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Barriers and opportunities for innovation in rice production in the inland valleys of Benin

E. Totin[a,b,c,*], B. van Mierlo[a], A. Saïdou[b], R. Mongbo[b], E. Agbossou[b], L. Stroosnijder[c], C. Leeuwis[a]

[a] Communication and Innovation Studies, Wageningen University, P.O. Box 8130, NL-6700 EW Wageningen, The Netherlands
[b] Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, 01 BP 526 Cotonou, Benin
[c] Land Degradation and Development, Wageningen University, P.O. Box 47, NL-6700 AA Wageningen, The Netherlands

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ABSTRACT

This study investigates the technical and institutional factors that hinder the effective use of irrigation water and the development of the local rice value chain in an inland valley of Benin. Primary data have been collected in three areas: Koussin-Lélé, Bamè and Zonmon. The diagnosis indicates that both local and higher level institutional barriers affect the development of the local rice value chain negatively. The barriers to innovation include an unclear division of responsibilities between local farmer groups and the government for canal maintenance, a lack of effective local rules for the distribution and maintenance of the irrigation infrastructure and distrust among farmers, related to privileges of the farmer leaders, as well as the constraining formal and informal credit systems and uncertain market outlets. The barriers depress rice output and the income of farmers. The windows of opportunity to stimulate innovation comprise consumers' affinity to local products and territorial product labels, private–public community partnerships, the irrigation potential of inland valleys by the use of small pumps in combination with shallow tube well irrigation.

1. Introduction

The economic liberalization policies and reforms undertaken in Benin since the 1990s have led to the transfer of the control of irrigation infrastructure to farmer organizations [1]. Subsequent reform of the agricultural sector aims to revitalize water management in order to improve water use for agricultural purposes and ultimately farmers' livelihoods [2]. However, an exploratory study conducted recently in the inland valleys shows that problems related to water management in rice production remain [3]. Many technological options that address water management problems are waiting on the shelf but are not widely used [4] and farmers still experience the effects of drought and flood that limit their production [3]. The non-maintenance of irrigation canals is one of the main factors causing problems at the level of the rice plots managed under gravity irrigation [3].

For a long time, innovation has been regarded as the technical output of research [5], and as something to be transferred to the users. However, the introduction of infrastructure and new technologies is not effective if they are not appropriate for the context in which they are promoted and not adapted to users' realities [6,7]. Empirical studies demonstrate that innovation involves a simultaneous re-configuration of the social and technical dimensions of use [8,9]. Participatory approaches like farming systems research and extension emerged in response to the limitations and undesirable effects of linear technology transfer. Their focus on the field to farm level within a recommendation domain, however, has met with less success than expected; our first hypothesis is that this may be attributed to the limited room for change at the level of the single farm, local farmer group or village.

Effective deployment and application of technology in complex problem situations calls for a more comprehensive approach to innovation [7,10,11]. In this perspective, institutions are seen to play an important role. This article focuses on the institutions that hinder innovations but that could create space for positive changes in the use of irrigation water and farmers' livelihoods. Our second hypothesis is that neglect of the institutional dimensions of innovation processes may lead to a disappointing performance of any intervention or self-organizing initiative for change [12].

In the context of this study an understanding of the relation between practices and rules is developed in order to examine why the problems in rice production are so persistent and why relevant, seemingly simple solutions are not taken up. We consider farmers' practices to be shaped by institutional barriers and opportunities

* Corresponding author. Tel.: +229 97475607.
E-mail address: edmond.totin@gmail.com (E. Totin).

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that exist in and around the current production–consumption system. For the purpose of the study we understand institutions to include formal and informal rules, implicit cultural norms, values and symbols and social rules embedded in relations, physical artefacts and infrastructure [13–15]. We use the term 'institutional barriers' to refer to constraints related to the institutions that prevent promising technologies from being used [16].

The study is based on research carried out in the Agonlin Plateau region of Benin from July through November 2010, where farmers seek to create a living out of rice production but hardly succeed because of the many barriers. The research aimed first to identify the main problems in rice production and then the institutional barriers that hinder significant improvement of the local rice value chain and effective water use. Thirdly, promising windows of opportunity for innovation are identified. The article focuses on (1) farmers' practices in the study areas, (2) the socio-technical problems in the local rice value chain; (3) the institutional barriers in which farmers' practices are embedded, and (4) potential institutional opportunities for innovation. The next section provides a description of the research design including data collection and analytic methods, followed by the findings on the above mentioned four issues, analysis and discussion. The article concludes by summarizing the main institutional barriers and pointing to promising opportunities for an integrated approach to innovation.

2. Methodology

2.1. Area selection and properties

Three areas of the Agonlin Plateau (Koussin-Lélé, Bamè and Zonmon) were selected on the basis of an exploratory study that screened 18 rice producing villages located throughout Benin [3]. The areas were chosen because the issues around water use were found to be persistent and because (1) they offer contrasting water use practices and opportunities, (2) the farmers have a long experience in irrigated rice production, and (3), a number of projects (including the Urgent Food Security Programme (PUASA), AfricaRice, and Nerica Project) are ongoing in these areas and provided an opportunity to study how these projects deal with the challenges of innovation.

The irrigation schemes were constructed in 1976 with the help of Chinese experts who introduced rice production in each of these areas. For the first two years, the schemes were controlled by public authorities and the Chinese irrigation project, which provided seeds, farm tools, rice processing and marketing facilities. After the project leaders left in 1978 the production of rice collapsed. The reforms taken under the liberalization process in the 1990s led to the revitalization of farmer associations and the government shifted control of the irrigation infrastructure to the associations. Table 1 provides further relevant information about the context of the three cases.

