An institutional perspective on farmers' water management and rice production practices in Benin

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Chapter 1

Introduction

Introduction

1.1 Rice policy and problems in Benin

1.1.1 Rice production

Rice has always been a common staple food in many countries in Africa. It is now the most rapidly growing food source across the continent (AfricaRice, 2011). Its consumption is increasing rapidly because of changes in consumer preferences and urbanisation. West Africa has become a significant player in world rice markets, but 40% of its rice requirement is supplied by importation. Because of its increasing share of rice imports, West Africa now accounts for 20% of the rice traded internationally (CoS-SIS, 2013). Nigeria, Senegal, Côte d'Ivoire and Benin are among the main importers (Moseley et al., 2010). According to Index-Mundi (2012), Benin imported 200,000 metric tons of milled rice in 2012 and did not export any, although there is evidence of informal cross-border trade between Benin, Niger and Nigeria (Paquet and Savard, 2009).

In Benin, rice is produced mainly in inland valleys. Inland valleys are the upper reaches of river systems, comprising valley bottoms and minor flood plains which may be submerged for part of the year (lowlands) and contiguous upland slopes and crests (Figure 1.1) (Andriesse et al., 1994). Inland valleys offer high potential for rice production (Abe et al., 2009; Kiepe, 2009). The country has up to 205,000 ha of lowlands and more than 110,000 ha of flood plains suitable for rice crop. With this potential, the country may be able to produce enough rice to cover domestic rice consumption. Despite this relatively high natural production potential and the favourable annual rainfall pattern (1,200 mm), local rice production has traditionally been weak and satisfied only about 10–15% of the national demand (Adegbola and Singbo, 2005). The blame was assigned to 'inappropriate' rice policies which were not suited to supporting domestic production against imported rice (Dalohoun et al., 2009).

Benin does not have a long tradition of rice growing compared with other West African countries such as Nigeria, Mali, Senegal and Côte d'Ivoire. Until 1997, it produced no more than 20,000 metric tons of rice per year, whereas domestic consumption was about 70,000 metric tons (Index-Mundi, 2012). Benin, as many other West African countries, relies heavily on importation to satisfy national rice consumption. Since 2007, local rice production has increased in most West African countries. Between 2007 and 2012, it increased from 47,000 to 96,000 metric tons in Benin; from 118,000 to 443,000 metric tons in Senegal; and from 703 to 1,310 metric tons in Mali.

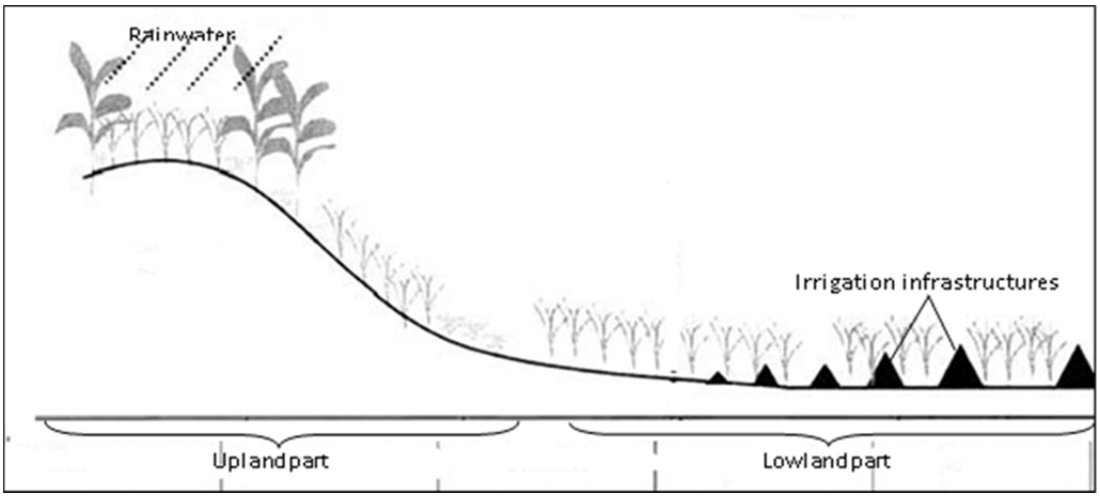

Figure 1.1: Schematic topography of inland valleys in Benin

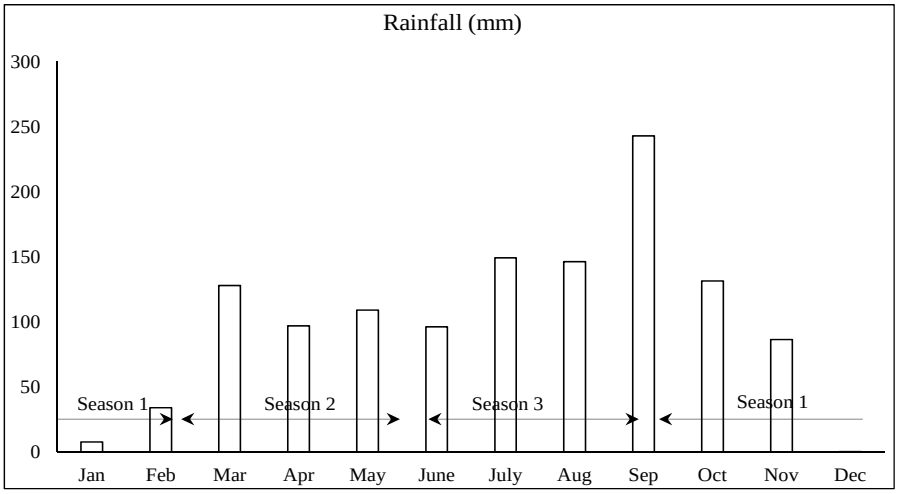

Figure 1.2: Rainfall (2009) and the production seasons
(Source: http://www.tutiempo.net/en/Climate/Bohicon/01-2010/653380.htm)

Traditionally in Benin, farmers cultivated rice once a year in the lowlands during the most favourable season (October–February). Since 2007, with new interventions aimed at intensification of local rice production, farmers have extended cultivation into two to three seasons (Figure 1.2), both in the lowlands (under gravity irrigation) and in the uplands (using pumped water).

1.1.2 Rice policies

Increasing domestic rice production to satisfy the growing consumption and to ensure food security has been an important target for the government of Benin. Numerous interventions through successive generations of projects have been undertaken. After independence in the 1960s, a first generation of projects was initiated to increase local rice production (*e.g. Société d'Aménagement de la Vallée de l'Ouémé: SADEVO, Société Nationale d'Irrigation et d'Aménagement Hydro-agricole: SONIAH* and so forth). These interventions focused on organising farmers into cooperatives and developing large irrigation schemes for rice production. Nearly 2,236 ha of command areas were created throughout the country, with the assistance of Chinese projects (Sodjinou et al., 2008). However, studies have suggested that these first interventions aimed at promoting rice production in the inland valleys yielded limited success (Abiassi and Eclou, 2006; Adegbola and Singbo, 2005) because they underestimated the complexity of the institutional context (Vincent and Roth, 2013). Illustratively, national rice production rose from 6,000 metric tons in 1974 to 13,000 in 1977, after the construction of infrastructures, and stayed around 7,000 until the 1990s. This first generation of interventions targeted mainly the creation of irrigation infrastructures to stimulate local rice production, but rice production is not only a matter of irrigation infrastructures. Lack of marketing facilities, an inadequate credit system, poor extension services and several socioeconomic factors are also considered to have limited farmers' productivity (Adegbola and Singbo, 2005).

The rice crisis of 2007, during which world rice prices more than tripled, lead some rice-exporting countries to ban rice exports to secure their domestic consumption (OECD, 2011). Since 2008, many African countries including Benin have initiated various new interventions aimed at local rice intensification (Soulé and Blein, 2008). To achieve this, a new generation of agricultural programmes has been crafted that provide institutional conditions for farmers to improve rice production. Through its PUASA programme among others, the government of Benin has taken a number of measures, including price incentives, subsidies on seeds and fertilisers, credit and marketing arrangements, to stimulate the intensification of local rice production (MAEP, 2010). These interventions are intended to lead to new forms of production and trade in the local rice value chain.

In all, the rice-production interventions instigated between 1976 and 1990 focused principally on technical supports, introducing large irrigation schemes and high-yielding rice varieties, whereas the new generation of programmes initiated after 2007 prioritised mainly the institutional conditions to stimulate the intensification of local rice production (e.g., market outlet facilities, subsidies and credit).

1.1.3 Water scarcity as a main problem in rice farming

A scoping study (prior to this research) on smallholder rice farming in Benin (Saïdou and Kossou, 2009) pointed at irrigation water stress as one of the main problems in the rice production chain. The authors blame poor maintenance of the irrigation canals and sediment accumulation in the canals as the causes of the water scarcity. According to Saïdou and Kossou (2009), the gradual silt deposition and growth of weeds in the irrigation infrastructure decreased the discharge capacity of the canals and the velocity of water flow. Besides these ascribed reasons, many other explanations for the water problem can be found in the literature: cognitive causes (farmers' lack of knowledge about water management); natural phenomena (manifestation of climate change); socioeconomic problems (lack of economic incentives); technical constraints (inadequacy of the irrigation schemes); and so forth.

It has become popular to consider the lack of irrigation water in agriculture as a direct manifestation of climate change (Carter, 2008). However, a recent detailed analysis of 40 years of daily rainfall records for Kandi (north Benin) showed no evidence of a change in rainfall distribution (Sauliou and Stroosnijder, 2013). According to Stroosnijder (2012), rainfall changes due to climate change are apparently often a 'myth.'

Mondegnon (2012), for example, linked the lack of irrigation water in the rice production areas to a lack of farmers' knowledge. According to him, farmers are suffering from water scarcity because they lack knowledge of water management practices in inland valleys. This analysis is questionable because, even though rice production is a very recent activity in Benin, farmers did not complain about irrigation water scarcity when they produced only during the favourable growing season (Djagba, 2006). The water problem emerged when they started intensifying their rice production (up to three cropping seasons per year) on schemes designed normally for one copping season during which the command area received enough water flows to meet the crop's needs.

Moreover, these same farmers worked and maintained the canals on the plots used by the researchers for the field experiments, but they were not doing so in their own plots. Thus, the ineffective canal maintenance that causes the water scarcity may not be linked to a lack of knowledge on water management practices, as Mondegnon (2012) suggests.

It might then be too simplistic to interpret the water scarcity problem as resulting from climate change consequences, or a manifestation of a lack of knowledge on water management practices, or even faulty canal maintenance as the scoping study suggests (Saïdou and Kossou, 2009). Given the diversity of explanations provided in the literature, it might be better to analyse the whole rice value chain because the apparent water problem cannot be seen in isolation; rather, it needs to be analysed from various angles.

1.1.4 Problems in the rice value chain

The situation in the research areas has changed significantly since 2010 because of the gradual implementations of the government rice intensification programmes. Before 2011, there was little incentive for farmers to contribute to the effective maintenance of the canals because of the lack of guaranteed market outlets for farmers to sell the resulting extra rice. Moreover, while the government was promoting local rice intensification, rice of higher quality, and sometimes even cheaper than the local rice, was still being imported (Figure 1.3). Studies evaluating the impact of rice imports on the domestic production in Benin, including those of Adegbola and Singbo (2005) and Abiassi and Eclou (2006), indicate that the market for local rice has been shrinking due to rice imports. The proportion of local rice available in Beninese markets is far less than that of imported rice (Figure 1.4).

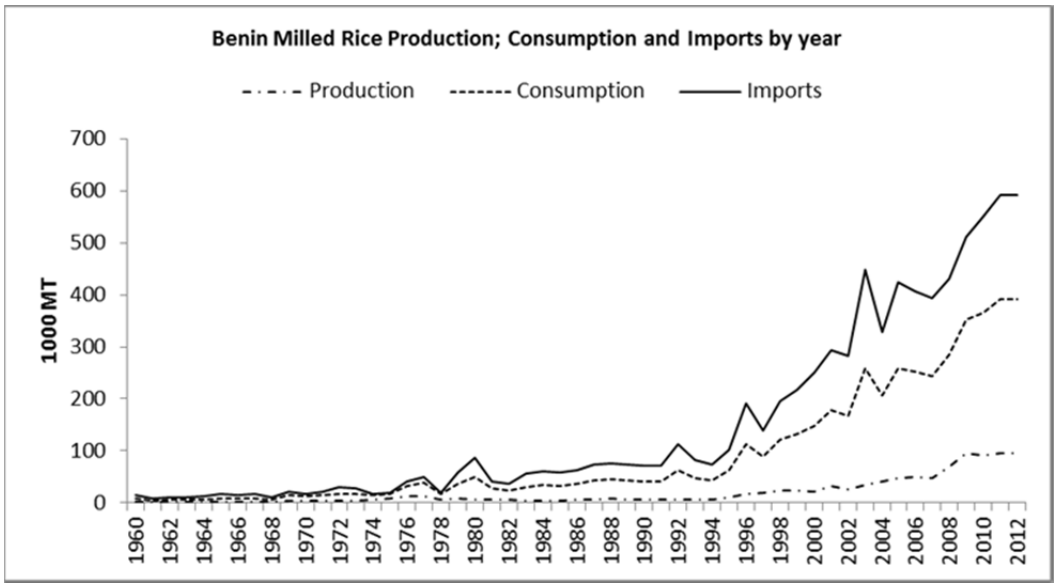

Figure 1.3: Benin milled rice production; Consumption and imports from 1960 to 2012 (Source Index-Mundi, 2012)

The first generation of rice policy, between 1976 and 1990, relied heavily on public financial resources (Lançon and Erenstrein, 2002). Before 1984, the maintenance of irrigation infrastructure was the responsibility of the Ministry of Agriculture. However, with the implementation of the structural adjustment reforms in the 1990s, farmers were obliged to take on responsibility for the maintenance of the infrastructure in their command areas. With limited resources, farmers were not able to ensure effective management of the infrastructure. Therefore, silt deposition, weed infestation, malfunctioning of the canals affected the water delivery.

Without an appropriate agricultural financing system and in the absence of government control, rice farmers were left to the mercy of local traders who dictated loan conditions and the selling price of rice. The farmers had little or no negotiating power on the rice price. They then earned so little from rice production that their limited income did not motivate them to invest in collective canal maintenance (Le Coq and Trebuil, 2005).

Figure 1.4: Photo of a rice shop in Cotonou[*] (Source: Oxfam Intermon)

[*] This is a prototype of rice shops in Benin. In most of these shops, traders sell imported rice only. However, some traders cheat and pack local rice in containers used for imported product.

From the analysis of the local rice value chain, it appears that a mono-technical explanation cannot give a deep enough understanding of the existing water problem, which clearly has various dimensions. This study therefore assumes that an institutional perspective would provide a better understanding of the barriers, opportunities and approaches to addressing institutional issues.

1.2 Theoretical perspectives

1.2.1 Agricultural innovation

Approaches to agricultural research for development have changed over time, in line with the understanding of how agricultural innovation comes about, and how institutions play a role in this process. Nowadays, in the thinking about agricultural innovation, institutions are an important issue. The high attention now paid to institutions is the outcome of a long process in innovation studies.

Innovation studies started with a linear-thinking model (Chambers and Jiggins, 1987). This approach looks at knowledge production and its application as separate activities. It assumes a straight and one-directional line between knowledge and practice: researchers are supposed to generate the knowledge; extension workers concentrate on the transfer of the established knowledge; and the farmers' role is merely to apply it.

Over time, the linear model of agricultural innovation was replaced by more participative lines of thought, to better understand complex rural development phenomena (Kefasi et al., 2012; Leeuwis and Aarts, 2011; van Mierlo et al., 2010a). Farmers, extension workers and researchers are recognised as elements of an agricultural system which have to collaborate to achieve large impacts (Röling, 1988). In line with this new thinking, several participative approaches have been suggested to enhance the cooperation between farmers and scientists, so that they can learn from each other (Gerber, 1992; Röling et al., 2004; Leeuwis, 2004a). Some well-known examples are Participatory Technology Development (Biggs and Smith, 1998; Cousins and MacDonald, 1998), Farmer First (Chambers and Ghildyal, 1985), and Agricultural Knowledge and Information Systems (AKIS) (Röling, 1988).

However, Röling et al. (2004) explain that, although participatory technology development is used in the agricultural sector, the impact of development projects has been limited because of the neglect of the institutional dimension. It became clear that technology was not the main bottleneck to improving rural farmers' livelihoods; institutional constraints also hinder farmers from using the (new) technologies and improving their livelihoods (Hounkonnou et al., 2012). In the same vein, Klerkx et al. (2012) underline that production and exchange of (technical) knowledge are not the only prerequisites for innovation. Several additional factors, such as policy, legislation, infrastructure, funding and market developments, also play a key role in the success of innovation. In the 2000s, the innovation system approach helped to switch the focus from technology to innovation (Leeuwis, 2004a; Walters et al., 1999, Nederlof et al., 2011). The emphasis in the innovation system approach is on the institutional component of the innovation, rather than the technology part alone.

In line with the innovation system approach, this thesis adopts the perspective that involving farmers in the technology development process as advocated in the participatory approach may not be sufficient to create enabling conditions for local changes to increase rice production. Beyond participation, a consideration of the institutional dimension is also needed. Thus, technical and institutional dimensions should be complementary (Klerkx et al., 2012; Röling et al., 2012).

1.2.2 Institutions

In its popular interpretation, 'institution' is regarded as 'organisation.' However, in this thesis, institution is considered from an economic and a sociological perspective. Adopting an economic perspective, North (2005) defines institutions as "the humanly devised constraints that shape human action". Like North, Edquist (1997: 182) conceives an institution as a set of common habits, norms, routines, established practices, rules or laws that regulate the interactions between individuals, groups and organisations. Bandaragoda (2001) stresses that institutions inherently have dual facilities to both constrain and enable individual and group action. According to him, a good example is how the law and the court system restrict some human actions, and also provide freedom of action in some other instances.

In addition to the established formal rules, informally established procedures are part of the institutional framework that defines and fashions behaviours and practices in societies (Klein Woolthuis et al., 2005). Regarding the water use context, even when farmers draw up formal written rules to guide their water sharing, the informal setting inherited from tradition also influences their water use practices. Thus, there is a mutual relationship between the formal and informal rules that guide people's behaviour.

1.2.3 Practices

Institutions are considered as the rules that guide practices. There is an interrelation between institutions and practices, but first of all, what is practice?

Focusing on the farming context, Leeuwis (2004a: 61) uses the term "practices" to refer to things people "do" (and "do not do") on a more or less regular basis. This conception of practice emphasises its enduring nature. Giddens (1984) also establishes that practices are created, sustained and transformed through their reproduction in everyday life. For Reckwitz (2002), practice is "a routinised type of behaviour."

Schatzki (2002: 87) distinguishes between practice as a coordinated entity and as a performance actualised and sustained through individuals' reproduction of it. Practices, however, are often misunderstood as relating only to what people do, or to what they say about what they do, rather than to the ways in which these doings and sayings are socially constituted and interconnected (Strengers, 2010: 8). In these instances, the practices are re-framed as 'behaviours', which are viewed as the product of individuals' decisions rather than individuals' performances. From Strengers' perspective, farming for instance is not itself a practice but rather an aggregation of many practices of farmers carrying out their day-to-day activities (Strengers, 2010: 5–6).

1.3 The research questions

Institutions have become a major issue in the current literature on agricultural innovation as a response to the limitations of the linear innovation model and participatory methods. An example of such an approach is being experimented with in the Convergence of Sciences, Strengthen Innovation System (CoS-SIS) research programme (see pages 159-161). The central ideas of this programme are: 1) smallholders are aware of (biophysical and technical) opportunities to raise productivity, but 2) institutional changes are needed to create the enabling conditions for farmers to make use of the existing opportunities.

The current research is part of this programme and seeks to contribute to the wider debate about the roles of institutions in innovation processes. Given the changing context in the local rice value chain, the research is interested in investigating how institutions shape practices of water management and rice production in the inland valleys of Benin.

As explained above, between 1976 and 1990, the Benin government initiated numerous – relatively ineffective – interventions to increase local rice production. Rice farmers hardly succeeded in creating a

living out of rice production because of the many barriers that existed in the rice chain. Therefore, the first main research question addressed in this research is (1) what are the constraints in the local rice value chain and the opportunities for innovation in the research areas?

After the 2007 rice crisis, the government turned to another type of intervention which prioritised facilitating institutional conditions (subsidies for seeds and loans for fertiliser, market facilities and so on) to support the intensification of local rice production. These interventions have had successful outcomes in terms of increased rice yield, rice production and farmers' income. Thus, this research intends to study the effectiveness of the two generations of interventions in the rice value chain. Hence, the second research question addressed is: (2) how and to what extent does the new generation of interventions create space for rice production in the research areas and overcome the shortcomings of previous interventions?

1.4 Research design

A case study approach is used throughout the research investigation. Case studies are commonly used to capture details that provide insight into human behaviour by means of on-site fieldwork in combination with (participant) observation, (in-depth) interviews and/or document analysis (Yanow et al., 2010). Yin (2004) has explained that the case study method is pertinent to address either a descriptive question (*what* happened?) or an explanatory question (*how* or *why* did something happen?) and *how often* something has happened.

Three rice producing areas were selected as case studies (see below). They are different in terms of the importance of rice income for farmers' livelihoods, the farmers' experience in rice production and rice water practices. The case study approach was used to explore the complex context of the rice production system in the three areas and determine to what extent the differences between the areas explain the farmers' practices (cooperation for water management) and their responses to the interventions of the government programmes. Such a detailed contextual analysis of a diversity of cases helps to add strength to analysis based on previous more general research in the area about rice production (Baxter and Jack, 2008; Saïdou and Kossou, 2009).

Critics of the case study method believe that the study of a small number of cases can offer no grounds for establishing the reliability or generalisability of findings (Flyvbjerg, 2006). This is one of the limitations of this approach that needs to be considered when conclusions are being drawn. The purpose of this research, however, is not to generalise but to gain in-depth understanding of the comparative three cases. Consequently, the case study approach fits well with the aims of the research. Although the case study approach cannot be used for generalisation, comparative case study research can highlight very important principles that serve as inputs for further wide research.

1.4.1 Selection of case studies

On the basis of a scoping study that screened 18 rice producing areas (Saïdou and Kossou, 2009), three research areas were selected (Koussin-Lélé, Bamè and Zonmon, Figure 1.5) in which rice was produced in the complex context of inland valleys. The fact that they differ in many respects promised a fruitful comparison across the areas. A first major difference relates to farmers' water use practices.

There are also other relevant differences between the three areas. In terms of area devoted to rice production, by 1978, the Chinese project had built 106 ha of irrigation schemes in Koussin-Lélé, which farmers themselves extended to the current 160 ha. Originally, 33 ha were constructed in the lowlands in Bamè, but now only 4.5 ha are allocated to rice farmers who are also producing in the uplands, on about 15 ha. Of the 88 ha built in Zonmon, currently only 15 ha are used for rice production.

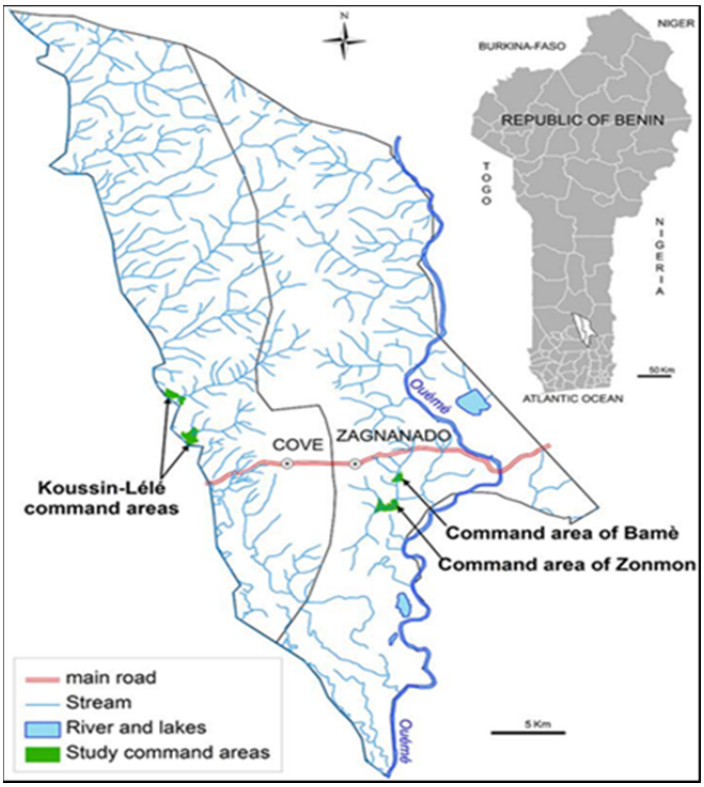

Figure 1.5: Covè and Zagnanado districts with irrigation command areas in the research areas

Rice production was introduced into all three areas with the irrigation projects. However, soon after the Chinese left in 1978, management no longer functioned properly and, to a varying degree, yields as well as the areas under production declined, and farmers increasingly abandoned the schemes. In Koussin-Lélé, farmers resumed rice production slowly after 1984, and it became more prominent after the renovation of the irrigation scheme in 1989. In Bamè, rice production restarted in 2008, and lately in 2009 in Zonmon with the projects initiated to promote the intensification of rice cultivation after 2008.

Whereas in Koussin-Lélé more than 200 farmers are now engaged in rice production – which represents the major source of income for 85% of them – only 20 farmers are producing in Bamè, and, as of July 2012, 21 in Zonmon, where rice is not the main income source. Economically, rice production does not have the same importance across the three communities. In Koussin-Lélé, farmers depend on rice production as their primary source of income, whereas, in Bamè and Zonmon, rice production is relatively recent and not the main source of income. Finally, Koussin-Lélé is a production area in which farmers from different villages work during the day and return to their respective communities in the evening. In Bamè and Zonmon, the irrigation command areas are located within the boundaries of the villages and are therefore used only by people from the villages.

1.5 Research phasing

The research was conducted in three stages: (1) a baseline/diagnostic study, (2) action research, including technical experimentation and (3) intervention monitoring and evaluation.

1.5.1 Diagnostic study

Based on the research gaps identified in the scoping study (Saïdou and Kossou, 2009), a diagnostic study was conducted in the selected three research areas. Diagnosis refers to the practice of determining the nature of a disease, malfunction or disorder (Jiggins, 2012). The identification of symptoms is the key process in the analysis, from which causation is inferred. Diagnostic analyses that identify systemic

problems and their causes can inform policy designs (Edquist, 2011). Such a diagnostic system analysis provides an overview of the existing failures in a system. Hence, to be able to work on improving a system, it is important to have a good understanding of the failures, the existing opportunities and how the system operates (Edquist, 2011). Hence, the diagnostic study in the rice production areas was conducted to explore technical and institutional barriers that hinder a significant improvement in local rice production and effective water use. More specifically, it focused 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 hinder innovation and (4) potential institutional opportunities for innovation.

