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Livestock in the rice-based economy of Office du Niger: The development potential for increased crop–livestock integration through multi-actor processes

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ABSTRACT

A diagnostic study of the development potential of livestock for the rice-based economy of the Office du Niger (ON) was conducted in Mali. The functioning of selected farming systems and value chains were studied by means of interviews, surveys and farmer group discussions. The findings show that in the ON rice remains the prime agricultural activity; although half of the farm households own cattle (for capital insurance and draught power), livestock management is troublesome because of a lack of grazing land and water points. Rice production is lucrative but approximately half of the farmers in the area studied do not have the land or capital to obtain a good harvest or sell at a profit. The ON supports rice farming through the provision of infrastructure and subsidies but the hierarchical structure of the ON's services and limited human resources hinder the timely availability and quality of its services. More affluent farmers do cope but poorer farmers have a problem to make ends meet. Diversification towards intensive livestock production might offer a new opportunity. The research station, dairy processing unit and dairy co-operatives are dynamic organizations and farmers appear eager to explore this opportunity but our analysis shows the revenue remains modest. We conclude that in order to improve the livelihood of the farmers, especially of the poor, it is critical to focus on institutional change within the rice sector. New forms of collaboration between the ON and the rice farmer organizations might solve most service delivery problems. However, this would require a long process of delicate brokerage, farmer organization and advocacy training. It would be important in the meantime to support activities that generate short-term visible results in the rice or dairy sector.

1. Introduction

In Mali, the agricultural value chain is a corner stone of the national economy, employing 70% of the country's labour force, contributing 50% of the export earnings and 33% of the gross domestic product [1]. A large part of national food production and export earnings comes from the approximately 26,000 farm households that cultivate about 80,000 ha of irrigated land in the Office du Niger (ON) [2,3]. The ambition of the government[1] is to make ON 'the rice granary' of the country, responsible for at least 50% of the commercial rice production [2]. The parastatal, the ON, is charged to promote intensive rice production [4]; now production levels of 4–6 metric tons per ha have been obtained but output does not live up to the ambition and output trends are flat decreasing. Small plots (56% of farmers own less than 3 ha), coupled with limited access to and late deliveries of subsidized fertilizers constrain rice production and lead to a progressive impoverishment cycle [5]. For the ON farmers diversification through integration of vegetable production and livestock production into rice farming seem to offer new opportunities [4,6]. These enterprises are promoted by the government and by various development NGOs. Farmers began to grow vegetables, notably onions, some two decades ago and by 1995/1996 this activity accounted for 20% of farm incomes [7]. In 2005, the government created the National Directory of Animal Production and Industries (DNPIA) to design and implement research and development programmes to increase farmers' earnings from livestock production. In the ON about half of the farm households own livestock, herded by pastoralists, and some have started intensive livestock production. Livestock contributes to the households' food security, generates extra income, and serves as capital insurance as a cushion against strong income fluctuations and emergencies like illnesses. And last but not least, it supports rice production through the provision of traction and manure [8–11]. Moreover, the demand for livestock products is expected to rise in most parts of Sub-Saharan Africa [12,13]. Real milk prices in Bamako have

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increased steadily over the last decade. To reduce the import of milk, presently valued at about 22 billion FCFA [€33.6 million] per year, and to valorize the potential of the large Malian livestock herd, in 2008 the government launched the project Prodevalait. This project provides 41 regions with milk collection centres, and with research and development projects related to fodder production, feed technology and breed improvement. So dairy production is presently promoted as a viable development option for ON farmers. Therefore the initial question and focus of the present study was to assess the development potential of livestock, notably dairying, for the rice-based economy of ON.

The aim of the diagnostic study was to gain insight into the development potential of livestock in the rice-based economy of the ON through a study of the functioning of the rice and livestock value chains, and of selected farming systems related to these chains. The starting assumptions were that (1) most local and farm-level development interventions, including livestock related ones, would have limited potential if they do not tackle systemic imperfections, notably in the performance of infrastructure, markets and financial provisions, knowledge management, and the formal and informal institutions [14–17]; and (2) successful innovation requires a multilevel, multi-actor process of technical and institutional learning and change [18–21].

This paper takes a broad perspective, first describing the historical–political economy of ON, the technical–institutional functioning of the inter-dependent rice and livestock value chain, and selected farming systems. We then provide a farmer-led diagnosis of system constraints and opportunities and their preferred options for development. Finally, we analyse and assess the effect of the identified constraints on farm income, the causal relationships among the identified factors, and the desirability and feasibility of the various technical–institutional options for development.

2. Materials and methods

2.1. Initial selection of study villages and farming systems

The topic of this diagnostic study was determined by a stakeholder workshop at which the participants noted how the various research and development projects in the ON focused on the rice and vegetable value chain, to the neglect of the potential of livestock. The diagnostic study thus was designed to focus on farmers involved in rice production, coupled with extensive livestock or milk production. Because milk production is carried out mainly by farmers in six villages that supply milk to the dairy processing unit in Niono, two of these villages from each of two contrasting ON zones within Niono district were selected as primary sites for the field research: Tenegue and Koyan Coura in the Niono zone and Bagadadji and Molodo Bamanan in the Molodo zone. The characteristics of the study villages are presented in Table 1.

In order to study the role of livestock in the various rice-based farming systems in these four villages we distinguished, on the basis of ON data and the relevant literature, the following three farming systems:

1. Farms with rice production but without a substantial stock of cattle (referred to as Rice-Only (RO) farming system). Many of these farms have no draught oxen.
2. Farms with rice production and a substantial stock of cattle that are herded on communal grazing lands outside the irrigation zone during the cropping season (referred to as Rice plus Cattle on Shrub Land (RCSL) farming system).
3. Farms with rice production and RCSL as well as dairy cattle (referred to as Rice and Dairy (RD) farming system).

Table 1
Household (hh) characteristics of the four villages studied.

Village	Tenegue	Koyan Coura	Bagadadji	Molodo Bamanan
hh per village	322	133	335	400
hh members[a] per hh	8.1	6.5	11.0	12.5
Rice area (ha per hh)	3.7	3.2	3.1	4.2
hh without cattle (%)	48.4	47.5	47.8	42.8
hh with ≤30 cattle (%)	30.1	35.1	27.1	37.1
hh with 30–70 cattle (%)	17.1	10.2	20.1	15.1
hh with ≥70 cattle (%)	4.5	7.5	5.1	5.2
hh with dairy cows (%)	6.8	7.5	6.9	6.2
Dairy cows per hh with dairy cows	3.6	4.5	3.6	3.5

Source: Data for 2010, from Chambre Regional d'Agriculture.
[a] Includes men, women and children.

2.2. Data collection and analysis

Because of our interest in integration as an innovation pathway we studied technical as well as institutional issues at various system levels. Institutions here are taken to refer to norms and values as expressed in formal laws and procedures, informal working routines, and forms of collaborations that guide and support daily practices. Institutions are socially constructed, historically embedded and evolve in a path-dependent way through experimentation and communication [22–24]. In order to get a feel for the institutional 'space for change' we first studied the literature on the history of the ON, farm surveys and stakeholder interviews about the present situation.

The present diagnostic study aimed to generate scientifically credible, stakeholder relevant and legitimate information about the role of livestock in the rice-based economy of the ON [25]. The specific objective was to identify the concrete technical and institutional problems that farmers or other stakeholders in the rice or livestock value chain were willing and able to tackle. The study comprised a literature review, a farm survey and group discussions, and in-depth interviews with stakeholders.

