Characteristics of the smallholder dairying farmers in West African countries: Economic viability and paths for improvement.

Socio-economic research Working Paper 2

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ISBN 9983 9910 44

Correct citation:
Somda, J., Kamuanga, M., Münstermann, S., Keita,K., Mendes, A. 2004.
Characteristics of the smallholder dairying farmers in West African countries: Economic viability and paths for improvement.
Socio- economic research Working Paper No 2. ITC (International Trypanotolerance Centre), Banjul, The Gambia, 55 pp.

Table of contents

List of tables

Abbreviations and acronyms

FCFA	Franc CFA
CIRDES	Centre International de Recherche-Développement de l'Élevage
DGP	Direccio Geral da Pecuaria
DLS	Department of Livestock Services
DNE	Direction Nationale de l'Élevage
FAO	Food and Agriculture Organisation
GMD	Gambia Dalasi
IDRC	International Development Research Centre
IFPRI	International Food Policy Research Institute
ILCA	International Livestock Centre for Africa
ILRI	International Livestock Research Institute
INPA	Instituto Nacional de Pesquisa Agraria
IRAG	Institut de Recherche Agricole de Guinée
IRD	Institut de Recherche pour le Développement
ITC	International Trypanotolerance Centre
NARS	National Agricultural Research Systems
PASA	Programme d'Ajustement Structurel du Secteur Agricole
PROCORDEL,	Programme Concerté de Recherche-Développement de l'Élevage en Afrique de l'Ouest
SSA	Sub-Saharan Africa
US$	US dollar

Acknowledgements

This study was conducted as part of a broader Research-Development agenda under the Programme Concerté de Recherche-Développement (PROCORDEL) on Livestock in the West Africa countries. The research project was funded by the European Union under REG/6061/006, and implemented by the International Trypanotolerance Centre (ITC) with the collaboration of the National Agricultural Research Systems (NARS) and the International Livestock Research Institute (ILRI). We thank the following people, without whose help during the fieldwork, this paper would not have been completed . They are Binta Jallow, Sisawo Jarju and Yusupha Sama from ITC and the staff of the Department of Livestock Services (DLS); and the enumerators from Guinea (Direction Nationale d'Elevage, DNE and the Institut de Recherches Agricoles de Guinée, IRAG) and Guinea Bissau (Instituto Nacional de Pesquisa Agraria, INPA and Direcao Geral da Pecuaria, DGP). The authors wish to thank **Dr Alexandra P M Shaw (**A P Consultants, England) and **Mr Martin Taylor,** BSc. (hons), DIC MSc, Cbiol, MIBiol, The Gambia, for scientific comments, editing and proof reading. Usual disclaimers apply.

EXECUTIVE SUMMARY

This study examines the characteristics of the smallholder dairy farmers in three West African countries, namely The Gambia, Guinea and Guinea Bissau. In these countries as in much of West Africa, milk is produced within mixed crop-livestock farming systems. Traditionally farmers own cattle for various purposes including milk, meat, draft animal power, and so forth. Milk and milk products in these systems play an important role in providing food and income. It is argued that an increase of milk production will generate more income and contribute to poverty alleviation. Whilst there is an increasing interest in smallholder dairy schemes by the different governments in the region, at the same time information on the current situation from the producers' perspective is scanty.

The overall objective of the study is to assess cost-effectiveness and sustainability for domestic milk production in relation with the socio-economic characteristics of smallholders. Specific objectives in each country were (a) to characterise livestock production systems with a focus on milk production; (b) to typify milk-oriented smallholder farms; (c) to evaluate the economic performance and viability of smallholder milk production, and (d) to identify domains/areas for improving domestic milk production.

Detailed data on the resources and milk production variables were collected at the farm household level in each country's representative sites, in terms of their livestock population. The household was defined as single units of individuals living, producing and consuming together and led by the head of the household (HH). Cluster and discriminant analyses were used to characterise and typify the household on the resource endowment basis. Enterprise budgeting techniques allowed estimating of the economic performance and viability of the current milk production. Simple comparison test statistics were used to assess the effect of the resources level on the milk production (sales and home consumption), and on the economic performance and viability. Comparisons were also carried out on the herd structure, the management of

the major resources used in milk production (labour, feed and veterinary inputs), as well as on the milk offtake (sales and home consumption).

For the households considered in this study, there were significant differences in levels of resources such as land, herd cattle (local and cross bred cattle), family labour and the amount of agricultural investments. Various socio-professional individuals are involved in cattle rearing, including civil servants and other groups. The education of most farmers remains at a minimum level. Generally two types of resource-based smallholders were identified, using the cluster and discriminant analyses. Although dissimilarities exist between smallholders in terms of resources in general and cattle assets in particular, the herd structure was similar between those farm households owning few cattle and those with large herds. On the other hand, the composition of the herd differs whether the farmer is wealthy or not. For example, in The Gambia, the wealthiest farmers import Zebu breeds from Senegal to upgrade their local N'Dama population. Other similarities of the smallholder farm households were the feeding, health care practices and labour management for livestock production. As feed resources, they all rely on natural forage, crop residues and some agricultural by-products. Veterinary inputs are provided by private or state services.

Based on resource levels, an average gross margin of US $3,238 was estimated for the richest farmers, US $1,894 for the rich, US $307 for the medium group in Guinea Bissau, whilst the poorest farmers realised an average of US $203 per farm, annually. In The Gambia, the gross margin from milk production averaged US $911 and $1,111 for the resource-poor and medium farmers, respectively. This value is estimated at only US $1.99 for the poor farmer and US $41.84 for the medium group in Guinea sample. Overall, the current dairy production is economically profitable, although clear differences exist between countries. These results call for different dairy development approaches between countries and also between smallholders within the same country.

For all but the resource-poor in Guinea and Guinea Bissau, the capital turnover ratio was less than one, at the point where farmers could be indifferent between selling all the dairy stock out or keeping it for milk production. The resource-poor groups in Guinea and Guinea Bissau would have been better off if they could sell out their dairy cattle rather than keeping them for milk production. One reason why this is not so could be that they are still at the accumulation stage and expect to benefit later from milk production.

There are several options for increasing milk productivity and developing smallholder dairy systems. However, these systems face two major challenges in the current production environment of West Africa: inappropriate technologies, and the need to increase efficiency associated with the environmental problems. Increasing the number of the dairy cattle represents one such option in the smallholders' hands irrespective of the resource levels. Likewise, increasing cow productivity through improved feeding and health care constitutes another option, which is not related to the resource levels. However, improving the genetic merit of the local cattle would likely be resource-related, as indicated by results obtained from The Gambia study. This technology also requires more investment for feed and healthcare, and for labour input requirements as well.

In sum, smallholders in West Africa should not be considered as homogenous. They are differently endowed in productive resources (land, labour, cattle) and in their investment capability as well. Although they might face the same hidden constraints (access to credit and market facilities), small producers with much fewer resources find it difficult to improve their production base. Poverty alleviation policies must be slated in an approach to help the rural poor to better participate in the economic growth made possible through the perceptible increase demand in dairy products. There will otherwise be a risk that industrial dairy producers drive out the poor, and the only growing market they presently compete in will be closed to them. Future research should also be geared towards producing a diversified range of appropriate technical options to suit the needs of farmers with different resource endowments,

management skills and the ability to bear risk. Further research would also be needed to extend this static analysis in order to capture the long-term strategies of the smallholder dairy farms. Setting a simple monitoring scheme would allow accounting for the value of calves and cows' replacement in the economic analysis of dairying in the farming systems.

I. INTRODUCTION

Over 95% of the milk produced in West Africa is derived from the traditional livestock sector (Mbogoh, 1984). The dairy herds are kept primarily in smallholder's households, where milk is processed before selling. Milk production, processing and marketing are thus combined within numerous small independent dairy "units". In the last few decades, growth in agricultural production has been slow in tropical Africa in general and West Africa in particular. During this period, the increase in animal production has been achieved primarily through increase in livestock numbers whilst the productivity of animals remains very low (Ibrahim Bulale, 2000). This has led to some extent to the deterioration of natural resources and land degradation thereby adding to the phenomenon of drought, malnutrition and starvation.

On the other hand, the low productivity of the agricultural sector has increased the gap between the supply and demand for food. For instance, in sub-Saharan Africa (SSA), dairy products supply fewer than 2% of calories and around 4% of protein in the average human diet (Michael et al., 1991). In 1998, it was estimated that West Africa accounts for 25% of the SSA cattle (FAO, 1999), the main dairy livestock in this region. Consequently, sub-Saharan countries have for long time been net-importers of food, particularly products of animal origin such as milk. Aggregate demand for dairy products in West Africa grew steadily in the 1960s through the early 1980s due to rising human populations, urbanisation, and increase in per capita income (Walshe et al., 1991; Delgado et al., 1999). In 1997 the net dairy import consumption per capita rose to 7.5 kg/capita from 5.1 kg/capita in 1987 (Nicholson et al., 1999). There was also a small increase in production from 8.1 to 10 kg/capita.

It is shown in Nicholson et al. (1999) that West Africa as a region has not only one of the highest urbanisation and population growth rates, but also harbours the emerging markets in the coastal cities (Dreschel et al., 1998) that will make the region a major consumption centre of livestock products in general and dairy products in particular. Whether the domestic production systems will positively respond to the increased

demand for dairy products, and take advantage of it, remains questionable. It is well known that the domestic source of supply of dairy products in these countries is dominated by the mixed crop-livestock production system. This system is relatively well developed because of the beneficial effects resulting from inter-relationships and complementarities between crops and livestock processes (Ibrahim Bulale, 2000).

Dairy production, in this context, is to be seen as a component of the farming system, in which dairy and crops enterprises are associated and mutually beneficial. The individual landholding allows for opportunities for improved feed production. Thus, smallholder dairy production can be improved without affecting the primary function of animals and could be attractive in the mixed farming system, as it offers the opportunity to diversify operations, spread risk and provide income (Gryseels, 1988).

Despite the substantial amount of investment made in livestock development projects throughout Africa, the success and impacts have generally been disappointingly small. Livestock owners did not widely adopt the technology packages brought about through the projects. Several reasons are advocated for these failures and the beneficiaries' reluctance due to cultural and socio-economic factors (Kebede et al., 1990; Starkey, 1991). For the World Bank (1985), the reasons for the failures of livestock development projects could be due to inappropriate project design arising from lack of understanding of livestock production systems, as well as lack of suitable and thus appropriate technologies. All these criticisms in summary identify the need and necessity to improve our knowledge of the farming systems any time such intervention is contemplated. Thus, it is important to analyse the rationale for integrating dairy production enterprises into farming systems and to identify the conditions needed for improvement.