1.5.2 Action research

Lack of collective maintenance of the irrigation infrastructure and ineffective use of the irrigation water in rice farming are, among other things, the main barriers identified as hindering local rice production. In order to stimulate the exchange of knowledge about efficient water use in the upland areas among the farmers in the research areas and strengthen their cooperation, an action research approach was chosen. Brydon-Miller et al. (2003) explain that action research seeks to bring together action and reflection, theory and practice, in participation with others. Action alternating with reflection is the point at which action research and experiential learning intersect (Dick, 2006). The main activities in this action research were (1) facilitation of a joint experiment in Bamè involving rice farmers from the three research areas and an extension agent and (2) regular meetings with the stakeholders to reflect on the findings and draw lessons.

Essential to the approach used is that the content and design of the technical field experiment, its implementation and evaluation of results were done in collaboration between farmers, extension agents and the researcher. It aimed to show the farmers that they could gain a lot by working together.

1.5.3 Evaluation

Finally, an evaluation study was conducted in the three areas. To be able to assess the actual changes, the monitoring data collected were compared with the findings of the diagnostic study (before–after approach). The main weakness of the before–after design is that change brought about by a given policy cannot be separated out from change that would have happened anyway (El-Basyouny and Sayed, 2011; Purdon et al., 2001). Therefore, through an analysis of the change process based on timelines, the contribution of policy interventions was included to provide convincing arguments for the contribution of the policy interventions to change.

In the case of this study, it was assumed that the government programme interventions did not directly trigger change, but that the social changes resulted from the interplays between the interventions and farmers' local actions. The assessment of change also built on the assumption that change of institutions at a higher level can create opportunities for smallholders to improve their livelihoods (Hounkonnou et al., 2012; Röling et al., 2012). Interventions of the programmes were thus regarded as creating an institutional environment, and an analysis was made of whether and to what extent they indeed provided enabling or hindering conditions for changes in the research area.

1.6 Data collection and analysis

1.6.1 Methods for data collection

Details about the different methods used are further explained in each relevant empirical chapter. In this section, the focus is on the general strategy used. An overview of the methods is also given, as synthesised in Table 1.1. A combination of interviews, focus-group discussions, questionnaire sample surveys and direct observations were used to answer the different research questions formulated.

Table 1.1: Overview of the research design in relation to the methods used for each empirical study (Chapter) and the strategy for data collection

Methods	Chapter in which method is used	Strategy used
Focus group discussion	Chapters 2, 3 and 5	Discussion were tape-recorded, translated and transcribed for detailed analysis
Questionnaire survey	Chapters 2, 3, 4 and 5	Individual (formal) discussion with farmers and questionnaire form was filled out for quantitative analysis
Individual interview	Chapters 2, 3 and 5	Individual interviews were tape-recorded, translated and transcribed for detailed analysis
Participant observation	Chapters 2, 3, 4 and 5	Implication in the farmers' activities
Informal discussion	Chapters 2, 3 and 5	Informal talks
Archival document checking	Chapters 2, 3 and 5	Reading of farmers' records; extension and projects staffs' repots

Focus group discussion was one of the main tools used to collect information. The focus group discussions were often organised before the individual interviews in order to identify some of the critical issues relating to the topic under study that needed further clarification. After the individual interviews, a new range of focus group discussions was conducted in order to validate the information collected during the individual interviews.

Questionnaire surveys were used to gather quantitative information relating to yields, production costs, rice price fluctuations and so forth. The data on yields were triangulated with the records of the farmers' association and the information presented by the extension staff. The rice prices were collected directly from the farmers and the markets located in the research areas.

Informal discussions and participant observations gave the opportunity to collect information directly without putting farmers in a formal interview condition (Jacob, 1998). In this study, they also enabled the validation of the information provided by farmers in the formal interviews about practices in the day-to-day lives of the people.

1.6.2 Strategy for collecting reliable information

At the beginning of the fieldwork, the researcher spent almost one month visiting farmers, without asking any direct questions. The time was used to help the farmers in their work, transplanting rice from the nursery or weeding the rice plots. The purpose was to establish a first contact and to gain their confidence. We were aware of the sensitivity of data gathering in rural areas, from our previous experiences. Farmers consciously give wrong information if there is no trust relationship between farmers and researchers. We believed that by building a strong relationship of trust and not being considered as a researcher (*akowé*) or an outsider (*djonon*), but as one of their friends or relatives, we could get more reliable information. We therefore chose purposely to work and interact with the farmers in their daily activities to create mutual acceptance and dissipate the barriers that exist between *akowé* and farmers.

It was established during formal discussions that most of the time farmers can become resistant when researchers start taking full notes (Jacob, 1998). We also experienced this resistance. One of the farmers whom we visited to trace back how the rice production and water use practices had changed over the time in the village refused to tell us the history: "I will not tell you anything about our village […] if you are going to write all the information down. I did it many times and your 'colleagues' used our stories to write their books and are now big men, with big cars. When they finished, they did not care about us, about our development!" This is anecdotal of the blockage described. To avoid such a blockage, in most cases, we

asked the interviewees' permission to record the interviews and wrote down only a few key notes to guide the later process of transcribing the recordings. In most cases, people gave more detail and specificities of the issues discussed than when we tried to write down all their responses.

1.6.3 Data analyses

All through the thesis, different data analysis approaches were used. They were very specific to each chapter and depended on the specific issues tackled. Detailed explanations are provided about the different approach used to analyse the data in each of the empirical chapters. An overview of these approaches is presented in this section.

In order to explore rice farming and water management practices, and the barriers to innovation in the local rice value chain, the socio-technical root system (Leeuwis, 2004b) was used to structure the interrelations between the technical and social problems elicited. The main institutional barriers to the improvement of the situation of the local rice value chain were identified from analysis of the findings, using the innovation system framework (van Mierlo et al., 2010b) (cf. Chapter 2). The analysis of institutional barriers builds upon the problem tree identified in the focus groups, supplemented by a literature study of the historical roots of these problems.

The data already collected through interviews, participant observations and archival research were additionally used to analyse the farmers' cooperative behaviour (Chapter 3). A framework for the analysis was drawn from the literature on the key factors influencing collective action. The interviews were transcribed and analysed to explore (1) how and to what extent the farmers in the three areas cooperate in the maintenance of the irrigation infrastructure, (2) the characteristics of the irrigation water supply systems of the groups involved in the maintenance of irrigation infrastructure and (3) the incentives and disincentives for cooperative actions created by the existing institutions in the three inland valleys.

The data collected for Chapter 4 were both qualitative and quantitative. The findings of the joint experiment were analysed from the perspectives of the different stakeholders involved in the platform (researcher, extension agent and farmers). The members of each stakeholder category (rice farmers, extension agent and researcher) decided on their own assessment criteria, and the effectiveness of each experimental option was assessed by combining the perspectives of all the stakeholders.

Chapter 5 investigates the changes in the social practices of actors in the rice value chains in the three areas and how the external interventions interacted with the actions of farmers. To this end, the information collected during additional interviews and observations at the end of the study was compared with the data collected for the diagnostic study. The latter were used as the baseline against which changes in social practices, local institutions and income brought about by the external interventions were analysed. Timelines to define critical events and their relations helped to trace back the reasons for the changed practices. These timelines chronologically capture the interplay between the external interventions of the governmental programmes, farmers' local activities and the research activities.

1.7 Outline of the thesis

The two main research questions are addressed in a number of studies that together form this dissertation (Figure 1.6). Chapter 1 (this chapter) presents the local rice context and related problems in Benin, the resulting research questions and the methods used to gather information.

The first research question about the constraints in the local rice value chain and the opportunities for innovation is addressed in Chapters 2, 3 and 4 of the thesis. The diagnostic study reported in Chapter 2 explores the main problems in rice production. It focuses on technical and institutional factors that hinder significant improvement of the local rice value chain and effective water use in the inland valleys of Benin.

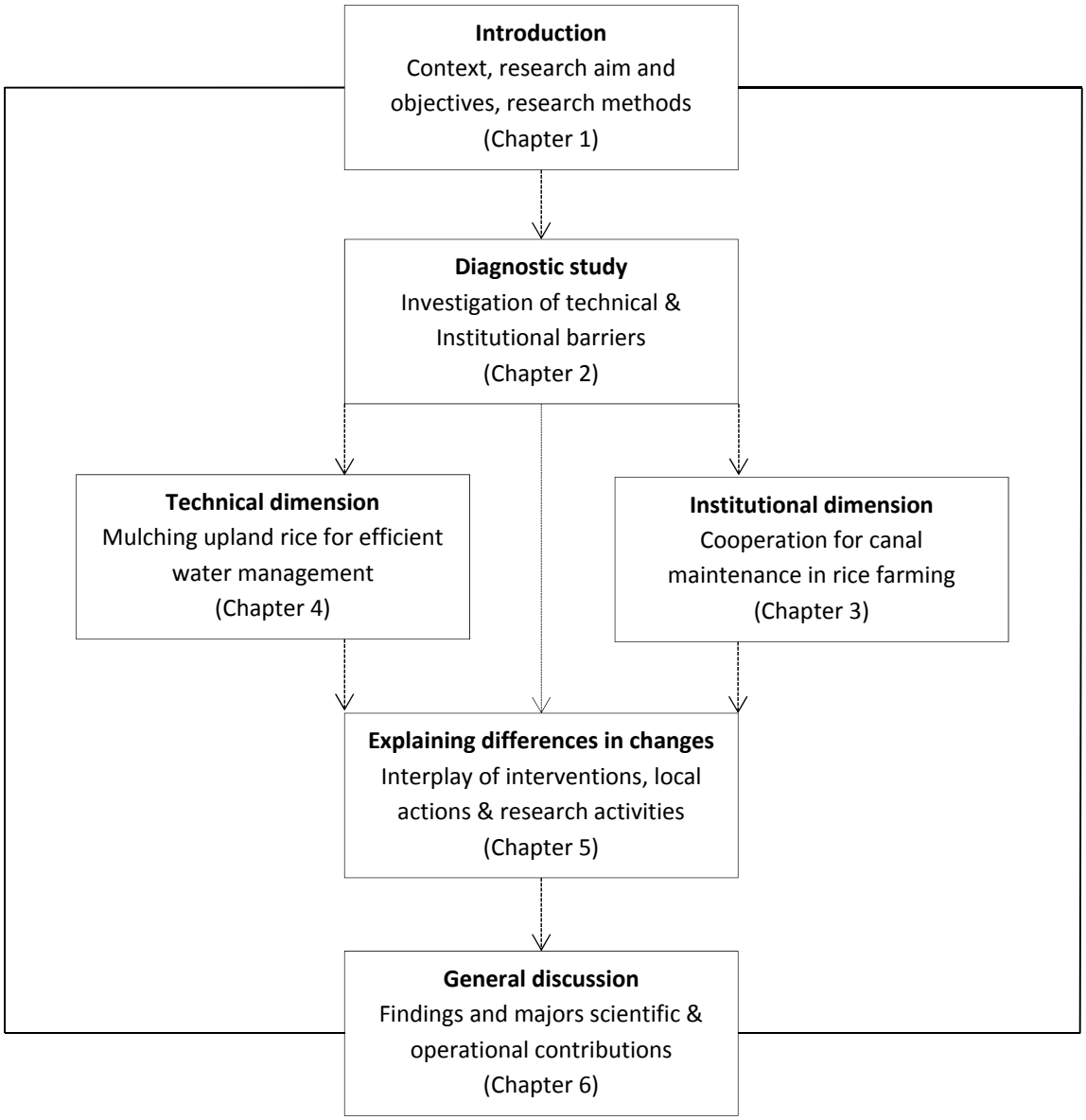

Figure 1.6: Relation between the chapters

After analysing the farmers' practices and the socio-technical problems in the local rice value chain, the chapter identifies promising windows of opportunity to stimulate innovation that can allow smallholder farmers to have a better profit from their rice production.

Chapter 3 attempts to explain the reasons for lack of collective action, identified in Chapter 2 as one of the main barriers to effective water use. It focuses on the case of canal cleaning in the lowlands and explores the factors that affect individual farmers' cooperation in the three different rice production areas studied. This chapter demonstrates that the extent to which farmers choose to cooperate in the face of a public good dilemma depends on a number of factors that appear to differ significantly across the three communities, although these communities are located in a seemingly similar environment.

Chapter 4 also tackles one of the socio-technical constraints hindering rice production identified in Chapter 2. It describes how a collaborative approach involving a mixed group of stakeholders was used to identify and test mulching as a potential method for improving irrigation water efficiency for growing rice in the upland parts of Benin's inland valleys. The chapter then turns to examining how each group of stakeholders gives meaning to the outcomes of the technical experiment and how the different

perspectives improved the generation of knowledge about a viable option for more efficient water management in rice farming in the uplands.

Chapter 5 explores the interplay between policy interventions and local actions of farmers. It then addresses the second research question. It explains the contribution of the policy interventions to the changes in farmers' practices. It also explains why not all changes were similar, although the policy interventions were. The importance of rice production in each area, the different production options and the natural circumstances influence the local actions of the farmers and contribute to explaining the diversity of social practices in the three research areas.

Chapter 6 focuses on the major findings of the study and provides answers to the research questions formulated in this chapter. It presents the major scientific and operational contributions of the research and suggests some research topics for further exploration.

Chapter 2

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

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

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 governments 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 farmers' 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.

Keywords: institutions, water management, innovation, rice value chain.

2.1 Introduction

The economic liberalisation policies and reforms undertaken in Benin since the 1990s have led to the transfer of the control of irrigation infrastructure to farmers' organisations (Minot et al., 2001). Subsequent reform of the agricultural sector aims to revitalise water management in order to improve water use for agricultural purposes and ultimately farmers' livelihoods (van Koppen et al., 2005). However, an exploratory study conducted recently in the inland valleys shows that problems related to water management in rice production remain (Saïdou and Kossou, 2009). Many technological options that address water management problems are waiting on the shelf but are not widely used (Labitan, 2010) and farmers still experience the effects of drought and flood that limit their production (Saïdou and Kossou, 2009). 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 (Saïdou and Kossou, 2009).

For a long time innovation has been regarded as the technical output of research (Dormon et al., 2007), 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 (Hall et al., 2003; Nederlof et al., 2007). Empirical studies demonstrate that innovation involves a simultaneous re-configuration of the social and technical dimensions of use (Geels, 2002; Klerkx et al., 2010). 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 farms, local farmer group or and village.

Effective deployment and application of technology in complex problem situations calls for a more comprehensive approach to innovation (Biggs, 2007; Hall et al., 2003; World-Bank, 2007). In this perspective, institutions are seen to play an important role. This article focuses on the institutions that

hinder innovations 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-organising initiative for change (Leeuwis, 2004a).

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 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 (Bandaragoda, 2001; Giddens, 1984; North, 2005). We use the term institutional barriers to refer to constraints related to the institutions that prevent promising technologies from being used (van Huis, 2008).

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 research 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 summarising the main institutional barriers and pointing to promising opportunities for an integrated approach to innovation.

2.2 Methodology

2.2.1 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 eighteen rice producing villages located throughout Benin (Saïdou and Kossou, 2009). 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 Centre, and Nerica Project) are on- going 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, that 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 liberalisation process in the 1990s led to the revitalisation of farmers' associations and the government shifted control of the irrigation infrastructure to the associations. Table 2.1 below provides further relevant information about the context, for all the three cases.

Table 2.1: Description of the three cases

	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
Farmers' groups	11 farmers' associations (200 producers)	3 farmers' groups (19 producers)	3 farmers' groups (21 producers)
Experience in rice production	Since 1976, farmers have produced rice but production decreased between 1980 and 1984.	Rice production resumed three years ago (in 2008) after collapsing in 1978 when the Chinese left the region	

Source: field data; FGDs

2.2.2 Data collection and analysis methods

Data were obtained using focus group discussions (Kitzinger, 1994) with rice farmers regarding (1) their practices of producing 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 organised per area and the rice farmers' association registered with the regional authority. No more than eight members were invited for each discussion, to aid effective facilitation. We conducted twelve focus group discussions with sixty-five of the two hundred farmers at Koussin-Lélé, three focus group discussions at Bamè with fourteen out of the nineteen farmers, and two focus group discussions with sixteen out of the twenty-one farmers at Zonmon. In total ninety-five 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 (Leeuwis, 2004b), in order to structure the interrelations between the technical and social problems elicited. The discussions were organised to let the farmers reflect together and to provide an opportunity to the researcher to observe the interaction among the rice farmers (Duggleby, 2005). 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 sixty randomly sampled rice producers (thirty-five at Koussin-Lélé, fifteen at Bamè and ten at Zonmon).

Table 2.2: Description of the research design

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

Participant observation (Laurier, 2008) 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 organised to reflect on our findings concerning the main problems identified during the study and to explore their responses to the innovation opportunities identified. Table 2.2 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 framework (van Mierlo et al., 2010b). The Innovation System consists of a matrix of system elements: barriers that may block learning and innovation (displayed in the in rows), and the actors who reproduce the barriers (displayed in the columns). Our design classified the following barriers:

- Infrastructural barriers relating to the knowledge infrastructure made up by departments of Research and Development, universities, research centres and all related regulation, and the physical infrastructure, consisting principally of roads and telecommunications.
- Hard institutional barriers relating to formal rules and regulation, and soft institutional barriers relating to symbols, values and norms.
- 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.
- Market structures, relating to the position of and relations between market parties along the value chain.

Originally, the Innovation System framework was developed and applied to a national system of innovation in order to analyse systematically the barriers in that block the development, use and diffusion of new products and technologies. It has been used in adapted form also to analyse institutional barriers relating to persistent problems of sustainable development (van Mierlo et al., 2010b).

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 to the barriers were explored. Subsequently the researchers held meetings with a number of organisations that are involved in the rice sector, including the regional extension office and the national committee of the

rice farmers 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 thirty four rice farmers, from the three study areas, the researchers, the extension officers who operate in these areas and two representatives from the PUASA project.

2.3 Major findings: problems and barriers to innovation

2.3.1 Farmers' practices

The practices of the rice farmers in the three areas are summarised in Table 2.3. We concentrate on those practices that relate to the five main problems 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.

Water access and distribution

In Koussin-Lélé all the rice farmers can take as much irrigation water from the Koussingo-Lélégo streams as they need from September to December (during the first production season). However, in the dry season from January to March the water discharge decreases and water becomes scarce, irrigating only 63% of all the plots (almost 97 hectares) 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 which 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, nineteen farmers produce rice all the year in the inland valley on 4.5 hectares under gravity irrigation, and on 10 hectares in the upland area with pump irrigation. For the gravity irrigation the farmers use and share the water from the Ahoho and Agluiglui streams that run through the valley. Each of the ten farmers that produce on the upland has his own (mobile) motor-pump 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 twelve of the rice producers concentrate on their activities in the valley because pumping water for the upland plots requires the 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 of producers manage by delaying their rice cultivation and, because of this delay, not all producers need water for irrigation at exactly the same time.

In Zonmon, 14 rice producers use an area of 5 hectares under a gravity irrigation scheme. The production site is irrigated by Somètè stream and the water that flows from Bamè (via the Agluiglui and Ahoho streams). There is free water distribution among producers; at any time a farmer who wants to irrigate their plots just opens the gate. However, often from January to February the water level in Somètè stream is lower than the level at the intake from the canal. At this critical period the producers use a small rented motor pump to get water from the main canal. As the use of a motor pump incurs the additional costs of fuel and maintenance, the farmers have started producing 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.

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 gates and the canal lining 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 farmers' organisation. According to the 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 which adjoin his or her plots, one or two times a year. Some farmers who share the same secondary canal organise themselves to do this collectively. Others prefer to clean their secondary canals individually. About one out of ten farmers, mainly the landowners, some farmers' 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 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 the maintenance of canals 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.

In the upland area at Bamè where farmers use small individual pumps for irrigation, the farmers' access to water is not so dependent on the gravity system. Each farmer organises 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 farmers' leaders in Koussin-Lélé and Bamè ask a service provider to carry out the repairs; they collect fees to cover the cost. The fees are collected from each rice farmer, after each harvest, and mainly dedicated to the purchase and maintenance of collectively-used machinery like cultivators and processing machines, 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 at a higher level (55 ha at Zonmon and 18 ha at Bamè). However, the pumps were not repaired when they broke down and have remained unused ever since, even though they are necessary for irrigating the higher areas.

Rice production cycles

Figure 2.1 presents the growing seasons at Koussin-Lélé in relation to the rainfall. Until 2004, most of farmers in this area produced rice only once a year, during the first growing season. Currently almost 56% of farmers grow rice in all three seasons; 32% produce during the first and the second seasons (in October and March) on the irrigated area and rent the lands that surround the command area for 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 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 nineteen rice farmers grow rice all year round because they use both the valley and the upland and the farmers harvest almost three times per year.

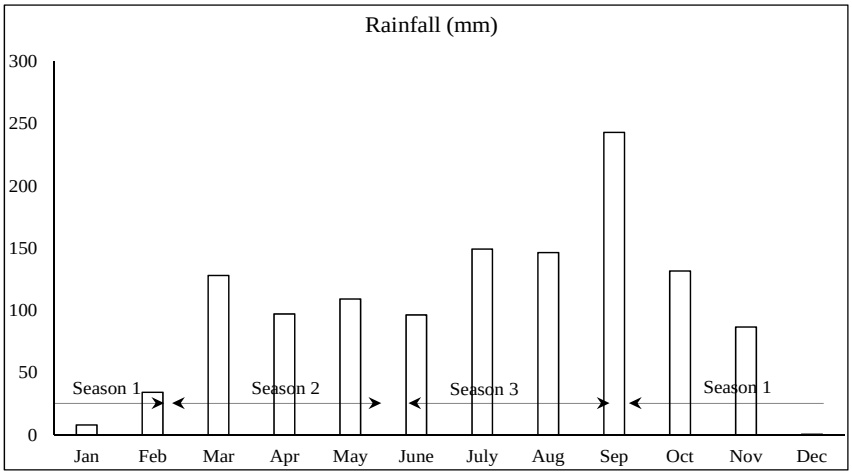

Figure 2.1: Rainfall (2009) and the production seasons
(Source: http://www.tutiempo.net/en/Climate/Bohicon/01-2010/653380.htm)

In all three areas, farmers use a mix of rice varieties including Beris 21, Tox long, Tox 447, IITA 314, and Nerica. Producers exchange seeds among themselves. 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 3 metric tonnes ha^{-1} and 5 metric tonnes ha^{-1} depending on the amount of fertiliser applied, the seed used and the potential of the land. Koussin-Lélé is the largest production area and in 2010, farmers harvested 357 metric tonnes of paddy. In the same year at Bamè, they harvested 21 metric tonnes of paddy, and 12 metric tonnes at Zonmon. One metric tonne of paddy is equivalent to about 0.7 metric tonne of processed rice.

Selling

At Koussin-Lélé and Bamè the farmers sell two kinds of products: paddy rice and processed rice. The paddy outlet is not an important market for the producers. About eight out of ten farmers sell the processed 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 package the local rice in the 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 processed rice directly to local consumers because their production volume 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.

Financing of the production

At the beginning of the first growing season about seven out of ten rice producers (those with less three harvests per year) need to access additional finance in order to purchase fertilisers 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 production period (September/October) is most 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 the rice production and no other food crops. These banks provide credit for groups of up to 11 members that are controlled by the farmers' 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 prove any proof of ability to re-pay or collateral before receiving the 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 rice farmers establish direct relations with specific local traders. They obtain the credit during the production season and they pay back in-kind from their rice harvest. In 2010 in Koussin-Lélé, for instance, farmers received 6000 F cfa (1€ = 655 F cfa) 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, that had a value of at least 12 500 F cfa. At Bamè, eight of the nineteen rice farmers asked for credit from a tontine (a revolving savings and credit group); the re-payment conditions are similar to the traders' credit.

2.3.2 Socio-technical problems at local level

The study revealed that two main problems 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. Figure 2.2 shows the aggregated problem tree constructed from the problem analyses made in the focus group discussions.

Low rice production

The theoretical rice production capacity of the command area for the three irrigation schemes recently has been estimated to be 640 metric tonnes of paddy for Koussin-Lélé, 150 metric tonnes for Bamè and 400 metric tonnes for Zonmon (Sohinto and Akomagni, 2008). 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 floods in the valleys during the rainy seasons and poor maintenance of the canals.

Almost three quarters of 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.

Table 2.3: Farmers' practices in the three research 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 to 3 times per year)	Collective maintenance of canal only when silted up (valley) Individual maintenance of canals and pipes (upland)	Irregular collective maintenance of canal
Rice production cycles	3 production seasons per year	Continuous production (two seasons in the inland valley and one in the upland). Per year three harvests on average	1 production 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-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

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 which control the water flow from the main canal to the secondary canals are broken because of a lack of maintenance and these gates are very old (constructed in the years following 1976-1978). These also contribute to substantial water losses. For instance, eight of the eleven farmer members of Group 3 at Koussin-Lélé reported that they lose almost 30% to 40% of their harvest because of a 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, the stated that the restoration of the water gates and the broken lining of the irrigation canals should be the responsibility of the irrigation department, while 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 ten rice farmers irrigate their plots of about 15 hectare each with water pumped out of the stream, using their small individually-owned l pumps. In the past, although more than 65 hectares at Koussin-Lélé, 55 hectares at Zonmon and 18 hectares 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 mentioned this situation as a serious problem that prevents them from extending their rice production area.

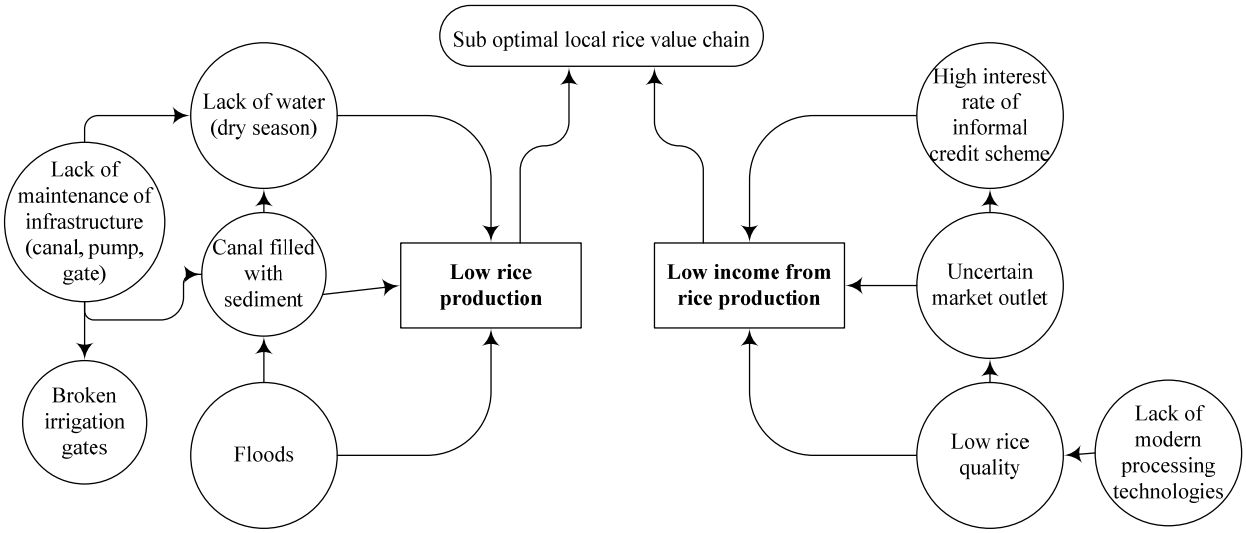

Figure 2.2: Problem tree: the three areas combined

Low income from local rice production

Almost nine out of ten rice producers (farmers as well as farmers' leaders) stated that the rice production does not provide them a decent income. For the producers in Koussin-Lélé this is a severe 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 realised 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 motor bike. […] 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 the local rice production we have estimated the total average return that each farmer gets from rice production (Table 2.4) and have compared this to the official minimum wage level. For this purpose, we estimated the production costs and selling prices by building on the responses to the questionnaire survey of sixty rice producers 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, fertilisers, labour, etc.).We included the interest rate (I_1) for informal credit in terms of kilograms of paddy. For instance, when a farmer receives 6 000 F cfa 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 F cfa. In this case, the informal credit cost (I_1) is almost 92 F cfa per kilogram of paddy ((12 500 – 6 000)/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 processed rice that is sold in order to derive the total return per farmer. In the case where farmers sell both paddy and processed rice, the processed rice was converted into paddy rice using a processing out-turn rate of 70%.