2.2.1. The farm survey

The farm survey collected detailed information on 60 rice farms (15 farms in each village). The respondents were selected using the snowball method [26,27]: farmers were asked to identify 'farms that depended on rice, with no substantial livestock herd', 'rice farms with a substantial livestock herd', and 'rice farms with dairy'. The information was used to make farm system analyses in order to characterize the main assets and practical management strategies of each type of farm activity, such as use of inputs and labour, outputs, economic profitability and cash flow. At the end of the formal questionnaire, the farmers were asked to highlight the production constraints they experienced at farm level. Farming system data from the survey were statistically tested for differences in SPSS (version 19) by an ANOVA procedure. The Bonferroni post hoc test was used to compare the means of the three farming systems.

2.2.2. Group discussions

Group discussions were organized in each village after the survey had been completed, to get clarification and deeper understanding of the collected data. The village leader in each case called for this meeting; hence the farmers attending included some of the respondents of the survey but also others. It became clear through the discussions that the farms included in the survey were not representative of the whole spectrum but rather of the more affluent in each category. For instance the average land area of RO farmers in the survey was found to be 2.8 ha, whereas in the group discussions the farmers explained that about half of the RO farmers

owned less than 1 ha. The average livestock herd of the RCSL farmers in the survey was found to be 70 head of cattle, whereas a herd of about 30 cattle was thought by the discussants to be more common and representative for the villages (Table 1). So the survey results probably are not representative, but still give some insight into the reasoning and strategies of farmers in the identified cattle ownership category.

2.2.3. In-depth interviews with stakeholders

In-depth interviews ($n = 3$) were conducted at the Niono research station with the chief of livestock research, the cattle livestock officer, and the officer of agricultural services in charge of rice production. At the ON office, in-depth interviews were carried out with the chief of the rural services, the land registry officer, the credit and water fee officer, and the statistics officer ($n = 4$). More information about the credit associations was gathered from the application officer of the Farmer Credit Association in Niono. Finally, in-depth interviews were carried out with the representative of the central milk-processing unit about the unit's activities and the relationship between the unit and dairy co-operatives ($n = 1$). These nine interviews focused on technical and related institutional issues.

2.2.4. Farming system group discussions

At the end of the study, three focus group discussions [28] were organized to systematically inquire about the functioning of the value chains. Each focus group discussion gathered 12 representatives of a specific farming system (three representative farmers from each village). These so-called farming system group discussions were facilitated by the livestock extension service, to allow the researcher to record the data. The discussions followed the format of the system analysis matrix [14,29], which enabled participants to make a value chain analysis and reflect on perceived constraints and opportunities regarding the knowledge infrastructure, infrastructure, formal institutions, informal rules and routines, interaction among stakeholders and the market structure. At the end of the system analysis, the different farmer categories were asked to prioritize 'options for development'. There was a chance that the relatively poorer farmers were underrepresented in these focus group discussions. However, we asked the groups to reflect on the results and they regularly referred to the situation of their poorer fellow farmers to provide a realistic picture that we triangulated with the information given by the professionals.

Emerging issues are considered in the analysis and discussion section of this paper. Causal diagrams were constructed by the researcher from the findings to identify root causes and effects. To get a clear idea of the financial consequences of existing combinations of constraints, we elaborated three RO farm sub-typologies to complement the RO farms included in the farm survey (the relatively wealthy ones that had either traction available (ROdraught) or not (ROcommon)) with the marginalized RO farm (ROmarginalized) that, according to the farmers, represented a considerable group of RO systems. The high number of constraints listed, and the observed 'lack of stakeholder enthusiasm' to tackle issues in the rice value chain, persuaded the researchers to primarily focus future action research on the opportunities of the small but dynamic dairy value chain, although it was realized that this would not immediately benefit the most marginalized rice farmers.

3. Results

3.1. History of the Office du Niger

The literature search indicated that in 1932 the French colonial power created the Office du Niger with a twofold objective: to support the French textile industry by providing a secure supply of cotton fibre and to become the rice granary of West Africa [30]. Settlers from different regions of French West Africa, some of whom were forced to join the scheme, were granted renewable tenancies but also became subjected to the 'economic police', a military body in charge of ensuring all produce was sold through government channels (Coulibali, cited by [10]). When Mali gained independence in 1960, the socialist regime of Keïta inherited the ON which then operated 45,000 ha of irrigated land. They pursued construction works, promoted co-operatives and collective fields, and started mechanization to improve the agricultural production and export. However, because of the ethnic diversity, low farm-gate prices, and problems with mechanization, these initiatives failed [31,32].

After the military coup in 1968 the government abandoned the non-profitable production of cotton, started infrastructural rehabilitations, changed co-operative rules and increased farm gate prices. These reforms led to an improvement in production during the 1970s. In the 1980s a number of donors joined together to support a large-scale rehabilitation programme on the existing 50,000 ha of irrigated area, coupled with the liberalization of marketing and the creation of village associations to facilitate credit, input supplies and marketing at the local level. In 1994, the ON was restructured again: the number of ON staff was cut from 3000 to 1000 employees and its mandate was changed. From then onwards ON became primarily responsible for the infrastructure, allocation and management of land and water, and extension services.

The restructuring and rehabilitation of the 1980s led to increased rice yields: from 1.5 to 5.5 metric tons per ha over 10 years [33]. However, whether this productivity level can be sustained is questionable. Between 2001 and 2004 the productivity of rice and vegetables decreased by 22% and 10% [34], respectively. Experts reported a deficiency in the drainage system and subsequent alcadisation–sodisation of the soils [35]. The farmers complained that the soils degraded because of prolonged cultivation with insufficient fertilization [33,36]. In 2008, when one third of the farmers had become indebted and could not repay their fertilizer costs, the Malian government launched the Rice Initiative. The initiative guaranteed a 50% subsidy on fertilizers and required the banks and micro-credit institutions to provide the necessary credit [37].

In the future, scarcity of irrigation water may become a severely limiting production factor for smallholder production, because rainfall trends are declining while the government is attracting funds from the West African Economic and Monetary Union, from foreign investors such as the Libyan, Chinese and Senegalese governments, as well as from the Malian company Tomota and the South African company SoSuMar to expand the ON irrigation area for rice, sugar and oleaginous crops [2,3,33,38–41]. It is questionable to what extent such investment projects will provide irrigation land and employment to the existing ON farmers. The government has proposed farm diversification as the solution to their survival and has created a new Ministry of Integrated Development (MIDON) (which has taken over the ON portfolio from the Ministry of Agriculture) to push the diversification agenda.

3.2. The technical–institutional functioning of the rice and livestock value chain

The findings about the technical–institutional functioning of the rice and livestock value chain, and the identified farm system typologies, are based on the farm survey, the group discussions and the in-depth interviews with stakeholders, and on the literature.

3.2.1. The rice value chain

Rice production in the ON zone is a relatively input- and labour-intensive food and market-oriented production system. There are two cropping periods. The main cropping period coincides with the rainy season, which starts with the first rains in June and leads to a harvest in October–November. The second cropping period coincides in the irrigated areas with the dry season when part of the farm land is cultivated with rice and vegetables.

Since the 1990s, the markets of inputs and rice have been somewhat liberalized. Farm gate prices at that time were favourable for producers because the government regulated rice output prices via the purchase and sales of a rice security stock, and restricted tax exemptions for rice imports at times of a domestic rice shortage. To facilitate the organization of input supply, rice processing and marketing in a more liberalized market, the government in 1994 stimulated the creation of village associations. This has worked well for the seed system in the villages in our survey. Farmers are organized in seed producer unions and produce their own seed. They may also get seed from the seed research centre in Niono and from the ON board. Many improved varieties are available and farmers can choose among these, based on their particular preferences. The organization of credit for fertilizers has been less successful. The village associations were perceived by farmers themselves as part of the ON extension services rather than as an organization of farmers' own interests, and they lacked both the legal status and capacity to tackle the misuse of funds and non-repayment of fertilizer credits. As a consequence, many village associations have dissolved and farmers have regrouped into new, smaller GIE's (Groupement d'Intérêts Economiques) and mutual savings organizations. Higher-level financial institutions have forced the remaining village associations to improve their financial management [2,31].