This study attempts to analyse the present situation of dairy systems in selected countries of West Africa, namely The Gambia, Guinea and Guinea Bissau. The study is limited to dairy production and marketing at the household level. The marketing structure is depicted from the small-scale producers' point of view, where sales are not

directed to consumers but rather have to pass via intermediaries, with the description stopping at the point when the milk products are no longer in the hands of the producers and sellers.

This study forms part of a wider research-development programme of livestock production in West Africa (PROCORDEL), conducted by the International Trypanotolerance Centre (ITC) with the collaboration of the National Agricultural Research System (NARS) in the selected countries. The programme aimed at gaining sufficient understanding of the existing livestock production systems in order to develop appropriate and improved technologies to increase productivity.

II. OBJECTIVES OF THE STUDY

The overall objective of the study is to assess the cost-effectiveness and sustainability of domestic milk production in relation with the socio-economic characteristics of smallholders.

The specific objectives in each country were to:

1. Characterise livestock production systems with a focus on milk production;
2. Typify milk-oriented smallholder farms;
3. Evaluate the economic performance and viability of smallholder milk production;
4. Identify domains for improving domestic milk production.

III. HYPOTHESES

1. Heterogeneity of smallholders

Smallholders are not homogenous in terms of resources they own. Structural variables such as the household size, cultivated land area, the size of the herd, the investment made for farming and rearing livestock, and the breed owned by the producers are determinant in discriminating smallholders into wealth groups.

2. *Dairy stock, milk production and management*

As a consequence of the resource endowment, the farmer's wealth can affect the herd composition and structure; and subsequently the production and management of milk.

3. *Performance and viability of smallholder dairy production*

Smallholder dairy production units are economically profitable and viable, but this is affected by the farmer's wealth. It is therefore hypothesized that not all smallholder dairy farmers can achieve the same level of cost efficiency.

4. *Dairy production technology adoption*

Possible options for increasing domestic milk production and closing the gap between demand and supply are available:

- increasing cow productivity
- increasing the number of milking cows
- improving the reproduction rate and genetic merit of existing herds (Agyemang, 2000).

It is further hypothesized that needs for improved technology for dairy production is wealth-related.

IV. SAMPLING PROCEDURES, DATA COLLECTION AND ANALYSIS METHODS

The methodologies described hereafter are adapted from Rey et al. (1999) after inclusion of relevant modifications regarding the approach. Instead of a system-based approach, this study follows an approach that is based on the producer as focal point, regardless of the system in which he is operating. Basically, we argue that what matters for the performance of the domestic dairy system as a whole, is the resources that producers are endowed with. Furthermore, in the mixed farming system under study, extensive and intensive production systems often coexist in the farm household. This implies that intensification is more related to the resources available at farm level, than to fortuitous evolution of a system. The system characterisation thus focused on crop-livestock systems that included milk production as an activity.

4.1. Location of the study sites

The study sites were located in three countries, namely The Gambia, Guinea, Guinea Bissau. In each country, sites were purposely selected to reflect locations of the most important milk-oriented production systems. Thus local government areas contiguous to the cities or high human concentration areas were selected; thereafter villages and households were randomly selected after a sample frame was either established or updated.

The Gambia is one of the most densely populated countries in Africa (103 inhabitants per km^2) with a population of 1.1 million people, and total land area of 6,300 km^2 (Camara and Kamuanga, 1995). About 68% of the total area is considered arable agricultural land suitable for crops and livestock (Camara and Kamuanga, 1995). Cattle population predominantly consists of trypanotolerant N'Dama and to a lesser extent trypano-susceptible zebu cattle, a breed introduced from Senegal. N'Dama cattle are owned and managed by smallholders under traditional low-input systems (Njie and Agyemang, 1991; Somda et al., 2003) whilst a few Zebu cattle are kept under backyard management practices. In addition, crossbred cattle are being introduced at farm level in the Western Division. Three administrative divisions (Central River Division, Lower River Division and Western Division), were selected due to their high cattle population. Of the total cattle stock estimated at around 300, 000 heads, the 3 divisions account for 55% of the total (DLS/ITC, 1993). In each Division, villages were purposely selected with the assistance of the livestock assistants from the Department of Livestock Services and a list of livestock of all owners was established as a sampling frame.

Guinea has a total land area of 247,857 km^2 with a relatively low density (19 inhabitants per km^2). The country possesses enormous agricultural potential, which varies according to the four natural agro-ecological zones: Guinée Maritime, Moyenne Guinée, Haute Guinée and Guinée Forestière (DNE, 1997). The predominant dairy cattle breed is the N'Dama, which is managed under low-input system. However, few

crosses (N'Dama x zebu cattle) are found in Haute Guinea. The regional distribution of cattle from the census conducted in 1995, is as follows: Maritime (17%), Moyenne (41%), Haute (34%) and Forestière (8%). The Haute Guinea thus represents the second most important region in terms of livestock production. Furthermore, several projects are being implemented with a dairy component and the introduction of crossbreeds. In this region, villages were purposely selected.

Guinea-Bissau lies on the west coast of Africa and has a land area of 36,125 km^2. Land surface accounts for 78% of the total area, the remaining being mangrove forested land (Teixeira, 1962 cited by Gonçalves, 1995). The total population is estimated at 976,322 (DEA/MDRA, 1992) with a density of 37 inhabitants per km^2. The country is administratively divided into nine regions where the population is unevenly distributed. Likewise, the regional density of the livestock population and specifically cattle is unequal. The Eastern zone (regions of Bafata and Gabu) has the highest livestock density accounting for 74% of cattle (MDRA/DGP, 1991). The Northern zone (regions of Cacheu and Oio) follows the east in terms of livestock numbers, particularly the Oio region with 13% of cattle. Cattle belong exclusively to the N'Dama breed (FAO, 1980) and are extensively managed in relation with the socio-economic background of the livestock owners (Gonçalves, 1995). In Guinea Bissau, the regions of Bafata and Gabu were selected because of the high number of cattle, mainly N'Dama breed. A list of villages was obtained from the livestock services to serve as a sampling frame.

4.2. Farm household sampling

A household is defined here following Waters-Bayer (1988) as: "all persons living in one group of dwelling and associated with at least one herd of cattle under the management of the household head". Hopen (1958) had similarly defined the Fula household as "that group of individuals of both sexes who lay legitimate claim to the resources of a given herd". The procedures used in the selection of households differed in each country, as was the final sample size. Depending on the availability of

secondary data in the selected countries, the sampling of the farm households proceeded as follows:

In The Gambia, the study sites were selected based on Agyemang et al. (2000) who reported basic information on livestock production with emphasis on milk. A census was then conducted between April and May 2001 to identify farm households and constitute a sample frame. A total of 501 farmers were enumerated during this census in selected areas and data collected on farming activities (crop and livestock), production objectives, and utilisation of crop and livestock products and cash farm income. The information collected provided an opportunity to randomly select a sub-sample of 90 livestock owners involved in milk production.

In Guinea, a database from the previous livestock census in the Labé area (Moyenne Guinée) was used to randomly select 100 potential milk producers of which 88 livestock owners were actually enumerated to complete the socio-economic survey.

Finally, in Guinea Bissau, a different sampling procedure was used: key informants were asked to assist determining a purposeful sample of milk-oriented farm households. Extension agents, assisted by village' leaders, were asked to update the list of livestock owners and the number of cattle they owned. A total of 133 livestock owners were then enumerated in Guinea Bissau.

In practice overall sample selection of farmers was based on two main criteria: cattle ownership and raising a minimum of three milking cows.

4.3. Data collection methods

Information was obtained normally through individual interviews with households' heads, who could be replaced—when and where necessary—by the person in charge of milk management or any other respondent involved in milk production and management. Open-ended questionnaires were pre-tested in each country site to adapt

the content to the local socio-economic environment and for clarity of the interview session.

The structure of the questionnaire was similar in all three sites/countries, in order to facilitate data entry, processing and analysis using the Statistical Program for Social Science (SPSS). This made it possible to compare the results across countries.

The questionnaire comprised eight sections: .

- In Section I, information was collected on the socio-economic background (age, ethnicity, education, etc.) of the household's head and the characteristics of farm households, the size and structure of the household, the area cultivated with associated crops and production.
- Section II provides for information on agricultural investment and/or assets (farming equipment, buildings, etc.), herd size, composition and structure.
- Section III gives information on health care and herd rearing including feeding;
- In section IV and subsequent sections, data were collected on feeds (Section IV), milk production and management (Section V), reproduction and genetic improvement (Section VI), exploitation of livestock and livestock products (Section VII) and milk marketing and finance (Section VIII).

4.4. Data analysis and statistical methodology

In describing the farming system, descriptive statistics such as mean, standard error and deviation and frequencies or percentages were calculated for area under cultivation, crop and production, cattle number and composition, feeding strategies, household size and composition, and other socio-economic characteristics of the farmers.

To typify the smallholder farmers, two analytical steps were used: (1) a stepwise cluster analysis to predict resource-based group membership from a set of structural variables including household labour, the stock of local cattle, the stock of improved

breed (if any), the land areas, investments into intermediary and short-term assets; then (2) a discriminant analysis was applied to the stratified smallholder farmers in order to identify the variables that most determine the differences between farmers or groups of farmers.

The statistical procedure for the cluster and discriminant analyses uses the theory of maximising between groups' differences while minimising within group variation (Klecka, 1980). The K-means analysis is applied to assign a specific case (farmer) to the particular group it belongs or most closely resembles. Given n farmers with p variables measured on each farmer, x_{ij} for $i = 1, 2, \ldots n$; $j = 1, 2, \ldots, p$. K-means clustering consists of allocating each observation to one K groups or clusters to minimise the within-cluster sum of squares (equation 1):

$$(1) \qquad \sum_{k=1}^{K} \sum_{i \in S_k} \sum_{j=1}^{p} \left(x_{ij} - \bar{x}_{kj} \right)^2 ,$$

where S_k is the set of farmers in the k^{th} cluster and $\bar{x}_{kj}$ the mean for the variable j over cluster k. The number of K was selected to ensure the recommendations drawn from the results are technically and practically feasible, rather than theoretical.