Table 2.4 shows that, in our example, at Koussin-Lélé, producers made a total return of 49 000 F cfa per hectare and per rice harvest season and a margin of 14 F cfa per kg of paddy. At Bamè, they obtained a total return of 14 630 F cfa and a margin of 8 F cfa per kg of paddy. Producers from Zonmon obtained a total return of 9 800 F cfa and a margin of 5 F cfa per kg of paddy.

Table 2.4: Average revenue per farmer (in F cfa) for one harvest of paddy per hectare (2009 data)

	Koussin-Lélé	Bamè	Zonmon
	2009	2009	2009
Production cost (per Kg)	109	113	118
Selling price (per Kg)	123	121	123
Margin (per Kg)	14	8	5
Average amount sold per farmer (Kg)	3500	1900	2000
Average return per farmer (cycle/4 months)	49,000	14,630	9,800
Average return per farmer per month*	12,250	3,658	2,450

Source: questionnaire survey

A rice production season covers four months so in practice farmers earn the returns presented in Table 2.4 within that period, assuming that farmers cultivate 1 hectare. However, as can be seen from Table 2.1, the average holding is less than 1 hectare in Bamè and Zonmon. The official minimum wage level is 31 625 F cfa per month; it would seem from our calculations that the rice income is low when rice producers' return is compared to the minimum wage. In Koussin-Lélé, the most successful area, where each farmer can obtain three harvests per year, a farmer's return is still only about 39% of the current minimum wage level (12 250 F cfa compared to 31 625 F cfa). In Bamè the return per farmer is 11.5% of the minimum wage level and only 7.7% in Zonmon. Three main factors were mentioned by the farmers as the cause of their low rice incomes: (1) low quality of the local rice because of the 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 the imported rice. The lack of an organised 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 complain about the uncertain market for their production, 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 fifty-five percent of rice producers to turn to the informal credit system provided by local lenders. These rice producers are highly dependent on informal credit and thus in effect their harvest is under the control of the lenders.

2.3.3 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 the persistence. We distinguish institutional barriers that arise in the context common to all three areas, from barriers that are defined by local institutions (presented in Figure 2.3).

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 (MAEP, 2007). 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 (Sohinto and Akomagni, 2008). Over the last five years the rice farmers' associations have been developing a their organisational structure, with a national board at the apex, but the implications for farmers' organisations of the reform measures are still unclear A small number of our respondents (just under two out of ten) still perceive maintenance to be a task for the public irrigation

engineers. The following extract from a focus group discussion at Koussin-Lélé illustrates farmers' perceptions clearly:

> *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 fertilisers, insecticides, etc.) to private companies (Hugon, 2007). This sector, formerly controlled solely by public companies, is now led by private businesses seeking high profit (Sinzogan, 2007). Input distribution today is monopolised by a few private companies and they give preference to cotton production areas because cotton producers use an important amount of inputs and the companies make more profit by selling cotton pesticides and fertilisers. Further, since rice is not an official cash crop with a guaranteed collection system, input suppliers perceive there to be higher risks in supplying the rice production sector. Each year rice producers have to search by themselves for production inputs. Furthermore, a fertilizer that has been specifically adapted for the rice crop and the soils of the inland valleys, is not available.

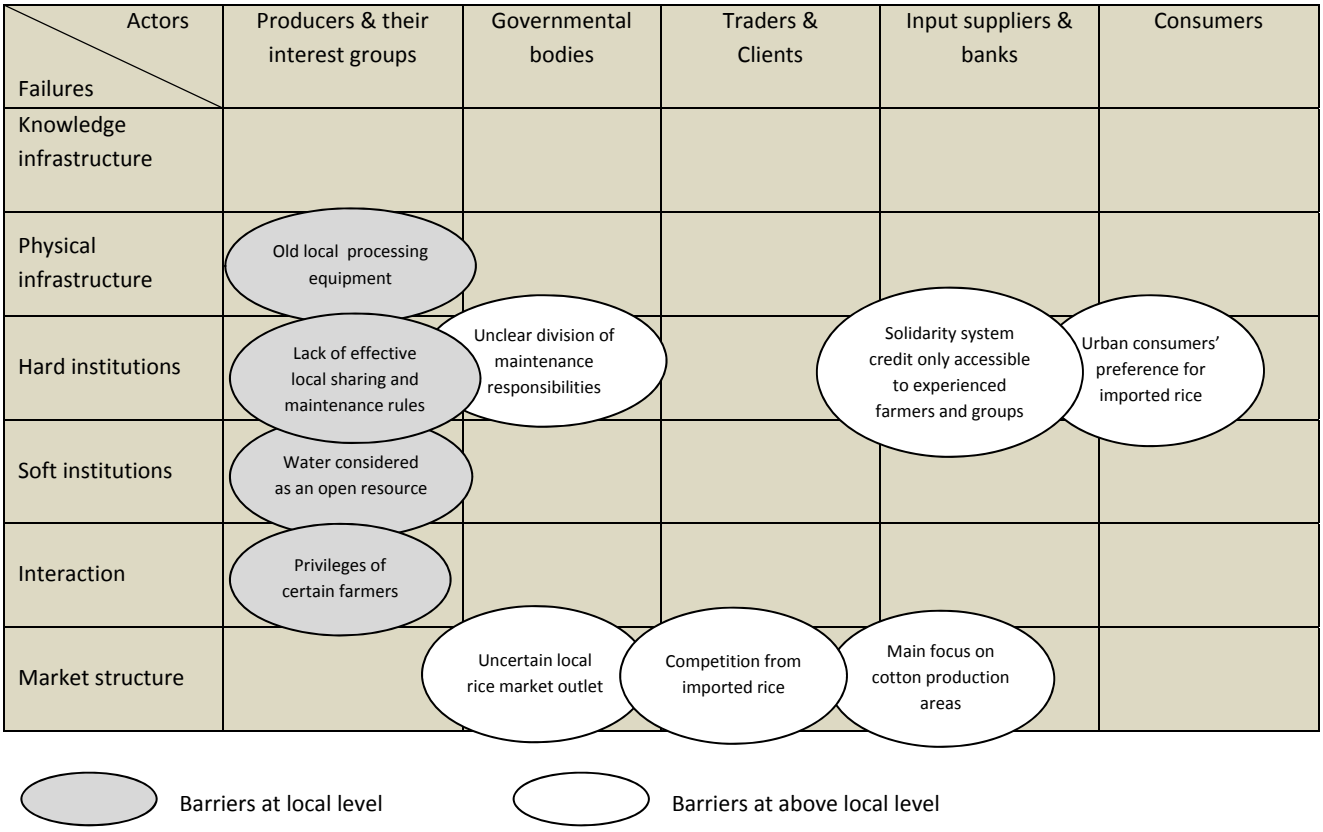

Figure 2.3: Institutional barriers to innovation in the local rice value chain

Until 1985 the government prohibited rice imports but under the economic reforms the private sector was allowed to import rice under license (Abiassi and Eclou, 2006). After 1990 the licensing scheme was removed 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 markets relationships have become unstable. Following the rice market liberalisation farmers themselves 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 market remain small. Many NGOs (such as Veco- a Belgian Association, and a local NGO like Entreprises Territoires et Développement) in partnership with the rice farmers national association are working with local rice farmers' 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.

Institutional barriers at local level

The solidarity credit system is preferred by all farmers, because of the much lower interest rates it offers compared to 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 of 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 all the year for the users. However, at Koussin-Lélé rice producers 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 in previous sections). This might be related to the fact that the farmers in Koussin-Lélé seem to be more dependent on the rice production in their inland plots than in the other two areas.

The local rules for restoring the canals are also not sufficiently effective. Ever since farmers' organisations have been given the direct control of the irrigation infrastructures, insufficient means 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 farmers' 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 to 15 years), and the leaders of farmers' 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 groups' members get access to credit or to plots). They also avoid sanction: 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 producers manage to ignore the rules without sanction. 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 resultant unfair access to resources and use rights, create frustration and lead to mistrust among the farmers.

The farmers in consequence 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 to taking initiative to sustain water use. It also diminishes farmers' awareness of the actions undertaken by water users in the upstream area 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.

2.4 Discussion: innovation opportunities

Many technological packages for rice introduced in Benin have been hardly used. The large irrigation schemes developed at Domè, Mitro, Zounguè, Yokon for improving local rice production currently are not used for rice production. We have shown that it is the institutional dimensions that influence the space for change for individual farmers and communities (Adegbola and Singbo, 2005; Hounkonnou, 2001) There are evidently significant gaps between technicians' expectations (policy-makers, researchers, extension workers, etc.) and farmers' perspectives, needs and opportunities.

Farmers in the research 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 emphasised the importance of addressing the institutional issues (both barriers and opportunities) (Nederlof et al., 2007) 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 reference 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. They are summarised in Figure 2.4.

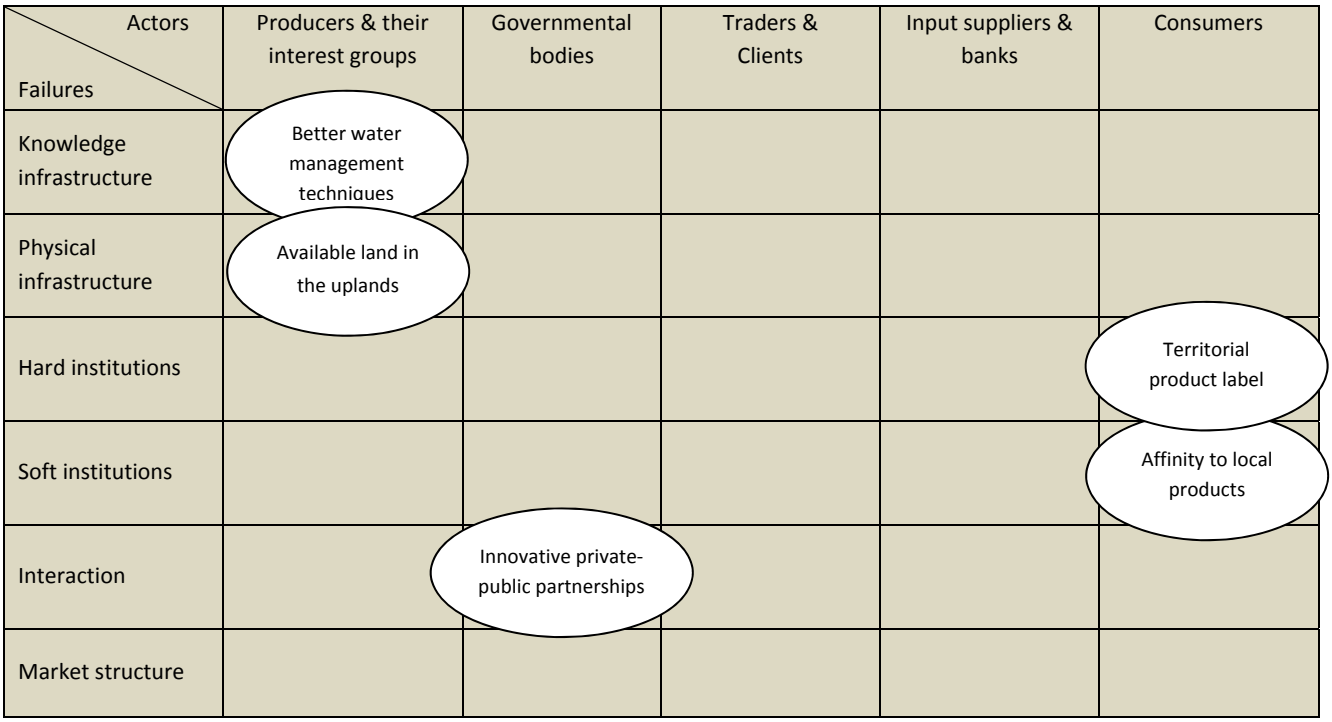

Figure 2.4: Windows of opportunity in the rice value chain

2.4.1 Rice demand and consumer affinity to local products

Rice demand is increasing over time in Benin; it is more frequently consumed, and in an increasing number of households. National rice demand was estimated in 1960 at 30,000 metric tonnes; by 2008 it had increased to 120,000 metric tonnes (Sohinto and Akomagni, 2008). The fast growth in demand could be an opportunity for the inland valley producers. Participants at 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 (Bricas and Sauvinet, 1989). 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 (Leeuwis, 2004a). 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.

2.4.2 Territorial product labels

Territorial product labels have been developed for a number of products in Benin 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 whole country because of their clear quality criteria and recognisability 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, allows producers 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 (Remigio, 1995).

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).

2.4.3 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 (Weiermair et al., 2008). Since 2008, through the private-public partnership scheme, private companies (for instance, *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 (Weiermair et al., 2008) that can close some of the gaps in the rice value chain. We heard from the rice farmers in Bamè that in mid-2011 they began testing an innovative business arrangement in cooperation with ESOP. The company contracts with rice farmers' 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, fertilizer, and bags for packaging 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.

2.4.4 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 on the fertile inland valley soils can easily yield 30 to 50% more than in the uplands (Abe et al., 2009).

The main advantage of improved maintenance of the irrigation system is expected to be that water levels in the rice fields can be controlled more accurately and reach 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 demonstrated at Malanville in the Northern region of Benin, dig shallow tube wells directly in each plot from which they pump the ground water into 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 solution for the fuel needed for the regular motor pumps. Such wells could help to use the water available more efficiently.

2.4.5 Available land in the upland areas

At Bamè, the nineteen rice producers use only 4.5 hectares, which means that each farmer has less than 0.24 hectare. At the same time, they have access to more than 58 hectares in the upland area where each rice producer has the possibility to extend his or her production. Since in the upland the topography does not allow gravity irrigation 40% of the rice producers have installed small fuel pumps to draw water from the Assanto stream into their plots. Pump irrigation allows farmers to produce rice all year round. Three rice farmer 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 seems to enrich soil fertility. This practice has the potential in the upland to increase rice yield and reduce the demand for water.

At Koussin-Lélé rice producers have access to 200 hectares 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 hectares 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 into the upland plots and to earn more by producing more rice.

2.5 Conclusion

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 organised 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 farmers' leaders induce frustration among 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 institutional dimensions of change and thus have met with limited success.

At higher institutional levels we show that the market liberalisation 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 2/3 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.

Chapter 3

Drivers of cooperative choice: canal maintenance in smallholder irrigated rice production in Benin

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Drivers of cooperative choice: canal maintenance in smallholder irrigated rice production in Benin

Abstract

Rice production in inland valleys in Southern Benin was initiated by the public sector. The subsequent devolution of responsibility for maintaining the collective irrigation infrastructure to farmers created an opportunity to study the factors that affect cooperation in canal maintenance. We used a social dilemma perspective to compare three rice production areas that differed in the extent of cooperation, based on focus group interviews, surveys and archival research. The findings draw attention to the nature of the resource, the characteristics of the user group and farmer-based institutional arrangements as explanatory variables. Specifically these include the (1) balance between water demand and availability, (2) the existence of inequities and privileged positions within the group, and (3) the strength of group organisation and ability to sanction uncooperative behaviour. The existence of alternative sources of livelihood also influenced cooperation. Contrary to our expectations, the largest and most diverse group of producers appeared best organised and equipped to engage in cooperation. Size and diversity might actually allow emergence of institutional arrangements that can overcome social dilemma situations and demotivation emanating from customary privileges and exemptions, as well as better use of Africa's irrigation potential.

Keywords: Collective action; canal cleaning; water management, inland valleys.

3.1 Introduction

Rice production in inland valleys is a relatively recent phenomenon in Benin. Starting in 1976, irrigation schemes for small-scale farmers were constructed with the help of Chinese projects. The Marxist-Leninist regime of the day all over the country organised farmers into various kinds of 'revolutionary' groups and cooperatives, but these were not responsible for the maintenance of irrigation infrastructure. That was the responsibility of the Ministry of Agriculture. The Government also set up public companies to provide production and marketing services. Meanwhile, most farmers continued their customary un-irrigated crop production. Rice production was an add-on to the traditional farming system.

The Structural Adjustment Policies imposed by the International Monetary Fund between 1988 and 1992 led to restructuring of agricultural services to reduce public sector costs (Ahmed and Lipton, 1997; Sodjinou et al., 2008). When the socialist regime came to an end in 1990, farmers were asked to take on responsibility for the maintenance of the infrastructure in their command areas and for solving the related water management and agronomic problems. The food crisis in 2008 led to a 50% increase in rice retail prices in Benin, which has stimulated farmers' interest in rice production (WFP, no date).

A recent exploratory study conducted in 18 rice production areas in Benin showed that many of the problems related to farmers' insufficient or variable access to water are caused by faulty maintenance of irrigation canals (Saïdou & Kossou, 2009). A diagnostic study in three of these 18 areas (Koussin-Lélé, Bamè and Zonmon, see Figure 3.3) explored technical and institutional factors that hinder effective use of irrigation water (Totin et al., 2012). It revealed that not all farmers contribute to the maintenance of irrigation canals that serve them all. Faulty cleaning and sediment accumulation in the canals mean that the water requirements of many farmers cannot be satisfied. In all three cases, more effective water management would also allow expanding the rice production area and more farmers to increase their living

standards. In order to reduce current yield losses and increase total production, rules have been enacted that require all farmers to contribute to maintaining the infrastructure.

As this article will show, differences exist in the extent to which these rules are followed in the three areas. In Koussin-Lélé, participation in the maintenance of the irrigation canals is moderate. To escape sanctions, farmers do clean the canals albeit too slow and not very thoroughly. In Bamè, farmers do not contribute at all to the maintenance of canals. In Zonmon, farmers do not always comply with the rules and canals are often insufficiently cleaned. Similar differences between the three areas were observed with regard to maintenance of collective machinery and the payment of fees. At the same time, other forms of organisation exist that seem to function reasonably well. For instance, farmers cooperate to collectively purchase inputs, make collective credit requests and sell their harvested rice. Why is the collective maintenance of the irrigation infrastructure so problematic?

The case study reported here seeks to answer this question and, through comparing the three production areas with a focus on canal cleaning, improve our understanding of the factors that affect cooperative action.

3.2 Theoretical framework

3.2.1 Collective action

The literature on collective action is extensive (e.g., Olson, 1965; Wade, 1988; Ostrom, 2000; 2003 & 2009). Collective action may occur when the contribution of more than one individual is required to achieve a common goal (Ostrom, 2004). Most definitions of "collective action" feature the involvement of a *group of people* who take *coordinated and distributed action* in pursuit of a *shared interest* (Ostrom, 2003).

In the case of irrigation infrastructure maintenance, we are essentially dealing with a public goods dilemma: the individual farmer is faced with the choice whether or not to contribute to the maintenance of public service or good, from which all may benefit, regardless of whether they have helped provide it (Leeuwis, 2004: 73; Brewer and Kramer, 1986; Kollock, 1998). Implicit is the temptation to enjoy the good or service without contributing to its maintenance (Leeuwis, 2004: 329). In the longer term, such free riding may undermine the willingness of others to cooperate and eventually lead to the collapse of the public good. Willing co-operators may fear that not enough others will cooperate and choose to defect (Kollock, op cit; Eek and Biel, 2003; Holzinger, 2008: 14). A public goods dilemma is characterised by tension between short-term individual interests and the public interest (Leeuwis, 2004: 73). The short-term individual choice often prevails, although in the longer term all would have been better off if all had made the cooperative choice.

Failure of collective action can thus be regarded as emerging from non-cooperative choices of individual farmers, including non-participation in group work and disregard of established community rules.

3.2.2 Factors influencing cooperative choices

Several studies deal with the factors that contribute to successful cooperative action (Wade, 1988; Ostrom, 1990; 2003 & 2011; Gopalakrishnan, 2005; Fujiie et al., 2005; Araral, 2009; Hanatani, 2010; Woodhill, 2010). Sandler (2004: 25-36), Gopalakrishnan (2005) and Ostrom (2009) identify three main categories of factors that relate to participation in collective action: (1) physical and technical characteristics of the resource around which the group work is organised, (2) characteristics of the user group (number, homogeneity, etc.), and (3) attributes of the institutions that govern the interaction among the different users of the resource (e.g., rules that govern collective well-being). We discuss each of these in turn.

Resource characteristics: Wade (1988) demonstrated that the availability of a given resource affects the way people cooperate for its maintenance. In the case of irrigation, for instance, if water supply is abundant relative to demand, there is no incentive for users to undertake cooperative action to augment

the supply or economise on consumption (Fujiie et al., 2005). When water is moderately scarce, cooperative activities, which aim to increase water supply at plot level (e.g., de-silting of canals) will generate the highest perceived direct economic benefits, and people are therefore more likely to contribute to these activities.

Characteristics of the user group: Based on social-psychological literature, Koelen and Röling (1994 cited in Leeuwis, 2004), Velded (2000), Dayton-Johnson and Bardhan (2002), and Poteete et al. (2009) all argued that a small, socially homogeneous community (e.g., in terms of caste or ethnic group) and economic similarity increase the likelihood of successful cooperative action. Conversely, people are less likely to act in the collective interest when communities are large or heterogeneous. Olson (1965) suggested that cooperative action is more difficult to organise in larger groups. As group size increases, individuals will argue that their marginal contribution does not significantly affect the likelihood that the good will be provided and therefore refrain from making such contributions. Fujiie et al. (2005) concluded that this theory applies to irrigation systems and that group work is hard to manage in water users' associations with a large number of members.

Institutional arrangements: Group members will pursue a collective goal only when they expect other members to contribute as well (Eek and Biel, 2003). In these conditions, effective leadership and experience of fair enforcement of rules is crucial. When exploring the causal mechanisms of cooperation for sustainable resource management, Hanatani (2010) found that people are able to successfully participate in group work when institutions (e.g., the possibility of agreeing on rules, surveillance of compliance and fair sanctions) exist, even when some of the facilitating conditions, such as the size and the homogeneity of the user group, are absent. We regard institutions to include formal and informal rules, implicit cultural norms, shared values and symbols that influence farmers' cooperative choice.

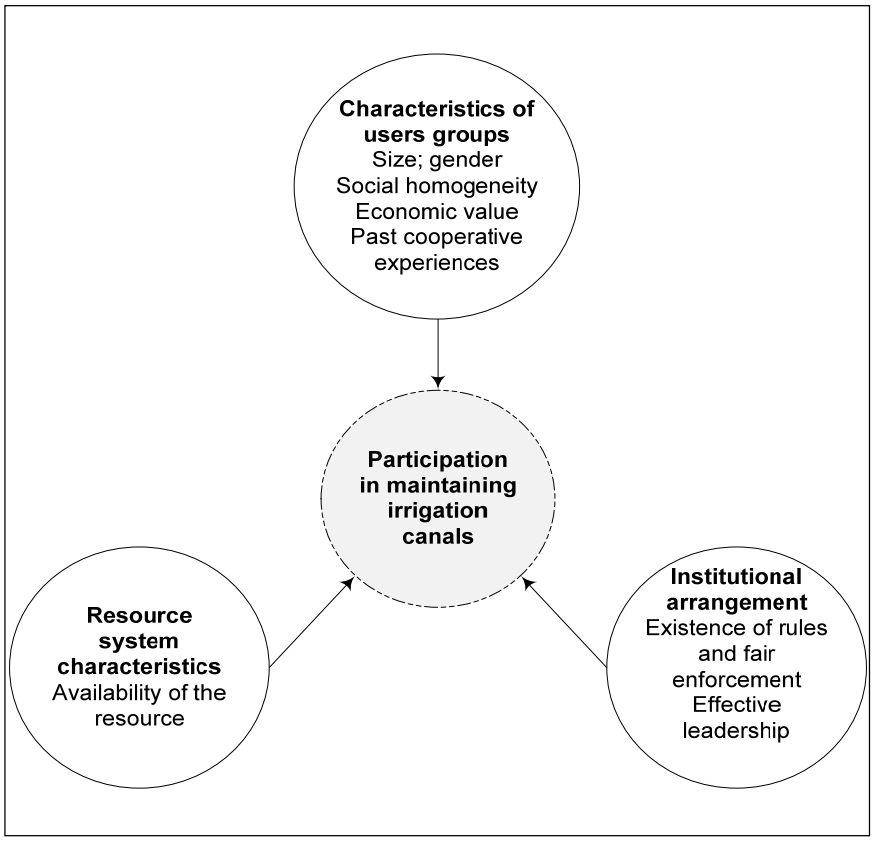

Figure 3.1: Clustering of factors influencing farmers' cooperative behaviour in maintaining irrigation canals

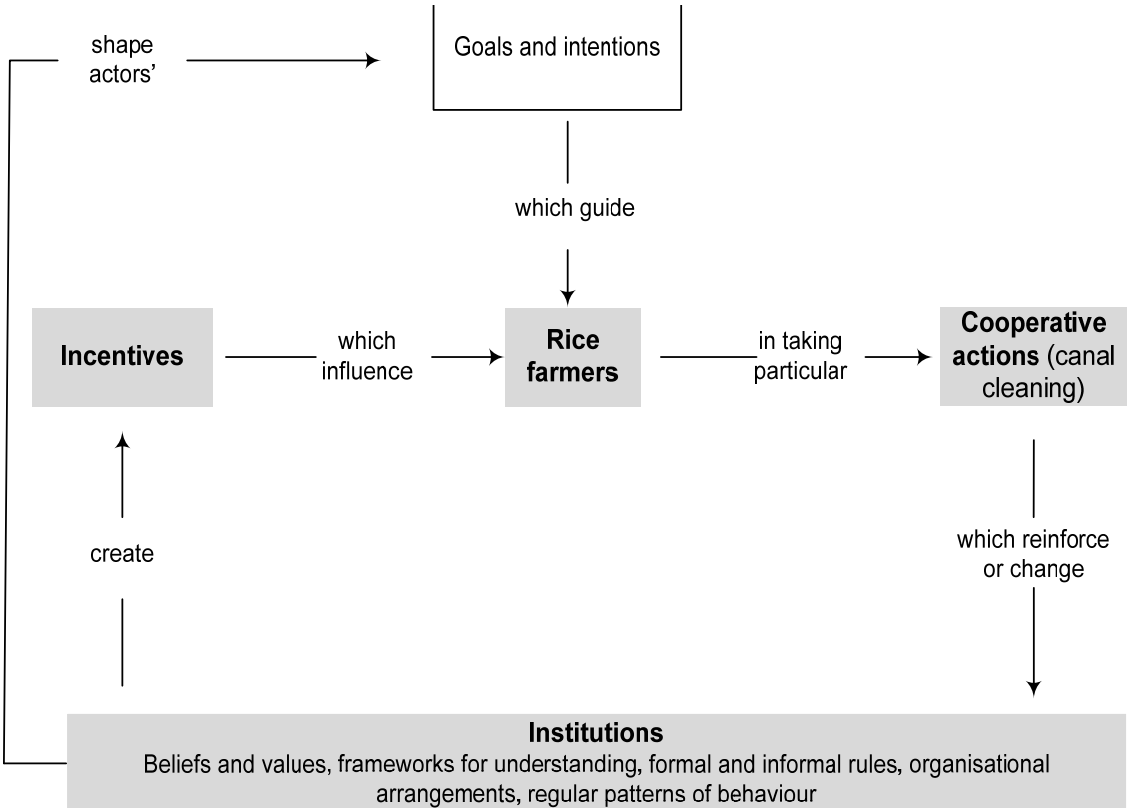

Figure 3.2: Institution and action model: Cooperative action as the result of incentives created by institutions; Source: Adapted from Woodhill (2008)

Among the conditions associated with successful cooperative choice, institutions such as local rules and controls can therefore play an important role (Lustiger-Thaler et al., 1998; Ostrom, 1999; 2004 & 2011; Hargrave et al., 2006). Hill (2000) adds that the existence of rules and controls is effective in reducing the rate of non-cooperative choice. The various factors we reviewed are synthesised in Figure 3.1. A further analysis of the way institutions influence cooperative action suggests that they do not directly restrict or shape people's behaviour as external conditions, but provide incentives (positive and negative) for individuals and groups to behave in particular ways (Figure 3.2; Woodhill, 2008).