Nowadays, it is private traders who organize farmers' access to fertilizer and pesticides. The use of inorganic fertilizers is widely held to be critical for the output. Donovan et al. [42] note that nitrogen (N) and phosphorus (P) fertilizers make up 20% of rice production costs, but this is seen as a worthwhile cost because the potential value/cost ratio in the ON for rice is 3.6. To stimulate the use of inorganic fertilizers, also by resource poor farmers, the government in 2008 launched a 50% fertilizer subsidy. In order to obtain subsidized fertilizer, the farmer associations organize tenders for input traders, and simultaneously apply for credit at banks and micro-credit institutions. Such institutions disburse loans for the supply of agricultural inputs to creditworthy farmer organizations and producers against an interest rate of 11–15% [43]. The ON supervises the bidding among fertilizer suppliers and grants subsidy budgets to the traders [43]. Traders use the grants to deliver the subsidized fertilizer, but they tend to deliver late and too little. Unfortunately, the farmer organizations have not organized themselves in higher-level federations that could put pressure on the traders but deal with traders on an individual basis.

In our study, the farmers confirmed the importance of fertilizers for their output and they generally apply the recommended quantity of six 50-kg bags of either urea or di-ammonium phosphate per ha. They apply for subsidized fertilizers through the ON board and micro-credit institutions but, when this fails, they try to get fertilizers directly from the market at the market price. The farmers primarily use family labour to carry out rice cultivation but during two peak periods they need additional labour: the transplanting and weeding period, and the harvesting and threshing period. For most farmers the first peak is the most critical, particularly because early and frequent weeding is essential to avoid weeds choking out the transplanted rice seedlings Transplanting and weeding require 7 and 10 labour days per ha, respectively, and farmers recruit 15–20 labourers per day to have the work done in time. During the peak seasons, 97% of the farmers pay for labour. In these periods, many labour migrants but also local women and young men earn some extra cash. Men and women have specific tasks (Table 2). Hired labour is contracted for an average daily wage of 1250 FCFA (€1.91) and food, but wages vary with the type of activity and may increase to 2000 FCFA [€3.05] during the peak periods.

Farmers store part of the rice harvest for their own consumption but a lot is sold at harvest time, when prices are relatively low because farmers urgently need to repay credit and water fees (67,000 FCFA [€102.29]) per ha) before 31 March. Farmers reported that the selling prices for a kg of paddy varied from 150 FCFA [€0.23] when the market became flooded to 325 FCFA [€0.50] at the start of the rainy season.

The research institute in Niono, which is a subsidiary of the ON board, executes research on rice, soil fertility and livestock. The ON itself is primarily responsible for the allocation and management of land, the rehabilitation and maintenance of secondary canals, and technical advice [36]. After the rehabilitation of the irrigation system, most farmers in Niono and Molodo area obtained rights to an annual tenancy of three hectares. When farmers have cultivated rice for two years, contributed to the maintenance of the tertiary irrigation system, and correctly paid their water fees, they are official entitled to a 'heritable' tenancy right (Permis d'Exploitation Agricole). In practice, farmers who pay the water fees qualify for the inheritable tenancy right. Although it is illegal, many farmers who are in need of money sell (part of) their farm permit to other farmers or outsiders. It is also common that farmers who are not able to cultivate all their land or need money, rent their land out for sharecropping or cash payments [33].

Rice farmers themselves are responsible for water allocation and management at the tertiary level. Their representatives are part of local and higher level ON committees for managing water, land, and land allocation [44,45]. Responsibilities and collaboration among the state, the ON and the farmers are now regulated in triennial Contract Plans [30,31]. Unfortunately, the organization of farmers remains weak. Neither the ethnic diversity nor the increasing differentiation between poor, full-time rice farmers and the wealthier, part-time farmers contributes to a spirit of co-operation and collective action [31,44]. About half of the rice farmers have taken up other economic activities and become part-time farmers [45]. They delegate agricultural tasks, including water management, more and more to seasonal wage labourers, who are not properly informed or motivated and often ignored with respect to collective action [45]. Furthermore, the existing farmer organizations are diverse and have not organized themselves into federations to democratically represent farmer interests in the tripartite consultations with the ON and the government. Up to 2000, the tripartite Contract Plans were signed on behalf of all farmers by 'general farmer representatives', who participated under their personal title. In 2000, the ON labour union, SEXAGON, managed to become included in the tripartite negotiation [2] and up to the present represents and defends the farmers' interests in the ON, but is not sufficiently equipped to tackle the issues related to the fertilizer and rice marketing structure.

There are some ongoing, preliminary initiatives to improve the representation and influence of farmers in value chain arrangements, e.g., the inclusion of farmers in the Agricultural Chambers, and the promotion and support for the development of higher-level organization by the West African farmer organization ROPPA (Réseau des Organisations Paysannes et Professionnelles Agricoles). Furthermore, the World Bank programme PASAOP (Programme d'Appui Aux Services Agricoles et aux Organisations de Producteurs) funds a number of extension NGOs to support farmer organization capacity building. However so far the impact is still insufficient to ensure farmer friendly market arrangements [2].

Table 2
Rice farming activities and labour participation rates (defined as contribution to total labour input) in the main cropping season.

Farming activity	Participation rate (%)			Labour input[a]	Period
	Men	Women	Children	(working days per ha)	
Land preparation	95	–	5	5	June
Transplanting	2	98	–	17	June–July
Weeding	60	35	5	20	July–August
Water management	98	–	2	1	Whole cropping season
Fertilizer application	30	–	70	7	July–August
Pest and bird control	40	–	60	5	September–October
Harvesting	90	–	10	15	October–November
Threshing	5	90	5	15	November
Transport	2	–	98	10	November

Source: Village and farming system group discussions.
[a] Household labour and hired labour.

3.2.2. The livestock value chain

Households invest part of their earned income in livestock because livestock serves as draught power and capital insurance [5]. Over the period 1997–2001 Thibau and Brondeau [36] report an annual increase in the number of livestock in the ON of around 15%. In 1998 the cattle herd in Kala (a sub-region of the ON consisting of Molodo, Niono and N'Déboudougou), was estimated at 72,000 head of cattle, of which 18,500 served as draught power [36]. Despite the fact that 60% of the cattle herds in the ON are owned by rice growers and remain in the irrigated area for about six months per year, the 1994 ON restructuration and rehabilitation of the irrigation system economized on livestock infrastructure and did not support crop–livestock integration [36,42] but rather promoted the exclusion of livestock from the area [4]. Nowadays some in the ON still see livestock production as a competitor for land use, rather than an integrated component of a rice-based farming system [34,36].

Households with livestock usually keep some cattle at the homestead for traction, while their other animals browse outside the irrigation zone on rain-fed shrub land, herded by pastoralists. The livestock herds only enter the irrigation zone in the dry season where they graze around the rice fields and drink from the irrigation canals. When the rains arrive around May–June, farmers start their land preparations, and the large cattle population is sent out to the shrub lands about 50–100 km from the irrigation scheme. White Fulani cattle are the main breed. No feed is purchased for these animals. The cattle are vaccinated (about 5 times per year) against, amongst other diseases, rinderpest, pleuropneumonia, anthrax and bovine distomatose.