Then, a canonical discriminant function (equation 2) is derived to study the nature of group differences. It has the following mathematical form:

$$(2) \qquad f_{kn} = u_0 + u_1 X_{1kn} + u_2 X_{2kn} + \ldots + u_p X_{pkn} ,$$

where f_{kn} is the value (score) on the canonical discriminant function for case m in the group k; X_{ikn} represents the value on discriminating variable X_i for case n in group k; and u_i are coefficients that produce the desired characteristics in the function. The coefficients for each function are derived so that group means on the function are as different as possible.

Each type of farmers was assessed to determine the present gross margin from an economic analysis standpoint. This is based on the enterprise budget, which is a statement of costs and returns (e.g. costs of inputs such as feed, veterinary and labour, and income from milk production. The accrual method of accounting represents an

easier way to provide information on the economic performance of a farming activity, where common resources are often used and disentangling common costs is not feasible. The economic viability of a smallholder dairy production unit is an important aspect to examine in order to justify the farmer's decision to engage and invest in this enterprise.

V. RESULTS AND DISCUSSION

In sub-Saharan Africa, livestock production has been classified into three major systems (Jahnke, 1982): range-livestock production system, landless production system and crop-livestock production. The latter system can be defined as a land use system in which crops and livestock production are practiced in association (McIntire and Gryseels, 1987), and is predominant in the countries of the study. It is well known that crop and livestock production are integrated through the use of animal traction and manure for cropping and the use of crop residues as animal feeds. However, the strength of this integration depends on the intensity with which farmers make use of these by-products from both crop and livestock. It is therefore worthwhile to start the analysis of smallholder dairy production in the context of the mixed farming system by considering the potential of various feeds that can be derived from crop production.

5.1. Description of the mixed crop-livestock farming systems

Table 1 shows the major crops produced by the sample farm households in each country. In The Gambia, rice is the most frequent crop on farms (80% of the sample) and occupies the largest farmland area (1.94 ha). Millet represents the second most important crop in terms of the proportion of farmers involved (67%) and the average area cropped (1.38 ha). The third most important crop is groundnut, with 49% of the sample involved, and the average area estimated at 1.2 ha. Maize and cassava are marginally cropped amongst the sample farms, while sorghum, *fonio*, cashew and cotton are not found.

Table 1: Average farmlands' size (ha) and proportion of farm households involved (%)

	The Gambia (N=90)		Guinea (N=87)		Guinea Bissau (N=133)	
Major Crops	Mean (ha)	%	Mean (ha)	%	Mean (ha)	%
Rice	1.94 (1.83)	80.24	1.01 (0.93)	7.5	1.06 (1.26)	65.41
Maize	0.11 (0.44)	7.98	0.80 (0.39)	35.41	1.05 (1.11)	70.68
Sorghum	-	-	-	-	1.64 (1.44)	81.20
Millet	1.38 (1.69)	66.67	-	-	0.89 (1.08)	58.65
Fonio	-	-	1.22 (1.59)	32.5	0.02 (0.19)	1.50
Groundnut	1.20 (1.75)	49.10	0.19 (0.16)	9.17	0.72 (0.95)	56.39
Cotton	-	-	-	-	0.18 (0.59)	12.03
Cashew	-	-	-	-	0.09 (0.59)	3.01
Cassava	0.21 (0.48)	1.39	0.34 (0.16)	9.58	0.02 (0.18)	1.50

Figures in parenthesis are standard deviation. % is the percent of the sample farmers producing each crop.

Source: survey data

In Guinea, the types of crops most frequently grown are maize (35% of the sample) and *fonio* (33%). The average areas cultivated in maize and *fonio* are 0.80 and 1.22 ha, respectively. Groundnut, cassava and rice are minor crops in the survey sites in Guinea. Groundnut is cropped in 9% of the cases on small areas (0.19 ha). Likewise, cassava producers are not many (10%) and little land is reserved for this crop (0.34 ha). Although few farmers are involved in rice production (8%), the average area sown with rice is relatively high (1.01 ha).

The characteristics of sample farms in Guinea Bissau indicate a more diversified farming system. The most frequent crops are sorghum (81%), maize (71%), rice (65%), millet (59%) and groundnut (56%). The areas allocated to each of these crops are also larger: sorghum (1.64 ha), maize (1.05 ha), rice (1.06 ha), millet (0.89 ha) and groundnut (0.72 ha). Cotton (12%), Cashew (3%), *Fonio* (2%) and Cassava (2%) are minor crops both in terms of the proportion of farmers planting and the areas cropped as well.

5.2. Socio-economic profile of smallholder milk producers

Tables 2 and 3 indicate selected socio-economic characteristics of the farm households in the sample of each of the countries. The samples were mainly composed of man-headed households. Woman-headed households represented about 2% of the total sample in The Gambia and Guinea Bissau, and 26% in the Guinea sample. The average age of the households' heads was quite similar in all three countries, as was the average households' population, with the exception of Guinea where the average household size was low. However, a similar number of working-men or women were reported in all countries. Major differences were found in the ownership of cattle and the location of the production unit with regard to the nearest selling points for dairy products. On average, farmers in Guinea Bissau rear more cattle (92 heads/household) than their counterparts in The Gambia (57 heads/household) and Guinea (10 heads/household). These magnitudes are maintained when translated into density of cattle/man-equivalent.

Table 2: Human and cattle population of the sample smallholders

Variables	The Gambia	Guinea	Guinea Bissau
Number of heads of household	90	88	133
Women-headed households (%)	2.2	26.1	1.5
Average age of the hh's head (years)	54 (17)	58 (11)	53 (14)
Average household's size (persons)	20 (13)	11 (6)	23 (15)
Working men	6 (4)	3 (2)	6 (4)
Working women	6 (5)	3 (1)	6 (4)
Total labour force (man-equivalents)	12	9	12
Average number of cattle (heads)	57 (41)	10 (5)	92 (89)
No. of cattle/man-equivalent	4.3	1.1	7.6
Average distance to the market (km)	6 (4)	24 (10)	n.a.

Note: hh = household; n.a.c=not collected; values in parenthesis are standard deviation. The average distance to market measures the distance between the location of the milk production unit and the place where milk is usually sold.
Source: survey data

On the other hand, The Gambian farmers walk shorter distances (6 km) to deliver their dairy products than those in Guinea (24 km). The ethnic composition of the samples indicates the Fula group is the most represented across the countries. In terms of decision-making regarding any technical intervention in the herd, cattle owners are responsible in most cases across the countries. However, herders do have responsibilities in matters requiring technical interventions in the herd. A third possibility is the consultation between the herder and the cattle owners. In situations where two decision centres are recognized, the herders will often be co-owner of the herd.

Table 3: Ethnicity and decision making in production matters across countries (% of total sample)

	The Gambia	Guinea	Guinea Bissau
Ethnic groups			
Madinka	33.3	1.1	3.8
Fula	43.3	98.9	96.2
Wolof	4.4	0	0
Jola	17.8	0	0
Others (Serere, Majako, etc.)	1.1	0	0
Decision centres for technical intervention in the cattle herds			
Cattle owners only	71.1	52.3	93.2
Herders only	10	3.4	2.3
Both	18.9	44.3	3.8

Source: Survey data

The professional and education status of the samples are shown in Table 4. The question was asked to determine whether the livestock farmer engaged in livestock rearing as an exclusive activity. The results indicate that few livestock owners are strictly engaged in livestock rearing per se: none in The Gambian sample, 3% in Guinea and 2% in Guinea Bissau. It can also be noticed that other non-farmer professionals are interested in cattle rearing: 3% in The Gambia sample, 5% in Guinea

Bissau and 17% in Guinea. The most important activity association is the combination of crop and livestock production. The importance of each of these activities in the household perspective differs between country samples. In The Gambia 64% were practicing crop production as their main activity, and in combination with livestock as second; while 32% reported livestock production as their main activity seconded by crop production. In Guinea, 63% are engaged in crop production as main activity, and 17% considered livestock as their main activity. In Guinea Bissau, livestock production constitutes the main activity for 93% of sample households.

Table 4: Professional and education status of the sample smallholders (% of total sample)

	The Gambia	Guinea	Guinea Bissau
Main/secondary activity			
Crop/livestock	64.47	17	0
Livestock/crop	32.23	62.5	93.2
Livestock	0	3.4	1.5
Others (civil servants, traders, etc.)	3.3	16.98	5.3
Education			
Illiterate	52.2	26.1	56.4
Literate in local and Arabic language	33.3	64.8	35.3
Primary	4.4	7.9	6
Secondary	10	1.1	0
Tertiary	0	0	0

Source: survey data

The educational status of sample heads of household reflects well what is known of the literacy and formal education levels in rural areas of the selected country: Fifty two percent of the respondents in The Gambia stated they were illiterate and 33% were literate only in local and Arabic languages. These proportions were 26% and 64% in the Guinean sample; and 56% and 35% in the Guinea Bissau sample.

5.3. Resource-based typology of the smallholder milk producers

The resource-based typology of smallholder milk producers is built on selected structural variables, namely the number of man-equivalents of household active members, the farm size, the estimated value of fixed agricultural assets (permanent and intermediary), the stock size (N'Dama, Zebu and/or crossbred). It is hypothesised that these variables are determinant in the decision of the farmer to engage in milk production. Moreover, if smallholders differ with regards to these resources, then the performance achieved in milk production and management will be affected. Results of the K-means and the discriminant analyses are given in Table 5. Regressions of the selected structural variables on the K-means group membership allow identifying the significant ones that contribute to smallholder discrimination. Note that not all variables were applicable to all country samples. Zebu and crossbreds were not found in the Guinean and Guinea Bissau samples, while no permanent assets were reported in The Gambia.