This article addresses the following questions: (1) how and to what extent do the farmers in the three areas cooperate in the maintenance of the irrigation infrastructure? (2) What are the characteristics of the irrigation water supply systems in the three inland valleys? (3) What are the characteristics of the groups involved in the maintenance of irrigation infrastructure? (4) What are the (dis) incentives created by the existing institutions and to what extent do farmers comply with, ignore, or go against established rules? And (5) to what extent do differences among the three areas explain the divergent degrees of cooperation?

3.3 Methodology

Three areas of the Agonlin Plateau (Koussin-Lélé, Bamè and Zonmon) were selected on the basis of an exploratory study that screened eighteen rice producing villages located throughout Benin (Saïdou and Kossou, 2009). The areas were chosen (1) because the issues around water use were found to be persistent, (2) they offer contrasting water use practices that promised fruitful comparison across the areas, and (3) because in these areas respondents considered the maintenance of the irrigation infrastructure a critical issue. In the three areas, the farmers have a long experience in irrigated rice production.

Koussin-Lélé is a production area in which farmers work during the day and return to their respective communities in the evening. In Bamè and Zonmon, the irrigation command areas are located within the village boundaries (Figure 3.3). When we refer to maintenance of irrigation infrastructure, we mainly refer to farmers' individual participation in canal cleaning and to farmers' contribution to operations undertaken to maintain agricultural equipment, for example in the form of paying fees.

The research reported here followed a comparative case study design and used qualitative methods to gain information about the three cases. Data were collected using focus group discussions (FGDs) (Kitzinger, 1994), a survey and archival research.

In total, ten FGDs were held (six at Koussin-Lélé; two at Bamè and two at Zonmon). These discussions were recorded, translated and transcribed as literally as possible. Based on the social status, we distinguished two categories: (1) privileged farmers, such as the (original) landowners (who were expropriated to develop the rice production areas), the traditional chiefs, and the leaders of farmer associations, and (2) non-privileged farmers. Assuming that status might be an important factor in determining willingness to contribute to canal cleaning, we organised separate FGDs for each category. The allocation of farmers to categories was decided with the help of extension officers who assist the farmers in their everyday activities. In total 73 farmers including 62 males and 11 females were involved in the FDGs. To allow for in-depth discussion, no more than eight farmers participated in each discussion. During the FGDs the farmers reflected on their maintenance activities, the local rules and the incentives (positive and negative) created by the existing rules.

Together with our direct observations of canal cleaning during the field visits, the FGDs helped us form a picture of the conditions under which rice farmers cooperate in canal cleaning and understand how and to which extent farmers cooperate in maintaining infrastructure and machinery, what local rules are in place and how the three areas differ.

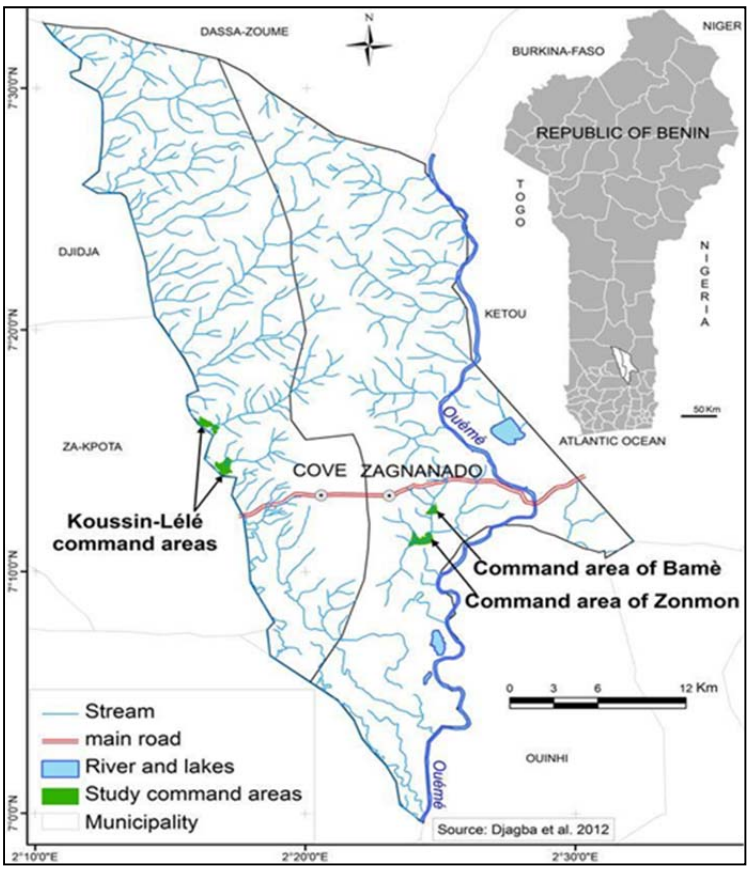

Figure 3.3: Map of Covè and Zangnanando districts showing the irrigation command areas

Table 3.1: Overview of data collection methods

Data collection methods	Numbers of farmers involved (N)	Area	Focus
Focus group discussions	48 15 10	Koussin-Lélé Bamè Zonmon	(1i) The way and the extent to which farmers cooperate (2) Characteristics of farmers' groups (3) Characteristics of irrigation water supply systems and (4) Institutions which lead to (dis) incentives
Survey	40 farmers (including 2 landowners, 1 traditional chief, 4 farmers' leaders and 33 non-privileged farmers) 15 farmers (including 1 landowner, 1 traditional chief, 3 farmers' leaders and 10 non-privileged farmers) 09 farmers (including 1 landowner, 1 traditional chief, 2 farmers' leader and 5 non-privileged farmer)	Koussin-Lélé Bamè Zonmon	(1) Farmers' maintenance practices (2) Various existing institutions related to irrigation canal cleaning (3) Influence of the existing institutions on farmers' cooperation (or not) choice related to canal cleaning (4) (Dis) incentives created by the existing institutions
Field visits and archival documents check			

In addition to the FGDs, 64 farmers were randomly selected from the two categories (16 privileged and 48 non-privileged rice farmers from sampling frames constructed for each area) and individually interviewed using semi-structured questionnaires. Interviews with key informants, participant observation and archival research completed the methods that were used to (1) gain insight into the existing institutions; (2) explore in-depth the (dis) incentives created by them, and (3) gauge differences and similarities between the three communities. The data collection methods are summarised in Table 3.1.

3.4 Major findings

Below, we describe the irrigation schemes from three angles: (1) the characteristics of the water supplies, (2) the characteristics of the groups and (3) the institutions. We then discuss how these elements are translated into maintenance practices, including fee payment. To assist the readers in capturing the information per research area, an overview of the key characteristics per area is already presented ahead of the findings in the Table 3.2.

Table 3.2: Overview of the characteristics per research area

	Koussin-Lélé	**Bamè**	**Zonmon**
Characteristics of water supplies	Water supplied by 2 streams Rice produced only in the lowlands Only 63% of all plots is sufficiently irrigated during dry season All the command area inundated from July to September	Water supplied by 2 streams Rice produced in lowland and uplands parts Seemingly a year-round abundance of water in lowlands 75% of the command area is flooded from July to September	Water supplied by 1 stream Rice produced only in the lowlands Use of pumps irrigation to supplement the gravity system during the dry season All the command area inundated from July to September
Characteristics of rice farmer groups	Almost 200 rice farmers organised in 11 groups Each group is lead by a committee of 3 elected farmers Farmers are from different villages Rice considers as a primary income source	20 rice farmers (in 2010) organised in 3 groups All 3 groups coordinated by a president and a treasurer No clear clear executive committee in place Farmers are all from the same village Rice is a major income source	21 rice farmers producing individually No executive committee existed Farmers are all from the same village Rice is not major income source
Institutions	Existence of a formal rule intended for canal cleaning and payment of fees	Agreement of farmers to all contribute to the maintenance of the canals and to pay a fees after each harvest.	No rules set for collective canal cleaning, or for payment of fees

3.4.1 Characteristics of water supplies

The apparent success of the Green Revolution in Asia led to attempts to repeat it in West Africa (Issaka et al., 2008). Supported by Chinese projects, the Government of Benin made major investments in large irrigation systems on expropriated lands. By 1980, the Chinese had built nearly 2.236 ha of irrigation schemes, including those in Bamè (33 ha), Koussin-Lélé (106 ha) and Zonmon (88 ha) (Sodjinou et al., 2008). The three command areas are located in inland valleys that appeared to have sufficient year-round water for gravity irrigation (Abe et al., 2009). Designed and managed exclusively for rice production, the command areas were placed under the responsibility of the Ministry of Agriculture. Soon after the Chinese left, management no longer functioned properly, maintenance levels dropped, to a varying degree yields as well as the areas under production declined, and farmers increasingly abandoned the schemes. Traditionally, farmers only cultivated rice in the most favourable season and did not face water scarcity. Due to increasing demand production was intensified, with farmers also planting in unfavourable seasons, leading to complaints about water availability. The areas differ considerably in the extent to which this happens.

In Koussin-Lélé, the water supply comes from two streams: *Koussingo* and *Lelego*. Rice growing resumed slowly after 1984 and gained prominence after 1989, following the renovation of the command area with the help of a Chinese project. In the dry season from December to March the discharge capacity of the canals and the velocity of water flow decrease and water becomes scarce, irrigating only 63% of all the plots sufficiently (Totin et al., 2012), as illustrated by the following quote:

> *We hardly get water in our rice plots during the dry season. During this period, we use to come late in the night to close the water gates of other farmers so that the water can reach our plots in the tail of the canal. We know this is not allowed because there are rules that organise the water allocation, but we have no other means to get water on our plots, especially in the dry season* (farmer from Koussin-Lélé, field interview, August 2011).

In Bamè, the inland valley in which the command area was created is divided into two areas: (1) a low-lying part, which allows gravity irrigation and (2) an 'upland' part where no natural source of surface water is available and a groundwater pump is required. Originally 33 ha were irrigated: 15 in the lowland and 18 in the 'upland'. Since the collective pump broke, the 18 ha are no longer used. Of the 15 ha under gravity, nowadays the farmers cultivate only 4.5 ha. But an additional 12 ha are being used in the 'uplands' with individually owned pumps. Farmers moved there because more suitable land is available.

The lowland gets its water from the *Ahoho* and *Agluiglu* streams, which flow year- round albeit with variable discharges. The migration of 12 of the original 20 farmers to the uplands allows the eight remaining in 2011 to have sufficient year-round access, as a farmer from Bamè noted on this point:

> *I do not produce rice in the upland area because I do not have a pump for irrigation. Somehow I am happy that some of my fellows left the command area for the uplands. We are now eight farmers producing in the command area and we can more easily get access to water than in earlier years* (farmer from Bamè, field interview, August 2011).

The "Sawah Rice Management System in an Inland Valley" trial that AfricaRice (formerly WARDA) at the time of writing was conducting in the area shows that low land plots receive between 300 and 500 mm of irrigation water per season from the two main streams (Danvi, pers. comm.). The Sawah experiment aimed to demonstrate to farmers that different agricultural practices might generate higher yields. Taking into account the additional annual average rainfall of 900 mm, it seems that water requirements for irrigated rice, estimated at 500-1200 mm per cropping season (Renault, 2004), are met.

In Zonmon, the command area is irrigated by the *Somètè* stream. The length of the canal is an estimated 1.8 km. Close to the water gate at the head of the canal some farmers are producing vegetables. The rice plots are located in the tail area As a result of intensifying production water demand there now is higher than supply. To increase water delivery to their plots, the rice farmers have to clean the total length of canal; a job that is not easy if not all farmers cooperate. From January to March the water level in the stream often is lower than the level of the intake. During this critical period, the farmers use small individually owned motor pumps to get water from the river into the main canal. Of the 88 ha formerly developed for rice cultivation, less than 8 are currently being used. More than 20% of the command area is used for vegetables and maize because these crops are less demanding and the available water is sufficient to cover the need.

In all, the areas differ in the balance between supply and demand and farmers do not to the same extent feel the need to enhance the supply. In Koussin-Lélé and Zonmon, farmers suffer from lack of water while in Bamè, there seemingly is a year-round abundance of water in the lowland area given the small land size under rice cultivation in this part (4.5 ha). Because of the topography of these areas, the command areas are frequently inundated, mainly from July to September. During this period, farmers from Koussin-Lélé and Zonmon are not able to produce rice at all, while in Bamè almost three quarters of the area is flooded.

3.4.2 Characteristics of rice farmer groups

This section looks at the characteristics of the groups in terms of (1) group size, (2) homogeneity and (3) past experiences with cooperative activities.

Group size

In Koussin-Lélé, more than 200 farmers are now engaged in rice production, which is the major source of income for 85% of them. The farmers' association is headed by a *Comité d'Administration* and is organised in 11 groups with about 15 members each. A committee of three leads each group. Farmers elect their leaders. The *Comité d'Administration* is responsible for allocation or irrigable land and facilitates access to credit, fertilizers and seed. The organisation in place obliges farmers to cooperate, as the following quote illustrates:

> *We are organised in such a way that each group of farmers is supervised and the fact that the whole command area is under the control of a coordination committee represents an advantage for us. This organisation obliges most farmers to cooperate* (Focus Group Discussion, Koussin-Lélé, September 2011).

Since production resumed in Bamè in 2008, the number of farmers keeps increasing. In 2008, ten farmers cultivated rice in the command area. In 2009 the number increased to 19 and currently, there are 20. They are organised in three groups coordinated by a president and a treasurer. There is no clear executive committee comparable to the one in Koussin-Lélé.

In Zonmon, rice production is a relatively recent activity. Farmers resumed in 2009 in the context of Benin's Emergency Support Programme for Food Security (PUASA), initiated to mitigate the effects of the floods in 2007 (de Schutter, 2009). Initially only 10, but since 2010, 21 farmers are producing rice in the area. Rice is not the major crop and all farmers also produce other crops. There is no executive committee in place.

Homogeneity of groups

All the farmers in the study areas belong to the same ethnic group (*Mahi*), but within this homogeneity, many categories and fractions can be discerned.

Farmers differ a great deal in their access to land. In general, large plots are allocated to farmer leaders and former landowners. In Koussin-Lélé for instance, each leader uses an average of 1.5 ha while regular farmers cultivate an average of 0.30. In Zonmon, because rice production is a recent activity, farmers are not yet very active and only one leader uses more than 2 ha, while the others use an average of 0.25. In the lowland area in Bamè, each farmer leader has eight plots (of 0.2 ha each) while regular farmers use an average of five. Beyond this differentiation in land size, many of the regular farmers complained that the poor land is allocated to them while leaders keep the well-irrigated and fertile land for themselves, as a farmer noted:

> *We are five farmers to whom they allocated the poorest part of the command area. Look at my soil, it is only sand, no clay in it! If you have time, go check around, you will not see such a poor soil in other farmers' plots. When the command area is inundated we expect to get sediment that fertilises the soil, but this part is not inundated. We hardly harvest 2 tons per ha of rice in these plots while some farmers located in the downstream have 3 tons* ha^{-1} (Farmer from Bamè, field interview, August 2011).

In the three areas, rice does not have the same importance and farmers' expectations and interests are different. In Koussin-Lélé and Bamè, rice is a vital source of household revenue. In Zonmon however, farmers have many other income generating activities.

A difference between Koussin-Lélé and the other areas is that the production area is not tied to a specific village. It is used by farmers from different villages, which adds an extra element of diversity. Koussin-Lélé is also the only area where women are engaged in producing rice. Two of the groups are entirely composed of women. Men and women produce separately: there are no mixed groups. In the other areas, women only provide labour for specific field activities such as planting, bird scaring, and harvesting, and do not own rice plots.

Past experiences

Farmers frequently referred to experiences with cooperative activities in the past. During the revolutionary era (1976-1983), many facilities were given to farmers as encouragement to produce more rice (access to fertilizer, seed, and marketing facilities). Public companies (e.g., SONIAH, *la Societé National pour l'Irrigation et l'Amenagement Hydro-Agricole*) contracted with rice farmers' groups to supply a fixed amount of rice at harvest against a guaranteed purchase price. The company provided seed of high yielding varieties and fertilizer. The input support and purchase guarantee offered major incentives to farmers to contribute to the cooperative activities, such as collective production and marketing, collective input purchase, etc.). Currently no such facilities and services exist; farmers have to fend for themselves in finding inputs and market outlets. These conditions and the uncertain markets for the local rice do not motivate farmers to cooperate. Other bad experiences affect farmers' current behaviour.

In Koussin-Lélé, farmers used to produce and sell the harvest together. The Association opened a shop to directly sell milled rice to consumers. They shared the returns according to the contribution of each farmer. Farmers reported that these experiences ended in frustration, as the following quote shows:

> *Until 1999 we all produced together and each farmer had to scare birds for five days during a season and had to harvest for half a day in the communal plots. Because of the poor management of our leaders, this initiative failed. The leaders did not contribute to the cooperative activities as the other farmers and when they sold the harvest, they kept an extra-profit for themselves. Because of these fraudulent practices, we all were de-motivated* (farmer from Koussin-Lélé, field interview, August 2011).

In Bamè, in 2008 when collective production was resumed, farmer leaders did not purchase fertilizers in a transparent way. Farmers reported that the leaders had over-charged the group. A bag of urea, for instance, was charged at 17,500 F cfa[*] instead of 12,500 F cfa, the market price. At the end of the season, regular farmers each received 42,500 F cfa, while each leader, pretending that they had used their own money to buy the fertiliser and need to be repaid after selling the harvest, pocketed 104,800 F cfa. The following growing season, all regular farmers decided to produce individually on their own plot.

In Zonmon farmers also have experience with cooperative initiatives. Until 2002, they engaged in collective fishery of which the returns were shared among the community members, but there was mistrust in leaders and farmers turned away from this cooperative activity.

We conclude that experiences with corruption by farmer leaders in all three areas have negatively affected willingness to make cooperation choices.

[*] The exchange rate during the study was fixed at 655 F cfa for 1€

3.4.3 Institutions: rules, control and sanctioning arrangements

In Koussin-Lélé, the Extension Service has helped the Association to formulate rules for equitable water distribution and for cleaning canals. All farmers who produce in the command area have to follow the established planning for water allocation and distribution and have to participate in canal cleaning. These rules are formally included in the text that regulates the Association. Each farmer is supposed to clean a number of canal segments, depending on how dirty the canals are. For example, at the start the first growing season the canals are grassed and silted as a result of deposits by the annual floods. For that season, each farmer is expected to clean a segment of 10 to 12 meters. In the second season, each farmer is responsible for cleaning 15 to 20 meters; canals now are less dirty. Also not all farmers produce rice during this period to avoid the risk of flooding that often occurs before the harvest. According to Koussin-Lélé rules, farmers who do not participate in cleaning the canals are not allowed to work in the command area for two to three seasons.

In Bamè, the earthen canals require frequent maintenance in order to facilitate efficient water delivery and farmers agreed to cooperate in cleaning and dredging the principal canals whenever they are silted. Formally, the *chef du village* allocates land for rice cultivation in the lowland as well as the upland areas, and summons the farmers to perform canal cleaning. Any member who does not participate in the group duties must pay the equivalent of 1,000 Fcfa per day missed.

In Zonmon neither a written document nor any other tangible form of agreement among farmers exists with respect to canal maintenance. Rice production is a very recent activity and as yet no organisation has emerged to regulate it. Before the growing season, farmers themselves decide when and how they clean the canals.

In addition to rules regulating canal-cleaning duties, two of the areas also have rules regarding the payment of fees. These fees are used to fix canals and/or maintain collective equipment used for rice production, such as cultivators, tractors and rice mills. In Koussin-Lélé, each farmer is required to pay 10 kg of milled rice per plot of 200 m^2. In Bamè the amount has changed over time (e.g., 2,000 F cfa per plot of 250 m^2 in 2008, 500 F cfa in 2009 and 1, 000 F cfa in 2010). In Zonmon farmers do not pay any fees.

3.4.4 Infrastructure maintenance practices

This section provides information about how farmers organise for the maintenance of irrigation infrastructure and about the extent to which they pay fees.

Maintenance of irrigation canals

In Koussin-Lélé, although according to the rules all farmers are supposed to contribute to the canal cleaning at the beginning of each growing season, it appears that privileged farmers such as leaders, landowners and traditional chiefs did not contribute (Totin et al., 2012). What is more, they have not been sanctioned and the unfair contribution to the collective canal cleaning induces a frustration, as noted in discussions with farmers and reported by the quote below. As a result, farmers at the tail of the canal hardly receive water.

> *I always participate to the canal cleaning because I think that we shall all contribute to improve the irrigation water delivery. I feel disappointed that our leaders who should lead by example do not worry for this task. It is frustrating!* (Farmer from Koussin-Lélé, field interview, November 2011)

The regular farmers (80% of the members of the Association) clean the canals twice a year according to the rules. However, they deliberately take more time than the one-day set for cleaning a specific segment, taking two or three days instead reportedly due to frustration with the way privileged farmers escape their responsibilities. They clean less well than they are supposed to do. Grass and silt remain in the canal.

Sanctions are effectively administered to defaulting regular farmers. A farmers' group that was assigned to harvest in the *Yovoglé*[*] did not perform the job as requested, and the whole group had to pay a fine of 20,000 F cfa. It seems that regular farmers participate in canal cleaning mainly to escape sanctions.

In Bamè for the first year (in 2008), the PUASA programme provided money for cleaning the canals. The following year (2009), only eight farmers participated in cleaning now that funding was no longer available. Since the end of 2010 when AfricaRice started to conduct agronomic experiments in the command area, the farmers have managed to off-load primary canal maintenance onto AfricaRice. AfricaRice maintained the irrigation canal in order to guarantee an efficient water delivery in the experimental plots. The stretch of the canal that is not supported by AfricaRice has not been cleaned for the last two seasons. Respondents indicate that the lack of maintenance is related to alleged fraudulent behaviour and corruption in relation with the *chef du village*:

> *Things are not going well in this group because of the deceitful behaviour of our leaders. For example, last year AfricaRice gave the rice harvested in the experimental plots to the community. Normally we should all share it, but it is the chef du village who sold all the harvest and kept the money. He promised to share it with us, but till now none of us received anything from him. With such a practice, if there is a group work they ask for our contribution, but when it is time to share the outcome, we are excluded*. (Farmer from Bamè, field interview, August 2011).

Interestingly, the leaders do not consider as unfair to their non-participation in the collective canal maintenance. As noted in the following quote, they purposely chose not to participate in the canal cleaning because of their responsibility in the community.

> *If I could use the time I spent in on the behalf of the association for attending meetings and arranging facilities for the members, in my own fields, I would have produced three times what I harvest this season from my rice plots. It is a lot responsibility for being a leader. For me it is a sacrifice. Some of the other members of the association do not see the hard work I accomplish each day in their name, and they required from me to always participate in the canal cleaning.* (A leader from Bamè, field interview, August 2011).

In Zonmon, only some farmers contribute to canal cleaning. Here the PUASA programme paid for the maintenance costs of the irrigation canals when farmers resumed rice production in 2009. In 2010, six of the 21 farmers had cleaned all the canals by themselves. For the following season, a farmer who also uses the irrigation water for his fish nursery paid labourers to clean all the canals, as reported in this following quote:

> *Last year I paid labourers to clean all the canals. None of other farmers contributed. I am struggling to let our village be known as a rice producing area because if we produce more, we can get many facilities such as agricultural equipment. Here we do not have any material and we are obliged to do everything by hand. I hope that with time, the other farmers will understand and more farmers will be involved in rice production* (Farmer from Zonmon, field interview, November 2011).

[*] A collective land farmed for the account of Chinese experts who assist the farmers in the maintenance of machinery. All the farmers worked in this collective farm in rotation.

Payment of fees for irrigation infrastructure maintenance

According to the individual interviews all farmers managed to pay the fee in Koussin-Lélé. The registers kept by the Association confirmed this. However, in Bamè not all farmers paid the fee and 40% of respondents expressed their frustration about this during in-depth interviews:

> *Many farmers did not pay the fee last year. Because they are cultivating large plots now, they disagreed with the rules because they know they have to pay a large fee. I cultivated 5 plots and I paid 5,000 F cfa, but those who have 50 plots should pay 50,000 F cfa. They found that too much, so they did not pay any fee to the group. The leaders who have to collect these fees and control the payments do not pay either* (Farmer from Bamè, field interview, August 2011).