Niono is the fourth largest livestock market in Mali. The market is well-structured, with specialized actors such as sales brokers (who help individual farmers to sell their livestock), livestock traders, transport agencies, lorry owners and exporters. The main suppliers of the livestock market are Fulani herders. Rice farmers tend to sell animals only when in need of cash for social events or to pay for inputs and fees related to rice. However, a notable new trend is that many more farmers have started to fatten small stock or cattle for commercial purposes.

Intensive livestock activities are promoted by the National Directory of Animal Production and Industries (DNPIA) that was initiated in 2005 with the specific responsibility to design, monitor and implement actions for improving animal production and industries. One such action is a large dairy programme, Prodevalait (about 800 million FCFA [€1.2 million] per year), which stimulates research and extension in feeding practices, and fodder production, while also subsidizing breed improvement through artificial insemination (personal communication, Mr. Konaté, director Provalait, 2011). As a consequence, the Niono research station has initiated research on fodder crops such as sorghum, maize and cowpea.

Recently, with the support of the French Development Agency (AFD), an energetic business woman established a milk processing unit in Niono and encouraged farmers to organize themselves in village dairy co-operatives to better co-ordinate the input provision and marketing of milk. To date, six co-operatives have been established, with about 10–18 members each (average: 11.1). The co-operatives function well; data from the milk-processing unit show that each co-operative currently delivers about 500–900 l of milk per month, depending on the season. The general assembly, which comprises the dairy unit and representatives of the co-operatives, negotiates and sets the price, and discusses the market, milk supply, feeding and breeding situation. The milk factory employs a veterinarian who visits all co-operative members individually to give advice. The aim of dairy development is, according to the business woman, not only to supply the local milk market but also to encourage farmers to integrate rice and livestock more intensively. Dairy production may stimulate the cultivation of nitrogen-fixing fodder crops and manure management, both contributing to a better soil quality and reducing farmers' dependency on inorganic fertilizers.

With respect to dairy farming, two situations were found to be common in the study villages: (1) the herder is member of the farm household (son or other relative of the household head), and (2), the herder is a Fulani who is hired to take care of the animals. In either case, the herder is remunerated either in kind or in cash.

3.3. Preliminary analysis of the three farming systems

Data from the survey of the three farming systems are presented in Table 3 and analysed in more detail below.

3.3.1. The rice-only farming system (RO)

The surveyed RO farmers cultivated less land, tended ($p < 0.09$) to have a lower rice yield than farmers with livestock, and used more household female labour on their farms. These differences with the other farming systems were found despite the fact that better off farmers were over-represented in the surveyed RO farming systems: The survey data suggested that the RO average field size is 2.8 ha but in the village meetings and farming system group meetings the farmers indicated that nearly half of the farmers belonged to the RO system and a large part cultivated less than 1 ha of land. Since all farms started with a tenancy of 3 ha, these indications from the focus group discussions imply that many RO farms have lost tenancy rights. The farmers mentioned that inability to pay the water fees or to repay credits has forced many farmers to sell all or part of their tenancy rights. In addition, farmers with debts purchase less fertilizer or resell subsidized fertilizer, which also negatively affects their rice yields. If indebted farmers are banned from the credit associations they may become dependent on credit suppliers who charge higher interest rates and, even more

Table 3
Survey parameters[a] for the farming systems rice only (RO), rice with cattle on shrub land (RCSL) and rice with dairy cattle (RD).

	RO (n = 22)	RCSL (n = 20)	RD (n = 18)	Statistical significance level of farming system effect (p-value)
Rice production				
Farm size (ha)	2.8[a]	4.0[b]	4.0[b]	0.01
Rice yield (metric tons per ha)	3.9	4.9	5.0	0.09
Livestock production				
Cattle on shrub land (#)	–	70.5[b]	40.0[a]	0.00
Dairy cattle (#)	–	–	4.1	–
Milk (litres per cow per day)	–	–	3.6	–
Family and labour				
Age head of household (years)	55.6	57.0	55.0	0.85
Household members (#)	13.3	12.0	11.6	0.10
Male labour (#)[b]	6.4	6.3	6.6	0.87
Female labour (#)[b]	5.3[b]	3.4[a]	3.5[a]	0.04
Hired labour for livestock (#)	–	0.9	0.9	0.93
Hired labour for rice (#)[c]	6.2	5.7	6.7	0.56

Source: Farm survey.
[a] Values in the same row, followed by a different superscript are statistically different (p<0.05).
[b] Family and hired labour force available at farm throughout the year, average as perceived by farmer.
[c] Hired labour force during transplanting, weeding or harvest season, average as perceived by farmer.

importantly, they no longer have access to subsidized fertilizer. RO farmers often lack their own draught livestock and ploughing equipment, and are unable to start land preparation at the beginning of the season. As a consequence, RO family members may begin the season by first working for others (on farm and in non-farm employment) and only later use or hire other farmers' equipment to cultivate their own farm. The resultant late harvest is affected negatively in terms of output, quality and price.

3.3.2. The rice and cattle on shrub land (RCSL) farming system

Our survey data indicate that RCSL farmers constitute about half of all households. Rice production is the major activity in this system; livestock plays a supportive role. RCSL farmers use the livestock for manure and draught power; most importantly, livestock is their capital stock, which they can sell in times of need. Cattle constitute the dominant livestock species, but households also own some goats, sheep and donkeys. The farmer typically gives his cattle in custody to a Fulani herder, and pays him a salary of 5000 FCFA [€7.63] per month.

The RCSL farms included in the survey had 4.0 ha of land and a production of 4.9 metric tons per ha. The village and farming system group discussions suggested that most RCSL farmers apply fertilizer according to the recommended quantities and they add some manure. Most RCSL farmers are members of the credit associations and do not experience major repayment problems.

3.3.3. The rice–dairy farming system (RD)

The farm survey indicated that the RD farmers had fewer cattle than the RCSL farmers. Land holdings and rice yield did not differ significantly between RD and RCSL farms. RD farmers mainly own the local Fulani or Maure species for milk production. Few farmers have crossbreds. RD farmers own 2–10 milking cows (average = 4.1), which are kept at the homestead, producing on average 3.6 l per cow per day. The average quantity of milk produced is 2–4 l per day for a Fulani cow, 3–6 l per day for a Maure cow, while a crossbred may produce 10 l per day under good feeding conditions. The lactation length varies from 150 to 200 days depending on the severity of the lean season from March to May when there is no rainfall and the major feed source is crop residues.

Dairy cattle are managed differently than the cattle on the shrub land. Dairy cattle remain in the irrigation zone during the cropping season. The RD farmers reported that dairy cows are fed with a variety of crop residues including cereal straw, groundnut hay and the green grasses that grow along the canals. They are also given some concentrates. Fulani herders are contracted to take care of the dairy animals but it is the RD household members themselves who collect, store and transport the manure produced by the animals. Some RD farmers also do composting, which requires additional labour. The collection of straw (from rice or others cereals) constitutes an intensive period of labour for RD farmers just after the rice-harvesting period.

3.4. The farmers' system analyses: identifying options for development

The farmer-led systemic analysis of the rice and livestock value chains, served to identify and rank their estimation of the constraints, and the opportunities for development.

3.4.1. The rice value chain

With the use of the system analysis matrix [14,29] the farmers in the farming system group discussions visualized the functioning of the rice value chain as in Fig. 1.