2.2. Data collection and analysis methods

Data were obtained using focus group discussions [17] with rice farmers regarding (1) their practices of growing rice and managing the water resource, (2) their problems and concerns, (3) the barriers for innovation in the local rice value chain and improving the effectiveness of water use, and (4) potential solutions. The focus groups were organized per area and included rice farmer associations registered with the regional authority. No more than eight members were invited for each group discussion, to aid effective facilitation. We conducted 12 focus group discussions with 65 of the 200 farmers at Koussin-Lélé, three focus group discussions at Bamè with 14 out of the 19 farmers, and 2 focus group discussions at Zonmon with 16 out of the 21 farmers. In total, 95 rice farmers including 72 males and 23 females were involved in the focus group discussions.

During the focus group discussions the farmers were invited to present and analyse the problems they face with the aid of a visual instrument, the socio-technical root-system [18], in order to structure the inter-relations between the technical and social problems elicited. The discussions were organized to let the farmers reflect together and to provide an opportunity to the researcher to observe the interaction among the rice farmers [19].

However, we noted that the tool induced some bias as individual farmers appeared to base their own responses and arguments on what was said by others.

The general problem tree presented in this article was developed by building on the problem trees developed by the participants in the group discussions. In addition, a questionnaire sample survey was used to gather quantitative data on production costs, plot size, rice output, rice prices in the local markets and production cycles over the year, in order to validate the income problems mentioned. The survey covered a total of 60 randomly sampled rice farmers: 35 at Koussin-Lélé, 15 at Bamè and 10 at Zonmon.

Participant observation [20] of informal meetings among farmers gave us the opportunity to triangulate the information from the focus group discussions about their daily practices, especially on farmers' illegal water management practices. At the end of the field work, a meeting with the farmers from all three areas was organized to reflect on our findings concerning the main problems identified during the study and to explore their responses to the innovation opportunities identified. Table 2 provides an overview of the research design.

The main institutional barriers to improvement of the situation were identified from analysis of the findings, using the innovation system (IS) framework [21]. The IS consists of a matrix of system elements: barriers that may block learning and innovation (displayed in the rows), and the actors who reproduce the barriers (displayed in the columns). Our design classified the following four barriers:

1. *Infrastructural barriers*, relating to the knowledge infrastructure made up by departments of Research and Development, universities, research centres and all related regulations, and the physical infrastructure, consisting principally of roads and telecommunications.
2. *Hard institutional barriers*, relating to formal rules and regulations, and soft institutional barriers relating to symbols, values and norms.
3. *Network barriers*, calibrated by strength of connectivity, whereby strong interactions cause blindness towards new ideas from outside and weak interaction hinder actors to combine their forces to work for change.
4. *Market structures*, relating to the position of and relations between market parties along the value chain.

Originally, the IS framework was developed and applied to a national system of innovations in order to analyse systematically the barriers that block the development, use and diffusion of new products and technologies. It has also been used in adapted form to analyse institutional barriers relating to persistent problems of sustainable development [21].

The analysis of institutional barriers in this article builds upon the problem tree identified in the focus groups, supplemented by a literature study of the historical roots of these problems (such as the constitution and regulation of the rice market in Benin).

The analysis of the opportunities for innovation in the current setting took a slightly different route, starting with meetings with farmers in each of the research areas at which potential solutions

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Table 1
Description of the three study areas.

	Koussin-Lélé	Bamè	Zonmon
Irrigation scheme area	200 ha – originally 120 ha were irrigated by the Chinese sponsors	33 ha in the inland valleys. 4.5 ha are currently used to produce rice; farmers also use 10 ha of upland	88 ha originally irrigated but less than 10 ha are used now for rice cultivation
Irrigation technique	Gravity system	Gravity system in the valley and pump irrigation on the upland	Gravity system
Farmer groups	11 farmer associations (200 members)	3 farmer groups (19 members)	3 farmer groups (21 members)
Experience in rice production	Since 1976, farmers have produced rice but production decreased between 1980 and 1984	Rice production resumed in 2008 after collapsing in 1978 when the Chinese left the region	

Source: field data; FGDs.

Table 2
Description of the research design.

Data collection methods	Number of farmers involved	Area	Focus
Focus group discussions	65	Koussin-Lélé	(1) Farmers' practices
	14	Bamè	(2) Farmers' problems and concerns
	16	Zonmon	(3) Barriers for innovation in the local rice value chain and improving the effectiveness of water use
			(4) Potential opportunities for innovation
Questionnaire survey	35	Koussin-Lélé	(1) Rice production cost
	15	Bamè	(2) Farmers' returns from rice production
	10	Zonmon	(3) Production area
Participant observation		All 3 areas	Daily situation and practices of rice farmers during growing season
Group meetings	34	All 3 areas	Validation of the identified opportunities for innovation

to the barriers were explored. Subsequently the researchers held meetings with a number of organizations that are involved in the rice sector, including the regional extension office and the national committee of the rice farmer association (*Comité de Concertation des Riziculteurs du Bénin* – CCR-B), in order to further explore the opportunities for innovation identified by the local level actors. Finally, the identified opportunities were discussed during the final meeting, attended by a total of 34 rice farmers, from the three study areas, the researchers, the extension officers who operate in these areas and two representatives from the PUASA project.

3. Major results: problems and barriers to innovation

3.1. Farmers' practices

The practices of the rice farmers in the three areas are summarized in Table 3. We concentrate on those practices that relate to the five main problem categories identified in the focus group discussions: (1) water access and distribution, (2) maintenance of the irrigation infrastructure, (3) rice production cycles, (4) selling, and (5) agricultural financing.

3.1.1. Water access and distribution

In the first production season (September–December) all rice farmers in Koussin-Lélé can take as much irrigation water from the Koussingo-Lélégo streams they need. However, in the dry season from January to March the water discharge decreases and water becomes scarce, irrigating only 63% of all the plots (about 97 ha) sufficiently. In addition, the irrigation canals are sometimes choked with plants, decreasing the discharge capacity of the canals and the velocity of water flow. In order to cope with the dry season shortage, the farmers have established a calendar that defines at which time and for how long each group can get water to their plots, by opening and closing gates in the secondary canals. However, some farmers bypass this regulation by fraudulently opening the gates that control the water flow (mainly at night). Some also make holes in the primary canal banks and attribute the damage to crabs (which indeed frequently break canal banks as well). Generally, the transgressors manage to bypass the regulation for water distribution without being punished.

