	☐	☐	☐	☐	☐	☐	☐

- *À qui appartiennent les animaux ?*

	Chef de famille	Femmes	Enfants	Autres
Boeufs	☐	☐	☐	☐
Moutons	☐	☐	☐	☐
Chèvres	☐	☐	☐	☐
Cochons	☐	☐	☐	☐
Poules	☐	☐	☐	☐

• *Combien d'animaux vous possédez ?*

Animaux	<3	3-5	6-10	11-20	21-50	>50
Boeufs	☐	☐	☐	☐	☐	☐
Moutons	☐	☐	☐	☐	☐	☐
Chèvres	☐	☐	☐	☐	☐	☐
Cochons	☐	☐	☐	☐	☐	☐
Poules	☐	☐	☐	☐	☐	☐
Autres	☐	☐	☐	☐	☐	☐

• *Quels problèmes rencontrez-vous en ce qui concerne l'élevage ?*

1.) ....
2.) ....
3.) ....
4.) ....
5.) ....
6.) ....

• *Comment les animaux s'alimentent-ils en eau ? (Mentions multiples possibles)*

Les animaux cherchent un point d'eau eux-mêmes	☐
Vous conduisez les animaux à un point d'eau	☐
Vous allez chercher de l'eau pour les animaux	☐
Alimentation d'eau personnelle	☐

• *À quelle distance se trouvent les sources ? (Minute à pied ou km)*

Minimum ....
Maximum ....

- *D'où vient l'eau pour les animaux ? (Mentions multiples possibles)*

	Saison des pluies	Saison sèche
Flaques	□	□
Marigot	□	□
Fleuve	□	□
Bassin de retenue	□	□
Puits	□	□
Camion-citerne	□	□
....	□	□
....	□	□

- *Avez-vous des frais d'eau pour les animaux ?*

Oui □ Non □

Si oui, combien coûte l'eau pour les animaux ?
À la saison des pluies .... FCFA / litre
À la saison sèche .... FCFA / litre

Ou (en cas de moyens d' échange)
À la saison des pluies ....
À la saison sèche ....

- *Complétez-vous le fourrage avec ...*

	Oui	Non
Des restes de récolte	□	□
Du sel	□	□
Une pierre à lécher	□	□
....	□	□
....	□	□

Si oui, quels sont les frais pour une unité de sel ? .... FCFA/kg
Si oui, quels sont les frais pour une pierre à lécher ? .... FCFA/pierre

• *Est-ce que vous faites vacciner les animaux ?*

Oui ☐ Non ☐

Si oui, alors :

Animal	Contre	Combien de fois	Frais
Par ex. Poule	Newcastle	par an	FCFA/vaccination

Si non, pourquoi pas ? ....

• *Comment élevez vous vos animaux ? (Mentions multiples possibles)*

Animaux	Libre	Attaché la nuit	Attaché toute la journée	Parc	Abri	Étable (avec des murs latéraux)
Boeufs	☐	☐	☐	☐	☐	☐
Taureaux	☐	☐	☐	☐	☐	☐
Vaches	☐	☐	☐	☐	☐	☐
Veaux	☐	☐	☐	☐	☐	☐
Chèvres	☐	☐	☐	☐	☐	☐
Moutons	☐	☐	☐	☐	☐	☐
Cochons	☐	☐	☐	☐	☐	☐
Poules	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐

• *Possédez-vous des surfaces fourragères vous permettant de cultiver du fourrage ?*

Si oui, quelles cultures et dans quel volume ? ....

Si non, pourquoi pas ? ....

• *Comment estimez-vous l'effet restrictif des points suivants ?*
(1= pas du tout limitatif ; 10 = extrêmement limitatif)

	1	-	-	-	-	-	-	-	-	10
Maladies	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Manque de fourrage	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Manque d'eau	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Pénurie de terre	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Accès aux vétérinaires	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

• *Que faites-vous, si vous n'avez pas assez de fourrage pour vos animaux ?*
....
....