In Koussin-Lélé Association leaders use the fees for the restoration of the canal lining and broken irrigation gates, as well as for the maintenance of collective equipment in readiness for the new season. The Bamè Association supports only the maintenance of a rice mill. When minor restoration is needed for the cultivator, farmers individually fix it so that they can plough their fields in time. In Zonmon, farmers do not pay any fees; maintenance of machinery is not an issue because farmers do not own any collective equipment. They till their fields using hand hoes and collaborate with farmers from Koussin-Lélé and Bamè to process the harvest. These differences are summarised in Table 3.3).

Table 3.3: Overview of farmers' participation in cooperative maintenance

	Koussin-Lélé	**Bamè**	**Zonmon**
Maintenance of irrigation canals	Moderate participation	No participation	Poor participation
Payment of fees	Large participation	Poor participation	No participation

Note: This table shows the relative extent to which farmers participate in canal cleaning and payment of fee in the three areas. It is not drawn on the basis of any statistical information

3.5 Analysis and discussion

Figure 3.4 pulls together the findings, focusing on incentives and dis-incentives for individual farmers to engage in cooperative behaviour. These are further discussed below.

3.5.1 The significance of the wider socio-economic context

It appears that, in addition to resource and group characteristics, and institutional arrangements, a fourth factor influences cooperative behaviour. It includes variables related to the wider socio-economic context, for example, the 50% increase in the retail prices of rice since 2008, and the extent to which people have alternative livelihood options or access to irrigable upland or money to buy pumps, that allow them to avoid working in collective production arrangements. Clearly, farmers' dependency on rice production as the primary source of income affects their contribution to canal maintenance. In Zonmon, rice production is relatively recent and not the main source of income, hence farmers there have little motivation to participate in group activities. This contrasts with Koussin-Lélé where rice has become the main income source. In Bamè, farmers have the opportunity to individually produce rice in the uplands of their valley and 60% of them have moved away from the collective lowland command area. These findings confirm earlier analysis of the conditions of collective action in the case of irrigation water management (Fujiie et al., 2005).

3.5.2 The limited relevance of group-size and diversity

We saw earlier that several scholars support the hypothesis that cooperative action is more difficult to organise in larger groups. Our study in Southern Benin found that the group of more than 200 farmers in Koussin-Lélé has a more effective water management system than Bamè with only 20. In Zonmon where 21 farmers regularly produce rice, canal cleaning is not performed well and not all farmers contribute. These findings concur with Gautam's (2007) conclusion that a clear relationship not always exists between engaging in cooperative behaviour and group size. They however, contrast with the findings of Fujiie et al. (2005) who explain that cooperation is difficult to engage where the size of the association is large.

An unexpected pattern was also observed with respect to diversity of the group. It is commonly assumed that people from heterogeneous communities are less likely to cooperate (Olson, 1965; Dayton-Johnson and Bardhan, 2002; Fujiie et al., 2005). Although the groups in the three areas are ethnically quite homogeneous, differences in social status that lead to inequitable access to land and other resources hinder the readiness of individuals to cooperate. In addition, the privileges of leaders, village chiefs and other elites are a clear source of frustration. While this kind of diversity indeed seems to undermine cooperation, we see that another form of diversity actually seems to be conducive. Despite the fact that Koussin-Lélé includes farmers from different villages, we see that the degree of farmer organisation and discipline are strong in this irrigation area, resulting in relatively high levels of cooperation. A possible explanation is that the very fact that the Koussin-Lélé farmers hail from different villages creates an urgent need for organisation and institution building. Bamè and Zonmon can and do fall back on their traditional *Chef du Village* and other governance structures, which are less suited to the collective discipline required for irrigation self-management. In Koussin-Lélé it is perhaps more difficult for traditional leaders to abuse or circumvent the rules. Put differently: when the command area overlaps with community boundaries it may be more difficult to set up parallel structures and bypass or correct the conventional leadership. In Koussin-Lélé decisions are not made by the traditional chiefs (as is the case in Bamè) but by the group committees and the Association board.

3.5.3 The significance of rules and sanctioning

Institutional arrangements and especially rules and their enforcement have considerable influence on readiness to engage in cooperative behaviour (Sandler, 2004; Ostrom, 2004).

In Koussin-Lélé, because of the rules and their enforcement, the regular farmers do clean canals at the established periods, even if they do not keep to the prescribed length of canal or honour the intention to clean it well to show their frustration with the privileged farmers who escape their duties. They clean to escape sanctions. As mentioned, Koussin-Lélé is not a traditional village like Bamè and Zonmon, but a production area with farmers from different communities. It has a relatively strong organisation with such effective leadership that it can and does enforce the sanctions. The decentralisation of control and decision making to groups seem to contribute to the fact that rules are followed. Nevertheless, also in Koussin-Lélé we see that traditional leaders get away with violating the rules and that the rules do not sufficiently compensate the power of traditional norms and values (Arowolo, 2010).

The privileges of traditional chiefs, landowners and farmer leaders contrast with the legal transparency and shared compliance expected by the extension workers who helped setting the rules for canal cleaning. In *Mahi* culture, the traditional chiefs are the guardians of ancestral beliefs and rituals. They cannot be punished as regular farmers even though they do not follow the rules. Their traditional responsibilities prevent them from being sanctioned. According to respondents, an example is an *Adjina*, the leader of a secret society, who was not punished even though he did not participate in canal maintenance because of his informal power in the community. In the collective understanding of those who belong to the secret society, it is normal that the *Adjina* was not sanctioned, but it frustrated farmers who do not. Thus, there is a conflict between the rules set by extension workers and the traditions that co-

exist in the irrigation schemes. The embedded traditional norms and values were neglected when the extension workers formulated the rules for canal cleaning (Vodouhè, 1996). While it is often suggested that traditional and formal rules can facilitate the implementation of good resource management decisions (Kwesi, 2007), this study shows that such institutions are not a panacea. However, institutions especially rules and their enforcement have considerable influence on effective cooperation and the institutional arrangements cannot be made without a combination of both formal and socio-cultural capital in which the communities are embedded (Cleaver, 2002). The question now is how to achieve a proper '*bricolage*' (integration of traditional and formal institutional arrangements) for stimulating cooperation.

3.5.4 The resource system: abundance and under-utilization

The study showed that farmers in the three areas are not equally affected by lack of irrigation water. In Bamè, the overall abundance of irrigation water in the command area explains why farmers are hardly motivated to perform canal cleaning. Collective canal cleaning is seen as wasted efforts because receive enough water to cover their needs. The farmers' cooperative behaviour in Bamè confirms the earlier assumption of Araral (2009) according to which, the scarcity of a common pool resource creates a positive incentive for cooperation. In the other two areas, water shortage is indeed a serious issue for the farmers whose plots are further away from the water source.

In all three areas we see that limited cooperation in canal cleaning reinforces underutilization of the irrigation potential and hence negatively affects the total production by the schemes (see Table 3.4). Valley bottoms remain under-used. Improved cooperation will provide additional opportunities for growing rice and other crops.

In sum, our case study on the factors that explain why rice farmers fail to cooperate in cleaning canals revealed that factors influencing farmers' cooperation choice differ in several aspects in the three areas. In Koussin-Lélé, farmers are more compelled to contribute to canals cleaning in comparison with Bamè and Zonmon, because (1) the rice crop is one of the main income sources for farmers' household; (2) there are seemingly strong rules that are partially maintained to force association members to cooperate and (3) farmers are more affected by water scarcity because of the intensification of rice production in this area. These factors explain why farmers from Koussin-Lélé contribute the most to canal cleaning. This is however, still not very effective from the perspective of some farmers and the potential for rice production in this inland valley. The privilege of elites is a source of frustration that affects farmer readiness to contribute fully to canal cleaning. In Zonmon, farmers hardly contribute mainly, because (1) rice production is a relatively recent activity and not a major income source; and (2) there is no clear regulation in place to organise the cleaning task. In Bamè as well, farmers fail to clean the canals because there is enough irrigation water to cover the water demand in rice farming in the lowland area, especially since a number of farmers have moved away from these lowland areas and started rice production in the uplands.

Table 3.4: Potential for irrigation in the three areas

Command area	Total area developed for rice cultivation by the Chinese (ha)	Total area used for rice production in 2011 in the lowland (ha)	Total area devoted to other crops in the command area developed by the Chinese (ha)	Percentage of irrigable land not used
Bamè	33	4.5*	8	62%
Zonmon	88	8**	18	70%
Koussin-Lélé	106	150		Farmers have access to 200 ha suitable for rice production that are not being cultivated

Note: * Originally 33 ha were irrigated, including 18 with pumped groundwater and 15 irrigated by gravity system. Since the pump that irrigated the 18 ha broke, this area is no longer used and of the 15 ha under gravity irrigation, nowadays the farmers cultivate rice on 4.5 ha, sugar cane on 3 ha, and maize on 5 ha.

** 88 were irrigated, but currently farmers used 8 ha to produce rice and almost 18 ha for mainly maize and vegetable; the remaining 62 ha are lying idle because the primary canals are severely deteriorated over time, and there is no functioning irrigation facility on these areas.

3.5.5 Policy implication

The research identifies the conditions in the three areas that create positive or negative incentives for the farmers' contribution to collective canal maintenance. In this section, we discuss policy interventions that could facilitate and strengthen cooperation for effective maintenance of the irrigation infrastructure.

Overall, the limited cooperation depends on the dis-incentive factors synthesised in Figure 3.4. Several of the incentives/dis-incentives were influenced by the rapid transfer of the maintenance responsibility to the farmer associations, without sufficient support to ensure that they could adequately execute the maintenance tasks. The farmer associations could have been effective in enforcing rules, if they had been trained about building their organising capacities, in the earlier stages of the transfer. A gradual implementation of the maintenance reforms could have helped to induce sustainability in the re-organisation. That could allow farmers to gradually take over their new maintenance responsibilities (Mehmood, et al., 1999). A gradual implementation of the reform could have created spaces for the farmers to negotiate their management responsibility with the public actors and also to learn from other associations' success stories. It can contribute to improve their cooperation and maintenance practices.

The study shows that when the importance of rice production is higher and the farmers' incomes increase, they are motivated to participate in the collective maintenance of the canals. Thus, by creating enabling conditions such as market outlet incentive, low interest loan facilities, state agencies could enhance the cooperation among the farmers, in the research areas.

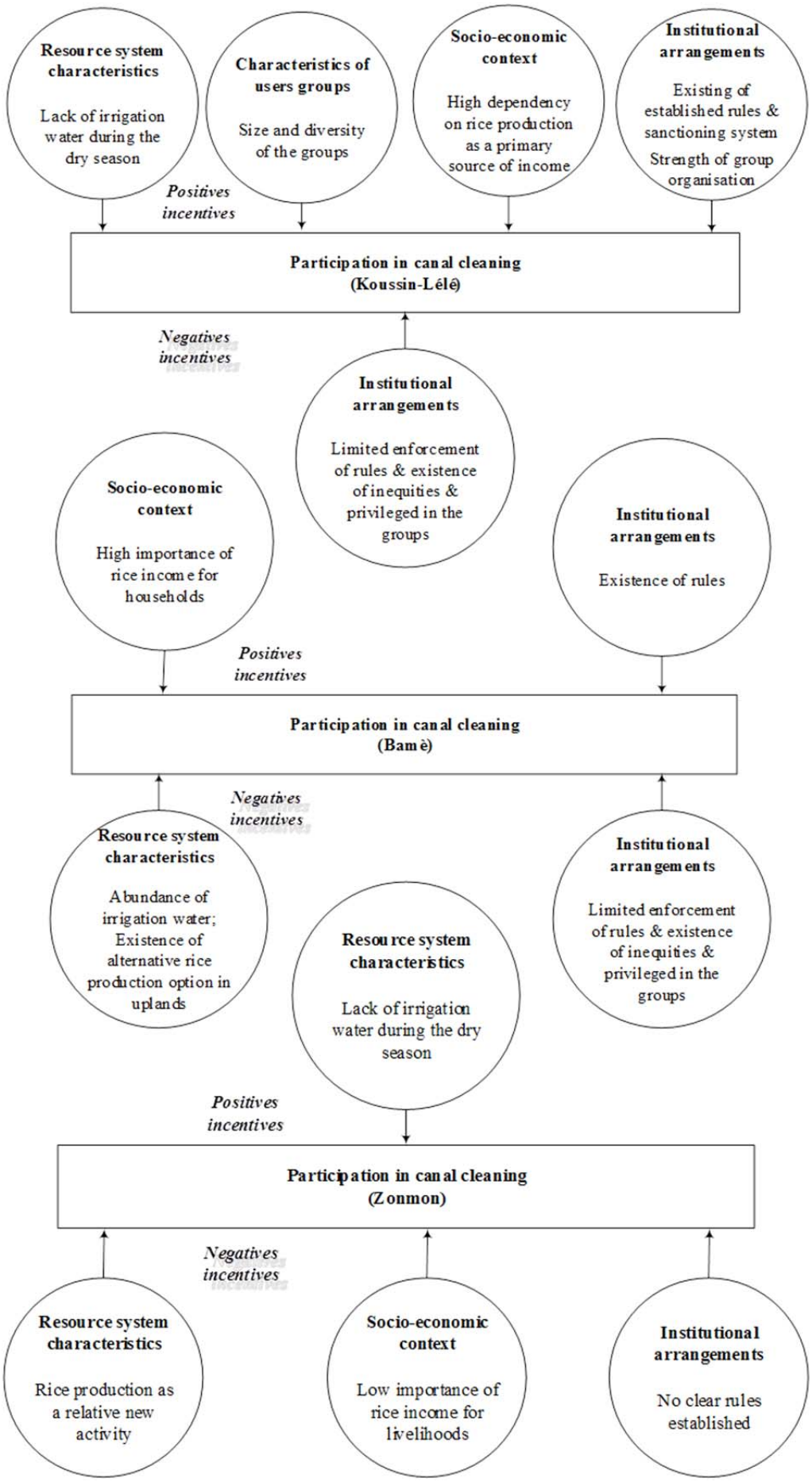

Figure 3.4: Synthesis of incentives affecting farmers' canal cleaning practices and payment of fees

3.6 Conclusion

This article shows that the extent to which farmers choose to cooperate in the face of a public good dilemma depends on a number of factors that appear to differ significantly across three communities, although they are located close to each other in what at first sight- are seemingly similar environment. These factors include resource system characteristics (e.g., water availability), characteristics of user groups (e.g., size, diversity and past experience), institutional arrangements (e.g., existence of rules and organisational capacity to sanction) and wider socio-economic conditions (e.g., dependence on rice production and access to alternative production areas). The case studies suggest that these factors are not independent from one another. The availability of alternative production areas and relative abundance of water clearly influence the intensity of use of lowland areas. Similarly, and contrary to our initial expectation, a relatively large and diverse group size may support the emergence of relatively strong organisation, institution building and sanctioning capacity. The study confirms that institutions play an important role in explaining the productivity of smallholder farming (van Huis et al, 2007; Hounkonnou et al., 2012). The existence of rules to regulate the maintenance of irrigation infrastructure and their effective enforcement are key drivers for cooperative behaviour. Institutions can create incentives (negative/positive) that (de) motivate individual farmers to contribute to the collective maintenance of irrigation infrastructure. In Bamè and Zonmon, the limited degree of cooperation is at least partially linked to a lack of rules and/or rule enforcement. Especially in Zonmon, since the maintenance of canal is totally voluntary, many farmers who would have contributed, are not doing so because there is no sanctioning rules for non-participants. In Koussin-Lélé, reasonably effective enforcement of rules contributes to the fact that most farmers in this area participate in the canal cleaning. However, the rules for maintenance of the irrigation infrastructure are counteracted by incentives provided by other institutions, namely the social status and privileges that allow elites to free-ride and evade sanctions. Thus, we see that institutional arrangements can contradict and compete with each other, and that there continues to be tension between 'formal institutions established by the extension workers and the traditional values of the communities.

This study shows that the lack of cooperation affects rice productivity. In the three irrigation schemes, the actual rice output remains far below the estimated potential of the command areas, given the water and land available in inland valleys. There is scope for a considerable increase in rice production and associated incomes by re-designing and re-negotiating the institutional arrangements and integrate the best of both traditional and formal rules to govern the utilization of inland valleys. Further research might be relevant to explore and compare the institutional '*bricolage'* in place in other irrigation areas and to what extent they are effective in facilitating and enhancing cooperation among the water users.

Chapter 4

Mulching upland rice for efficient water management: a collaborative approach in Benin

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Mulching upland rice for efficient water management: a collaborative approach in Benin

Abstract

Since the 2007 food crisis, the Government of Benin has created enabling conditions that urge small scale farmers to intensify rice production in inland valleys. Unsuitable irrigation infrastructures and lack of willingness to act collectively has led farmers to complain about water shortage. Adoption of mitigating technologies offered by government (extension) and scientists (e.g., Benin Agricultural Research Institute, AfricaRice) has been low due to the institutional context within which farmers are working. A socio-technical approach which combines technical and institutional dimensions was used to identify and test mulching as a potential method for improving irrigation water efficiency in growing rice in upland parts of Benin's inland valleys. Rice farmers (from three production areas), an extension agent and a researcher formed a multi-stakeholder platform and collaborated to test the application of mulch (three doses) and the use of a lowland rice variety in replacement of an upland rice variety during two growing seasons. Multiple methods derived from researchers and farmers' perspectives were used to evaluate trial results: quantitative scientific evidence was combined with qualitative evaluation using indicators agreed upon by the collaborative group. Results show that the lowland rice variety IR-841 with 10 Mg ha^{-1} 'rice-straw' mulch allows farmers to better use available water in the upland areas and increase yields. Although the preference for IR-841 over the special bred upland variety Nerica-4 is risky because of its high water demand and the uncertainty in rainfall, farmers use IR-841 for profit maximisation. Beyond its technical output, the joint experimentation facilitated the interaction of knowledge, experiences and practices among the involved actors.

Keywords: Irrigation, rice, learning, action research, innovation.

4.1 Introduction

4.1.1 Context

Rice plays a critical role in contributing to food security, income generation, poverty alleviation and socioeconomic growth in many African countries (Fagade, 2000). In most of these countries, rice supply cannot keep up with demand. In Benin the rice self-sufficiency rate is about 53%, resulting in the need for annual imports to meet the growing rice demand (MAEP, 2010). Given the large amount of rice Benin currently buys on the international market (e.g., 522,772 metric tons were imported in 2010); an increase in local rice supply is of great relevance for increasing food security.

Following the apparent success of the Green Revolution in Asia (Issaka et al., 2008), the Government of Benin (GoB), supported by Chinese funded projects, made major investments in irrigation systems to increase domestic rice production. In 1976, nearly 2,250 ha of irrigation schemes were built in inland valleys (Sodjinou et al., 2008). Inland valleys have specific characteristics that offer high potential for rice production (Abe et al., 2009) one of which is that they can be divided into a lowland part (where gravity irrigation is practised), and an upland part where farmers can grow either rainfed upland rice or apply irrigation (using pumped water) (Figure 4.1). In the latter case farmers can select between an upland rice variety (usually with a short growing cycle, e.g., Nerica-4) and a lowland variety (usually with a longer growth period, e.g., IR-841).

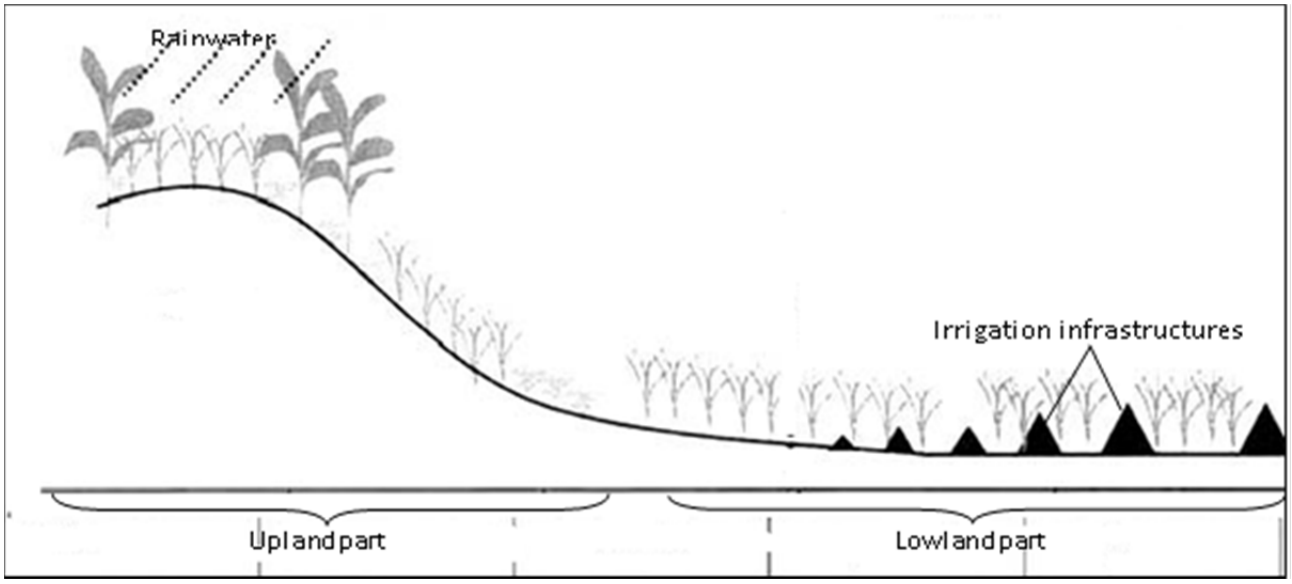

Figure 4.1: Schematic topography of inland valleys in Benin

The irrigation schemes were designed in the 1970's for one rice crop season (the most favourable season) and the central authority was responsible for maintenance and repair. Eventually, due to structural adjustment politics and termination of Chinese projects, maintenance was handed over to local farmers. Since these farmers were not organised to handle this, the maintenance levels quickly dropped, the infrastructure deteriorated over time and the schemes were abandoned.

Benin's dependence on rice imports has attained a critical monetary level following the global food crisis of 2007-2008 (*Direction Générale des Prévisions et des Statistiques Agricoles* [DGPSA], 2008; De Schutter, 2009). In response, the GoB, national and international research institutes and NGOs have intervened with the objective of improving the production of local rice. Their propositions included multiple cropping (up to 3 crops a year) and a higher use of inputs like fertilizer and water. Indeed, since 2008, local rice production has increased (from 73 853 metric tons in 2008 to 167 000 tons in 2011) because of improved input facilities (seed, fertiliser, etc.) made available to farmers through a range of programmes set up after the food crisis (PUASA, Nerica Project, PAPI, PASR, etc.). Additional technologies and techniques with potential for further increase rice production have also been developed and offered by the government and the scientific community. An attractive price is offered to farmers and a public company is charged to buy all the rice harvest to provide material for the industrial mill that the government promoted. The projects also introduce facilities for the rice farmers to have access to credit.

Although rice production has increased, the adoption of technologies offered by government (extension agents) and scientists (e.g., Benin Agricultural Research Institute, AfricaRice) has remained low; it means that the full potential for yield increases has not been realised. Totin et al. (2012) diagnosed several constraints that inhibit farmers from further intensification. The major issues were shortage of water and lack of collective maintenance of the irrigation infrastructure. Traditionally, farmers only cultivated once a year, in the most favourable season (season 1), which probably explains why they did not mention water scarcity during interviews conducted in an earlier study (Djagba, 2006). As a result of input intensification, which has extended the potential to grow rice across all three seasons, rice farmers nowadays complain about a lack of irrigation water. Finding ways to address these constraints has the potential to increase adoption of new technologies that can enable further advances in local rice production.

Even before considering the water scarcity and infrastructure maintenance issues, it is important to realise that one of the reasons for the stagnating production is the fact that not all inland valleys are suitable to grow three crops a year. This is illustrated in Table 4.1 for three irrigation schemes of different inland valleys: Koussin-Lélé (106 ha), Bamé (33 ha), and Zonmon (88 ha). All farmers grow rice in the lowland part of their valleys. Whether they also use the upland part depends on the water level in the river and on the rainfall pattern. Season 1 is traditionally the main growing season. There is little rain (plenty of sunshine; few diseases) and enough water in the river from the preceding wet season. Therefore farmers in all valleys can grow rice in the lowland sections in this season. In the second season, the water level in the river drops and problems begin to arise with the availability of irrigation water. During this season only 32% of the farmers in Koussin-Lélé are able to cultivate rice in the lowlands, there is no rice cropping at all in Zonmon, but in Bamè there are no problems because there is enough irrigation water to cover the water demand in rice farming in the lowland area, especially since a number of farmers have moved away from these lowland areas and started rice production in the uplands (Totin et al*.,* 2012). The third season is the rainy season. This causes flooding in 100% of the lowland parts of the valleys in Koussin-Lélé and Zonmon and 75% in Bamè. Thus no crop can be grown in the lowlands during this season. However, the abundant rain permits rainfed rice production in the upland parts of Koussin-Lélé and Bamè valleys. In these three inlands valleys, there are large differences in the way farmers are dealing with the water scarcity.

The 'water scarcity' paradigm needs careful definition because there are two sources of water: the river and the rain. Hence, we distinguish between two types of water scarcity: meteorological and technical. The first occurs when rainfall is much less than the mean or when the timing of a season shifts; there is some evidence of longer term shifts beginning to occur under climate change that adds additional uncertainty to the normal variability (Nyakudya and Stroosnijder, 2011). Reduced rainfall results in less water in the river for gravity irrigation, and less water for the rainfed crop as well. Technical water scarcity occurs when there are technical failures in the irrigation infrastructure, such as when the water intake is at too high a level, or the collapse of a canal bank. In addition, mis-timed or inadequate canal cleaning can cause serious shortages of water in the fields that are at the highest elevation within the command area. Another technical form of water scarcity occurs when there is insufficient water that can be pumped into the upland part of the inland valley.

The diagnostic study conducted in the three inland valleys mentioned in Table 4.1 established that production could be improved for the upland areas if there were a better control of the irrigation water. According to the farmers, several options exist which could help to improve soil moisture in the upland part of their valleys. The farmers' ideas have inspired this study.

Table 4.1: Rice cropping seasons with corresponding water resources in three inland valleys of Benin

Season	Months	River Water	Rain Water	Koussin-Lélé lowland	Koussin-Lélé upland	Bamè lowland	Bamè upland	Zonmon lowland	Zonmon upland
1	October-February	Medium	Relatively dry	100% Irrigated	-	100% Irrigated	-	100% Irrigated	-
2	March-June	Low	Medium	32% Irrigated	-	100% Irrigated	50% Rainfed	-	-
3	July-September	High	Peak	100% Flooded	22% Rainfed	75% Flooded	100% Rainfed	100% Flooded	-

4.1.2 Theoretical framework

In the last two decades, numerous studies have been conducted to explain why some technologies developed by researchers do not spread at all (Chambers, 1994; Pimbert, 1994; Douthwaite et al., 2001) and how the small farmers' use of agricultural technologies can be improved (World-Bank, 2007). Scientists are now aware that despite the effort that is spent on research and development activities, only a few of the technologies developed are used and consequently, rural poverty remains an intractable problem in many places (Douthwaite et al., 2002; Lundy et al., 2005, Hounkonnou et al., 2012). Among the many causes of this situation is the limited cooperation between researchers and the farmers (Walters and Holling, 1990; Doubwaite et al., 2002).