In Bamè, 19 farmers produce rice all the year in the inland valley on 4.5 ha under gravity irrigation and on 10 ha in the upland area using pump irrigation. For gravity irrigation the farmers use and share the water from the Ahoho and Agluiglui streams that run through the valley. Each of the 10 farmers that produce on the uplands uses his own (mobile) motorpump for irrigation. They do not have to share water and are independent in their practices. The focus group discussions revealed that during the dry season 12 of the rice growers concentrate their activities in the valley because pumping water for the upland plots means additional production cost of fuel. The farmers have not established rules for water sharing during the dry season although the water level decreases and becomes insufficient for irrigation. Many farmers manage by delaying their rice cultivation and, because of this delay, not all farmers need water for irrigation at exactly the same time.

In Zonmon, 21 rice farmers use an area of 5 ha under gravity irrigation. The production site is irrigated by the Somètè stream and the water that flows from Bamè (via the Agluiglui and Ahoho streams). There is free water distribution among farmers; at any time a farmer who wants to irrigate his plots just opens the gate. However, from January to February the water level in the Somètè stream is often lower than the level at the intake from the canal. In this critical period the farmers use a small rented motorpump to

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Table 3
Farmers' practices in the three study areas.

	Koussin-Lélé	Bamè	Zonmon
Water access and distribution	Fraudulent practices to bypass water distribution turn: opening the water gates and making holes in the primary canal banks	Open access to irrigation water in the command area Individual pumping devices used in the upland	Open access to irrigation water in the command area
Maintenance of the irrigation infrastructure	Collective maintenance of principal canals (1–3 times per year)	Collective maintenance of canals only when silted up (valley) Individual maintenance of canals and pipes (upland area)	Irregular collective maintenance of canals
Rice production cycles	3 growing seasons per year	Continuous production (two seasons in the inland valley and one in the upland area). Per year three harvests on average	1 growing season per year
Selling	Individual sales to local traders, and collectively to *Dadjè* (from Bohicon) and to PUASA (mainly as seed)		Collective sales to local traders
Rice financing	*Caution solidaire* system (from local banks against a reasonable interest rate of 24%) and credit from rice traders, money-lenders and tontine against high interest rates (up to 150%)		Credit from local rice traders

Source: FDGs; participant observation.

get water from the main canal. As the use of a motorpump incurs additional costs of fuel and maintenance, the farmers have started to produce earlier, following the retreat of the water level after the flooding (which occurs each year from July to September), in order to harvest before the dry season.

3.1.2. Maintenance of the irrigation infrastructure

Canal maintenance in the inland valley is critical because it directly affects water supply in the dry season. Two practices are of importance for efficient water use: the cleaning of the primary and secondary canals, and the restoration of the canal lining and the gates that allow the distribution of water to the higher fields in the valley. At Koussin-Lélé the primary canals are cleaned by the farmers collectively, on their own initiative, at the beginning of the first growing season (in September). The maintenance of primary canals is mandatory for the members of the farmer organization. According to current rules, farmers who do not participate in cleaning the canals are supposed to be punished and are not allowed to cultivate the plots in the command area for two to three seasons. However, this punishment is not fully implemented in practice. Powerful farmers such as landowners and traditional chiefs or the family heads (known as *Dah*) are not punished at all or receive just a symbolic sanction if they do not participate. Each farmer is responsible for cleaning the secondary irrigation and drainage canals that adjoin his plots, one or two times a year. Some farmers who share the same secondary canal organize themselves to do this collectively. Others prefer to clean their secondary canals individually. About 1 out of 10 farmers, mainly the landowners, some farmer leaders and family heads do not participate in this cleaning activity at all and leave the task to their neighbours. The neighbours, although frustrated by this behaviour, perform the task of cleaning also their neighbours' secondary canals and drainage canals, because it directly affects water delivery to their own plots. Notwithstanding the cleaning activity, most of the canals are filled with sediment although it is widely acknowledged by the farmers that clean canals would allow the water to reach the higher plots under the gravity system in the dry season.

At Bamè and Zonmon, in the inland valley area, the farmers usually dredge the principal canal together once a year if it has become too sandy. However, in Zonmon not all farmers are motivated to clean the canals and often canal maintenance is not well performed. In Bamè, the group members whose plots are located along the canal are responsible for cleaning a number of segments (3 m long), but they do not always carry this out.

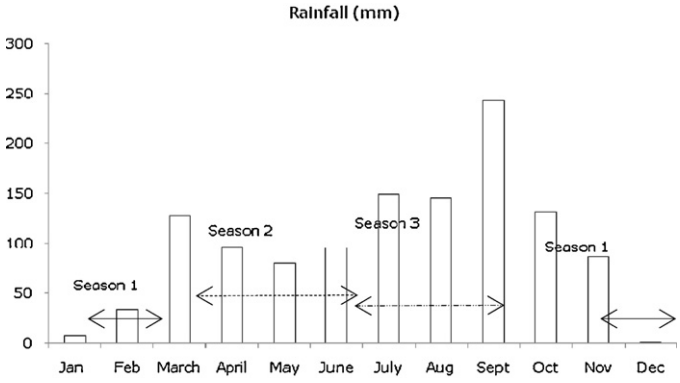

Fig. 1. Rainfall (2009) and the production seasons in Koussin-Lélé.
Source: http://www.tutiempo.net/en/Climate/Bohicon/01-2010/653380.htm.

In the upland area at Bamè, where farmers use small individual pumps for irrigation, farmers' access to water is not so dependent on the gravity system. Each farmer organizes as he chooses the maintenance of the irrigation infrastructure including the restoration of the piping, the maintenance of the irrigation canals and the individual pumps.