Table 5: Wilks' Lambda and univariate F-ratio of the discriminant analysis of smallholders

	The Gambia		Guinea		Guinea Bissau	
Variables	Wilks	F	Wilks	F	Wilks	F
Man-equiv.	0.98	2.09*	0.84	16.75*	0.93	3.09*
Land	0.95	4.56*	0.95	4.38*	0.94	2.90*
N'Dama	0.99	1.18	0.33	176.85*	0.13	282.43*
Zebu	0.93	6.93*	n.a.	n.a.	n.a.	n.a.
Crossbreed	1.00	0.00	n.a.	n.a.	n.a.	n.a.
Int. Assets	0.43	118.1*	0.96	3.35*	0.89	4.91*
Per. Assets	n.a.	n.a.	0.97	2.89*	0.95	2.25*
DF	1	88	1	86	3	129

Notes: n.a.= not applicable; Man-equiv.=HH active members in agriculture; int.=intermediary; per.=Permanent, includes built shed whose lifetime exceeds five years; DF = degree of freedom (the first value corresponds to the df1 and the second the df2); F and Wilks are the Fisher statistic and the Wilks' Lambda, respectively.
Source: Survey data

The estimated discriminant functions suggest that in The Gambia, the statistically significant variables were: the size of the Zebu stock ($p<0.01$), the farmland size ($p<0.06$) and the amount of investment in intermediate assets ($p<0.00$). In Guinea, the

structural variables that significantly discriminate smallholder farmers were: the number of man-equivalents in the household (at 1% level of significance), the size of the farmland (5% level), the size of the N'Dama stock (1% level), the investment in both intermediate (10% level) and in permanent assets (10% level). In Guinea Bissau, all the selected variables were reported statistically significant in discriminating smallholder farmers. The number of N'Dama cattle and the value of intermediate assets were both significant at 1% level. The number of man-equivalents in the household and the size of the farmland were significant at 5% level, while the value of long term assets was at 10% level.

The statistics of the goodness-of-fit test are reported in Table 6. The estimated canonical correlation between the selected variables and the discriminant function amounted to 80%, 84% and 94% for The Gambia, Guinea and Guinea Bissau samples, respectively. The Wilks's Lambda test indicates that all estimated discriminant functions (one for The Gambia and Guinea, and three for Guinea Bissau) were highly significant ($p<0.00$).

Table 6: Goodness-of-fit of the predicted discriminant functions

Tests statistics	The Gambia	Guinea	Guinea Bissau
Eigen values test	1.82	2.35	7.51
Canonical correlation (%)	80	84	94
Wilks' Lambda	0.35***	0.29***	0.11***
Chi-square (degree of freedom)	88. 17 (6)	101.05 (5)	277.69 (15)
Number of clusters identified	2	2	4

Notes: For The Gambia and Guinea, only one discriminant function was used in the analysis. For Guinea Bissau, three canonical discriminant functions were used in the analysis, but only the result of the first one is reported here. The two other functions are not significant and therefore are not reported. Figures in parenthesis are degree of freedom; ***, significant at 1% level.
Source: survey data

The statistical tests suggest that the selected variables allow discriminating among smallholder farm households. The most interesting finding is that at least two types (because of the probable influence of the sample size on the disentangling power of the

discriminant analysis) of resource-based smallholders can be identified. The resource groups of smallholders can be qualified as ***resource-poor*** (below the confidence interval for the means of the discriminant variables), ***medium*** (within the confidence interval) and ***resource-rich*** (above the confidence interval). Note that whatever is the number of types of smallholders, the ***resource-poor*** was always the most numerically important group of farmers. This group (type 1) accounts for 81% and 70% of the sample in The Gambia and Guinea, respectively. In Guinea Bissau the ***resource-poor*** farms (type 1) represent 59% of the sample, the ***medium*** (type 2) accounts for 30% and the ***resource-rich*** (types 3 and 4) for 11%. Although there are some similarities between the groups 3 and 4 in the Guinea Bissau sample, it is practical to consider the four identified groups as separate in order to capitalise on the few dissimilarities.

Table 7 summarises the group statistics for the discriminant variables. Although few Zebu and crossbreds were reported in The Gambia sample, the ***resource-medium*** farmers owned all the Zebu breeds. Crossbreds (including Zebu x N'Dama and Friesian x N'Dama) were disproportionately distributed between ***resource-poor*** and ***medium*** farmers. However, the difference was not significant. Land ownership is significantly unequally distributed between the two types of smallholder farm households. The ***medium*** smallholders have also shown a capacity to invest (farming equipment) more than the poor. On average, there were also no significant differences in the number of man-equivalents and the number of N'Dama cattle between the two types of smallholders.

Table 7: Resource-based groups statistics of the discriminant variables of smallholders

Discriminant variables	The Gambia		Guinea	
	Type 1	Type 2	Type 1	Type 2
Sub-sample size	73	17	62	26
Man-equiv.	11 (0.84)	14 (1.83)	5 (0.25)	7*** (0.47)
Land (ha)	5.45 (0.78)	9.12** (1.19)	2.15 (0.28)	3.18** (0.36)
N'Dama (heads)	54 (4.41)	71 (12.79)	8 (0.33)	16*** (1.09)
Zebu (heads)	0.00 (0.00)	0.12** (0.12)	-	-
Crossbreed (heads)	0.18 (0.09)	0.12 (0.12)	-	-
Int. assets (lc)	448.69 (63.18)	4,094*** (369.42)	113,815 (12,335)	179,242* (47,021)
Per. Assets (lc)	-	-	60,903 (16,550)	117,308* (32,692)

Notes: Hh= household; lc = local currency (Dalasi for The Gambia, Guinea Franc for Guinea and CFA Franc for Guinea Bissau). Values in parenthesis are standard errors. ANOVA test of equality of within country smallholder groups means: *, **, *** significant at 10%, 5% and 1% level. Type 1 farmers' resources are below the confidence interval of the sample average. Type 2 farmers are within the confidence interval.
Source: Survey data

In Guinea, the results indicate that for all the selected variables, smallholders were differently endowed. The ***medium*** farmers significantly own more farmland, have more man-equivalents in the household, more N'Dama cattle and have the capacity to invest more (farming equipments, cowshed, etc.) than the poor. Similar results were obtained in the Guinea Bissau sample, where the type 4 farms own on average more resources and have the highest capacity to invest in farming equipment and in permanent farm infrastructure.

Table 7 cont'd:

Discriminant variables	Guinea Bissau			
	Type 1	Type 2	Type 3	Type 4
Sub-sample size	79	40	10	4
Man-equiv.**	10 (0.66)	12 (1.23)	13 (1.98)	20 (8.38)
Land (ha)**	7.48 (0.51)	8.55 (1.06)	11.73 (2.61)	14.25 (7.47)
N'Dama (heads)***	48 (2.12)	104 (5.96)	264 (21.41)	425 (31.98)
Int. assets (lc)***	162,532 (15,990.68)	216,951 (39,385.09)	315,125 (92,167.4)	480,938 (142,193.1)
Per. assets (lc)*	19,513 (4,580.99)	22,938 (6,178.38)	20,000 (9,916.32)	72,500 (25,940.64)

Values in parenthesis are standard errors. One-way ANOVA test of equality of groups means: *, ** and *** significant at 10%, 5% and 1% level. Types 1 and 2 are defined as in the Gambia and Guinea above. Type 3 and 4 farmers' resources above the confidence interval of the sample average.
Source: survey data

An ultimate question raised by the dissimilarities in resources endowment among smallholders is whether their practices and management for milk production differ as well. In fact, in terms of economic perspective the determinants of the performance are not only the available resources at farm level, but also the way those resources are managed to generate output in an efficient way. Particularly for milk production, what matters is the conjunction of cattle holdings and the management of milk production.

5.4. Cattle ownership and management of milk production on smallholder farms

There are different ways to analyse the practices of cattle rearing and management of milk production on smallholder's farm households in relation to the dairy performance. One approach focuses on bio-technical factors such as calving intervals, lactation length and milk yield (Ibrahim Bulale, 2000). In addition, reproductive performance is a trait of an outstanding importance in dairy production because the size of the calf crop affects herd replacement, and lactation depends on reproduction (Kiwuwa et al., 1983). However, in the context of very few innovations in the crop-livestock production systems in the selected countries, those bio-technical factors are quite similar from one farmer to another. It will therefore not be worthwhile to adopt this approach, although it provides basic information in production systems not yet well known.

In this study, we followed Waters-Bayes (1988) who stated that in the smallholder dairy farm, the most important factors of dairy performance are: the herd structure and composition, the management of feeding and health aspects, and the management of labour.

5.4.1. Herd structure of resource-based types of milk producers

The herd structures of the types of smallholders are presented in Table 8. As indicated in Table 7 above, smallholders in Guinea and Guinea Bissau own only local N'Dama breeds, while in The Gambia an increasing number of crossbreds have been introduced

but the average number on farms is very small. Because of this small number of crossbreds, we focused on the local cattle herd structure. The first observation is that, irrespective of the types of smallholders and the age categories of cattle, farmers keep more females than male animals in the herd often in a proportion of over 60%. However, the herd structure of the two identified resource-based types of smallholders in The Gambia differ significantly (at 10% level) from each other, with the number of female calves of less than one year and male over three years.

Table 8: Comparative herd structure of resource-based smallholders

	The Gambia		Guinea	
Female	Type 1	Type 2	Type 1	Type 2
< 1 year	7 (0.78)	11 (1.84)*	1 (0.11)	2 (0.27)***
1-2 years	5 (0.66)	8 (1.32)	1 (0.09)	1 (0.29)
2-3 years	6 (0.91)	7 (1.33)	1 (0.13)	1 (0.29)
> 3 years	18 (1.57)	23 (5.14)	4 (0.18)	7 (0.49)***
Male cattle				
< 1 year	5 (0.57)	7 (1.91)	1 (0.11)	2 (0.28)***
1-2 years	5 (0.61)	7 (1.73)	0.33 (0.08)	1 (0.16)***
2-3 years	3 (0.45)	4 (0.82)	0.32 (0.06)	1 (0.29)***
> 3 years	4 (0.39)	5 (1.22)*	0.32 (0.11)	2 (0.28)***

Values in parenthesis are standard errors. One-way ANOVA test of equality of within country smallholder groups means: *, ** and *** significant at 10%, 5% and 1% level.
Source: Survey data

In Guinea, highly significant differences exist in all sex-age categories, except for male aged 1 to 2 years and between 2 and 3 years of age. Finally, in Guinea Bissau the four types of smallholders have shown highly significant differences in their endowment in all sex-age categories of cattle.