At the level of ON policy, the farmers criticized the unclear procedures for land allocation. The availability of external funds had enabled the ON to expand the irrigated area and more land had become available but local farmers did not get their usual priority on its allocation. The farmers alleged that in one way or another foreign countries and investors from Bamako, attracted by the good rice price, had entered the area and acquired land. At the level of infrastructure, the farmers in the Molodo zone complained about the absence of rehabilitation and maintenance by the ON of the primary and secondary canals. This de-motivated the farmers from organizing the management of the tertiary canals, and the allocation of water and drainage remained troublesome. Farmers had the feeling that the water fees they paid were too high in relation to the poor management and the quantity of irrigation water received.

The farmers appreciated the good farm gate price of rice as well as the availability, diversity and quality of the rice seeds. However, they were less satisfied with the supply of fertilizers. In order to gain access to the subsidized fertilizer, they had to pay entrance and interest fees to the farmer organizations, amounting to 2000–3000 FCFA [€3.05–4.58] per bag of fertilizer, and the whole procedure could take one to two months. Fertilizer deliveries were late and too little compared with the allocated quantity of subsidized fertilizer; the farmers suspected that the traders kept part of the subsidy for themselves. Meanwhile, many farmers, especially RO farmers, became indebted, especially when the weather was unfavourable as in 2009 and 2010 when floods inundated their rice fields, and

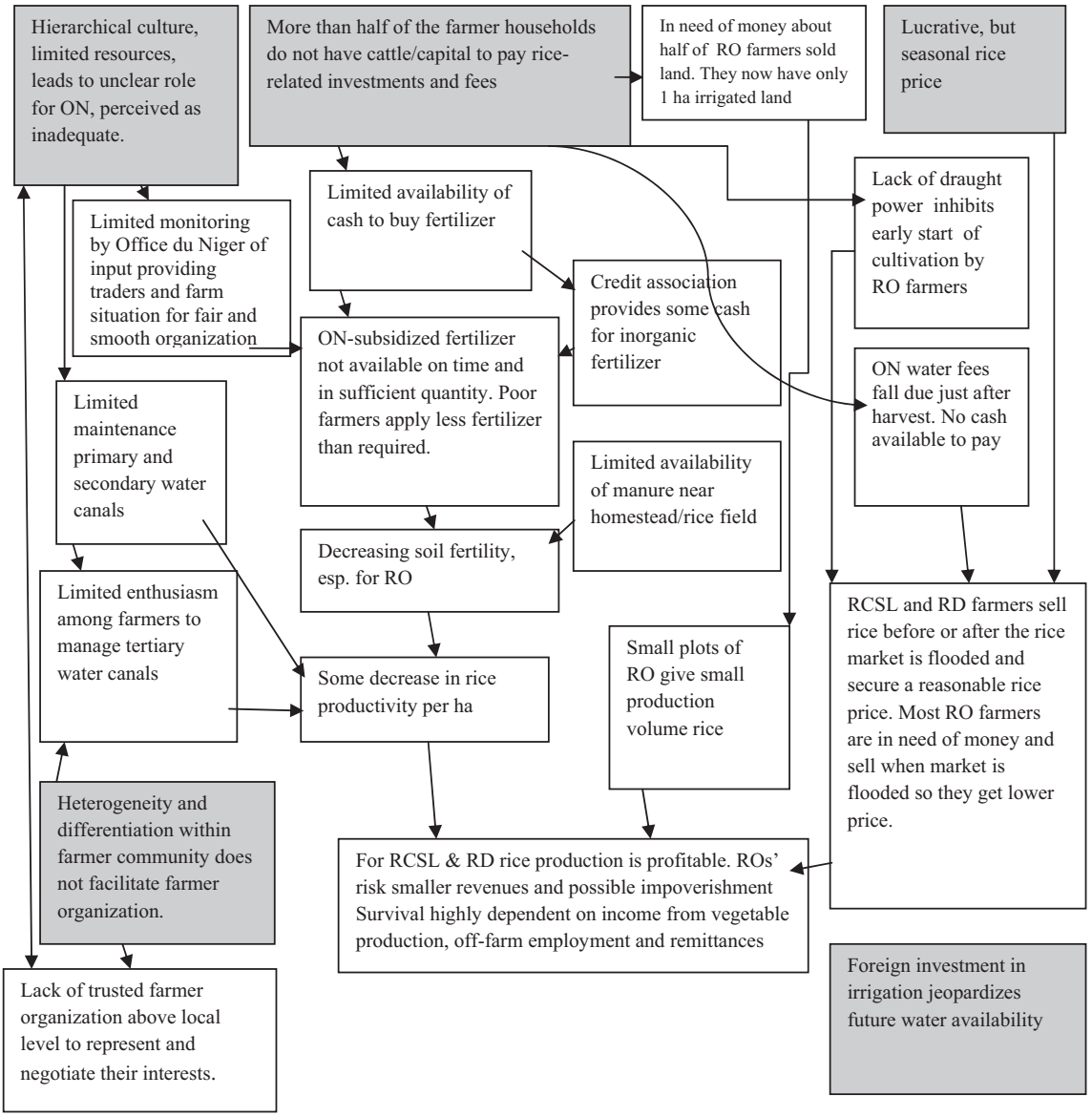

Fig. 1. Causal diagram rice sector Office du Niger (ON). *Notes*: Shaded boxes indicate core issues.
Source: Village and farming system group discussions.

they had to rent out land to more affluent farmers to make ends meet.

In the period 1980–1990 there had been many research and extension activities rice farmers had participated in, or they had witnessed the increased yields obtained in the experimental rice fields, hence their endeavours to strictly apply the recommended farm practices. However, decentralization had meant that the technical agricultural services of the ON had been privatized. The PASAOP and other donor-funded programmes enabled farmers to pay for some assistance but in the farmers' perspective this was not enough to provide them with adequate technical services. However, even more important, in the farmers' view, was the general lack of service provision by the ON. The process of land allocation and the management of primary canals were deemed to be non-transparent and insufficient and water fees were too high. The procedures for obtaining the ON-regulated fertilizer subsidies were too cumbersome and led to limited and late availability of affordable fertilizers. Farmers also complained that although, in times of flood, they were entitled to a water fee exemption, the ON officers did not arrive in time to make the official statement of damage. Overall, the respondents noted that there was mistrust between farmers and the ON, between farmers and farmer organizations, and between farmers and their representatives in the joint ON management committees because the farmers never received feedback about the meetings and were not informed about the triennial tripartite contract plans. In short, farmers felt let down, discouraged and lacked enthusiasm for their work.

When each of the three farmer categories in the farming system group meetings were invited to prioritize possible development interventions, all noted they would like to be informed about the Contract Plan and the mutual responsibilities that had been negotiated, and to have open discussions with the ON about the improvement of the water management and the water fee system. Furthermore, the RCSL and the RD farmers hoped they also could benefit from the ongoing investment projects that are creating new areas of irrigated land. The RO farmers, however, claimed that they first needed to improve the profitability of their rice production. So they hoped the ON would reconsider the level of the water fees and re-install the 50% subsidy on draught power and equipment.