When minor restoration is needed (e.g., fixing the broken irrigation gates in the canals) the farmer leaders in Koussin-Lélé and Bamè ask a service provider to carry out the repairs and collect fees to cover the cost. The fees are collected from each rice farmer, after each harvest, and are mainly used for the purchase and maintenance of collectively used machinery like cultivators and processing equipment, as well as for the occasional repairs to the irrigation infrastructure. In addition, in 2009 at Koussin-Lélé and Zonmon, the PUASA programme restored some of the irrigation gates and lined some of the primary canals that were broken, and at Zonmon and Bamè, the Chinese experts provided large collectively operated pumps to irrigate the rice plots located in the upland area (55 ha at Zonmon and 18 ha at Bamè). However, the pumps that broke down were not repaired and have remained unused ever since, even though they are necessary for irrigating the higher areas.

3.1.3. Rice production cycles

Fig. 1 presents the growing seasons at Koussin-Lélé in relation to the rainfall. Until 2004, most farmers in this area produced rice only once a year, during the first growing season. Currently, 56% of the farmers grow rice in all three seasons; 32% produce rice in

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the first and the second season (October and March) on the irrigated area and hire the land that surrounds the command area in the third growing season. It is worth noting that during the floods that frequently occur from July to September the farmers at Koussin-Lélé and Zonmon are not able to produce in the irrigated areas at all because all the fields are inundated. In Zonmon, the farmers produce rice only once a year, from September to January. In Bamè almost three quarters of the inland area is flooded but all the 19 rice farmers grow rice all year round because they use both the valley and the upland and harvest almost three times per year.

In all three areas, farmers use a mix of rice varieties including Beris 21, Tox long, Tox 447, IITA 314, and Nerica. The farmers exchange seeds. From 2008 onwards the perfumed IR-841 variety has become widely produced at Koussin-Lélé because of its aroma. The rice yield in the three areas varies between 3000 kg ha^{-1} and 5000 kg ha^{-1}, depending on the amount of fertilizer applied, the variety used and the potential of the land. Koussin-Lélé was the largest production area and in 2010 farmers harvested 357 metric tons of paddy. In the same year at Bamè, they harvested 21 metric tons of paddy, and 12 metric tons at Zonmon. One metric ton of paddy is equivalent to about 0.7 metric ton of processed rice.

3.1.4. Selling

At Koussin-Lélé and Bamè the farmers sell two kinds of product: paddy rice and milled rice. The paddy outlet is not an important market for the farmers. About 8 out of 10 farmers sell the milled rice collectively to local traders (*Dadjè*, located at Bohicon) and the rest sell it individually to local traders from Covè and Zangnanado. The *Dadjè* buy in bulk and they pay spot cash, but the other local traders usually buy only a small quantity at a time from farmers (a maximum of 200 kg per trader) and they delay the payment. The local traders pack the rice in containers used for imported rice in order to sell the local rice as an imported product. At Zonmon, the farmers – apart from a few – sell their milled rice directly to local consumers because their production is too low to sell it to the *Dadjè*.

In addition, from 2008 the Urgent Food Security Programme (PUASA) has begun buying almost 10% to 15% of the rice harvest from farmers in Koussin-Lélé and Bamè. The programme intervenes in the market in order to boost rice output for the purpose of achieving food security, re-distributing the purchased rice as seed to farmers in areas where rice production is being newly promoted.

3.1.5. Agricultural financing

At the beginning of the first growing season about 7 out of 10 rice farmers (those with less than three harvests per year) need to access additional finance in order to purchase fertilizers and to pay labourers. At Koussin-Lélé and Bamè in the upland area, where farmers cultivate a large area of land, almost three quarters of them hire labourers from Zakpota and Ouinhi regions to carry out various production activities (field cleaning, ploughing, sowing, etc.). The growing season (September–October) is crucial because it coincides with the beginning of the school year when parents need cash to pay the school fees and to buy school materials for their children.

Almost 40% of all the rice farmers obtain credit at an interest rate of 24% per year from two local rural banks, CLCAM and CAVECA, that finance only rice production and no other food crops. These banks provide credit for groups of up to 11 members who are controlled by the farmer leaders, using a form of social guarantee known as the *caution solidaire* in which all the group members are held responsible for re-payment. This solidarity system does not require farmers to provide any proof of ability to re-pay or collatoral before obtaining credit.

Rice farmers who get too little or no rice production credit under the solidarity system (almost 55% of all farmers), or for other food production and social needs (like a wedding, funeral or school fees for children) tend to turn to local lenders for money, on an individual basis. In fact, the lenders are the large traders and rich workers resident in these areas who lend money to farmers for a short period of time and in case of emergency, against high annual interest rates of up to 150%. There are various ways for farmers to obtain such an individual credit. Three quarters of the rice farmers establish direct relations with specific local traders. They obtain the credit during the growing season and they pay back in kind from their rice harvest. In 2010, in Koussin-Lélé, for instance, farmers received 6000 FCFA (1€ = 655 FCFA) during the second weeding period (almost two months before the harvest) and they repaid the traders one bag of 50 kg of processed rice at the end of the season, which had a value of at least 12,500 FCFA. At Bamè, 8 of the 19 rice farmers asked for credit from a tontine (a revolving savings and credit group); the re-payment conditions are similar to the traders' credit.

3.2. Socio-technical problems at local level

The study revealed two main problems that affect the rice value chain in all the three areas: (1) local rice production remains low, and (2) the current level of rice production provides little income for farmers. Fig. 2 shows the aggregated problem tree constructed from the problem analyses made in the focus group discussions.

3.2.1. Low rice production

The theoretical rice production capacity of the command area for the three irrigation schemes recently has been estimated at 640 metric tons of paddy for Koussin-Lélé, 150 metric tons for Bamè and 400 metric tons for Zonmon [22]. The actual rice output remains far below the estimated potential. The rice output recorded by the extension officers in 2010 indicated that 55% of the potential was obtained at Koussin-Lélé, 14% at Bamè and only 3% at Zonmon. This estimate of the gap between current production and what is attainable in each area can be explained by the lack of water for irrigation during the dry season, which is caused by the poor maintenance of the canals.