• *Vous partez en transhumance?*

	À la saison des pluies	À la saison sèche
Oui	☐	☐
Non	☐	☐

• *Est-ce que vous avez des contrats d'engrais avec les agriculteurs ?*

Oui ☐ Non ☐

II. Commercialisation et transport

• *Qui est-ce que décide la vente d'un animal ?*

....

....

• *Quand ou pourquoi les animaux sont vendus ? (date)*

Quand on a besoin d'argent	☐
Quand le prix est bon	☐
Quand l'animal est malade	☐
Quand il manque du fourrage	☐
Quand il manque de l'eau	☐
Quand l'animal est adulte	☐
....	☐
....	☐
....	☐

• *Où est-ce que les animaux sont vendus ? (Mentions multiples possibles)*

Animaux	Voisin	Marché du village	Marché régional	Commerçants	....	....
Vache	☐	☐	☐	☐	☐	☐
Taureau	☐	☐	☐	☐	☐	☐
Veau	☐	☐	☐	☐	☐	☐
Mouton	☐	☐	☐	☐	☐	☐
Chèvre	☐	☐	☐	☐	☐	☐
Cochon	☐	☐	☐	☐	☐	☐
Poule	☐	☐	☐	☐	☐	☐

• *Combien d'animaux ont été [. . .] l'année dernière (depuis le début de la dernière grande sécheresse)*

Animaux	vendus	Consommation privée	Donnés en cadeau (y compris cérémonie)	morts	achetés	nés
Boeufs						
Moutons						
Chèvres						
Cochons						
Poules						

• *A quelle distance se trouve le marché le plus proche ? (en km)*

....

• *Combien de fois un commerçant passe dans votre village?*

1 fois par semaine ☐
1 fois par mois ☐
1 fois par demi-an ☐
1 fois par an ☐
jamais ☐

• *Comment est-ce que vous emmenez vos animaux au marché ?*

À pied (vous-mêmes) ☐
En vélo ☐
En moto ☐
En taxi ☐
Avec votre propre voiture ☐
En camion ☐
.... ☐
.... ☐

• *Quels sont vos frais pour emmener vos animaux au marché, lorsque vous n'utilisez pas vos propres moyens de transport?*

.... FCFA/ ....

.... FCFA/ ....

.... FCFA/ ....

• *Quelles sont actuellement vos difficultés majeures en ce qui concerne la vente des animaux ?*

(1 = aucun problème; 10 = très grand problème)

	1	-	-	-	-	-	-	-	-	10
Distance	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Frais de transport	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Réfrigération	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Commerçants intermédiaires	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Accès aux marchés/taxe	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Prix bas	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Standards des vétérinaires	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

• *Quel âge ont les boeufs au moment de la vente ?*

Taureaux ....

Vaches ....

• *Quels seraient les moyens pour :*

- augmenter la production

....

....

- diminuer les conflits entre les fermiers et les propriétaires d'animaux

....

....

Nous vous remercions de votre collaboration !

The Expert Survey – Questionnaire expert

Nom : .... Organisation : ....
Date : .... Lieu : ....

I. Situation actuelle

• *Quelles sont actuellement les difficultés techniques de production majeures dans l'exploitation du bétail?*

1.) ....
2.) ....
3.) ....
4.) ....

• *Comment estimez-vous l'effet restrictif des points suivants sur la production?*
(1 = pas du tout limitatif; 10 = extrêmement limitatif)

	1	-	-	-	-	-	-	-	-	10
Maladies	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Manque de fourrages	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Manque d'eau	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Pénurie de terre	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Administration	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Accès aux vétérinaires	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

• *Existent-ils actuellement encore suffisamment d'aires de pâturage?*

		Sud[1)]	Centre[1)]	Nord[1)]
À la saison des pluies	oui	☐	☐	☐
	non	☐	☐	☐
À la saison sèche	oui	☐	☐	☐
	non	☐	☐	☐

• *Comment jugez-vous les chances pour une diversification des produits animaux au moyen des petits animaux?*

	Faible	Moyenne	Elevée
Amélioration des revenus du producteur	☐	☐	☐
Amélioration et augmentation de l'alimentation avec des produits animaux	☐	☐	☐

• *Quelles sont les entraves pour la réalisation d'innovations?*
(1 = pas du tout gênant; 10 = extrêmement gênant)

	1	-	-	-	-	-	-	-	-	10
Connaissances/savoir	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Droit d'utilisation des terres	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Manque d'argent liquide	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Manque d'un marché de crédits	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Achat de matériel	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

- entraves pour l'utilisation de charrue:
....
....
- entraves pour la culture fourragère:
....
....