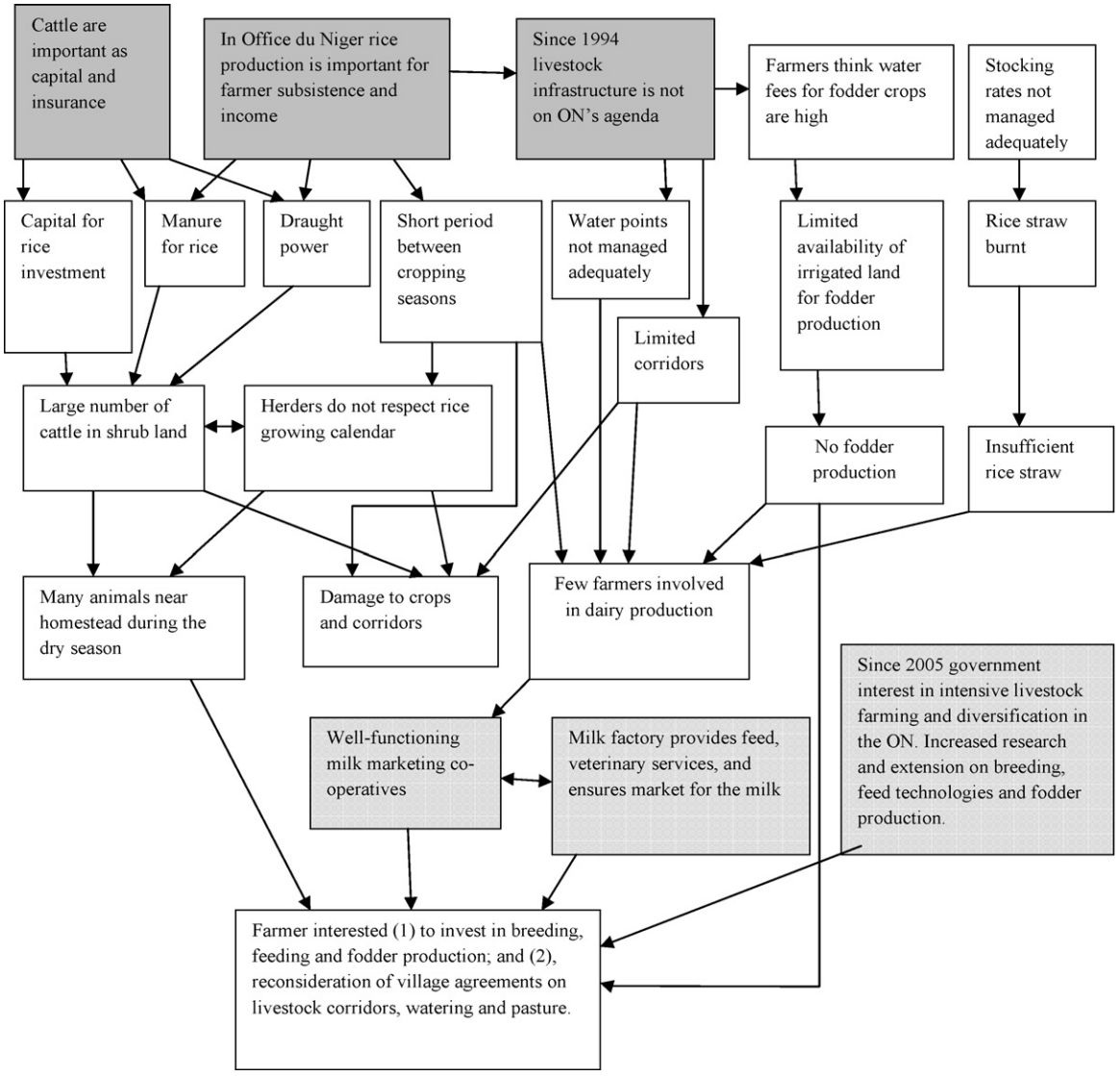

Fig. 2. Causal diagram dairy sector Office du Niger (ON). *Note*: Shaded boxes indicate core issues.
Source: Village and farming system group discussions.

3.5. The livestock value chain

The system analysis of the livestock value chain highlighted the issues visualized in Fig. 2.

In their analysis of the livestock value chain the farmers remarked that the ON's focus on rice production considerably affected the livestock system. In 1994, the ON had removed livestock management from its mission. Although vaccination programmes remained strictly implemented, new rehabilitation plans ignored livestock infrastructure and farmers were left to cope with a lack of pasture, watering points, and livestock corridors, and the limited availability of rice crop residues. Recently, diversification and livestock farming have re-emerged on the policy agenda: but most farmer respondents in our study were not aware of the new ON regulations designed to enable livestock intensification. For instance, they thought that the water fees for fodder production had remained at the same level as those for rice production, which severely limited their interest in the production of the fodder that would be necessary for livestock intensification.

There is no real market for livestock inputs: farmers were not accustomed to producing fodder for sale or to buying additional feedstuffs (until the dairy processing unit started to offer feed supplements on credit). Our respondents noted that more and more farmers in fact are starting to fatten livestock for commercial purposes. As milk consumption in the more urban areas increases, a milk market is emerging that is well organized by the milk processing unit and the dairy farmer co-operatives. Our respondents were of the opinion that the milk market has development potential as long as the dairy processing unit is able to expand its processing capacity as milk deliveries grow.

Recently, the government started the Prodevalait project to research, develop and provide better breeds, feed and fodder production technologies, and farmers noted that the livestock department of the research institute in Niono had started to visit them to discuss intensive livestock management practices. The dairy processing unit also supports its members by employing a veterinarian who visits farmers to give advice on animal health, milk breeds, feeding and other dairy related issues. The dairy co-operatives are dynamic and organize exchange visits but the farmers noted that most milk producers still lack essential knowledge on breeding, feeding and fodder production. Furthermore, the farmers remarked that at village level issues such as grazing, livestock corridors and watering points could be much improved if

co-villagers would better respect the agreed rules for passage and grazing.

The system analysis visualized the farmers' appreciation of overall development strengths and opportunities. When asked to prioritize development interventions, the farmers indicated their need for more productive (dairy) breeds and knowledge about feeding regimes and fodder production. They also suggested that it would help to start village level discussions about the need for pasture areas, livestock corridors and watering points.

4. Analysis and discussion

4.1. The relative importance of causal factors

In order to shift the focus away from symptoms to analysis of causal factors we constructed a causal diagram [29] from our findings to indicate the causal relationships that determine root problems (weak points and threats; dark grey) and opportunities (strengths and opportunities; light grey) vis-à-vis other mediating factors. In the rice value chain (Fig. 1) we identified three important factors that determine the present situation: (1) the lack of capital of the RO farmers, (2) the lucrative but seasonal rice price, and (3) the history-embedded hierarchic culture and unclear role of the ON. All farmers suffer from the poor organization of fertilizer subsidies, water infrastructure and water fees. The more affluent farmers cope with the situation as they have the capital to invest in draught power, obtain the required fertilizer from the commercial market and sell the rice at an opportune time to fetch a lucrative price and good rice income. However, many RO farmers lack the capital to obtain a good income from rice; their debts mean they experience difficulty in gaining access to the necessary amount of (subsidized) fertilizer and, in need of money, many RO farmers have sold their tenancy rights to irrigated land. Most RO farmers also lack the draught power necessary to start cultivation on time, which means they cannot sell their rice before the market is flooded and the price drops, leaving them with insufficient funds even to pay their water fees. It seems difficult to remedy the situation. The history of the ON, the heterogeneity of the farming population, and progressive differentiation among the members of the farmer community mean that farmers find it difficult to organize and represent their own collective interests vis-à-vis either the ON or private traders. The threat that foreign investors will tap the precious irrigation water to serve their own interests is a pressing and growing concern.