About three quarters of the rice farmers in the valleys (except those who are close to the water heads in the irrigation scheme) experience a lack of water that negatively affects rice production during the dry season. The field visits revealed that the irrigation canals are filled with sediment deposited by the floods during the rainy season. Because of the topography of the three areas, the valleys are inundated from July to October, and clay and silt are deposited by the flood waters. The sediment reduces the velocity of the water flow because it decreases the discharge capacity of the canals. Aquatic plants then root in the silt and further decrease the velocity of water flow, increase water loss deeper into the soil profile and reduce the total amount of water available for irrigation.

The sediment and plants could be removed from the canals by manual cleaning, to keep the water flowing up to the fields upstream under the gravity system. In all the three areas the water gates that control the water flow from the main canal to the secondary canals are broken because of lack of maintenance and because these gates are very old (constructed in the years following 1976–1978). This also contributes to substantial water losses. For instance, 8 of the 11 farmer members of Group 3 at Koussin-Lélé reported that they lose almost 30–40% of their harvest because of lack of irrigation water caused by poor canal maintenance. Moreover, because the fees that are collected from farmers after each harvest are mainly used for machinery and not for restoring these water gates, farmers – individually or collectively – lack the financial resources to take care of the irrigation infrastructure. It is for these reasons that, overall, the farmers interviewed during the focus group discussions ranked the difficulties of accessing water for irrigation and the lack of maintenance of the irrigation infrastructure as the most important issues. Some, however, stated

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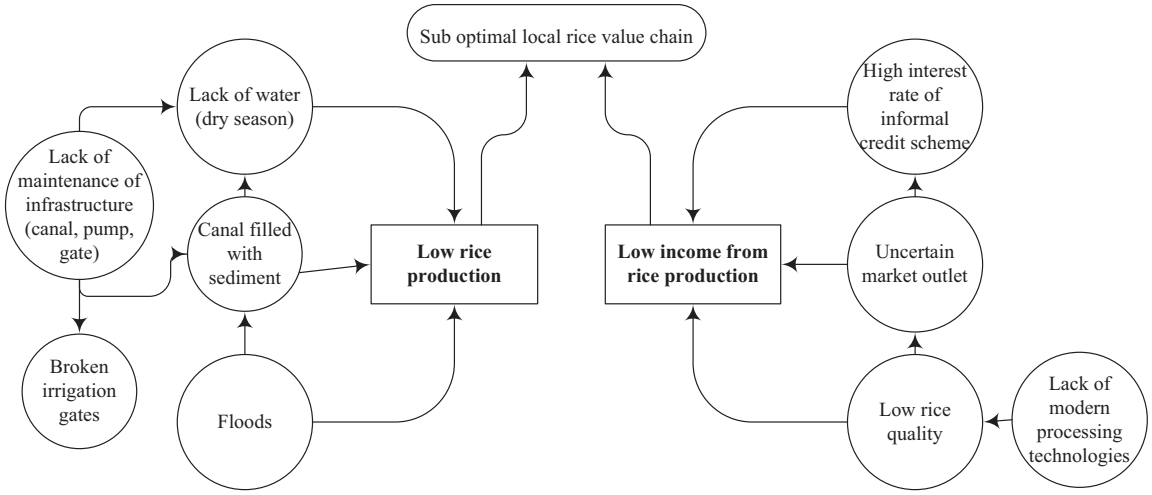

Fig. 2. Problem tree: the three study areas combined.

Table 4
Average revenue per farmer (in FCFA) for one harvest of paddy per hectare (2009 data).

	Koussin-Lélé	Bamè	Zonmon
Production cost (per kg)	155	162	168
Selling price (per kg)	175	173	175
Margin (per kg)	20	11	7
Average amount sold per farmer (kg of paddy)	3500	1900	2000
Total average return per farmer	70,000	20,900	14,000

Source: questionnaire survey.

that the restoration of the water gates and the broken lining of the irrigation canals should be the responsibility of the irrigation department, whereas others stated that they would take responsibility but lacked the financial resources to do so themselves.

Currently, upland plots that are not part of the gravity system, are used only in Bamè where 10 rice farmers irrigate their plots of about 1 ha each with water pumped out of the stream, using their small individually owned pumps. In the past, although more than 65 ha at Koussin-Lélé, 55 ha at Zonmon and 18 ha at Bamè were irrigated in the valleys by the large pumps installed by the Chinese experts between 1972 and 1973, once these large pumps broke down because of lack of regular maintenance, the rice farmers no longer produce on these lands. Many farmers mentioned this situation as a serious problem that prevents them from extending their rice producing area.

3.2.2. *Low income from local rice production*

Almost 9 out of 10 rice growers (farmers as well as farmer leaders) stated that rice production does not provide them a decent income. For the farmers in Koussin-Lélé this is a serious problem because they are mainly dependent on rice production. In Bamè and Zonmon, farmers have additional income activities but still suffer from low incomes, as the following illustrates: *I realized that the income that we get from the rice production is just enough to survive. Since I was producing here, I did not build another house, I just succeeded to buy a motorbike. [. . .] If we could find support to effectively address our problems of production, credits, inputs and especially marketing facilities, we can earn more by producing rice* (A.H., Bamè, 27/08/2010).

In order to validate how little farmers earn from local rice production we have estimated the total average return that each farmer gets from growing rice (Table 4) and have compared this with the official minimum wage. For this purpose, we estimated the production costs and selling prices by building on the responses to the questionnaire survey of 60 rice farmers in the three areas. We calculated the production costs (C) listed by these farmers by taking into account the costs per kilogram of paddy (C_1) for the inputs directly used in the production system (seeds, fertilizers, labour, etc.). We included the interest rate (I_1) for informal credit in terms of kilograms of paddy. For instance, when a farmer receives 6000 FCFA from the trader, and pays back in kind a bag of 50 kg of white rice (equivalent to 70 kg of paddy), the value of the paddy is at least 12,500 FCFA. In this case, the informal credit cost (I_1) is almost 92 FCFA per kilogram of paddy ((12,500–6000) per 70 kg). In addition, we calculated the interest (I_2) that farmers pay to the banks for formal credit. The total production cost $(C) = (C_1) + (I_1) + (I_2)$.