Table 8 cont'd: Comparative herd structure of the resource-based smallholders

	Guinea Bissau			
Female	Type 1	Type 2	Type 3	Type 4
< 1 year***	6 (0.37)	13 (1.00)	32 (6.35)	59 (13.24)
1-2 years***	5 (0.39)	12 (1.38)	36 (4.93)	59 (15.98)
2-3 years***	5 (0.35)	12 (1.93)	41 (6.16)	60 (18.09)
> 3 years***	17 (1.17)	37 (2.86)	87 (16.49)	131 (15.78)
Male cattle				
< 1 year***	6 (0.38)	11 (1.01)	25 (4.73)	31 (2.39)
1-2 years***	4 (0.33)	7 (0.62)	18 (2.57)	27 (4.25)
2-3 years***	4 (0.35)	6 (0.56)	16 (3.94)	46 (21.44)
> 3 years***	4 (0.30)	7 (0.69)	11 (2.31)	15 (4.85)

Values in parenthesis are standard errors. One-way ANOVA test of equality of groups means: *, ** and *** significant at 10%, 5% and 1% level.
Source: Survey data

5.4.2. Feeding strategies for dairy cattle

In all countries dairy production is influenced by seasonality in feed quality and availability. Irrespective to the type of smallholders, the most frequent source of feed is the natural pasture for 79% of the sample farm households in The Gambia, 59% in Guinea and 99% in Guinea Bissau. In the remaining cases in each country farmers reported that grazing animals are also supplemented with milling by-products, including groundnut cake and cereals bran. In the dry season, crop residues including cereals' straw, groundnut hay and other fodder trees (*Pterocarpus spp*.) are commonly fed to cattle.

Although it was difficult to collect reliable data on the amount of supplements fed to animals, farmers were able to provide qualitative information on the categories of supplemented cattle. Variable amounts were reported being supplemented to lactating cows and calves. Draft animals were also fed with supplements. There were differences in feeding practices for dairy cattle between countries. In The Gambia few

livestock owners (less than 3% of the sample) reported supplementing dairy cattle (lactating cows and calves) with priority given to draft animals (97% of the sample). When supplemented, dairy cattle are fed with groundnut hay (43% of cases), cereal brans (millet and rice) (9% of the sample), and groundnut cake (8%). Mineral supplementation is also practiced by about 7% of the interviewed farmers. Most of the livestock owners in The Gambia rely on the market to procure feeds for their animals.

In Guinea, feeding practices are more diversified. There were no differences between the two identified types of smallholders. Unlike The Gambia, farmers in Guinea give priority to feeding dairy cattle as compared to draft cattle. About 34%, 55% and 73% of the sample fed draft animals, lactating cows and calves, respectively. A variety of feeds are supplemented to lactating cows. Leaves of fodder trees are the most commonly used by 81% and 74% of the resource-rich and resource-poor farmers in the survey, respectively. Maize bran and *fonio* straw are also frequently fed to cattle. Groundnut hay, rice bran and maize straw were marginally fed in both resource-groups of farmers. Twenty-six and 19% of the ***resource-poor*** and ***medium*** farmers in the survey sample also practiced mineral supplementation with salt. Likewise, feeding practices for calves are mainly based on fodder trees in both groups (50% and 54% in the poor and medium group, respectively). The second commonly used feed for calves is maize bran - by 56% of the poor group and 23% of the medium one. The other resources (groundnut hay, rice bran, maize and *fonio* straws) are fed in small quantities. The calves received more attention for the mineral supplementation than lactating cows. About 56% and 38% of the poor and medium groups respectively were giving salt to their calves.

Feeding practices in Guinea Bissau are very similar to those of Gambian farmers. The most common categories of cattle that are supplemented are the draft animals (76%), lactating cows (7%) and calves (13%). Feed resources are groundnut hay, cereal straws and fodder trees. When supplemented, calves are fed with groundnut (53%) and cereals' straws (47%). The proportions of farmers in the 2nd and 3rd groups that use different feed sources are similar. In the 4th group, groundnut hay is commonly fed by

33% of the farmers, while cereal straws are used by 67% of the same group. On the other hand, 25% of the farmers in the 1st group feed cereal straws and 75% feed groundnut hay to their cattle. Feeding practices of the lactating cows are also based on groundnut hay (44%) and cereals straws (56%). Again the 2nd and 3rd groups are equally distributed in number between the usages of both feed resources. Groundnut hay is the most fed by farmers in the group 1 (67%), while cereal straws are the most common in the group 4 (100%). No use of additional mineral supplementation was reported.

5.4.3. Animal health management

There are several infectious diseases that particularly challenge the productivity and expansion of the dairy cattle industry in West Africa. Although questionnaire-based investigations of the major disease constraints at farmer level needs to be complemented by some clinical and laboratory tests, the perception of diseases as important from the farmers perspective, constitutes a step towards the organisation and implementation of in-depth epidemiological surveys. Depending on the farmers' knowledge on livestock diseases, the list of most important ones varies from one country-site to another.

In The Gambia, trypanosomosis and black quarter were reported as most frequent endemic diseases that affect livestock by 83% and 75% of the sample dairy farmers. Twenty-six and 9% reported Foot and Mouth Disease and tick and tick-borne diseases. Less frequently encountered diseases were also reported i.e. foot rot, tuberculosis, Peste des Petits Ruminants.

Livestock owners in Guinea reported black quarter (69%) and trypanosomosis (6%). Other diseases mentioned could not be properly identified in 25% of cases. In Guinea Bissau, black quarter was reported in 97% of cases, while 15% and 2% of the sample farmers listed pasteurellosis and brucellosis, respectively. About 62% of the farmers listed other diseases that could not be precisely identified.

The use of modern medicine to combat livestock disease is common amongst smallholders, irrespective of the resource ownership and the country of origin. In The Gambia, 84% of farmers reported they only referred to veterinary services for their animal health care. However, 3% rely on traditional medicine to cure their sick animals, and 11% combine both modern and traditional treatments. Similar results hold for the Guinea sample, where 85% use only veterinary services to control diseases in their herds, 6% still rely only on traditional medicine and 8% combine both modern and traditional treatments. Results in Guinea Bissau follow the same pattern as those in Guinea.

5.4.4. Labour management

In the smallholder milk-oriented farms, the management of labour is an important determinant of farm productivity. The employment of a herder, whether a family member or a hired one, creates a situation whereby some prerogative of managing the milk production is transferred by the owner to the herder. Three situations are common in the study areas: (1) the herder is member of the farm household (son or other relative of the household head), (2) the herder is not member and is hired to take care of the animals, and (3) the herder is the owner of the herd. In all cases, he could be remunerated either in kind or in kind and cash. Depending on the ownership of cattle, the herder can participate in the decision-making process for technical interventions in the herd (see Table 3 above).

In The Gambia, most herders are members of the household; those hired to take cattle for grazing are estimated at 8% of the sample. Only few cases of cash payment were reported. When it happens, it is intended to complement the payment in kind, particularly if there are few or no lactating cows in the herd. The average grazing time is evaluated at 8 hours (standard error = 1.91). In Guinea, 73% of the sample farmers rely on their relatives to graze their animals. However, only in few cases (1%) were cash payments reported. In Guinea Bissau, all the herders are relatives of the

interviewed farmers. The average grazing time is evaluated at 10 hours (standard error= 1.53).

All cattle herders were men. The nature of employment and the relationship between the cattle owners (generally the household head) and the herder make it difficult to evaluate the cost of labour for a smallholder dairy production system. In addition, the herders' wives assist in milking and selling milk and dairy products. Herders are paid in kind by keeping part of the milk. In general, morning milk is reserved for the cattle owner, while the evening one is for the herder and his family.

In summary, labour management in smallholder milk production units is a complex activity that needs specific monitoring in order to identify the labour flow that is needed in milk production. None of the managers of milk production received technical training on how to deal with their activity and the amount of milk off-take is likely to be influenced by the milking behaviour of the operator (milking duration and techniques). In fact, there were complaints from some cattle owners about the way herders share the daily milk produce.

5.4.5. Supply and marketing of milk and milk products at farm level

It is well known that the total quantity of dairy products sold per household depends on a number of factors including the nature of the product, the season of production and the amount that is consumed by the household. Smallholders commonly supply two major kinds of milk products. In The Gambia, 56% of the sample supplied fresh milk, 6% sour milk and 31% supplied both sour and fresh milk. In the Guinea sample, the major milk product sold is sour milk (67%), followed by the combination of fresh and sour milk (10%). Only 3% reported selling fresh milk. Results from the Guinea Bissau sample are similar to that of Guinea. Seventy-two percent of the sample farmers sell sour milk; 15% and 13% sell fresh milk and the combination of fresh and sour milk, respectively.

The seasonality of milk supply is characterised by the decrease of per cow production that affects the availability of product surplus after deducting the home-consumption. This fact influences the number of households participating in milk markets. For example, in The Gambia, most of the sample households (66%) sold milk and milk products year round. Few households (7%) could not sell at all, while 28% only sold during the rainy season. In Guinea, 8% did not sell milk during the period covered by the survey, 25% of the sample sold milk and milk products only during the rainy season, 67% were selling throughout the year. In Guinea Bissau, 56% reported selling dairy products only in the rainy season, 4% only in the dry season, 26% year round and 14% did not sell any products within the survey period.

The average quantity of dairy products sold by smallholder producers is presented in Table 9. A common pattern in these country-related results is that the quantity sold increases as the self-consumption increases. As a consequence of increase in milk production, the increments of the quantity self-consumed and sold by the household are resource-related. The richer the household in terms of resources the higher the amount of milk produced.

Table 9: Quantity of dairy products sold and self-consumed per household per year (litres)

	Type 1	Type 2	Type 3	Type 4
The Gambia				
Sales**	1780 (196.15)	2852 (688.99)	n.a..	n.a..
Self-consumption	662 (33.15)	713 (87.75)	n.a..	n.a..
Guinea				
Sales**	83 (17.11)	169 (36.09)	n.a..	n.a..
Self-consumption***	100 (8.72)	184 (39.33)	n.a..	n.a..
Guinea Bissau				
Sales***	375 (64.13)	1274 (209.06)	3579 (648.12)	5213 (1777.45)
Self-consumption***	569 (73.74)	1260 (134.71)	1786 (275.57)	2685 (1127.75)

One-way ANOVA test of comparison of group means: **, and *** significant at 5% and 1% level; n.a. = not applicable.
Source: survey data

It should be noted that, although both the self-consumption and the sales increase from the resource-poor farmer to the rich one, this increase is disproportionate. In The Gambia, self-consumption increases by 8% while sales increase by 60% for an increase of 46% in production. In the Guinea sample, increases of production, self-consumption and sales from the resource-poor to the rich farmer are higher and represent 93%, 84% and 104%, respectively. The Guinea Bissau sample however shows more complex situations. Production, self-consumption and sales increases are generally huge at the bottom of the scale of the resource-based types of smallholder. Between the types 1 (poor) and 2 (medium) smallholder farmers, the increase in production, self-consumption and sales are 168%, 121% and 240%, respectively. From the type 2 to the type 3 (second rich farmer group), production increases by 112%, while the self-consumption and the sales increase by 42% and 181% respectively. But from type 3 to type 4 (richest cluster), production, self-consumption and sales increments are 47%, 46% and 51%, respectively.