The causal diagram for livestock is complicated because the situation is changing (Fig. 2). From the time of the restructuring in 1994 up to 2005, three factors have defined the situation, to a large extent: (1) in the ON, rice production remained the primary base for farmer subsistence and income, (2) the ON did not invest in livestock infrastructure or encourage production for either meat or milk; and (3) farmers in the ON continued to invest in their livestock herds. As a result, livestock management became problematic and very few ON farmers took up specialized, intensive livestock production. This situation changed around 2005, when (1) the ON embraced the idea of diversification and the government started several projects to support intensive livestock production, notably dairying; (2) in Niono, with the support of AFD, a privately owned milk processing factory started; and (3) dairy farmers successfully organized themselves into dynamic dairy co-operatives. These three positive factors have attracted the interest of an increasing number of farmers in dairy production and related breeding, feeding and fodder techniques, and is motivating them to reconsider old agreements concerning livestock corridors, watering and pasture points.

4.2. The impact of causal factors on household income

In order to assess the impact of the identified constraints on and opportunities for the rice–livestock income in each of the three farming systems, we made an economic analysis. For the purposes of this exercise all prices are given in FCFA only. Since marginalized RO farmers were not represented in the farm survey and since focus group discussions indicated that they constitute a significant portion of RO farmers, the RO typology was further elaborated. The sub-typologies developed within this category are based on the levels of poverty and farm practices highlighted by the farmers during the farmer discussions, as follows:

- ROmarginalized. A marginalized household cultivates 1 ha of rice yielding 2 metric tons sold for a low price (150 FCFA [€0.23] per kg) because of reduced input use, poor quality, late harvest and a flooded market. Households get extra income from labour services rendered to other farmers at the start of the cropping season.
- An average RO household (ROcommon). Input use is according to recommendations. The rice price received is relatively low (200 FCFA [€0.30] per kg) because of the late harvests caused by lack of draught animals and equipment at the start of the cropping seasons. An ROcommon household gets income from labour services rendered to other farmers during the cropping season.
- An RO household with draught animals (RODraught). This household uses inputs as recommended and gets a good price (250 FCFA [€0.38] per kg) because they can start field preparation and planting early in the season.

The revenue and profit margins of the various farming systems are based on data from the farm survey and the village and farming system group discussions (Tables 4 and 5). Livestock costs in RCSL and RD are based on veterinary costs (350 FCFA [€0.53] per vaccination, which on average is done 5 times a year) and the salary for the 0.9 Fulani herder employed at a cost of 54,000 FCFA [82.44 Euro]. Farmers estimated the concentrate supplied to each dairy cow at 8 bags per year at a cost of 7500 FCFA [€11.45] per bag. Each bag weighs 50 kg. Dairy cows produce on average 3.6 l milk per cow per day with a lactation length of 175 days. Milk is sold at a price of 230 FCFA [€0.35] per litre.

Tables 6–8 give estimates of the costs and benefits of rice and livestock in the selected farming systems. These data indicate gross and net household revenues from rice in the main season, complemented by the revenue from the livestock production. These constitute the base income of the households but are not exhaustive because households try to complement this income with rice and vegetable production in the dry season (which according to one source [33], may range from 35,000 FCFA [€53.44] to 98,000 FCFA [€149.62] per household), off-farm activities and remittances from migrant family members. Especially for the poorer households such complementary revenues are of crucial importance for survival. Table 6 shows that for the ROmarginalized and ROcommon households rice income is not enough to ensure bare subsistence; it does not provide even 655 FCFA [€1.00] per household member per day (i.e., the general definition of the poverty line). The situation of ROmarginalized households is critical, hovering at the margin of risk; they cannot survive without significant off-farm income or remittances. The situation of RODraught farm households is somewhat better. Because of the availability of draught power they can start rice cultivation at the proper time; they do not have to pay for traction and transport; they may negotiate better rice prices by selling before market prices drop, and they enjoy a higher gross margin than farmers without draught animals. With an average of two or three well-fed oxen and one donkey, these rice farmers are able to carry out the recommended farm practices on time and obtain

Table 4
Farmer system analysis rice sector Office du Niger (ON).

Actors / System characteristics	Farmer organizations	Suppliers (input + credit)	Office du Niger	Technical and business advisory services	Research institutes	Rice market
Knowledge infrastructure: (technical farm knowledge, farm business management, price and marketing knowledge)				Long history, but presently lack research and extension for rice production		
Infrastructure: - Availability irrigation canals, roads, - Irrigation water, seeds, fertilizer, credit - Telephones, cars to transport rice production to markets etc.		Expensive, limited and late access to subsidized fertilizers	Insufficient maintenance by ON of primary and secondary canals; high water fees			
		Good availability of rice seeds	Foreign investment in new irrigation schemes that withdraw water; coupled with unclear allocation of new irrigated land			
Hard institutions: policies, implementation and support	Poor farmers 'illegally' sell land use rights to affluent farmers					Government import control and security stock to support rice prices
Soft institutions: informal contacts, communication and routines of collaboration	Moderate collaboration for maintenance of tertiary canals		Insufficient visits by ON officers to accord exemption from water fees for inundated crops			
Interaction among farmers within village, with other villagers, traders, ON etc.	Lack of communication and trust between farmers, farmer organizations and ON farmer representative		Lack of communication and trust of farmer (organizations) vis-à-vis ON officers			
Market structure						

Source: Village and farming system group discussions.
Note: Light shaded boxes indicate positive factors; dark shaded boxes indicate problematic factors.

good production levels [41]. In our exercise this leads to an increase in the gross margin of up to 35%. RCSL and RD households achieve the highest gross margins. According to our analysis RCSL farmers have enough capital to sell their rice at a time when prices are favourable. This enables them to increase their rice gross margin by 90% compared with those of the ROdraught farmers. This category of farmers has enough resources to live from, and may get involved in money-lending and trade activities. They are probably part of the 30% farmers for whom rice production is not their prime activity anymore [44]. RD farmers in our survey had fewer cattle than the RCSL, and invested in labour intensive livestock production such as dairying to gain additional revenue. However, the extra revenue gained by the dairy activity was limited as the production per cow was relatively low: it increased the farm's gross revenue only by 5%. In summary, our analysis of this exercise suggests that it is the limited access to land that forms the most severe constraint on rice-livestock income, followed by the 'timing of payment and level of the water fees', and a lack of draught power. The present revenue stream from dairying is small.

4.3. Desirable and feasible innovations

A successful innovation dynamic can be characterized in terms of continuous and evolutionary cycles of knowledge exchange, learning, experimentation by diverse value chain actors, driven by actual needs and creating new technical, organizational practices and institutions [46]. A much recommended innovation strategy is therefore the creation of a heterogeneous innovation platform composed of value chain actors. These actors may bring a diversity of knowledge to the change process, as well as linkages with organizations and networks that may provide necessary skills, resources, and legitimacy. A platform may provide new opportunities for individual and shared learning and experimentation [47]. Now the question is: is this approach recommendable for our case? What are the most desirable and feasible entry points for learning and innovation? Below, we attempt to formulate an answer to these questions.

The initial question and focus of this research was to assess the development potential of livestock, notably dairying, for the rice-based economy. The findings show that farmers use livestock mainly for capital insurance and draught power. Livestock production, however, is troublesome: the ON area lacks the necessary infrastructure and the herds cause considerable damage to the movement corridors and watering points. Farmers perceive that intensive livestock production such as dairying is an interesting development option but this activity so far generates little extra revenue for the rice farmers. The analysis indicates that it might

Table 5
Farmer systems analysis dairy sector Office du Niger.