• *Quels sont les frais par animal pour les vaccinations ?*

Bœufs	....	FCFA/animal et année
Moutons	....	FCFA/animal et année
Chèvres	....	FCFA/animal et année
Cochons	....	FCFA/animal et année
Poules	....	FCFA/animal et année

• *Quelles sont actuellement les difficultés majeures pour les producteurs d'animaux lors de la commercialisation des produits animaux ?*
(1 =pas du tout difficile; 10 = très difficile)

	1	-	-	-	-	-	-	-	-	10
Distance de transport/ frais	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Distance des marchés	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Moyens de transport appropriés	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Chaîne de congélation	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Commerçants intermédiaires	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Accès aux marchés	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Manque de possibilités de commercialisation	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Impôts	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Concurrence	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Standards des vétérinaires	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

• *La politique agricole béninoise s'occupe-t-elle plus de la production végétale ou de la production animale ?*

☐ Production végétale
☐ Production animale

Pourquoi?
....
....

• *Existent-ils des règlements gouvernementaux concernant :*

	Oui	Non
l'exploitation générale des pâturages	☐	☐
l'exploitation de l'eau	☐	☐
le passage de la frontière	☐	☐

Si oui, en quoi consistent-ils ? (Mots-clés les plus importants)

....

....

• *Quelles sont les obligations du propriétaire d'animaux lorsqu'il quitte ou entre au Bénin avec des animaux domestique ? (Mentions multiples possibles)*

	Oui	Non	Combien
Inscription préalable	☐	☐	
Enregistrement à l'entrée	☐	☐	
Payer une taxe par animal	☐	☐	.... FCFA/animal
Taxe par troupeau	☐	☐	.... FCFA/troupeau
Déposer une caution	☐	☐	.... FCFA/..................

• *Quels sont les impôts et les taxes que les propriétaires d'animaux doivent verser et quelle subvention reçoivent-ils?*

	Oui	Non
T.V.A. achat/vente d'animaux	☐	☐
Impôt sur le revenu	☐	☐
Impôt spécifique à l'animal	☐	☐
Taxe de marché	☐	☐
Commerçants	☐	☐
Taxe d'abattage	☐	☐
....	☐	☐
....	☐	☐
Produits d'entrée bon marché (par ex. sel, médicaments)	☐	☐
Subvention en cas d'innovations	☐	☐
....	☐	☐
....	☐	☐
....	☐	☐

• *Quelle législation serait utile*
- pour augmenter la production?
....
....

- pour diminuer les conflits entre les fermiers et les éleveurs ?
....
....

II. Tendances – développement

• *Comment l'augmentation des besoins en produits animaux sera-t-elle couverte dans les vingt prochaines années? (Mentions multiples possibles)*

☐ Augmentation des importations
☐ Expansion du nombre des animaux
☐ Augmentation du rendement

Raisons: ....
....

• *Faites votre propre évaluation: comment se composeront les races d'animaux d'utilité en 2025?*

	Races traditionnelles	Races croisées	Races de haut niveau
Bœuf	.... %	.... %	.................%
Mouton	.... %	.... %	.................%
Chèvre	.... %	.... %	.................%
Cochon	.... %	.... %	.................%
Poule	.... %	.... %	.................%

• *Comment se développeront les chiffres des animaux dans les vingt prochaines années?*

	Bœuf	Mouton	Chèvre	Cochon	Poule
Comme le nombre d'habitants, environ 2,8 %	□	□	□	□	□
Plus que le nombre d'habitants, $>$ 3%	□	□	□	□	□
Moins que le nombre d'habitants, $<$ 2,5 %	□	□	□	□	□

□ autre facteur d'orientation : ....