Since the late 1960s, "science" had been considered as the preserve of educated elites working in research stations, overlooking the capacity of farmers to innovate (McCown, 2001; Dormon et al., 2007; Waters-Bayer and Wolfgang, 2009). The linear thinking assumes that researchers and experts produce information materials for the transfer of knowledge to farmers through the extension system (Gibbons et al., 1994). This mode of thinking draws a straight and one-directional line between science and practice and a clear task division: researchers are supposed to generate the knowledge; extension workers concentrate on their transfer, while the farmers' role is merely to apply them. It seems from this perspective that researchers learn enough about farmers' needs and conditions. They then embed this knowledge in a technology and provide operating instructions that are sufficiently 'finished' to require little or no subsequent local adaptation (Rogers and Jiggins, 1987; Douthwaite et al., 2001). However, it is common to see farmers putting 'finished' innovations into practices by embedding their own knowledge in them. Illustratively, cotton farmers in Benin were found to adapt the recommended bollworm control options by mixing half the dose of the recommended synthetic pesticides with locally available botanicals to suit their socioeconomic conditions (Sinzogan et al., 2004). The linear thinking approach has been extensively criticised (Röling, 1988; Lundy et al., 2005; Klerkx et al, 2010; Kilelu et al, 2011).

Currently, the dominant linear model of innovation has been replaced by other bodies of thought to better understand rural complex development phenomena (Nyikahadzoi et al., 2012; Leeuwis and Aarts, 2011; van Mierlo, 2010a). Farmers, extension workers and researchers are recognised as elements of an agricultural information system which have to collaborate to achieve large impacts (Röling, 1988). In line with this new thinking, several participative approaches have been suggested to enhance the cooperation between end users and scientists, so that they can learn from each other (Gerber, 1992; Röling et al., 2004; Leeuwis, 2004). Collaboration of actors from different backgrounds provides a viable research model which emphasises on reciprocity, relationships, learning and creativity (Fish et al., 2010). Nyikahadzoi et al. (2012); Adjei-Nsiah et al. (2008) all recommend the multi stakeholder platform as a mean to strengthen social interaction and learning.

Ashby and Pretty (2006) show that when the participatory approaches are well applied, they are able to make considerable impact locally. However, Röling et al. (2004) explained that, although the participation technologies development is used in the agricultural sector, the impact of research has been limited because of the neglect of the institutional dimension. In other words, small farmers can make an effective use of technologies, unless the institutional context changes (Hounkonnou et al., 2012).

Our hypothesis is that working both on technical and institutional issues can facilitate the effective use of irrigation water in the rice plots. We are aware that irrigation water management is not only a technical issue. Then, the idea is not only to work on the technical aspect of effective water use in rice farming through a participatory technology development, but we also build on the institutional context to enlarge farmers' opportunities. In that perspective, an earlier study had identified some institutional barriers that hinder the efficient use of the irrigation water in rice farming. They are related to lack of collective action (e.g., canal cleaning, in the lowlands; collective use of equipments in the uplands) and power relations among the farmers (Totin et al., 2012). It is not the purpose here to address these

institutional barriers. We focus in this paper on the participatory water management experiment in collaboration with farmers and an extension agent. However, beyond the technical value of the joint experiment ground on both the scientific and endogenous perspectives, it aims to provide evidence for farmers that much can be gained by working together. This is the main difference between the participatory technologie development as commonly used and the pathway we follow in this study. Essential to the approach used is that the design of the technical field experiment, its implementation and evaluation of results are done through collaboration between farmers, extension agents and researchers. Our approach was guided by the following research questions: (1) what water management option would the farmers select and want to test? (2) What experimental set-up would come out of the collaborative discussion? (3) What evaluation criteria would be developed and accepted by the stakeholders involved in the collaboration? (4) What were the results of the tested water management option? (5) How were these results perceived by the different stakeholders? (6) What lessons were learnt from this research method?

4.2 Material and methods

4.2.1 Selection of the water management option to be tested

We invited all the rice farmers from three inland valleys (Koussin-Lélé, Bamè, and Zonmon) and local extension agents to a meeting in order to reflect on practical techniques which, in their experiences, increase water use efficiency in rice plots. These valleys are located near Covè in South Benin, Figure 4.2.

In total, 25 rice farmers (3 from Koussin-Lélé; 15 farmers from Bamè and 7 from Zonmon) and one extension agent attended this meeting; a summary of the findings is presented in Table 4.2.

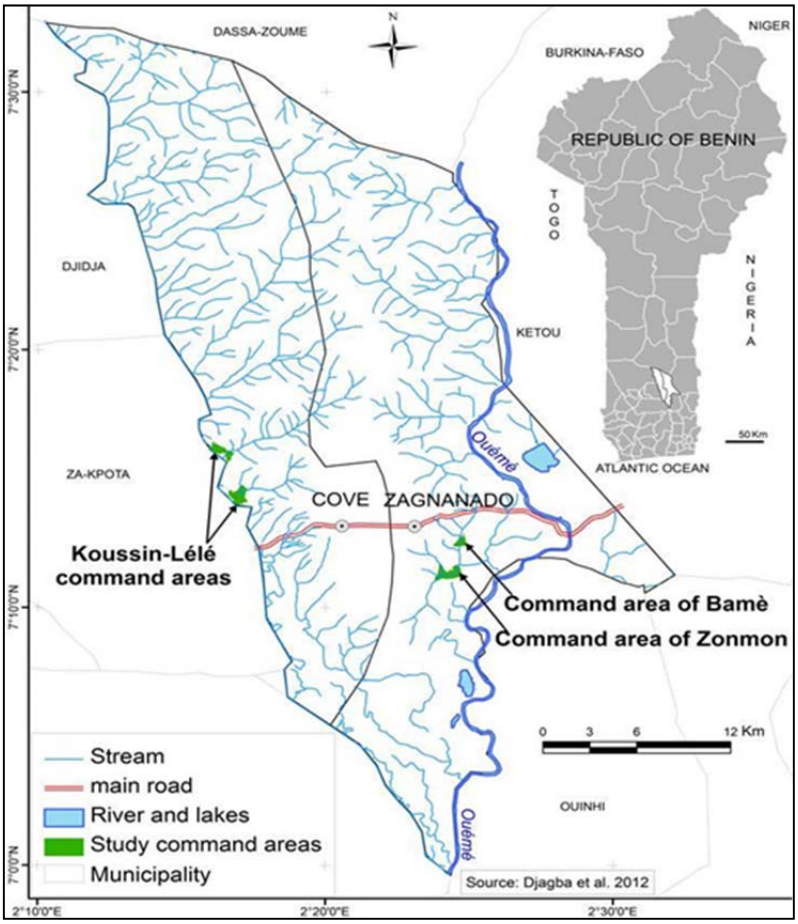

Figure 4.2: Map of Covè and Zagnanado districts showing the irrigation command areas (Source: Djagba, 2006)

Table 4.2: Water management activities in rice cultivation in three studied inland valleys in Benin

Koussin-Lélé	Bamè	Zonmon
Lowlands: - Irrigation scheduling - Use of mulch in early growth stage	***Lowlands:*** - Not transplanting rice all at the same time to regulate the water need - Production during the dry season because of abundant water ***Uplands:*** - Production during the wet season and use of pump to supply irrigation water during the dry season	***Lowlands:*** - Transplanting following the retreat of the water level after flooding. - Use of pumps to irrigate when needed

It can be seen that practices vary between the valleys. In Koussin-Lélé, 2 from 3 farmers located in the tail section of the command area apply mulch in their plots to the exposed soil surface at the early growth stage of the rice, in order to maintain the desired soil moisture level. In Bamè, in the face of land scarcity in the lowland part of the valley, some rice farmers use individual portable pumps connected to pipes to bring water from wells in the lowland to the upland. This technique was copied from the irrigation practices of vegetable farmers along the southwest Atlantic coast and adapted to local conditions (Atidégla et al., 2010). This practice has facilitated the use of groundwater as a supplemental water source, and enabled rice farmers to begin producing in the upland part of the valley, where there is more land available. It also allows farmers to produce rice all year round. However, the practice incurs considerable extra fixed and recurrent costs (pump, fuel and maintenance) and, in spite of its effectiveness, its use has not become widespread. Farmers are interested in cultural practices that save water. Bamè farmers have also been experimenting with different rice varieties. Farmers prefer to cultivate their upland plots with IR-841, a rice variety that is only recommended for use in the lowland. In Zonmon only the lowlands are used at this point, and the farmers start transplanting the rice nursery following the retreat of the water level after flooding. They use individual pumps when irrigation is needed.

After discussing various options for increasing water use efficiency, those who participated in this first meeting were invited to form, together with the facilitating researcher and an extension agent, a platform for collaborative learning and action research. In total, ten farmers (all men: 2 from Koussin-Lélé; 6 from Bamè and 2 from Zonmon) chose to join the platform. We present here what the group decided since it affects the set-up of the technical experiment presented in section 2.2. The group decided to explore the use of mulch in upland plots as a water saving option and also evaluate its effect on weeds in rice fields. The idea behind this joint experiment was to facilitate multi stakeholders learning process about an efficient water use option. If results are positive, mulching could enable the further expansion of rice production in the upland part of the valleys and strengthen cooperation among the farmers.

4.2.2 Experimental set-up

The field experiments were conducted by the multi stakeholder platform during the wet and dry periods from May 2011 to February 2012. The six farmers from Bamè, drawing attention to the land pressure in the lowland part of their valley (4.5 ha for nineteen rice farmers) and water scarcity in the upland part (as presented in Table 4.1), requested that the experiment be conducted in their area (in Bamè) where water scarcity is a critical issue. The other members of the platform agreed that this most problematic area would be a good experimental site. Further, the platform decided that the experiment should be in a location that all farmers could reach so that they could learn together and interact conveniently.

Table 4.3: Treatments in the research experiment. All plots with farmer's irrigation practice but with different rice variety and mulch dose (during two seasons in 2011-2012, Benin).

Treatments	Definition of treatments (Doses of mulch with rice varieties)
Ne-0	Nerica- 4 + 0 Mg ha^{-1} of mulch
IR-0	IR-841+ 0 Mg ha^{-1} of mulch
Ne-5	Nerica- 4 + 5 Mg ha^{-1} of mulch
IR-5	IR-841+ 5 Mg ha^{-1} of mulch
Ne-10	Nerica- 4 + 10 Mg ha^{-1} of mulch
IR-10	IR-841+ 10 Mg of mulch

The platform also identified materials for mulching. The first step in this process involved farmers and the extension agent deciding on criteria to ensure that the mulching material would fit the rice farmers' conditions. The key criteria were availability, ease of access, and the possible effects of application in rice plots. Because of the prevalence of rodents, the farmers decided that use of a *Vigna* substratum (Roy et al., 1988) might not be suitable in their context. The extension agent suggested the use of paddy husks (the main waste product of paddy hulling) as the mulch, but the transportation of this material, from the processing area to the rice plots, was assessed as being too demanding. A few years ago, one of the rice farmers from Bamè had received training on rice cultivation 'best practices' from a Belgian NGO (*Vredeseilanden*) involved in the promotion of the rice production chain in Benin. The trainer had recommended the use of the straw to fertilise the soil and to manage soil moisture. This farmer suggested that we test this material. Because the material is already available in the field after each harvest, its use would not demand additional transportation cost or effort. This suggestion was adopted by the platform. The platform further agreed to use three doses of mulch, 0; 5 and 10 Mg ha^{-1} with three replications (Table 4.3).

The researcher and the extension agent proposed the commonly used scientific design of a completely randomised block. Participants were briefed on the reasons why researchers considered it necessary to use this design. This proposal was accepted, so the trial was designed to consist of eighteen plots of 10 x 10 m^2 with 3 replicates.

In all three valleys involved in this research, IR-841 (a long-duration variety of 120 days) has become widely sown since 2008 because of its taste. Although the extension agents had recommended using the IR-841 variety in the lowland area only, Bamè farmers have chosen to sow it also in the upland area. The joint experiment gave an opportunity to validate their choice. The extension agent involved in the research, suggested including a rice variety that had been selected for upland area conditions (Nerica-4), so as to evaluate its performance (e.g., yield, water demand) against IR-841. Nerica-4, a short-duration, 90-day variety promoted by AfricaRice, the Benin Agricultural Research Institute and many NGOs, was selected for inclusion.

The platform also wanted to assess the effect of the mulch on weed control; specifically, to check the extent to which the additional cost of mulch application could be recovered from a reduction in weeding costs. For this reason platform members decided not to apply herbicide in the experimental plots, although the farmers usually apply *Herbextra 2,4-D sel d'amine* 720 g l^{-1} at the first weeding stage. Otherwise the platform followed farmers' regular practices, e.g., application of 150 kg ha^{-1} of NPKSB 14-23-14-5-1 mixed with half dose of urea (25 kg ha^{-1}) two weeks after transplanting; the other half dose of urea was applied during the flowering stage. In total, 27 kg of NPKSB 14-23-14-5-1 and 9 kg of urea were applied, meaning 7.92 kg of nitrogen used.

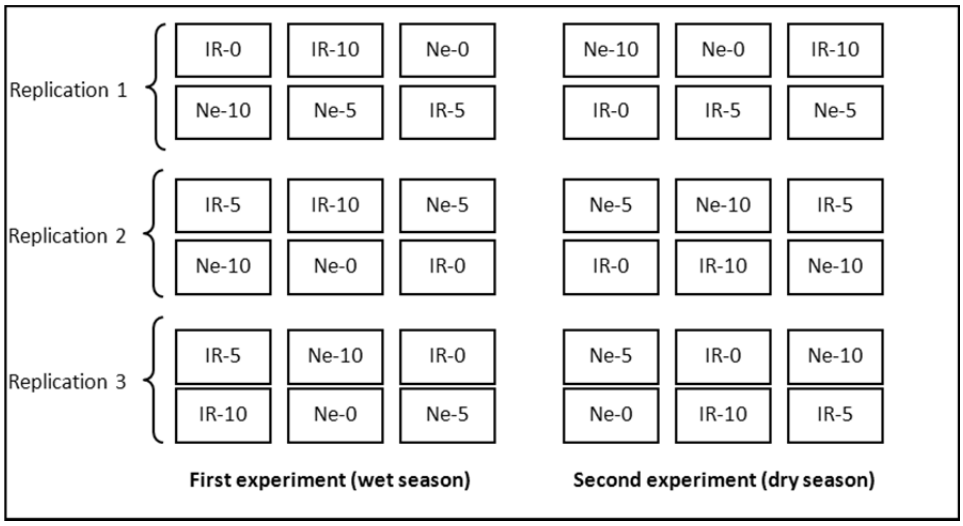

Figure 4.3: Experimental layout in Bamè, Benin during wet then dry seasons of 2011-2012. IR and Ne for IR-841 and Nerica-4 which are lowland and upland rice varieties, respectively. The number (0-5 r 10) corresponds to the quantity of mulch (rice straw) in Mg per ha.

The same dose of water was applied to the whole experimental area. The first irrigation was applied the day before transplanting and subsequent irrigations were applied according to the crop requirements depending upon the weather conditions. We used the same area for the two experimental periods. However, the treatments (dose of mulch + rice variety) were randomly selected for each period (Figure 4.3). The mulch applied during the first period was completely broken down and remnants were mixed with the soil before the second period.

4.2.3 Evaluation criteria

Through a series of meetings the platform discussed and negotiated not only the experimental design, but also the data collection, analysis and evaluation as well as the respective roles of the stakeholders. The findings of the mulch experiments were analysed from the perspectives of the different stakeholders involved. We supposed that people judge technologies partly by building on their own knowledge and experience, on the basis of the socio-economic, institutional and political environment in which they operate (Wynne, 1991; Waters-Bayer and Bayer, 2009). The members of each stakeholder category (rice farmers, extension agent and researcher) decided their own assessment criteria. Some criteria (e.g., yield, drought stress, and economic return) were common to all stakeholder categories. The researcher in addition collected data related to the weed biomass in each treatment.

Farmers chose a representative to record and report their regular observations made in the experimental plots in order to be able to judge the effectiveness of the options tested. At each platform meeting they shared their findings and concerns and discussed ways forward. The researcher and the extension agent determined more quantitative data.

Yield was measured with 5 quadrants (of 1 m^2) per plot in the direction of the two diagonals, in order to integrate as much as possible the variability in the plot. All the panicles of the rice plants were harvested in each quadrant. These were dried in the field for 2 days, as farmers themselves do, and then the grain yield was weighed for each quadrant and an estimate was made of the overall yield for each treatment. Weed samples were manually collected (hand weeding- twice, at 30 and 60 days after transplanting - DAT) in each quadrant. The fresh weed biomass was then oven dried at 70°C for 72 hours and the dry biomass recorded. The financial advantage of using mulch was assessed by comparing how much farmers earn from their usual practice compared to the return they could get when practicing mulching. Costs and benefits for both were derived from the responses to a household survey of all eleven rice farmers who grow rice in the upland area where the experiment was located.

Finally, we organised a field trip for rice farmers from each of the three communities who were not involved in the experiments, so they could visit the experimental field and also learn from this activity. The experiment was concluded by means of an assessment workshop that included 27 farmers from the three areas, four extension agents and a representative of AfricaRice. The participants were asked to review the evidence and judge the effectiveness of each tested option. They then discussed the extent to which the two logics (scientists' and farmers') contributed to an adapted water management practice appropriate to farmers' conditions.

4.3 Results

4.3.1 Effect of mulching on rice production

The results of the six treatments showed that the rice yield during the first experiment (the wet season) was higher than the yield of the second experiment (the dry season). For each rice variety, there was significant variation in the yields obtained with different doses of mulch ($p \leq 0.05$), except between Ne-0 and Ne-5 for the first period (Figure 4.4).

The differences in IR-841 yield between the two experiment periods were greater than the differences for Nerica-4. This suggests that IR-841 is more affected by the seasonal variation in moisture availability. In addition, the analysis showed that irrespective of the period and the rice variety used, the yields were significantly lower in the un-mulched plots ($p \leq 0.05$). In all treatments, the yields increased as the dose of mulch applied increased. The highest yield was obtained with IR-841 in the treatments that received 10 Mg ha^{-1} of mulch and the lowest with Nerica-4 in the un-mulched plots. Overall, the yield of IR-841 was higher than the yield of Nerica-4.

Figure 4.5 shows that weed infestation in the mulched Nerica plots was lower than in the un-mulched plots. The weed prevalence decreased as the dose of mulch increased. These differences were significant ($p<0.05$). The weed infestation in all IR-841 plots was quite low and there were no significant variations of the weed infestation in the IR-841 plots whatever the dose of mulch applied ($p>0.05$).

4.3.2 Effect of mulching on water variation in rice plots

In the first experimental period (wet season) the plots were irrigated once, just before transplanting the rice nursery. During the rest of this period, rain was the only source of water and was sufficient (Figure 4.6). Visual observation of the soil by the members of the platform indicated that the soil moisture in the top layer was higher in the mulched plots. For the second experiment there were no rains; the plots were irrigated each week. During the vegetative phase, there was no visual difference in the soil moisture for any of the 6 treatments. In the reproductive and ripening stages (with limited irrigation), soil moisture of the top layer was higher in the mulched plots than in the un-mulched plots.

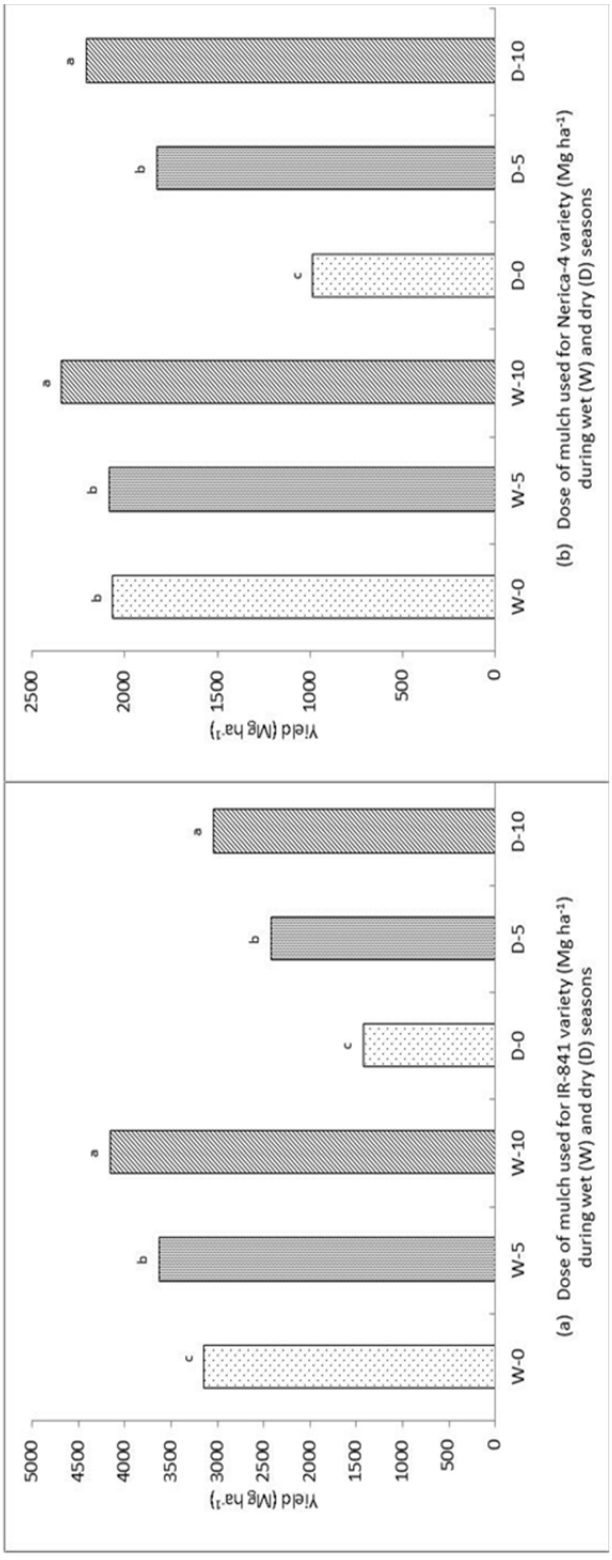

Figure 4.4: Paddy yields during wet and dry seasons for lowland and upland rice varieties with 0,5 and 10 Mg mulch ha^{-1}.

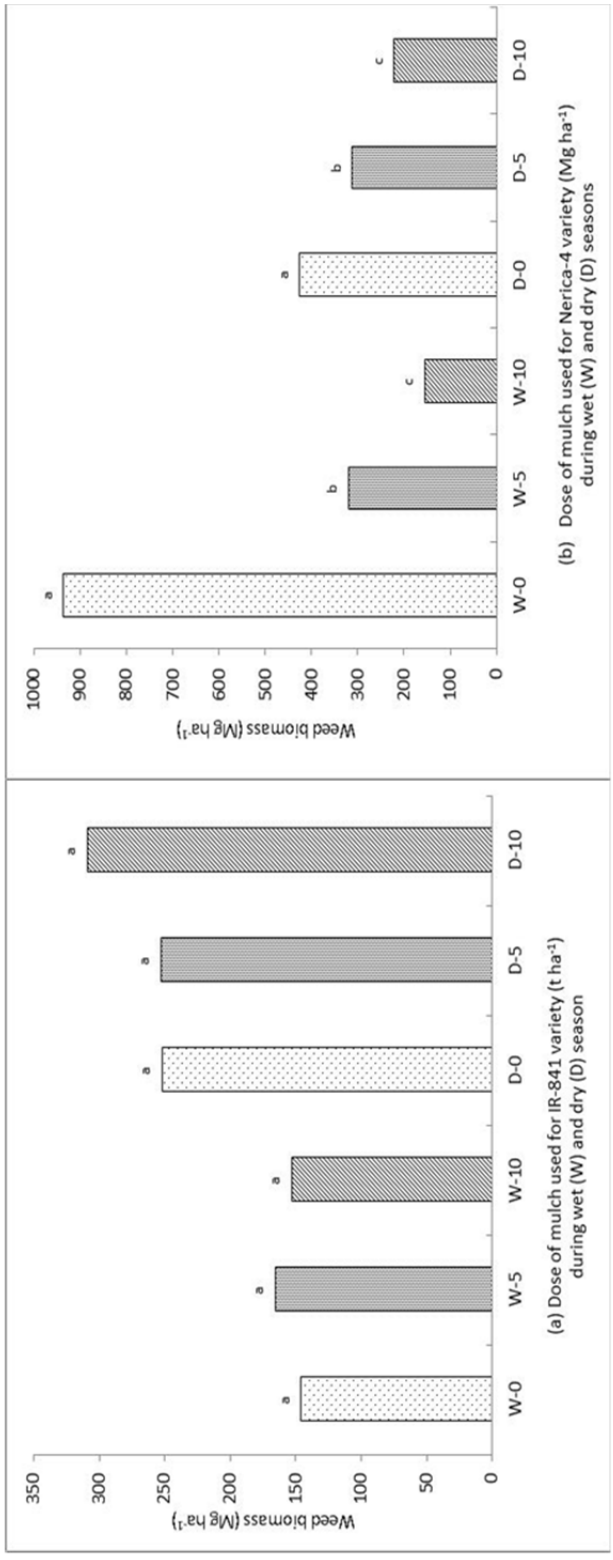

Figure 4.5: Weed biomass during wet and dry seasons for lowland and upland rice varieties with 0,5 and 10 Mg mulch ha^{-1}.

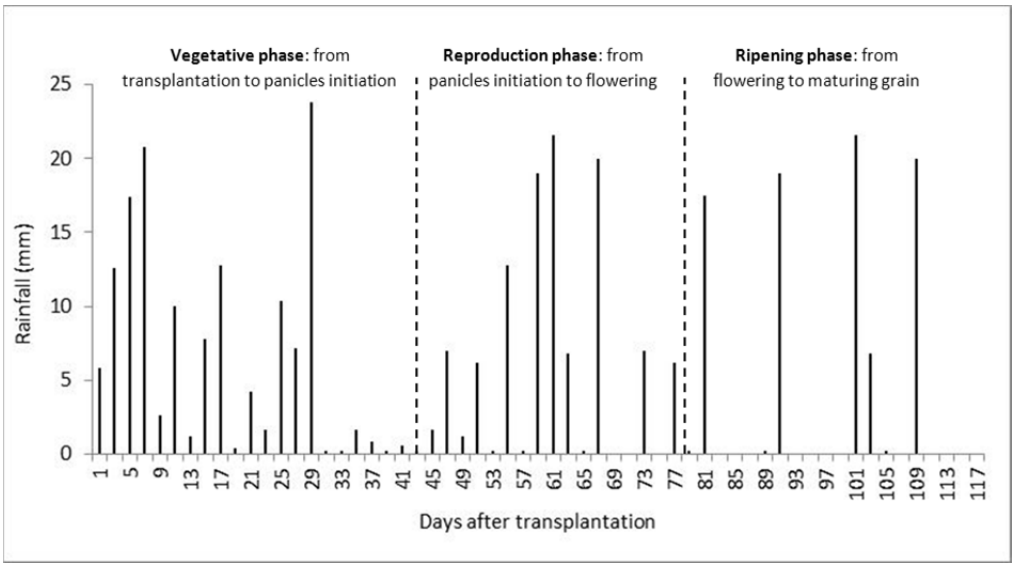

Figure 4.6: Rainfall distribution during the first experimental period (wet season)

4.3.3 Economic value of mulch in rice production

A comparative analysis of the estimated returns when applying mulch in the experimental plots for each of the two rice varieties indicated that the returns are generally higher for IR-841 (Table 4.4). This implies that, farmers can earn more by producing IR-841 with a dose of 10 Mg ha^{-1} of mulch (under Bamè agro-ecological conditions). Farmers could earn five-fold their current returns in the wet period, and seven-fold during the dry period, if they applied 10 Mg ha^{-1} of mulch in IR-841 plots. Although in the dry period the Nerica-4 returns were higher than the income generated for this variety during the wet period, overall Nerica-4 was shown to be not profitable for farmers under the ecological conditions of Bamè because of its low yields.