Dairy products are sold by households at the farm gate, along the main roads or in the market places. A variety of utensils including calabashes and plastic recycled "gallons" (5 or 20 litres) or metal bowls were used to fill milk products and carry them to the markets by foot, bicycles or taxis. Different outlets including selling directly to consumers, collectors and/or vendors are used. In The Gambia, 53% of the sample sells milk products directly to consumers, and 47% to collectors/vendors who then resell it to consumers. Eighty-three percent of the Guinea sample supplies their products directly to consumers and 17% to collectors/vendors. In Guinea Bissau, most smallholder farm households (61%) supply dairy products to consumers. The remaining 39% sell it to collectors/vendors. However, there were no formal outlets for marketing dairy products in all four countries.

Dairy products pricing at farm gate is based on bargaining between the buyer and the sellers, who are women in most cases. The pricing outcomes are then influenced by a variety of factors including the season of production, the amount being purchased, the relationship between the buyer and the seller, and of course the liquidity needs of the

farm household. This in turn affects the economic return of dairy production in smallholder farming systems. The prices received by smallholder milk producers are shown in Table 10.

Table 10: Average prices (local currency/litre) of local dairy products

	The Gambia	Guinea	Guinea Bissau
Dry season	8	500	500
Rainy season	5	400	350
Official exchange rate 2001[a]	15.30	1800	600

[a] exchange rate = local currency/$US. Local currencies: Dalasi in The Gambia, Guinea Franc in Guinea and CFA in Guinea Bissau.

Source: Survey data

Because milk was sold in volume rather than weight, all prices are expressed per litre. In addition, because of difficulties encountered to disentangle prices according to the types of dairy products sold by the producers, prices represent cost prices that account for all factors that likely influence dairy products pricing.

5.5. Economic performance and viability of smallholder milk production enterprises

The assessment of the economic performance and viability of the smallholder milk production units was based on the enterprise budget analysis using the accrual accounting methods. The use of enterprise budgeting helps to test whether dairy specialisation is possible within the mixed livestock-crop farming systems in West Africa. The purpose is to ascertain that dairy income can pay for the costs of the common variable items (feeds, veterinary products and labour) in such a system where cattle are viewed as a multipurpose asset, producing meat and milk, draft power, manure and other goods and services.

5.5.1. Costs and gross income of milk production

As shown in sub-sections 5.4.2 through 5.4.4, financial costs in cattle rearing include general cost for feeds and veterinary products. The actual expenditures on these items were estimated during the surveys. The Guinea Bissau sample was an exception as no feeds were purchased. Information from INPA was used to estimate the opportunity cost of the own produced feeds. Since most herders were only paid in kind (part of milk), the labour cost was evaluated at its opportunity cost. The monthly salary rate of agricultural labourers in institutions such as IRAG/DNE (Guinea), INPA (Guinea Bissau) and ITC (The Gambia) employing such staff was used. The reliability of this labour valuation was tested against an estimation of milk share of the herder valuated at the market prices in The Gambia. No significant differences were found. However, it was not possible to do the same exercise in Guinea and Guinea Bissau. In order to ease the comparison, we therefore took the agricultural labourers salary as opportunity cost for herding cattle. The estimated costs and gross dairy income are presented in Table 11.

The results indicate that cash investment for milk production among the smallholder dairy farms is very low. Expenditures on feeds are not statistically different between types of farmers in The Gambia and Guinea. On the other hand, the resource-poor farmers (type 1) are spending significantly less money on animal health care than those owning more resources. On average, because of low investment in feeds in particular, the economic performance of milk production depends essentially on the number of lactating cows owned by the household. The gross dairy income of the resource-rich farmers is 46% and 93% higher than that of the poor group in The Gambia and Guinea, respectively. In The Gambia, the gross margin from milk production averaged US $911.36 and $1,111.48 for the resource-poor and medium farmers, respectively. This value is estimated at only US $ 1.99 for the poor farmer and US $41.84 for the medium one for the Guinea sample. The estimates of the net cash income derived from milk are as follows: US $640.09 and $1,029.95 for the poor

and medium farmers, respectively in The Gambia sample; US $15.84 for the poor and $34.67 for the medium in Guinea sample.

Table 11: Annual cost, gross income and margin of the smallholder milk producers (local currencies)

	The Gambia ($1=GD15.30)		Guinea ($1= GF 1800)	
	Type 1	Type 2	Type 1	Type 2
Sales (1)	10,230.41 (1,117.49)	16,355.29** (4,018.60)	37,311.17 (7,700.74)	76,132.21** (16,239.76)
Self-consumption (2)	3,713.43 (182.79)	4,034.12 (497.29)	45,083.47 (3,924.21)	82,921.15*** (17,700.04)
Gross dairy income (3) = (1+2)	13,943.84 (1,188.03)	20,389.41** (4133.34)	82,394.64 (9,226.46)	159,053.40*** (25,121.93)
Feeds (4)	46.78 (17.76)	39.71 (21.74)	2,771.45 (411.53)	2,862.88 (572.44)
Health care (5)	390.23 (31.13)	557.29** (74.51)	6,029.46 (898.93)	10,870.04** (2,311.09)
Herder (6)	2,621.26 (74.13)	2,786.82 (166.79)	70,000 (0.00)	70,000 (0.00)
Total variable costs (7) = (4+5+6)	3,058.27 (90.77)	3,383.82 (196.54)	78,800.91 (1,154.57)	83,732.92** (2469.07)
Gross margin (3-7)	10,885.56 (1,190.34)	17,005.59* (4,193.58)	3,593.73 (8,848.48)	75,320.45*** (24,546.01)
Net cash income (1-4-5)	9,793.40 (1,117.06)	15,758.29* (4,011.93)	2,8510.26 (7,519.64)	62,399.29** (15,548.28)

Notes: Health expenditures were included all for cows, because of difficulty to disentangle those effectively applied. Values in parenthesis are standard errors. ANOVA test for equality of within country group means: *, ** and ***, significant at 10%, 5% and 1% level.

Source: Survey data

In the Guinea Bissau sample, the costs of feeding practices and the expenditures on animal health care are statistically different between groups of farmers at different resources levels. As opposed to The Gambia and Guinea, the importance of expenditures on veterinary products and costs of feeding practices in the Guinea Bissau sample is decreasing from the resource-rich group (types 3 and 4 farmers) to the poor (type 1). The gross dairy income follows the similar trend. The gross margin averaged US $3,238.59 for the type 4 farmers, US $1,894.84 for the type 3, US $307.26 for the type 2. The type 1 groups of farmers are economically loosing on

average US $203.27. On average, the net annual cash income derived from milk production amounted to US $2,983.82 for the type 4, $2,047.01 for the type 3, $725.69 for the type 2 and $203.19 for the type 1.

Table 11 cont'd

	Guinea Bissau (1$=CFA600)			
	Type 1	Type 2	Type 3	Type 4
Sales*** (1)	127905 (21996.25)	445900 (73172.67)	1252790 (226840.5)	1824550 (622108.9)
Self-consumption*** (2)	196186 (25657.91)	441061 (47149.75)	625240 (96450.23)	939575 (394713)
Gross dairy income*** (3) = (1+2)	324091 (39215.34)	886961 (102816.7)	1878030 (260770.9)	2764125 (934493.5)
Feeds*** (4)	23608 (360.87)	25537 (586.29)	31579 (2592.90)	35725 (1890.59)
Health care*** (5)	5986 (842.03)	10487 (1368.02)	24584 (6050.11)	34258 (4411.37)
Herder*** (6)	416459 (36778.33)	666583 (87336.45)	684945 (168125)	750990 (180693.6)
Total variable costs*** (7) = (4+5+6)	446055 (36778.21)	702608 (87648.73)	741107 (164828)	820974 (176315.6)
Gross margin*** (3-7)	-121964 (38447.22)	184353 (89433.98)	1136923 (248580.1)	1943151 (877537.4)
Net cash income*** (1-4-5)	121919 (21945.27)	435413 (72801.76)	1228206 (223978.7)	1790292 (625907.4)

Source: survey data

These findings reveal that milk production is generating income to smallholder dairy farm households. It is visualised that the purchase of feeds to supplement cows did not result in higher economic return, because most of the feeds purchased were essentially crop residues that are known to be of low nutritive value. Therefore self-produced feeds are likely to generate higher returns both in cash and in terms of opportunity cost. The results in Guinea Bissau confirm the importance of such a feeding strategy as compared to those in use in the other countries, namely The Gambia and Guinea. Although the smallholder dairy farms in this extensive exploitation of dairy cows

achieve relatively good economic performance, one should be cautious about the interpretation of such indices in absolute terms. It is therefore worthwhile to put these results into perspective.

5.5.2. Viability of the smallholder dairy farms

Several indicators were calculated in order to assess the viability of the smallholder dairy farms. The operating ratio (total operating costs over the gross dairy income) indicates the extent to which the income derived from dairy activities covers the variable costs involved in production. The capital turnover measures the comparative advantage of keeping cows for milk production as compared to selling them. The net cash ratios calculated include the ratio of cash income to the variable costs. This indicates whether milk production can be self-financing. The fixed and gross ratios measure the viability of dairy production in mixed crop-livestock production systems. Table 12 presents the viability indicators of the smallholder dairy farms.

Table 12: Comparative financial test ratios for smallholder dairying farms

Viability indicators	The Gambia		Guinea	
	Type 1	Type 2	Type 1	Type 2
Operating cost/gross margin	0.37 (0.04)	0.38 (0.11)	-1.06 (0.97)	-0.49 (1.03)
Capital turnover	0.28 (0.02)	0.24 (0.03)	-0.001 (0.01)	0.03* (0.01)
Total fixed cost/gross margin	0.05 (0.01)	0.51 (0.17)***	-2.41 (1.31)	0.53 (9.09)
Total expenses/gross margin	0.42 (0.05)	0.89 (0.27)***	-3.48 (2.14)	0.03 (10.05)
Net cash/variable cost	3.39 (0.38)	5.34 (1.47)*	0.36 (0.09)	0.73* (0.18)
Net cash/lactating cow	502 (56.39)	434 (74.31)	8,987 (2,230.51)	13,409 (2,900.81)

Values in parenthesis are standard errors. ANOVA test for equality of within country group means: * and ***, significant at 10% and 1% level, respectively.