Actors / System characteristics	Dairy co-operative	Milk factory (supplier of feeds + health services)	Research & University (breed improvement, feeding)	Government/ Office du Niger	Consumers
Knowledge infrastructure (expertise in dairy production, feed production, animal health, manure)	Farmers feel they lack knowledge (breeding, feeding and fodder production)		ON research institute and Prodevalait provide research and support breed improvement, feeding and fodder production increased		
Infrastructure - Livestock corridors, grazing area, water points, vaccination park, housing - Availability feed and health services		Energetic manager of milk processing unit organizes availability of feed, health advice, vaccination, for milk co-operatives.		Limited livestock corridors, water points and grazing area, but strict implementation vaccination programme	
Hard institutions: policies + rules about presence and grazing of livestock in irrigated area, water fees for fodder production etc.				Government officially promotes livestock production, notably dairy: lower water fees, fodder production, 80% subsidy artificial insemination	
Soft institutions: informal contacts, communication and routines of collaboration	No respect livestock owners of grazing areas, livestock corridors and watering points				
Interaction among dairy farmers in co-operative, village, with other villagers, traders, research	Well-functioning farmer milk co-operatives and farmers willing to invest in dairy				
	Increasing communication by farmer co-operatives with milk factory and research institute				
Market structure					Milk consumption in urban areas is increasing

Source: Village and farming system group discussions.
Note: Light shaded boxes indicate positive factors; dark shaded boxes indicate problematic factors.

be more valuable, especially for the poor, to work on structural problems in the rice value chain. This implies that interventions should focus primarily on institutional innovations that might support change in the collaboration routines of ON officers. Institutional changes that support better communication, accountability and responsiveness, required on the part of the ON, might solve the problems encountered by farmers in relation to water fees, water management and fertilizer subsidies. However, we consider it might be difficult to discuss a sensitive issue, such as the way in which the ON functions, in multi-stakeholder platform meetings. It might be better to use a more informal approach, based on identifying possible brokers or godfathers within the ON structure to create awareness, vision and change [47]. A federation of farmer organizations that is able to exert

Table 6
Estimated cost of rice production.

Input	Costs (FCFA × 10^3 per ha)[a]	Description
Seeds	17.5	50 kg per ha; 350 FCFA per kg
Fertilizer	75	Subsidized fertilizer, 6 bags at 12,500 FCFA
Water fee	67	
Traction and transport	30 (RO only)	RCSL and RD have their own donkeys and oxen
Hired labour	60	Weeding, transplanting, harvest and threshing

Source: Village and farming system group discussions.
[a] 1€= 655 FCFA.

Table 7
Farm income related parameters of five farming systems.

	ROmarginalized	ROcommon	ROdraught	RCSL	RD
Land in cultivation (ha)	1	2.8	2.8	4	4
Rice yield (metric tons per ha)	2	3.9	3.9	4.9	5
Price rice (FCFA[a] per kg)	150	200	250	250	250
Income labour elsewhere (FCFA $\times 10^3$ per year)[a]	75	75	–	–	–

Source: Farm survey and village and farming system group discussions.
[a] 1€= 655 FCFA.

political pressure and negotiate mutually beneficial arrangements, could support such a process of institutional change [48,49]. This in turn implies that farmers must also change ingrained attitudes of mistrust and apathy. Interventions such as training in organizational management, leadership and negotiation might help existing farmer organizations, such as the rice-related GIEs and dairy co-operatives, to become credible representatives and organize themselves into a federal association to negotiate with the ON on terms of greater equality. We recognize that institutional change at ON and farmer level is a hard and lengthy process, so it might take time before farmers would see the concrete results of such a transformative process. In order to create a positive motivating dynamic with short-term visible results, it may be a good idea to help farmer organizations start side-activities such as livestock-sharing projects, the provision of mini-tractors for ploughing services, or cereal banks.

Another possibility is to promote investment in the dairy sector. The initiation of a multi-stakeholder platform for dairying could help (1) to ensure intensive livestock production re-emerges on the ON infrastructural agenda and in the next contract plan, and (2), to better co-ordinate and enhance ongoing research and extension activities carried out by the research unit, Prodevalait, the milk factory and the dairy co-operatives in relation to breeding, feed technology and fodder production. These actors are active and interested in developing the sector; hence it might be relatively easy to bring them together. They could encourage local dairy co-operatives to start, for instance, Farmer Research Groups to enable farmers to share knowledge, create dialogue around common technical issues and management practices, and develop their confidence in breeding, feeding and fodder production techniques [46,47]. The dairy platform might also initiate village-level discussions about integrated livestock management and the need for basic infrastructure such as livestock corridors and watering points. Valuable livestock practices could be disseminated through field days, farmer-to-farmer exchanges or, if needed through Farmer Field Schools (an intensive, practice-based learning approach to knowledge development). Such activities might be especially interesting to those farmers who own some cattle but who might still have problems to make ends meet. Intensive livestock production demands high management and hard labour; hence the more wealthy farmers usually show little interest. It may be interesting to ROdraught farmers also to join in so as to improve the health of their draught animals and small stock. On the basis of our findings and analysis, we suggest in sum that development of intensive livestock production might be a positive, complementary innovation pathway that would (1) enable presently disparate stakeholders such as farmers, researchers and the ON to get to know each other, gain trust and establish communication and collaboration; (2) enable farmers to become re-energized, develop confidence and take a pro-active role with respect to development of the smallholder farming sector; (3) support farmers to obtain additional revenue and improve rice production

Table 8
Costs, revenues and gross margins for rice and milk production in the RO, RCSL and RD farming systems. All amounts are in FCFA $\times 10^3$ per household per year, unless stated otherwise. 1€= 655 FCFA.

Item	RO			RCSL	RD
	Marginalized[a]	Common	Draught		
Rice					
Seed	8.8	49.0	49.0	70.0	70.0
Fertilizer	37.5	210.0	210.0	300.0	300.0
Water	67.0	187.6	187.6	268.0	268.0
Traction	13.5	75.5	–	–	–
Hired labour	30.0	158.0	158.0	240.0	240.0
Input costs	156.8	690.1	614.6	878.0	878.0
Rice revenue[b]	300.0	2184.0	2730.0	4900.0	5000.0
Revenue from labour[c]	75	75	–	–	–
Gross margin rice and labour	218.2	1568.9	2115.4	4022.0	4122.0
Livestock					
Vaccination				123.4	77.2
Feed				–	246.0
Herding				54.0	54.0
Input costs				177.4	377.2
Livestock revenue[d]				–	594.1
Gross margin livestock				−177.4	216.9
Gross margin rice, labour and milk					
FCFA $\times 10^3$ per household per year	218.2	1568.9	2115.4	3844.6	4338.9
€ per household per year	195.44	2391.77	3224.90	5861.04	6614.60
€ per household member per year	14.70	179.83	342.47	488.42	570.22

Source: Farm survey and village and farming system group discussions.
[a] Only 1 ha land in cultivation, rice yield 2 metric tons per ha; if compared with common RO, fertilizer and labour input 50%, low market price (FCFA 150 per kg rice).
[b] Assumed: one harvest of rice per year. Only 10–20% of the land is used for irrigated rice production in the dry season.
[c] Income from labour services at other farms.
[d] Revenues from cattle on shrub land not included, since RCSL- and RD-farmers stated that cattle sales are emergency sales and not a regular source of income.

through the improved health of draught animals, the cultivation of nitrogen-fixing fodder crops, and increased manure production.

5. Conclusions

The diagnostic study included a historical analysis of ON, the functioning of the rice and livestock value chain, and the various farming systems. The results of the systemic, causal and financial analyses showed that the development potential of all types of rice-based farming systems is determined largely by institutional factors. However, change of ingrained institutional routines requires slow, subtle and informal manoeuvring by key actors, coupled with farmer training on organization, leadership and negotiation. Because the long-term nature of institutional change may discourage the actors involved, it is important to simultaneously work on technical and organizational changes in the rice- and livestock domain that generate short-term, concrete improvements at the farm level.

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