Table 4.4: Comparison of the average revenue per hectare from eleven farmers' fields with calculated revenue from mulch experiment (2011-2012 data).

	Farmers' fields		**Experimental field**			
	Wet	Dry	Ne-10 Wet	IR-10 Wet	Ne-10 Dry	IR-10 Dry
Inputs cost (€)	*116*	*106.9*	*103.9*	*103.9*	*103.9*	*103.9*
Seed	27.5	27.5	27.5	27.5	27.5	27.5
Fertilizer	76.5	76.4	76.4	76.4	76.4	76.4
Herbicide	12.0	3.0	0.0	0.0	0.0	0.0
Labour (€)	*394*	*335.9*	*458*	*458*	*412.2*	*412.2*
Field cleaning	45.8	30.5	45.8	45.8	30.5	30.5
Construction internal bunds	30.5	12.2	30.5	30.5	15.3	15.3
Land preparation	84.0	59.5	84.0	84.0	68.7	68.7
Mulching	0.00	0.00	61.1	61.1	61.1	61.1
Nursery transplantation	53.5	53.5	53.5	53.5	53.5	53.5
Weeding	18.3	18.3	21.3	21.3	21.3	21.3
Bird scaring	48.9	48.9	48.9	48.9	48.9	48.9
Harvest	36.7	36.6	36.6	36.6	36.6	36.6
Post-harvest activities	76.3	76.3	76.3	76.3	76.3	76.3
Irrigation cost (€)	*18.3*	*53.5*	*5.3*	*13.7*	*13.7*	*22.9*
Yield(Mg ha^{-1})	*2600*	*2040*	*2341*	*4155*	*2208*	*3041*
Selling price (€ Kg^{-1})	*0.2*	*0.3*	*0.2*	*0.2*	*0.3*	*0.3*
Total average returns € ha^{-1}	**67.2**	**33.3**	**-31**	**376**	**43.4**	**250.4**

4.4 Discussion

We took the approach of identifying efficient water management options jointly through a multi-stakeholder process because, despite massive expansion over the past three decades, success of earlier participatory approaches has remained limited (Ojha et al., 2013) and the term 'participatory' is often used as a mere label without substance (Douthwaite et al., 2001; Pijnenburg and Nhantumbo, 2002; Pain and Francis, 2003; Leeuwis, 2004). Through involving rice farmers as well as an extension agent in all stages of the experiment, we hoped to overcome this bias and have more chances to put research findings into use. We agree with others who believe that conclusions drawn by people themselves, on the basis of their experiences, may have a greater impact on adoption than insights formulated by others (Kolb, 1984; Leeuwis and Aarts, 2011). Since the evaluation methods of farmers (qualitative) and researcher (quantitative) were somewhat different, the overall assessment and evaluation were also done in a mixed method that others have found successful (Janssen and van Ittersum, 2007; Ton, 2012).

4.4.1 Scientific assessment

The effect of mulch is clear: when the dose of mulch increased, the yields also increased for both rice varieties. Yields in the first (wet) period were higher for both rice varieties than the yields recorded in the dry period. A significant contributor to this yield difference is the improved water availability (Araya et al., 2011). But the variation could probably also be explained in part by a fertilising effect of the mulch. By the end of the first experimental period, the mulch was almost completely decomposed and remnants incorporated into the soil. We think that it may have contributed to soil fertilization, as Ramakrishna et al. (2006) and Adeniyan et al. (2008) also found.

During the second experiment, there was no rain. Observations by all stakeholders indicated that plants of both varieties suffered from water stress; however the visual symptoms of water stress were noticed mainly in the un-mulched plots (Araya et al., 2011). Despite the water stress, yields nonetheless increased with the dose of mulch applied. The variation in the yields for each of the two periods showed that Nerica-4 tolerated the moisture stress better than IR-841. This is in accordance with Koné et al. (2008) who demonstrated Nerica-4's drought tolerance. However, when yields for the two experimental periods are combined, IR-841 had much higher total yield. This variety thus appears to be economically more profitable and a secure choice for farmers. This likely explains why, although IR-841has been recommended as a lowland variety, farmers also use it in upland areas.

Generally, weed infestation in the first experiment was less than during the second period. Two factors could explain this observation. During the first experimental period, the rainwater remained on the surface in most of the plots which may affect weed growth. A significant variation in weed infestation was observed between the Nerica-4 mulched and Nerica-4 un-mulched plots. However, there was no significant variation observed in the IR-841 treatments where weed infestation was quite low even in the un-mulch plots. Numerous studies show that mulch serves as a physical barrier that can reduce weed growth (e.g., Rosemeyer et al., 2000; Freeman and Gnayem, 2004; Ramakrishna et al., 2006; Isaac et al., 2007) and this seemed to be the main effect at work in the Nerica-4 plots. The growth characteristics of IR-841 plants may help to explain the low weed infestation and lack of variation observed for this variety across the two periods. IR-841 has drooping leaves that shade the soil surface and limit weed emergence compared to Nerica-4, which has erect leaves.

The field observations indicated that the mulch kept the soil wetter. The mulch acted as vapour barrier that decreased evaporation of soil water (Araya and Stroosnijder, 2010; Stroosnijder et al., 2012). If the use of mulch helps to retain soil moisture, it can provide room for farmers to reduce the frequency and amount of irrigation. As a result, there would be no need for each farmer to have an individual motor-pump. Rather, a more limited number of pumps could be cooperatively owned, lowering overall costs. We estimate that up to 5 farmers could share one pump.

4.4.2 Assessment by farmers

The yields recorded showed that Nerica-4 had the lowest yield. It is reasonable to expect that, because of its potential to withstand soil moisture stress, farmers would cultivate Nerica-4 during the dry season. However, the farmers usually do not cultivate it in their own plots because of its lower yield, which implies lower economic return. While the income that Nerica-4 generated during the second experimental period increased (Table 4.4), this was mainly because of an increase in the rice price in the dry period. Although IR-841 is a long cycle variety and is water demanding, the farmers thought that they could make better profits in uplands because of its high yield. This is illustrated by the farmers' responses: ''in the same plot size, we harvested 3 bags of IR-841 for 1 bag of Nerica-4'', or ''Although Nerica-4 is a three-month cycle, it is more profitable for us to produce IR-841 (a four-month cycle) to get more rice''. The intensification of rice production and the higher demand for rice contributed to farmers' decision.

However, IR-841 is not reliable in the upland area if there is not enough water to meet its high water demand. Farmers act strategically to build on the economic potential of their resources by producing IR-841 in uplands even though there is no guarantee that they could have enough water for irrigation (Henrich and McElreath, 2002; Stroosnijder, 2012). With the increasing uncertainty in the seasonal regularity of rainfall, as a direct manifestation of climate change, the sustainability of the farmers' choices might be questioned. In years of poor rainfall, they know that they can lose their entire harvest if there is no water available for irrigation. Their choice to nevertheless use IR-841 might be risky but, because of the related economic gain and the facilities that are now given to rice farmers in the context of local rice promotion, they all chose to continue producing IR-841. According to our interviews and informal discussions, the production of IR-841 is viewed by the farmers as an important strategy for profit maximisation. Even if it is a seemingly illogical practice to adapt a lowland variety for use in the upland area, our results (Table 4.4) show that the yield and economic returns that IR-841 generates in upland areas is sufficiently high, especially with mulching, that the farmers choose this option because of what they expect to gain.

4.4.3 Benefits of the platform: lessons learnt

All actors involved in the experiment noted that their participation in the platform allowed them to discover and discuss things they did not know before (e.g., weed control and soil moisture capacity of mulch). The platform was a space where the participants exchange and discuss their experiences with each other. Through this process, they together generated knowledge through a hybridisation of farmers' understanding inherited from their everyday farming practices and the scientists' experiences (Darré, 1999). The process also provided the participating farmers with more confidence in collaboration with the other stakeholders such as the extension agent and the researcher. In addition, the platform facilitated cross exchange of experiences among farmers from the three areas (Nederlof et al., 2007).

The participants' feedback on the outcomes of the experiment indicated that all of them gained better understanding of the growth stages of the rice plant, soil moisture management, and the skills of interacting with the other stakeholders. Initially, the farmers were not aware of the potential of mulch to affect soil moisture during the growing stages of the rice plant. They usually burned the biomass waste at the end of the growing season. As a result of the experiment, they have decided to keep the rice straw in their fields after the harvest for use as mulch during the following season. 2 from 3 farmers recognised during the interviews that the mulch use is beneficial in rice production (better yields, less weed infestation and low production cost), but its application required a lot of work. Based on that, they explained that they will prioritise its application in the plots where rice plants suffered the most from water stress.

According to the participants, another important outcome was the linkage that the farmers made with another research project that was on-going in the same area, about the use of Urea Deep Placement (UDP) Technology (Gaudin, 2012). The two farmers from Koussin-Lélé involved in the platform had also participated in the UDP experiment. They came to the conclusion that by combining the mulching and the

UDP technologies, they can improve the efficient use of urea in rice farming and soil moisture as well. Moreover, the farmers deduced that by using mulch in their rice plots, they could control weed infestation more effectively. The additional labour cost of mulching could be recovered by the reduction of weeding costs and the yield increase. The joint experiment also validated the farmers' adoption of IR-841 for upland areas.

The researcher and the extension agent gained an understanding of farmers' practices and demonstrated that farmers are not passive adopters of others' recommendations but, rather, adapt technologies to their own needs and conditions (Long, 2001). The extension agent said that following this experience he would look at farmers' practices with a different perception. The researcher and extension agent became convinced, like Janssen and van Ittersum (2007), that even though farmers are not developing technologies by means of scientific criteria, they are continuously involved in daily experimentation so as to adapt to their environment, and changing production and market conditions.

4.5 Conclusions

We can conclude that the process used to select a viable option for more efficient water management in rice farming, involving a mixed group of stakeholders, facilitated the interaction between the members of the platform, the co-generation of knowledge for efficient water use by integration farmers' understanding and scientific inputs. Evaluating the resulting technical field experiment with multiple methods provided sufficient evidence for a clear result: the long-term lowland variety IR-841 with 'rice-straw' mulch at 10 Mg ha^{-1} allows farmers to better use available water and increase yields in their upland plots. Beyond its technical value, the joint experiment created room for the participants to share their knowledge and perspectives and to learn from each other. This is an important achievement since the same farmers had earlier shown little willingness to act collectively in their lowland command area. Although the adoption rate was not directly studied, the participants in the platform and final workshop considered that the adaptive collaborative research approach that was used would improve adoption rates of new practices considerably.

Chapter 5

Diversity in success: interaction between external interventions and local actions in three rice farming areas in Benin

A slightly modified version of this chapter was submitted to Agricultural Systems:
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Agricultural Systems

Diversity in success: interaction between external interventions and local actions in three rice farming areas in Benin

Abstract

Since the rice crisis of 2007, the government of Benin has initiated many programmes for rice intensification. Comparison of three rice production areas shows that local rice production has indeed been increased by the facilities provided by the government programmes. Although broadly the same facilities (market outlet, credit, input, etc.) were provided to rice farmers in the three study areas, which are located close to one another, there are similar, but also different outcomes regarding farmers' social practices. The study explores the interplay between these external interventions of government programmes and local actions of farmers to explain the different outcomes. Using an actor-oriented perspective, the study concludes that the local actions of the farmers interact at diverse junctures with the external interventions. The subsistence strategies to resolve livelihood problems, the different production options such as the availability of an upland area, and natural flood conditions influenced farmers' local actions and contributed to explaining the diversity of social practices.

Keywords: Agency; change; social practices; intervention, interplay; rice production.

5.1 Introduction

Developing irrigation facilities for agricultural purposes has always been an issue of interest for public actors (IFAD, 2008; Sharma, 2001). Soon after independence in the 1960s, the Benin government created nearly 2,236 ha of command areas, used mainly for rice production with the assistance of Chinese projects (Sodjinou et al., 2008). The termination of this project in 1979 and the gradual structural reforms of the economy led to the collapse of these irrigation schemes, and rice production declined. Numerous interventions through successive generations of projects were undertaken to increase local rice production (e.g., *Société d'Aménagement de la Vallée de l'Ouémé* (SADEVO), *Société Nationale d'Irrigation et d'Aménagement Hydro-agricole* (SONIAH), *Office béninoise d'Aménagement Rural* (OBAR), *Projet d'Aménagement des Petits Périmètres Irrigués* (PAPPI), *Projet Vallée du Mono, Projet Périmètres Pilotes de la Sota*, etc.). However, studies suggested that these yielded limited success (Abiassi and Eclou, 2006; Adegbola and Singbo, 2005) because they had mainly a technological goal and underestimated the complexity of the social context (Vincent and Roth, 2013).

Since 2007, a new generation of programmes has been crafted that provide institutional conditions for farmers to improve rice production. The government has provided subsidies on seeds and fertiliser, as well as credit and a market facility for local rice intensification. The government's investment is supposed to lead to new models of rice production and trade (MAEP, 2010). Between 2007 and 2012, local rice production increased from 47,000 metric tons to 96,000 metric tons (Index-Mundi, 2012) in Benin. The intervention programmes address major barriers in the local rice chain, e.g., lack of a market and bank credit (Totin et al., 2012). They have also been successful in providing access to formal credit and the market to most rice farmers. The same facilities were provided to rice farmers in three study areas located close to one another with similar, but also different, outcomes regarding farmers' social practices.

Numerous studies have portrayed interventionists in 'heroic' terms, as authors of positive changes in local areas (Hawkins et al., 2001; Khavul et al., 2013; Rollnick et al., 1992); less attention has been given to the initiatives that local actors take to create space for change (Janssen and van Ittersum, 2007; Morgan,

2001; Paul, 1987). Local actors have often been regarded as passive adopters or followers of externally devised interventions (Kristjansona et al., 2002; Long, 2001). Such analysis does not capture the complexity of change processes (Chizema and Buck, 2006; Walters et al., 1999). Therefore, this research studies the interplay between external interventions and local actions of farmers. The following research questions are addressed: (1) what are the changes in the social practices of actors in the rice value chains in the three areas? (2) How did the external interventions interact with the actions of farmers in the three areas? (3) To the extent that the outcomes are different, why did similar interventions lead to the diverse changes in social practices? And (4) how did the interplay between the interventions and local agency make room for change?

We start with the description of the actor-oriented theoretical perspective used to analyse the findings. Then we turn to the design of the research, based on chronological causal reasoning constructed around the timelines of the key events drawn from interviews and observations. The changes in social practices are analysed by comparing these data with information gathered during a baseline study (Totin et al., 2012). This is presented in two sections. The first section presents the changes in social practices in comparison with the baseline situation (section 4). The second section describes the key events chronologically (section 5). For each event, we show the immediate outcomes of the interplay between the external interventions of the government programmes and farmers' local actions. After analysis of the main factors influencing the diversity of the outcomes, the implications for evaluating external interventions are reflected on in the section 6. The study ends with the conclusions and draws the key lessons learned.

5.2 Theoretical framework

The intervention programmes are specifically designed to intensify rice production (higher yields and more production cycles). We investigate their effects on farmers' social practices in relation to rice production and the wider impacts on farmers' livelihoods in terms of rice yield, rice production and income. We consider social practices in this study as the daily activities of people in their social, cultural, economic and political contexts (Shay, 2008).

We assume that the external interventions do not directly affect the social practices, but that social change results from the interplay between interventions (state-directed as well as NGOs' interventions) and farmers' local actions. According to this assumption, the change process is recursively shaped by two processes: (1) the on-going practices of people who try to accommodate themselves to everyday contingencies and (2) external institutional forces (Cunha and Cunha, 2003).

The intervention programmes fit well with the theoretical assumption in some recent studies that argue that institutions at a higher than local level are needed to provide smallholders the necessary conditions to create local opportunities and improve their livelihoods (Hounkonnou et al., 2012; Röling et al., 2012). Pal et al. (2002), taking the example of the Green Revolution in Asia, suggest that enabling conditions for growth in agriculture could be achieved through the establishment of public–private partnerships, supporting institutions such as credit and land reforms and incentives such as crop prices.

Notwithstanding the valuable contributions of the actor-oriented approach to policy studies, it does not pay much attention to institutional contexts and their effect on actors' agency (Giddens and Audet, 2005). In this study, we regard the interventions constituted by government programmes as new institutional contexts for local situations. We analyse whether the interventions provide enabling or hindering conditions for the changes observed in the research areas.

To better understand the interplay between external interventions and farmers' local actions, we further explore two key concepts associated with the actor-oriented approach: agency and arena.

5.2.1 Farmers' agency

The notion of agency attributes to the actor 'the capacity to process social experience and to devise ways of coping with life, even under the most extreme forms of coercion' (Long, 2001:16). Furthermore, Long (2001:17) explains, the way people make use of the external interventions rests fundamentally on how each agent 'translates' the interventions in accordance with his/her own interest. Similarly, paraphrasing Arce, Verbole (2009) argues that the term agency covers the styles by which actors embody, internalise and translate the influence of external interventions. Long (2001: 13) argues that local actors should not be viewed as simply passive recipients of interventions, but as 'active participants' who try to transform external interventions to fit their needs and agendas (Long, 2001:17; Verbole, 2000). Long (2001: 12) argues that they do indeed have the capacity to influence change process by interacting with the interventions. When people make use of externally recommended options, they try to create space for their own interests and make a choice among options that best fit with their own needs (van der Ploeg and Long, 1994; Verbole, 2000).

5.2.2 Local rice production chain as an arena of conflict

The interplay between external interventions and local dynamics can be described in terms of what Long (2001: 15) defined as an 'interface,' i.e. the point where different life-worlds and social fields intersect. Olivier de Sardan assimilates the notion of interface to arena, a social space of interaction and encounter (de Sardan, 1995: 185; Hasselskog, 2009: 10). Bierschenk (1988) suggests that a development project can be seen as an arena where stakeholders act according to their own interests, using different frames of reference for social interaction. He argues that the key characteristics of an arena are: different stakeholders act in the same space where each stakeholder's action depends on his (her) interest and expectation, and on negotiation among the actors.

In this study, we consider the arena of interest to be the local rice production system where the encounter between farmers and government interventions gives rise to a new set of interactions. As diverse goals and rationales are brought into contact in the arena, a clash of expectations is likely. That is, we take it as inherent in the idea of an arena that there will be competing interests and rationales, and hence also tension and conflict (Long, 2001: 59). Rarely does a development project, policy or process create only winners (Kanbur, 2003). With interventions, there are winners and losers, and thus interventions are accompanied by conflicts.

5.3 Research design

Central to this research are three rice production areas (Koussin-Lélé, Bamè and Zonmon) located in inlands valleys in the Agonlin Plateau region of Benin. In these areas, a few hundred farmers produce rice alone or in combination with vegetables and maize, using a gravity irrigation system in the lowlands and a pumping system in the uplands.

The investigation started concurrently with the first intervention of the rice intensification programme (*Programme d'Urgence d'Appui à la Sécurité Alimentaire*: PUASA) in each area, around 2009, and ended in November 2012 when the final fieldwork was finished. We chose this period because PUASA was the first major programme after the rice crisis. Like succeeding additional programmes, it aimed to intensify local rice production (Soulé and Blein, 2008).

To explore the changes in social practices, we conducted 58 interviews with individual farmers in the three areas (33 from Koussin-Lélé, 15 from Bamè and 10 from Zonmon) between August and November 2012. With a snowball sampling procedure, the interviewees were selected by asking initial farmers to identify other potential interviewees (Biernacki and Waldorf, 1981). Recruitment of additional interviewees ceased when potential information collected became redundant and we believed a saturation level of

opinions and insights about the changes had been attained. On average, each interview lasted 45 minutes to an hour. Each was digitally recorded, and, accompanied by detailed field notes, the recordings were translated from the local dialect (*Fongbé*) into English and transcribed.

Building on the outcomes of the individual interviews, we organised nine focus group discussions (FGDs) (five at Koussin-Lélé, two at Bamè and two at Zonmon) (Kitzinger, 1994), during which we invited farmers to reflect on the changes that they framed as relevant. The number of participants in each focus group ranged from six to eight as usually recommended (Asbury, 1995). Each focus group meeting lasted approximately an hour to an hour and a half. The focus group discussions were also recorded, translated and transcribed.

To validate the perceptions of change espoused in the interviews, farmers' practices were observed. The unfair application of canal maintenance rules was identified as one of the major barriers hindering rice production at baseline. We then observed directly in the fields (mainly from September to October) how the rules established for canal maintenance have changed and how the canal cleaning is now performed. The information collected during the interviews and the observations were compared with the data collected for the diagnostic study (Totin et al., 2012) and used as the baseline against which changes in social practices, local institutions and income brought about by the external interventions are analysed.

The influence of the government programmes on farmers' rice-production income was assessed by administering an additional questionnaire survey to 50 rice farmers (26, 12 and 12 in Koussin-Lélé, Bamè and Zonmon, respectively) based on a stratified random sample. The farmers were selected from the different groups producing in each area, on the basis of land size diversity, credit condition (farmers without credit, or credit from local traders, or from local banks, or both bank and traders' loans) and whether rice is the main or secondary income source. These selection criteria aimed to produce a good representative sample of the different categories of farmers.

The survey focused on rice yields during the three cycles, production costs, amount of rice that each farmer sold, credit conditions and the selling prices. For each of the 50 farmers, we estimated the yields by building on the farmers' responses which were triangulated with each farmer's written reports. We calculated the production cost (C_p) for each farmer during the first growing season by including the direct input costs for seed, fertiliser, herbicides and labour. The labour costs were estimated by assuming that labour is hired for all activities. Thus, the farmers' involvement (family labour) was not considered. When a farmer received credit from both local traders and the government programme (*Projet de Développement Agricole des Communes*: PDAC), we estimated the cost of the credit (C_c) per kilogramme by dividing the total amount paid for each type of credit by the farmer's total production. (For instance, if a farmer received (1) a loan of 15,000 F cfa from a trader and paid back 25,000 F cfa at harvest time, and (2) 10,000 F cfa from the PDAC programme and reimbursed 10,300 F cfa with a total production of 600 kg, the cost of the credit per kilogramme of paddy is: C_c= (25,000/600) + (10,300/600) ≈ 59 F cfa per kg. Then, the total cost C = C_p + C_c. The average amount sold per farmer was calculated by building on the 50 farmers' responses to the questionnaire survey. The rice output in the three areas was estimated based on the survey. The data collected both from the extension officers and one of the projects working in the areas were not accurate. Farmers report purposely less than their real harvest, so that they pay a lower fee.

Finally, to investigate the interaction of the programme interventions with the farmers' local actions, we invited farmers to reflect during the FGDs on whose actions influenced each of the changes that they framed as relevant and what other (unexpected) events were seen as facilitating the changes. Additionally to the farmers' FGDs, we conducted 20 individual interviews with programme staff, the extension officers operating in the research areas (three agents from *Société Nationale pour la Promotion Agricole*: SONAPRA, four from PUASA, two from PDAC, five members of the CoS-SIS platform and six extension agents). They were questioned about the causes of the main changes. We explored the extent to which the interventionists related the changes to the interventions in the area, the unexpected events or farmers'

actions. The recorded and transcribed interviews provided information for detailed qualitative analysis of both similarities and differences between interventionists and farmers' perspectives. The transcripts were analysed with a specific focus on the order of events and in what way one event triggered a next one. Guided by an actor-oriented perspective (Long, 2001) and building on the interviews with the stakeholders in the three areas, we then drew timelines of the critical events in each area. Thus, the timelines capture chronologically the interplay between the external interventions of the programmes, farmers' local activities and our research activities.

5.4 Interventions and outcomes

In this section, we first present the major intervention programmes and then the changes that occurred in the three areas in the context of those interventions. The changes described relate to rice production, revenues from rice production and practices of rice production, selling, financing and water management.

5.4.1 National intervention programmes

The government of Benin initiated a variety of short-and long-term measures, such as the removal of tariffs on rice imports, provision of subsidies and the establishment of diverse programmes aimed at providing access for farmers to agricultural inputs (MAEP, 2010). Some long-term programmes aimed at strengthening rice self-sufficiency. The first large national programme was PUASA. It aimed to increase domestic rice production in order to mitigate the short-term impact on households of increasing consumer prices for rice and to expand food-crop farmers' access to agricultural inputs (World-Bank, 2008). The programme offered subsidies for seeds and fertilisers, as well as credit to farmers. The programme also supported the expansion of irrigated lands for farmers. In Koussin-Lélé, Bamè and Zonmon, the programme supported the rehabilitation of the irrigation schemes and provided agricultural equipment to rice farmers.

In October 2010, PDAVV (*Programme de Diversification Agricole par la Valorisation des Vallées*) was initiated to (1) facilitate access to appropriate funding services for micro and small enterprises operating in the local rice chain, (2) increase the chances of sustaining farmers' gains within the rice chain and (3) to facilitate the sustainable integration of micro and small enterprises in the rice market (CARD, n.d.). The programme funded nine rice farmers in Bamè and four in Zonmon to increase their rice production.

To ensure food security for low income households, the government charged SONAPRA, the national company for crop promotion, to buy and mill the farmers' paddy. Between 2010 and 2011, SONAPRA contracted with the private entrepreneurs specialised in processing to mill the paddy. Since 2011, the government has promoted two large-capacity milling industries under SONAPRA's auspices. With this new infrastructure, SONAPRA increased the amount of rice bought from the farmers. SONAPRA provides fertilisers to farmers, the cost of which is deducted before farmers are paid for their paddy. In addition, it offers a better price than the local traders in order to secure the crop for the government's mills. Consequently, the local traders have been forced to increase their price.