Source: Survey data

In The Gambia, the ratio of total operating costs on the gross income (operating ratio) shows that the expenditures (feeds, veterinary and labour) incurred for milk production were economically cost-effective i.e. one unit of gross income was generated for less than a unit of variable costs, and the difference between the two identified types of farmers was not significant. However, keeping cows for milk production is not comparatively profitable as compared to selling them out at the time the survey was carried out. The capital turnover was less than one unit, the point where the farmer could be indifferent between selling all the dairy stock out or keeping it for milk production.

Nevertheless, domestic milk production is a profitable activity and the ratio of the net cash on the variable costs averaged 3.39 for the resource-poor farmer and 5.34 for the medium one. Although medium farmers are significantly (at 10% level) earning more than the poor per unit of investment, the productivity per lactating cow (net cash ratio per lactating cow) indicates that US $32.81 per cow are derived in the poor group whereas the rich group earned US $28.37.

Table 12 cont'd

Viability indicators	Guinea Bissau			
	Type 1	Type 2	Type 3	Type 4
Operating cost/gross income	-1.54 (1.52)	14.15 (11.49)	1.39 (0.77)	0.03 (0.36)
Capital turnover***	-0.11 (0.03)	0.03 (0.01)	0.12 (0.04)	0.07 (0.03)
Total fixed cost/gross income	-0.68 (0.95)	2.03 (1.10)	0.52 (0.29)	-0.28 (0.47)
Total expenses/gross income	-2.22 (2.43)	16.17 (12.33)	1.92 (0.78)	-0.25 (0.83)
Net cash per variable cost***	0.29 (0.04)	0.68 (0.09)	1.99 (0.39)	2.08 (0.78)
Net cash per lactating cow ***	9,742 (1,634.69)	17,914 (2,390.93)	23,909 (4,191.29)	18,147 (6,606.04)

Values in parenthesis are standard errors. ANOVA test for equality of within country group means: * and ***, significant at 10% and 1% level, respectively.

Source: Survey data

Likewise in Guinea and Guinea Bissau, milk production appears to be economically cost-effective, with very low comparative advantage as compared to selling the dairy cows. The net cash ratios are very low in Guinea and Guinea Bissau as compared to that of the Gambia. In Guinea, the net cash ratio is estimated at 0.36 and 0.73 for the resource-poor and the medium farmer, respectively. In Guinea Bissau, this indicator amounted to 2.08 for the type 4, 1.99 for the type 3, 0.68 for the type 2 and 0.29 for the type 1 farmers. The productivity values per lactating cow are as follows: US $4.99 and $ 7.45 for the resource-poor and medium respectively in the Guinea sample; and US $30.25, $39.85, $29.86 and $16.24 for the type 4 and 3 (the resource-rich), type2 (medium) and type 1 (resource-poor) in the Guinea Bissau sample.

5.6. Discussions

The findings of this study, together with previous results from various authors (Waters-Bayer, 1988; Goncalves, 1995; Agyemang, 2000) can be used to predict the likely outcomes and trends in milk offtake and sales. Cattle management in West Africa is primarily gender-specific. For instance, in all three countries, men are mainly responsible for the herd management and few women were enumerated as cattle owners, although they are also involved in milk management. It can be shown, following Waters-Bayers (1988), that the benefit of inputs will be directed into animal survival and growth. Thus participation of cattle owners in the smallholder dairy industry would result more in an increase of beef production than of milk for sale. Another important point to be made is the non-specialisation of cattle owners. They are always practising mixed farming systems whereby cattle are reared together with the growing of various crops. The advantages of these systems are well known and documented (Sandford, 1989; McIntire, 1992; Savadogo, 2000). From this generalisation, however, differences can be drawn between households based on the available resources of the cattle-keeping families.

Similar production systems are encountered across West African economies characterised by the fact that farmers are involved in cropping and keeping livestock

as well. Thus rice, maize, millet, groundnut and cassava are produced in all countries' sample farms. The residues of these crops left in the fields (except the groundnut hay) are fed to animals. Given the increasing importance of manure for maintaining fertility, it is incorrect to assert that crop residues are poorly utilised (Barton and Bennison, 1994). Gathering and storage of all these crop residues might be constrained by insufficient labour. Other similarities in the selected countries are the increasing number of civil servants and other professional groups investing in cattle, the decision making process is becoming collegial between the cattle owners and the herders, particularly when the latter own some cattle. However, these similarities between West Africa countries should not be taken as sufficient conditions for designing similar schemes for smallholder dairy development by country.

To feed the growing human population with products of animal origin, particularly dairy products, the efficiency of resource utilisation in each country must be increased and alternative technologies must be developed. Careful analysis is then required so that dairy development strategies can be reoriented towards better use of local resources. There is evidence of dissimilarities concerning livestock resources between countries. On average, Guinea Bissau sample farm households have the highest cattle/man equivalent ratio, followed by Gambian and Guinean farmers. Given that milk is produced under extensive systems in the selected countries, recorded differences in milk offtake (home-consumption and sales) can be attributed to difference in average herd size per farm. While each country's particulars in dairy systems ought to be considered in formulating dairy development strategies in West Africa, one should focus on factors determining this development, including a better definition of the target recipients' needs (Sansoucy, 1994). The definition of the target recipients arises out of the evaluation of the capability of the farmers to uptake the improved technologies. Farmers' resources are therefore important in predicting the technology uptake capability.

Results of discriminant analysis indicate a diversity of smallholder farms in terms of their resource endowment within each country. The significant discriminating

variables can be divided into two groups: **common** and **country-specific**. The **common** factors include land ownership (farm size) and investment in intermediate assets (equipments, feeds and veterinary inputs, etc.). **Country-specific** variables that discriminate among groups are the number of Zebu cattle in The Gambia. Farmers are introducing this breed from Senegal in order to improve the productivity of the N'Dama cattle. In Guinea and Guinea Bissau, the number of N'Dama cattle, the available labour force on farms (man-equivalent) and the investment in permanent assets (e.g. construction of kraals) are the most telling. There are therefore smallholders with relatively larger resources than others. Particularly for cattle ownership, significant differences exist in the number of dairy cattle (more than three years old female and less than one year). The consequences of these dissimilarities are reflected in the economic performance of the smallholder dairy systems, whereby the more dairy cattle the farmer owns, the higher the gross margin derived from milk. The economic viability of the current milk production heavily depends on the accumulation of cattle. Unless appropriate strategies are put in place to rescale the size of cattle herds, the risk of environmental damage is increased with the current milk production, particularly in peri-urban settings. However, imported technologies would fail to overcome the constraints imposed on local farming systems if they do not meet the socio-economic requirements of the farmers.

It was hypothesised that smallholders are heterogeneous in their productive resource endowments. Although, the production systems are predominantly mixed crop-livestock farming, the results of this study confirm the hypothesis by showing that smallholders do not own the same amount of resources, particularly cultivated land, labour (men-equivalent), cattle, and other investments. Second, the hypothesis that the composition and structure of the cattle herd are related to the resource-based type of producers was partially confirmed. On one hand, where farmers introduced Zebu breeds to upgrade the local cattle breed (N'Dama), as the case of The Gambia, results show that only resource wealthier farmers were able to do so. On the other hand, there is no difference in herd structure between smallholders, as more dairy cattle were kept irrespective to the resources level. Thirdly, we found that economic performance was

related to the level of resources owned by smallholders. For instance, the farmers with larger cattle herds also owned and managed more dairy cattle. Consequently, more milk is produced for consumption and sale, which generates higher income. Although, households with fewer cattle also did well, cost-effectiveness was comparatively lower.

There are several options for increasing milk productivity and developing smallholder dairy systems. However, farmers face two major challenges in the current production environment in West Africa: inappropriate technologies and the need to increase efficiency, associated with the environmental problems. Delgado et al. (1999) surveyed the technologies and policies available or in development to meet these challenges. The fourth hypothesis was that options for increasing milk production are resource related, is partially confirmed by study. Increasing the number of dairy cattle represents one option for milk producers, irrespective of the resource level. Likewise, increasing cow productivity through feeding and health care constitutes another option, which is not related to the resources level. Studies in Kenya (Waithaka, 1998; Batz, 1999) also report that adoption of feeding and heath care technologies is not significantly affected by the smallholder' resources. However, improving the genetic merit of the local cattle would likely be resource-related, as indicated by results from The Gambia. This technology requires more investments for feed and healthcare, and for labour requirement as well. It is not surprising that attempts to implement such technology on large scale in West Africa fell short of expectations, because the majority of smallholders are still resource-poor (Delgado et al., 1999). They earn low income from dairying, and this is not enough to meet the high costs (direct and indirect) of technology. Therefore, the research should be geared towards generating a diversified range of technical options to suit the needs of farmers with different resource endowments, management skills and ability to bear risk.

VI. CONCLUSION AND POLICY IMPLICATIONS

Traditionally, cattle in West Africa are kept on-farm for a variety of purposes, including food, income, savings, animal draft power and so forth. Demand-led increases in livestock production, particularly in dairy products have led to the intensification of production near major urban markets in some countries. To date, the highest levels of intensification have occurred primarily in the developed countries (Delgado et al, 199). On the other hand, the past expansion of milk production in West Africa has come from increased herd sizes. There is evidence that this option remains smallholders' preferred strategy, as long as the uptake of productivity increase technologies is constrained by various factors at farm level. With the increasing interest to promote smallholder dairy schemes, there is need to refine policy and research approaches to suit the needs of farmers.

This study showed evidence that smallholders in West Africa should not be considered as homogenous. They are differently endowed in productive resources (land, labour, cattle) as investment capability also differs. Although they might face the same hidden constraints (access to credits and markets facilities), small producers with fewer cattle find it difficult to increase the production base. Given the current marketing systems, these farmers can only gain sufficient income from milk production to overcome urgent needs. Consequently, the investment capability is rather limited as compared to their counterparts with more resources, particularly cattle number.