Raisons: ....
....

• *Comment se développera l'élevage des bêtes de trait jusqu'en 2025?*

	Sud[1)]	Centre[1)]	Nord[1)]
Diminution du nombre de bêtes de trait	□	□	□
Nombre de bêtes de trait constant	□	□	□
Augmentation du nombre de bêtes de trait de 2,5%	□	□	□
Nombre de bêtes de trait supérieur à 3%	□	□	□

• *Comment se développera la transhumance?*

Jusqu'en 2015 :	Sud[1)]	Centre[1)]	Nord1[1)]
Maintien du volume actuel	☐	☐	☐
Diminution du nombre d'animaux	☐	☐	☐
Pas de grande transhumance	☐	☐	☐
Augmentation du nombre d'animaux	☐	☐	☐
Jusqu'en 2025 :	Sud[1)]	Centre[1)]	Nord[1)]
Maintien du volume actuel	☐	☐	☐
Diminution du nombre d'animaux	☐	☐	☐
Pas de grande transhumance	☐	☐	☐
Augmentation du nombre d'animaux	☐	☐	☐

• *Y-aura-t-il un accroissement du rendement dans les 20 prochaines années?*

	Oui	Non	Actuellement	En 2025
Production de lait (kg/vache et année)	☐	☐	200 kg/année	.... kg/année
Production de viande de bœuf (kg/animal)	☐	☐	117 kg/animal	.... kg/animal
Production de viande de mouton (kg/animal)	☐	☐	10 kg/animal	.... kg/animal
Production de viande de chèvre (kg/animal)	☐	☐	10 kg/animal	.... kg/animal
Production de viande porcine (kg/animal)	☐	☐	20 kg/animal	.... kg/animal
Mortalité bovine (%)	☐	☐	7,5 %	.... %
Mortalité des petits ruminants (%)	☐	☐	18 %	.... %
Mortalité porcine (%)	☐	☐	6 %	.... %
Mortalité des poules (%)	☐	☐	2-63 %	.... %

• *Quel est le facteur déclencheur pour intensifier la technique de production et augmenter la production? (par ex. intervention d'un vétérinaire, culture fourragère, changer le système d'élevage, élevage)*
(1 = attrait faible; 10 = attrait fort)

	1	-	-	-	-	-	-	-	-	10
Manque de fourrage	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Manque d'eau	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Pénurie de terre	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Manque de personnel	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Maladies	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Prix du marché élevés	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Produits d'entrée bon marché	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Vulgarisation gouvernementale	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Expérience du voisin	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Accès facile aux produits d'entrée	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Législation	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Standards de commercialisation	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

• *À combien estimez-vous le volume de la culture fourragère par rapport à la surface d'exploitation agricole?*

En 2015: .... % de la surface agricole
2025: .... % de la surface agricole

• *Quelles conditions est-ce qu'il faudra encore créer, afin d'intensifier l'élevage d'animaux?*

1.) ....
2.) ....
3.) ....
4.) ....
5.) ....

• *La consommation de viande actuelle s'élève à 7- 8 kg de viande par personne et par an. Comment la consommation de viande se développera jusqu'en*

2015: .... kg/personne ou .... %
2025: .... kg/personne ou .... % ?

• *Le taux des animaux négociés, qui sont vendus sur les marchées autonomes augmente-t-il ?*

	Oui	Non
Bœufs	☐	☐
Moutons	☐	☐
Chèvres	☐	☐
Cochons	☐	☐
Poules	☐	☐

• *Quelles sont vos demandes pour les années prochaines?*
....
....

Nous vous remercions de votre collaboration !

1) Sud = départements Atlantique, Littoral, Ouémé, Plateau, Mono, Couffo, Zou
Centre = départements Collines, Donga, Borgou
Nord = départements Atacora, Alibori