We then considered the equivalent of the paddy that corresponds to the milled rice that is sold in order to derive the total return per farmer. In the case where farmers sell both paddy and milled rice, the milled rice was converted into paddy rice using a conversion factor milled rice/paddy of 0.70.

Table 4 shows that, in our example, at Koussin-Lélé, farmers made a total return of 70,000 FCFA per hectare and per rice harvest season and a margin of 20 FCFA per kg of paddy. At Bamè, they obtained a total return of 20,900 FCFA and a margin of 11 FCFA per kg of paddy. Farmers from Zonmon obtained a total return of 14,000 FCFA and a margin of 7 FCFA per kg of paddy.

A rice production season covers four months so in that period farmers earn the returns presented in Table 4, assuming that farmers cultivate 1 ha. However, as can be seen from Table 1, the average holding in Bamè and Zonmon is less than 1 ha. Our calculations show that the rice grower's income is low in comparison to the official minimum wage of 31,625 FCFA per month. In Koussin-Lélé, the most successful rice growing area, where each farmer can obtain three harvests per year, a farmer's return is still only about 55% of the current minimum wage level (70,000 FCFA against 126,500 FCFA). In Bamè the return per farmer is 16.5% of the minimum wage and only 11% in Zonmon. Three main factors were mentioned by the farmers as the cause of their low rice incomes: (1) the low quality of the local rice because of poor processing technologies, (2) an uncertain market, and (3), high dependency on informal credit.

The lack of modern processing technologies in the study areas means that the local rice is not always well polished. It also contains contaminants such as gravel and the grains do not have a uniform shape. All these characteristics encourage consumers' preference for imported rice. The lack of an organized market outlet for local rice is also one of the main factors discouraging farmers from investing in rice production. In all the three areas, the farmers complained about the uncertain market for their production,

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Table 5
Institutional barriers to innovation in the local rice value chain. The column 'Farmers and their interest groups' contains barriers at local level. The other columns contain barriers above the local level.

Failures	Farmers and their interest groups	Governmental bodies	Traders and clients	Input suppliers and banks	Consumers
Knowledge infrastructure					
Physical infrastructure	Old local processing equipment				
Hard institutions	Lack of effective local sharing and maintenance rules	Unclear division of maintenance responsibilities		Solidarity system credit only accessible to experienced farmers and groups	Urban consumers' preference for imported rice
Soft institutions	Water considered as an open resource				
Interaction	Privileges of certain farmers				
Market structure		Uncertain local rice market outlet	Competition from imported rice	Main focus on cotton production areas	

which means they are left to the mercy of local traders who operate without any formal control. The (experienced or anticipated) lack of access to and insufficiency of formal credit facilities and the lack of a stable market for their rice harvest urges almost 55% of the rice farmers to turn to the informal credit system provided by local lenders. These farmers are highly dependent on informal credit so that their harvest – in effect – is under the control of the lenders.

3.3. Institutional barriers

Why are the above-mentioned problems so persistent and hard to solve? Why has an intervention like the PUASA project had so little effect? Institutional barriers hindering innovation help to explain this persistence. We distinguish institutional barriers that arise in a context common to all three areas, from barriers that are defined by local institutions (Table 5).

3.3.1. Institutional barriers originating above the local level

Before the 1990 reforms the irrigation department in charge of irrigation infrastructure faced major constraints in fulfilling its maintenance task (principally an insufficient budget and lack of materials [23]). The reform allowed the public authorities to hand over the costly maintenance responsibility to water users but little provision was made to ensure that the maintenance costs would be covered and that the task could be performed [22]. Over the last five years the rice farmer associations have been developing an organizational structure, with a national board at the top, but the implications of the reform measures for farmer organizations are still unclear. A small number of our respondents (just under two out of ten) still perceive maintenance to be a task of the public irrigation engineers. The following extract from a focus group discussion at Koussin-Lélé clearly illustrates farmers' perceptions: *The maintenance of the irrigation infrastructure is the task of the irrigation department. The authorities know that farmers do not have enough financial capacity to deal with this. The irrigation engineers can have a subsidy or a public fund to do the job but since a while they leave this task to us* (GD1, Koussin-Lélé, 17/08/2010).

The Structural Adjustment Programme negotiated with the International Monetary Fund forced the Beninese government to open the input supply sector (for fertilizers, insecticides, etc.) to private companies [24]. This sector, formerly controlled solely by public companies, is now led by private businesses seeking high profits [25]. Input distribution today is monopolized by a few private companies and these give preference to cotton production areas because cotton growers use a large amount of inputs and the companies make more profit by selling cotton pesticides and fertilizers. Furthermore, since rice is not an official cash crop with a guaranteed collection system, the input suppliers perceive the risks in supplying the rice production sector much higher. Each year, rice farmers have to search for production inputs themselves. Furthermore, a fertilizer that has been specifically adapted to the rice crop and the soils of the inland valleys is not available.

Until 1985 the government prohibited rice imports but under the economic reforms the private sector was allowed to import rice under license [26]. In 1990 the licensing scheme was abolished and anyone was allowed to import rice at any time. The penetration of the domestic market by companies selling foreign rice at a competitive price and uniform grain size and quality, catalysed urban consumers' preference for imported rice. This has affected the local rice sector in the sense that local traders today face severe competition from imported rice, and market relationships have become unstable. Following the rice market liberalization, farmers have to find their own markets for their products. Moreover, they are not able to negotiate a good price with traders because the quantities they bring to the market remain small. Many NGOs (e.g., Veco – a Belgian Association, and the local NGO *Entreprises Territoires et Développement*) in partnership with the national rice farmer association are working with local rice farmer associations to find more lucrative urban market outlets for the local rice. Many problems remain, however, including the low quality and irregular availability of local rice.