On the ground, smallholders seem to have integrated productivity increase and capital accumulation in the same scheme of livestock development. The best thing well-motivated agencies can do to promote smallholder dairy schemes in West Africa, particularly in The Gambia, Guinea and Guinea Bissau, is to facilitate sustainable and market-oriented livestock production by resource-poor producer, the most numerically important group involved in dairy activities. Strategically, the study shows three pillars, on which smallholder dairy schemes can be based, to sustainably improve the livelihood of livestock owners and increase the availability of dairy products to reduce

the demand gap: an increase in cow productivity, an increase in the herd size, which balances with the feed resources and the diffusion of appropriate technologies.

In the case of this study, attention should be geared toward improving the quality of the existing feeds at the farm level (crop residues and agricultural by-products), the accessibility of the marketed feed (concentrate such as groundnut cake) and ensuring an effective livestock health care support. Irrespective to the resources level, smallholders are already using such inputs to increase their livestock productivity.

Above all, publicly funded research and extension should focus on agricultural resource management that comprehensively furthers policy goals. Enhancing the design of investments in smallholder dairy schemes is required. Rather than emphasising output maximisation above resource management, research and extension should find ways to use the dynamics of the existing production systems. This requires substantial improvements in the creation, dissemination, analysis, and use of policy-relevant information concerning livestock production systems and the characteristics of the owners. Differences and overlaps between the ecological and in particular between the economic efficiency of livestock producers need to be soundly defined, such that interventions are targeted to the beneficiaries.

A number of issues could not to be addressed during this study. For example, this study has not captured the value of the calves and the cows' replacement. Information on calves' survival is required for the former, while for the latter a long-term monitoring is needed. Setting a simple monitoring system to understand the dynamic of the smallholder dairy farms could easily extend this static analysis.

REFERENCES

Agyemang, K. 2000. Dairy development in West Africa: Results of research by ILRI and its partners (1978-1998). Market-oriented smallholder dairy Working Document No. 8. International Livestock Research Institute, Ibadan, Nigeria.

Barton, D. and Bennison, J.J. 1994. the production objective and feeding strategies of livestock owners in The Gambia. IRDCurrents, No 13/14.

Batz, J.F. 1999. Improving priority setting for livestock research by using technology characteristics for adoption assessment. Dissertation. Humboldt universität zu Berlin, Germany.

Camara, E. and Kamuanga, M. 1995. Baseline study of livestock production and disease control practices in the Bansang-Missira area of the Gambia. Working Paper No. 1, International Livestock Research Institute and International Trypanotolerance Centre.

DEA/MDRA, 1992. Anuário estatistico – 1991. Divisao de estatistico Agricolas, Ministério do Desenvolvimento Rural e Agricultura, Bissau.

Delgado, C., Rosegrant, M., Steinfeld, H. Ehui, S. and Courbois, C. 1999. Livestock to 2020- The next food revolution. Food, Agriculture, and the Environment Discussion Paper 28. IFPRI/FAO/ILRI.

Delgado, C., Rosegrant, M., Steinfeld, H., Ehui, S. and Courbois, C. 1999. Livestock to 2020: the next food revolution. Food, Agriculture and the Environment. Discussion paper 28. IFPRI, Washington, DC.

DLS/ITC, 1993. National livestock census. Department of Livestock Services and International Trypanotolerance Centre, The Gambia.

DNE, 1997. Stratégies et plan d'action de développement de l'élevage à moyen et long terme (1997-2010). Document Principal. Direction nationale de l'Elevage et FAO. Guinée.

Dreschel, P., Quansah, C. and Penning de Vries, F. 1998. Stimulation of urban and peri-urban agriculture in West Africa - Characteristics, challenges, and need for action. Paper delivered at IDRC workshop on Urban Agriculture, 15-18 June 1998, Ouagadougou, International Board for Soil Research and Management and University of Science and Technology, Kumasi, Ghana, and Bangkok, Thailand, 21 pp. (June)

FAO, 1980. Le bétail trypanotolerant en Afrique Occidentale et Centrale, Volume I, Etude Générale. Etude FAO : Production et Santé Animales 20/1, Rome.

FAO, 1999. www.fao.org

Gonçalves, V.S.P. 1995. Livestock production in Guinea Bissau: Development potentials and constraints. PhD dissertation. Department of Agriculture, University of Reading.

Gryseels, G. 1988. Role of livestock on mixed smallholder farms in the Ethiopian highlands. A case study from the Baso and Worena Wereda near Debre Berhan. Dissertation. Agricultural University, Wageningen. The Netherlands.

Hopen, C.E. 1958. The pastoral Fulbe family in Gwandu. IAI/OUP, London.

Ibrahim Bulale, A. 2000. Smallholder dairy production and dairy technology adoption in the mixed farming system in Arsi Highland, Ethiopia. PhD dissertation. Free University of Berlin.

Jahnke, H.E. 1982. Livestock production systems and livestock development in Tropical Africa. Kieler Wissenschaftsverlag Vauk.

Kebede, Y., Kunjal, K. and Goffin, G. 1990. Adoption of new technologies in Ethiopian agriculture: The case of Tegulet-Bulga District, Shoa Province. Agric. Econ. 4:27-43.

Kiwuwa, G.M., Trail, J.C.M., Kurtu, M.Y., Worku, G., Anderson, F.M. and Durkin, J. 1983. Crossbred dairy cattle productivity in Arsi region, Ethiopia. ILCA Research Report No. 11. ILCA, Addis Ababa, Ethiopia.

Klecka, W.R. 1981. *Discriminant analysis*. Sage University Paper series Quantitative applications in the social sciences, series no. 07-019. Beverly Hills and London: Sage Publications.71pp.

Mbogoh, S.G. 1984. Dairy development and internal dairy marketing in sub-Saharan Africa: performance, policies and options. LPU Working Paper No. 5. Addis Ababa: ILCA.

McIntire, J. and Gryseels, G. 1987. Crop-livestock interactions in sub-Saharan Africa and their implications for farming research. Experimental Agric. (23): 235-243.

McIntire, J., Bourzat, D. and Pingali, P. 1992. Crop/livestock integration in sub-Saharan Africa. World bank Regional and sectoral studies, Washington DC, USA.

MDRA/DGP, 1991. Inquerito sobre os efectivos de gado nas regiões de Oio, Bafata et Gabu. Direcção Geral da Pecuaria, Ministério do Desenvolvimento Rural e Agricultura, Bissau.

Michael, J., Walshe, M.J., Arend, N. and Bachmann M. 1991. Dairy development in sub-Saharan Africa. A study of issues and options. World Bank Technical Paper No. 135, African Department Series, Washington, D.C.

Nicholson, C.F., Rutherford, A.S., Staal, S.J., Thorpe, W., Thorthon, P. and Kruska, R. 1999. The impact of income growth and urbanisation on dairy consumption in developing countries. International Livestock Research Institute, Nairobi, Kenya.

Njie, A. and Agyemang, K. 1991. Performance of the station-managed N'Dama herd in The Gambia. Tropical Animal Health Production (23): 45-54.

Rey, B., Agyemang, K., Thorpe, W., Mullins, G., Diedhou, M., Nokoe, S. and Shapiro, B. 1999. A research methodology for characterising dairy production systems. Market-oriented smallholder Dairy Research Working Document N0. 4. ILRI, Nairobi, Kenya.

Sandford, S.1989. Crop residues/livestock relationship. In: Renard, C.; Vandenbeldt, R.C. and Parr, J.F. (eds), soil, crop and water management systems for rainfed agriculture in the Sudano-Sahelian zone. Proceedings of an International Workshop, 11-16 January 1987, ICRISAT Sahelian Centre, Niamey, Niger. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, India, pp. 169-182.

Savadogo, M. 2000. Crop residues management in relation to sustainable land use: a case in Burkina Faso. Tropical Report Management Papers, No 31. Wageningen University and Research Centre, Netherland.

Somda, J., Kamuanga, M., Münstermann, S. And Bittaye, A. 2003. Socio-economic characterisation of smallholder dairy systems in The Gambia: Milk proudction, marketing and consumption. Socio-economic research Working Paper No. 1. ITC (International Trypanotolerance Centre), Banjul, The Gambia.

Starkey, P. 1991. Animal traction in Guiné-Bissau: status, trends and survey priorities. Report of a consultancy mission carried out from 22 February to 5 March 1991. Projecto de Apoio aos Servicos Agricolas, PASA-Pecuaria, Guiné-Bissau.

Waithaka, M. 1998. Integration of a user perspective in research priority setting: the case of dairy technology adoption in Meru, Kenya. Dissertation. Humboldt universität zu Berlin, Germany.

Walshe, M.J., Grindle, J., Nell, A. and Bachmann, M. 1991. Dairy development in sub-Saharan Africa: A study of issues and options. World Bank Technical Paper 135. The World Bank, Washington, DC, USA.

Waters-Bayer, A. 1988. Dairying by settled Fulani agropastoralists in central Nigeria. Farming Systems and Resources Economics in the Tropics, Vol. 4. Wissenschaftsverlag Vauk Kiel, University of Hohenheim, Stuttgart, Germany.

World Bank. 1985. The smallholder dimension of livestock development. A review of Bank experience. Operation Evaluation Department Report No. 5979. Washington, DC.

Appendix A: Herds' composition in percentage

	Guinea Bissau				The Gambia		Guinea	
	Type 1	Type 2	Type 3	Type 4	Type 1	Type 2	Type 1	Type 2
Female (%)	**64,71**	**70,48**	**73,68**	**72,20**	**67,92**	**68,06**	**78,04**	**64,71**
< 1 year	11,76	12,38	12,03	13,79	13,21	15,28	11,15	11,76
1-2 years	9,80	11,43	13,53	13,79	9,43	11,11	11,15	5,88
2-3 years	9,80	11,43	15,41	14,02	11,32	9,72	11,15	5,88
> 3 years	33,33	35,24	32,71	30,61	33,96	31,94	44,59	41,18
Male (%)	**35,29**	**29,52**	**26,32**	**27,80**	**32,08**	**31,94**	**21,96**	**35,29**
< 1 year	11,76	10,48	9,40	7,24	9,43	9,72	11,15	11,76
1-2 years	7,84	6,67	6,77	6,31	9,43	9,72	3,68	5,88
2-3 years	7,84	5,71	6,02	10,75	5,66	5,56	3,57	5,88
> 3 years	7,84	6,67	4,14	3,50	7,55	6,94	3,57	11,76