3.3.2. Institutional barriers at local level

The solidarity credit system is preferred by all farmers, because of the much lower interest rates compared with informal credit sources. The rules, however, neither support individual production, nor newly established rice producing groups since these do not have a credit history and the leaders do not have enough experience with the members' behaviour to trust them and to support their credit requests.

Farmers and other groups share irrigation water for many purposes, including bathing and washing. Access to water is not regulated in the same way everywhere. At Bamè and Zonmon access to irrigation water is free for the users all the year. However, at Koussin-Lélé rice farmers have set rules to regulate water distribution from January to March, the period when water sharing becomes critical. In spite of these rules, farmers in this area employ fraudulent practices that hinder effective water sharing (as described above). This might be related to the fact that the farmers in Koussin-Lélé seem to be more dependent on rice production on their inland plots than the farmers in the two other areas.

The local rules for restoring the canals are also not sufficiently effective. Ever since farmer organizations have been given the direct control of the irrigation infrastructures, insufficient means

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have been made available to cover the maintenance costs. The new responsibility has compelled farmers to contribute to the maintenance of their infrastructure by paying fees after each harvest but these fees are still not enough to allow farmers to perform the task. Moreover, the management and the use of these financial resources are not transparent. Many farmers complain that the fees collected for the restoration of the infrastructure are not used well by the leaders, alleging in all three areas that the resources are sometimes spent for other purposes (functioning of the farmer association, celebrations) instead of financing the maintenance of the canal infrastructures.

The members of the small communities producing rice know each other very well, and over the years they have strengthened their relationships. But there are large power differences between the leaders and other farmers. The *Dah* (traditional chiefs and heads of families), the *Mèho* (who have been producing rice for at least 10–15 years), and the leaders of farmer associations are privileged and they enjoy many privileges (such as first use of equipment, more access to formal credit and the power to define whether other group members get access to credit or to land). They also avoid sanctions. For instance, while farmers in Koussin-Lélé are supposed to follow the established rules for canal cleaning and water use during the dry season, the privileged farmers manage to ignore the rules without sanctions. The other farmers cannot intervene since they are dependent on these leaders' goodwill in relation to land allocation and group credit applications to the local banks. These power differences, and the resulting unfair access to resources and use rights, create frustration and lead to mistrust among the farmers.

As a result, the farmers continue to perceive water as an open access resource, arguing that all farmers have the right to take as much as they need. A typical comment made by a participant in the focus group discussions illustrates this point: *I do not understand why we set a schedule for water distribution. Water is an open resource and everybody can take as much as needed. Anytime when I need to irrigate my plots, I will always open my gates, no matter what can happen* (GD2, Koussin-Lélé, 18/08/2010).

This perception discourages farmers from anticipating or taking initiatives to sustain water use. It also diminishes farmers' awareness of the actions undertaken by water users in the upstream areas that can affect water availability downstream. A few fishermen, for instance, have established fishponds in the upper reaches of the Koussingo-Lélégo River. If this activity expands it will affect water availability for rice farmers but there is no appreciation of this inter-dependence in how the water resource is used.

4. Discussion: innovation opportunities

Many technological packages for rice introduced in Benin have hardly been used. The large irrigation schemes developed at Domè, Mitro, Zounguè, Yokon for improving local rice production are currently not being used for rice production. We have shown that the institutional dimension contributes to create space for change for individual farmers and communities [31,32,33]. There are evidently significant gaps between technicians' expectations (policy-makers, researchers, extension workers, etc.) and farmers' perspectives, needs and opportunities.

Farmers in the study areas are aware that many intertwined factors impede the functioning and development of the rice value chain and the efficient use of irrigation water. They are conscious that suitable solutions can be found by a more integrated approach. They have emphasized the importance of addressing the institutional issues (both barriers and opportunities) [6] and are interested in the options identified in this study. Currently, a number are being tested in the framework of the Convergence of Sciences – Strengthening Innovation Systems programme. The data collected for this diagnostic study will be used as the base line against which changes in practices, local institutions and productivity and income brought about by these institutional experiments will be analysed, in all three areas, in a few years time.

In this section we focus on these options, principally on the opportunities to increase the efficiency of water management, rice production per hectare and per household, and farmers' income in relation to the rise of demand for rice and the affinity of consumers to local products with territorial product labels, new investment policies based on private–public partnerships, the availability of better water management practices, and the availability of land in the upland areas (Table 6).

4.1. Rice demand and consumer affinity to local products

Rice demand in Benin is increasing; it is consumed more frequently and in an increasing number of households. National rice demand was estimated at 30,000 metric tons in 1960, and by 2008 had increased to 120,000 metric tons [22]. The fast increase in demand could be an opportunity for the inland valley rice farmers. Participants in one focus group discussion observed: *We can remember that a few years ago it was very hard for us to find somebody to whom we could sell the rice. Since two years, it seems that traders are always waiting for the paddy. We sold all the rice almost two weeks after the harvest. Something is changing somewhere* (GD5, Bamè, 27/09/2010).

A significant number of consumers seem to have lost trust in imported foods and prefer to buy local products [27]. Basically, they fear that anonymous actors in the value chain, such as primary producers in other countries, food processers or animal feed industries are more concerned with earning money than with the health of consumers [12]. Imported products do not guarantee chain transparency. These perceptions could be an open door for local products associated with a system of traceability along a value chain that uses little chemical inputs, for instance. The challenge in this context is the ability of producers to guarantee to consumers the desired added value.

Table 6
Windows of opportunity in the rice value chain.

Opportunity	Farmers and their interest groups	Governmental bodies	Traders and clients	Input suppliers and banks	Consumers
Knowledge infrastructure	Better water management techniques				
Physical infrastructure	Available land in the upland area				
Hard institutions					Territorial product label
Soft institutions					Affinity to local products
Interaction		Innovative private–public partnerships			
Market structure					Increased rice demand

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4.2. Territorial product labels

In Benin, territorial product labels have been developed for a number of products to promote the association between products and their region of origin. For instance, rice from Natitingou is promoted under the *Nati Rice* label and groundnut oil from the Agonlin Plateau is sold in Benin under the label of *Agonlin mi*. These two products are well known throughout the country because of their clear quality criteria and recognizability in the market. For instance, visitors to the Agonlin Plateau area are willing to buy the local oil (*Agonlin mi*) because they trust its quality and like its taste. Selling a product under a territorial label of origin allows all those in the designated territory to enter the market while protecting the integrity of their production system from the entry of outsiders, allow farmers to add non-economic value to the product, and to establish a market niche for the product. The associated regions become visible as an active space for innovation, where the actors use their resources to create additional values for their communities [28].

In the case of the *Nati Rice*, the local authorities are engaged in promoting this label as a local product from their community and it helps rice farmers from this region to sell their rice in return for a percentage of the advertising profit. Moreover, the Natitingou region (from which *Nati* label is derived) is a centre for tourism and the local authorities use the touristic value to promote local products and to increase the linkages between domestic and international visitors and the local economy.

An added value from a local rice label could be developed in our study areas and thereby provide the rice farmers access to new markets and increased sales. In addition, a territorial rice label could open opportunities for other sectors of the local economy. This potential is highlighted in the following statement of a town council officer in Covè Municipality: *If we can get the support of the public authorities for our rice value chain, that can help us to promote another range of our local product like the groundnut cake, the groundnut oil, etc. and the tourism sector as well. It can generate additional resources for producers* (Covè's town council officer, October 2010).

4.3. Public–private partnerships

From 2006 onwards the public authorities have begun developing new investment policies based on an innovative private–public community partnership for collective investment. The partnership allows farmers to obtain assistance in sectors where public actors are not present [29]. Since 2008, through the private–public partnership scheme, private companies (e.g., *Tunde SA, Entreprises de Services et Organinations de Producteurs* (ESOP) that offers farm product marketing facilities) have become involved in local rice processing. The partnerships allow farmers to process easily their harvest and make use of improved marketing facilities. These private companies share the public interest in business-oriented economic development [29] that can close some of the gaps in the rice value chain. We heard from the rice farmers in Bamè that mid-2011 they began testing an innovative business arrangement in co-operation with ESOP. The company contracts with rice farmer groups to supply a fixed amount of rice against a purchase guarantee. The company provides the contracted farmers with the seed of high-yielding varieties, fertilizers, and bags for packing their harvest. The ESOP leaders, the national association of rice farmers and the extension officers agree in advance of each season the price the company will pay the farmers for the contracted volume of paddy.

4.4. Better water management techniques

Inland valleys have specific characteristics that offer high potential for rice production. With proper water management practices, rice yields per hectare could be improved considerably. Rice can easily yield 30–50% more on the fertile inland valley soils than on the upland soils [30].

The main advantage of improved maintenance of the irrigation system is expected to be that water levels on the rice fields can be controlled more accurately and that the water reaches the upstream fields under the gravity system. In addition, the available groundwater could be pumped into the rice plots that receive little water during the dry seasons. The rice farmers at Malanville in the northern region of Benin showed the possibilities of digging shallow tube wells directly in each plot from which they pump the ground water onto their fields. The shallow tube wells option could also be used in the southern areas. If they are combined with the new technology using small solar pumps they would offer a sustainable alternative for the fuel needed by the regular motorpumps. Such wells could also help to use the available water more efficiently.

4.5. Available land in the upland areas

At Bamè, the 19 rice farmers use only 4.5 ha, which means that each farmer has on average less than 0.24 ha At the same time, they have access to more than 58 ha in the upland area where each rice farmer has the possibility to extend his production. Since in the uplands the topography does not allow gravity irrigation, 40% of the rice farmers have installed small motorpumps to draw water from the Assanto stream into their plots. Pump irrigation allows farmers to produce rice all year round. Three rice farmers already harvest two times per year in the upland area and it is technically possible for them to harvest three times per year in this area if they were to adopt practices like mulching (as one of the farmers already does). The mulch covers the exposed soil surface at the early growth stage and conserves soil moisture. At the later growth stages the mulch might enrich soil fertility. This practice has potential in the upland area to increase rice yield and reduce the demand for water.

At Koussin-Lélé, rice farmers have access to 200 ha in addition to the land they currently use but they do not use this area because it has no functioning irrigation facilities. In Zonmon, 55 ha are lying idle because the pump broke and has not been repaired. There is clearly a potential for farmers in all the three areas to extend their production on the upland plots and to earn more by producing more rice.

5. Conclusions

In this paper we set out to explore the factors that hinder the development of the local rice value chain and the effective use of water, and to identify promising opportunities for innovation. The diagnostic study revealed a number of significant institutional factors that hold production and incomes below their potential and act as barriers to innovation.

At the local level we have shown that there are no effective rules for water sharing and for maintaining the irrigation infrastructure. The lack of canal maintenance negatively affects the use of water (and hence output and incomes) in the inland valleys. Although farmers are organized in groups, they seem to face dilemmas of collective action related to existing power relations. The diagnostic study revealed that the privileges enjoyed by the farmer leaders induce frustration and maintain an unequal access to resources. These institutional barriers restrain farmers' ability or willingness to develop or effectively make use of a range of options to improve local production and living conditions. The public actors in the agricultural sector in Benin have relied on technical change to boost rice production, principally by introducing high-yielding varieties and irrigation technologies. This strategy did not integrate the

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institutional dimensions of change and thus have met with limited success.

At higher institutional levels we showed that the market liberalization policy has created a significant new barrier in so far as it opened the door to strong competition from imported rice. Since the inland valley farmers currently lack an alternative market outlet their dependence on local traders has increased as competition for market share has increased. We further showed that although two thirds of the farmers receive formal credit from local banks against a reasonable interest rate most are dependent also on high interest credit from local traders (up to 150%), leading to significant indebtedness and a weaker market position.

Our main conclusions are that although options exist for significant innovation in the current situation there is a risk that local production will remain low and that the national objective of boosting local rice production to meet domestic demand seems way out of reach unless local institutional issues are addressed.

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