In August 2012, PDAC began to facilitate access to agricultural financing for all entrepreneurs operating in rural areas. It was established that each rice farmer could receive €245 per ha of rice cultivated, including a €90 fertiliser subsidy. One of the prerequisite conditions for accessing the PDAC credit was that the extension agents had to validate the land size that each farmer cultivated and approve the credit request before the applicant could receive the credit. The programme partnered with SONAPRA to enable deduction of the loan from the price paid for the farmers' harvest, at an interest rate of 9% per year. One hundred and fifty-seven rice farmers participated in the programme in Koussin-Lélé, 20 in Bamè and 48 in Zonmon.

5.4.2 Rice intensification and revenues

In combination, the intervention programmes addressed major barriers in the local rice chain. They provided access to formal credit and a market outlet for most rice farmers that facilitated the intensification of local rice production. Table 5.1 shows the intensification of production in the three areas. Total local rice production had increased in all three areas (from 357 to 471 metric tons in Koussin-Lélé, from 21 to 78 metric tons in Bamè and from 12 to 36 metric tons in Zonmon). Table 5.1 shows that this increase relates to the expansion of the rice-growing area and the number of rice farmers, the increase in production seasons or the increased rice yield.

Additionally, the total average amount of rice sold by farmers increased, as presented in Table 5.2. Given that the rice production cycle covers four months and the official minimum wage in 2012 was 31,625 F cfa per month, the average returns presented in Table 5.2 show that, in Koussin-Lélé, the most successful rice production area, the average return in 2012 was about 160% of the minimum wage level, during the first growing season. In Bamè, the farmers' return was about 63% of the current minimum wage level, and only 45% in Zonmon. During the second and third seasons, the return per farmer was lower because the yields and the average amount sold decreased.

5.4.3 Changes in social practices

The rice intensification results from an expansion of land and number of farmers but also to changed practices. In the three areas, the main changes in social practices documented in the study related to (1) rice production, (2) rice selling, (3) agricultural financing and (4) water management, as presented in Table 5.3.

Table 5.1: Intensification of rice production

	Koussin-Lélé		Bamè		Zonmon	
	2009	2012	2009	2012	2009	2012
Total rice cultivated land (ha)	200	350	15	17	10	27
Number of rice farmers	200	200	19	20	21	48
Yields 1st cycle (t ha^{-1})	3.2	3.9	2.0	2.5	3.5	3.9
Yields 2nd cycle (t ha^{-1})	2.2	2.5	2	1.8	0	2.3
Yields 3rd cycle (t ha^{-1})	2.0	2.3	0	1.8	0	0
Average of production cycles per year*	2.4	2.8	2	3	1	2
Total annual production (t)	1480	1871	60	103.7	35	167.4

*Not all farmers produced during the three cycles

Table 5.2: Average revenue per farmer (in F cfa) (paddy) for one production cycle per hectare (2009, 2011 and 2012 data) (N=50)

	Koussin-Lélé		Bamè		Zonmon	
	2009	2012	2009	2012	2009	2012
Production cost (per Kg)	109	105	113	121	118	134
Selling price (per Kg)	123	160	121	160	123	160
Margin (per Kg)	14	55	8	39	5	26
Average amount sold per farmer (Kg)	3500	3700	1900	2040	2000	2200
Average return per farmer (cycle/4 months)	49,000	203,500	14,630	79,560	9,800	57,200
Average return per farmer per month*	12,250	50,875	3,658	19,895	2,450	14,300

* We assume that labour is hired for all activities; the exchange rate during the study was fixed at 655 F cfa for 1€

Rice production

In 2010 in Koussin-Lélé, almost 56% of farmers grew rice in three seasons, 32% grew rice in two seasons and the rest produced only in one season. After the interventions, four in five farmers cultivated during the three seasons and the rest produced in two seasons. They produced within the command area during the first and second seasons, and hired land around the command area to produce during the third season.

In Bamè, the farmers also increased the average number of production cycles, from two to three. They all produced rice in the potential three cycles per year. Among the 20 farmers that had previously produced rice in the lowlands only, in 2012, eight still produced only in the lowlands and five in the lowlands during the two dry seasons and in the upland area during the wet season. The seven other farmers produced three seasons in the uplands.

In Zonmon, in 2010 the farmers had all produced only during the first growing season. Since March 2012, farmers have started producing during both the first and the second seasons each year. In addition, many farmers changed from growing vegetables and maize only to a combination of vegetables/rice and maize/rice.

In 2010, in all three areas, farmers transplanted the rice seedlings unevenly, using their feet as a guide. Since March 2012, the rice farmers have modified the transplanting practice and two in five transplant in lines using a string or a rope. One in five often transplants the seedlings uniformly, at an equal distance, but not in lines. The rest still plant randomly. This change in transplanting practice presumably has contributed to the yield increase in the three areas.

Farmers were used to spreading urea fertiliser in the three areas. Since the national staff of the International Fertiliser Development Centre (IFDC) conducted a urea deep placement (UDP) field experiment in Koussin-Lélé with the rice farmers, almost one in five farmers there have started applying urea super-granule at a 7–10 centimetre soil depth, shortly after the paddy is transplanted. However, the urea application practice did not change in Bamè and Zonmon.

Rice selling

In all three areas, the farmers customarily sold the rice, all locally milled, to local traders and directly to consumers. Farmers who received loans from local traders were committed to paying back the loan in kind from their rice harvest. With facilities provided through formal credit and the market outlet, farmers sold the harvested paddy directly to SONAPRA. Since 2011, SONAPRA has been coming to buy the paddy directly in the village, at harvest time, and offers a better price than the local traders. This formally organised paddy outlet represented 90% of the market for the farmers. The farmers in all three areas who received credit from traders to produce maize and other food crops (2 in 10) paid back with milled rice.

Agricultural financing

In 2010, in Koussin-Lélé and Bamè, 40% of rice farmers obtained credit from the rural banks (CLCAM and CAVECA). The banks provided credit for groups, in a solidarity system where all the group members were held responsible for repayment. The credit was provided only for rice production, not for other food crops. The banks did not give credit to newly established rice farmers since these did not have a credit history and the banks did not have enough experience to trust them. The 80% of farmers who did not receive bank credit, or not enough to cover their needs for other food production, turned to local lenders for individual loans. In Zonmon, the banks did not provide credit for the rice farmers, as they had neither experience in rice production nor any bank credit history.

The PDAC programme facilitated access to formal credit for all rice farmers, under the conditions discussed in section 4.1. However, because the credit was given only for rice production, 28% of farmers in Koussin-Lélé, 12% in Bamè and almost 30% in Zonmon still engaged in a relationship with local traders.

Water management

In Koussin-Lélé, in the dry season from January to March, water becomes scarce. In 2010, to cope with the water shortage, farmers agreed to work together to clean all the canals. The regular farmers (80% of association members) indeed cleaned the canals twice a year according to the rules. However, they deliberately took more time than the prescribed one day, taking two or three days instead. They cleaned less well than they were supposed to do. The privileged farmers (elected group leaders, traditional chiefs and landowners) predominantly escaped from this duty.

After the government programme interventions, in Koussin-Lélé, the farmers still cleaned their canals twice a year, in October and December, but no longer collectively. Instead, each farmer was responsible for cleaning the segment of canal around his (her) plots at the set period. Farmers who were not available during the set period were allowed to pay a labourer to clean his (her) segment. Also, 43 farmers whose plots were located at the tail-end of the irrigation scheme had started using individual pumps to supplement the gravity irrigation.

In Bamè, during the dry season, the water discharge decreases in the lowlands, due in part to the weeds growing in the canals. No rule was established for collective canal cleaning. Some of the farmers coped with the water shortage during the dry season by delaying their rice cultivation, so that not all of them needed water at the same time.

Since the end of 2010, when AfricaRice Centre started to conduct agronomic experiments in the command area, the farmers have managed to off-load the primary canal maintenance onto AfricaRice Centre. With the facilities provided by the intervention programmes (e.g., credit and market outlet), 12 farmers moved to the uplands where they used individually owned pumps as the irrigation system. About four farmers also used mulch in their plots in the uplands to manage the soil moisture in order to reduce irrigation frequency, and thus the related production costs.

In Zonmon, among the 20 farmers who produced in 2010, only about six to eight contributed to cleaning the canals. During the dry season, when the water level decreased, the farmers rented motor pumps to get water from the main canals to their plots. Some farmers, who were unable to afford the pumping irrigation costs, chose to start earlier, following the retreat of the water level after the flooding in order to harvest before the dry season.

Since summer 2011, the number of rice farmers involved in rice production has gradually increased, from 20 to 48 farmers. All 48 farmers (including the 20 who started in 2009) worked together, in September 2012, to clean the main canal. The groups agreed that each farmer would clean a number of canal segments. Farmers expected that, during the dry season, they would not need the pumping facility because the canals were well cleaned.

The external interventions facilitated changes in the social practices relating to rice production (more cycles per year) and financing and rice selling in a formalised market system (Table 5.3). In this respect, expected changes in social practices occurred in all three areas. Beyond these similarities, there are some obvious differences between the three areas.

The most obvious ones are the change from limited collective canal cleaning to individual canal cleaning in Koussin-Lélé, the use of pumps in upland areas in Bamè and farmers who changed from growing vegetables or maize alone to growing rice in combination in Zonmon. The changes regarding water management might be read as an indirect effect of the interventions. In the following section, we explore this diversity and explain how the interaction between the general external interventions and local actions led to different outcomes from a process perspective.

Table 5.3: Overview of changed practices

Areas	Situation in 2009 (Baseline)	Situation in 2012
Koussin-Lélé	- Rice production: o Almost half of the farmers grew rice in 3 seasons per year o Random transplantation of rice seedlings (not in line) - Rice selling: o All farmers sold their harvest to local traders and local consumers (respectively, about 85 and 15 %) - Agricultural financing: o About 55% of farmers had loans from local traders and a minority of farmers had access to credit from the rural banks - Water management: o Collective primary canal cleaning o Use of gravity irrigation only	- Rice production: o Almost 4 in 5 farmers grew rice in 3 seasons per year o Transplantation in line - Rice selling: o All farmers sold part of their harvest to SONAPRA o About 18–20% of farmers sold part of the milled rice to local traders - Agricultural financing: o About 4 in 5 farmers had credit from the rural banks (through PDAC) and some farmers (about 28%) still received credit from local traders for their other food crops - Water management: o Individual canal cleaning o Use of individual pumps in addition to gravity irrigation (43 farmers)
Bamè	- Rice production: o All 20 farmers grew rice in the lowlands o Almost half of the farmers grew rice in 3 seasons per year o Random transplantation of rice seedlings (not in line) - Rice selling: o Farmers sold the milled rice to local traders - Agricultural financing: o Almost half of the farmers received credits from local traders and almost 50% had bank credits - Water management: o Use of gravity irrigation o Use of pumping in the uplands by 9 farmers	- Rice production: o Of the 20 rice farmers, 8 grew in the lowlands, 7 grew rice in the uplands, 5 grew rice in uplands and lowlands o All the farmers produced rice in 3 seasons o Transplantation in line - Rice selling: o All farmers sold their paddy harvest to SONAPRA o About 10% of farmers sold part of their harvest to local traders - Agricultural financing: o All rice farmers obtained bank credit and 12% of farmers still received credit from traders. - Water management: o Use of individual pumps in the uplands by 12 farmers and the gravity irrigation in lowlands o Mulch application in uplands (33% of farmers)
Zonmon	- Rice production: o All 20 farmers grew rice in 1 season per year o Random transplantation of rice seedlings (not in line) - Rice selling: o Farmers sold the milled rice to local traders and consumers (respectively, about 60 and 40%) - Agricultural financing: o Except for 1 of them, all the farmers asked for credit from local traders - Water management: o A few farmers contributed to collective canal cleaning (about 6 to 8 of the 20 rice farmers) o Use of gravity and pump irrigation	- Rice production: o 28 farmers turned from vegetables to rice o 29 of the 48 famers produced twice per year o Random transplantation of rice seedlings - Rice selling: o Farmers sold 80% of their paddy harvest to SONAPRA and kept the rest for their own consumption - Agricultural financing: o All the rice farmers received bank credit, but 1 in 3 farmers still also received credit from local traders - Water management: o More farmers (48) were involved in canal cleaning o All farmers worked together, but each of them cleaned a specific segment of the canal

5.5 Understanding the evolution of changed practices

In order to trace how the most striking changed practice in each area came about, this section describes the key events chronologically and, for each event, focuses on whether and how it contributed to increasing the room for change. Thus, the interaction between the external interventions, farmers' local actions and the research activities are investigated.

5.5.1 From collective to individual canal cleaning rules in Koussin-Lélé

The events identified as key, leading to a change in the canal cleaning rules in Koussin-Lélé, are described in Figure 5.1. There are three groups of farmers (G1, G2 and G3) along the main canal: G1 members located close to the watergate at the head of the scheme; G2, 500m from the watergate; and G3 at the tail-end (approximately 900 m from the gate).

Water shortage resulting from broken watergates and silted canals created frequent conflicts among these groups of farmers, often between January and March-April. In March 2009, during the dry season a conflict emerged between two farmers from G2 and G3. At that time, water delivery decreased. A G3 farmer closed the intakes in the neighbouring plots in G2 to increase the water flow so that it could reach his plots in G3.

The G2 farmer protested against these water cuts, because he was also expecting the water to weed his rice plots. A dispute and physical fight arose between the two farmers over the water distribution. It spilled over into a huge conflict between the two farmers' families. In response, farmers' leaders, traditional chiefs, extension officers and the elected municipal leaders organised a meeting with representatives of the rice farmers to discuss the problem and resolve the conflict.

The farmers reported that, although the conflict was not good in itself, at least it helped to attract the attention of the extension staff and the elected leaders. Moreover, the conflict created space to open a discussion about the water problem among all farmers, including those who had no problems with water supply (e.g., G1 members). The farmers' leaders agreed to impose additional penalties on members who obstructed the water course illicitly or did not follow the water turn as planned. The G2 and G3 members thought that this penalty system was not the solution to their water problem. A huge amount of water was being lost because most of the watergates were broken, and therefore they were of the view that irrigation infrastructure rehabilitation was the solution.

In September 2009, the extension officers and the municipal mayor solicited PUASA's help to renovate the irrigation infrastructure. The programme staff agreed to fix the broken canals if farmers would ensure regular infrastructural maintenance. A committee composed of eight farmer representatives and two extension agents was formed to identify the segments of broken canal that needed to be lined. Two months after the rehabilitation, a portion (almost 50 metres) of the lined canals collapsed in the tail-end section. Therefore, the farmers located in this part complained that their access to irrigation water had become more difficult.

In January 2010, a similar conflict arose about water distribution, so the extension officer organised another meeting with the farmers' leaders. At this meeting, it was decided that the farmers should repair the broken segment. Moreover, all farmers in the command area had to follow the established plan for water allocation and participate in canal cleaning. According to farmers, canal cleaning was a wasted effort because of the lack of a reliable market for the resulting production. In effect, the meeting between the extension officers and the farmers' leaders did not produce any change in the field: G3 farmers continued with illegal water cutting practices, none of them followed the water turns plan and the canals were not cleaned either.

Since May 2010, the PUASA programme has bought farmers' harvest at a good price compared with local traders' price. Farmers explained that previously they were not motivated to clean the canal because of the absence of a guaranteed market. However, although now a market outlet existed, farmers' contribution to the maintenance of the infrastructure did not improve. The G3 members were still suffering from irrigation water scarcity.

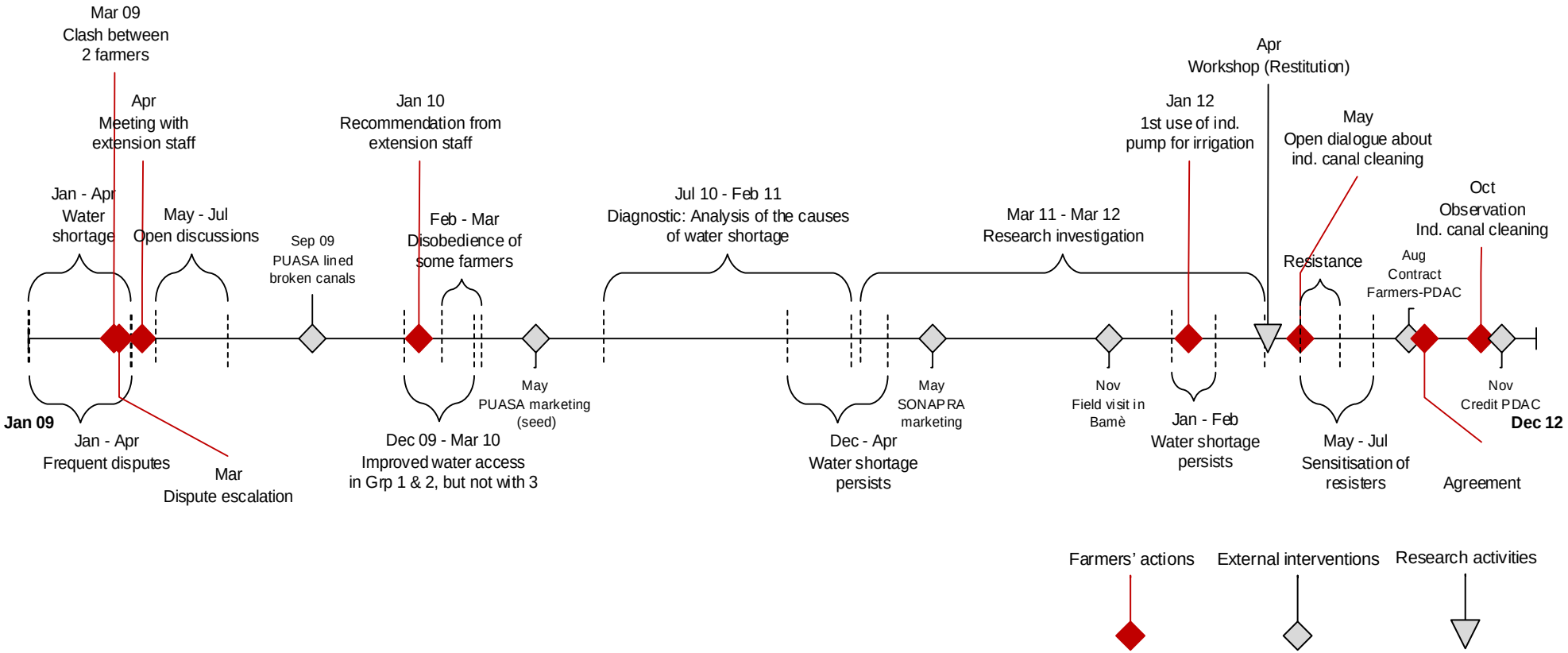


Figure 5.1: Timeline of critical events in the change process in Koussin-Lélé

At the same time, both the G1 and the G2 members were receiving enough water to cover their needs since the rehabilitation of the canals. According to them, the canal cleaning would not add any value to the amount of water they were already receiving. Therefore, the canal cleaning was no longer a real challenge. Then, four of the G3 farmers bought individual pumps to irrigate their plots during the critical period. They also rented the pumps to other rice farmers. In total, 43 of the 200 farmers used the pumps to irrigate their plots from January 2012 to April 2012. These pumps provided the farmers at the tail-end section with more water for their plots. However, G2 farmers reported that for them the use of the pumps had negative effects:

> *Since they started using the pumps, we now have less water for irrigation. The water flow decreased and I spent four to six hours getting water into all my plots. Before they started using the pump, I could finish in three hours. Pump use is not a good solution to improve water delivery. If the canals are well cleaned and the broken gates fixed, we will all have enough water without using the pump.* (G2 farmer Koussin-Lélé, Benin, field interview, September 2012)

In April 2012, the researcher organised a workshop aimed at stimulating reflection among the participants about the lack of effectiveness of the local rules that regulate the collective maintenance of the irrigation infrastructure. The extension officers supported this aim. They suggested raising the unfair application of the rules, so that the workshop could be a forum to discuss this with the stakeholders. Most participants stated in the interviews that the workshop helped them to 'break the former established rules' and to take action for change.

At the workshop, the G2 members who experienced water shortage because of water pump use in G3 suggested changing the rules so that each farmer must clean the segment of canal around his own plots. However, at first not all farmers were convinced of the desirability of having this rule (e.g., the privileged farmers), as the following statement shows:

> *The individual cleaning facilitated individualisation, instead of promoting cooperation. When we are in a group, we should do things together. Group members need to have a unified heart to support and guide one another.* (Farmers' leader, field interview, November 2012).

This disagreement was finally resolved with the start of the PDAC programme, which provided a formal credit facility for all farmers producing rice, thereby solving the last major barrier to rice production in the area. Because of the market outlet, credit and input (seed and fertiliser) facilities, they were able to make a better profit from rice production, and they then finally reached agreement on individual canal cleaning. The extension officers sensitised them to adopt better water management practices and to avoid conflict in order to make better use of the existing opportunities (market, credit, inputs). In October 2012, we observed that the farmers indeed cleaned individually.

5.5.2 Starting to use the uplands for rice production in Bamè

The major change observed in Bamè relates to the use of the uplands for rice production instead of growing rice in the lowlands only, and mulch application in these uplands by a small number of farmers. Figure 5.2 shows the sequence of events that accounted for this change.

The support of the PUASA programme in terms of maintenance of the irrigation infrastructure and equipment (cultivator and a small mill) to farmers on a credit basis stimulated 11 farmers to produce rice for the first time in 2008. They worked together and cultivated 2 ha of land. The PUASA programme bought all the harvest. The 11 farmers were supposed to share the revenues evenly. However, farmers reported that, after the harvest was sold, the regular farmers received €65 each, whereas the elites (leaders, landowners, etc.) pocketed €160. Frustrated, the regular farmers expressed their desire to produce individually, so that they could sell their harvest on an individual basis. The farmers' leaders did not agree and insinuated that it was impossible because the extension officers would not allow it.

To evaluate the effectiveness of the PUASA programme during the first season, the extension staff organised a meeting with rice farmers to discuss the constraints they faced. The regular farmers regarded the meeting as a good occasion to inform the extension staff about their problems and their desire to produce individually. The farmers' leaders tried to explain why not all farmers had received the same amount of money by arguing that some of them had used their own money to buy the fertiliser and were repaid after selling the harvest. When these arguments did not convince the extension staff, the leaders agreed with the option to produce and sell the rice individually.

With this decision, a huge conflict emerged among the farmers about how to allocate the land in the command area for individual rice production. From informal discussions with the farmers, it appeared that the leaders chose to keep the well-irrigated and fertile lands for themselves and distributed the poor lands to other farmers. Three-quarters of farmers interviewed said that the leaders claimed to be large producers and that they should get 10 plots, whereas only three or four were given to the regular farmers.

Some of the farmers reported the unfairness of the land allocation to the extension officers and asked their advice to resolve it. Together with the village elders, the extension officers sought a consensus. They suggested that the farmers' leaders should get eight plots and the regular farmers an average of five. This did not resolve the frustration among the regular farmers, who stated this decision was taken because of the close relationship between their leaders and the traditional chiefs.

> *They allocated the poorest part of the command area to me. Look at my soil, it is only sand, no clay in it! The group leaders had the best lands. They did it purposely to compensate for the fact they did not succeed in acquiring the land size they expected.* (Farmer from Bamè, field interview, October 2012)

In November 2009, motivated by the incentive price that the PUASA offered to farmers, nine new members joined the rice farmers, and all 20 farmers produced individually in the command area. Because of the latent conflict over land allocation and the difficult access to bank credit, the extension officers suggested that all rice farmers should apply for the new public entrepreneurial fund (PDAVV programme) in order to have the finance to cultivate new additional plots. Only nine farmers were selected for the credit. Among other things, they were expected to buy a pump in order to have a full control of irrigation water and to increase their rice production. Since it was not possible to enlarge the rice area in the lowlands, the programme stimulated the nine farmers to move to the uplands where they had access to 50 ha of virgin land.

The guaranteed market outlet that SONAPRA offered from April 2011 onwards had an additional effect on the development of rice production in the uplands. It motivated three additional farmers who had not received credit from PDAVV to start producing rice there. The migration of farmers to the uplands helped to reduce the tension about land allocation in the lowlands.

The pumps, however, entailed considerable extra fixed costs and increased the cost of rice production in the uplands. Therefore, the farmers anticipated that the costs could be reduced if the soil moisture was controlled better. The farmers' analysis inspired the researcher to organise a meeting (in March 2011) together with the rice farmers from the three areas under study and an extension agent. The aim was to reflect collectively on practical techniques that could help to increase the efficiency of water use in the rice plots. In conclusion, 10 farmers decided to start an experiment with the use of rice straw mulching. The outcome of this meeting was that they implemented the experiment together with the extension officer and the researcher in a communal field (Totin et al., 2013).

The findings of the joint experiment stimulated four participating farmers to apply mulch in some of their own plots in the following growing season. Another farmer who was not involved in the experiment used the mulch in the upland plots where he grew peppers, because he learned it from farmers with nearby experimental plots.

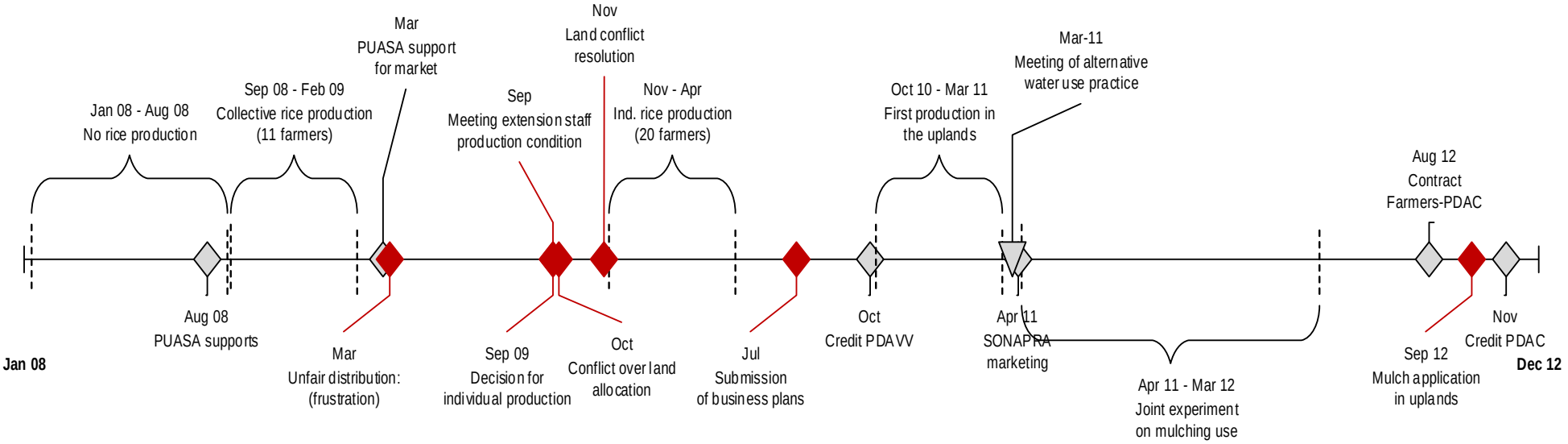


Figure 5.2: Timeline of critical events in the change process in Bamè

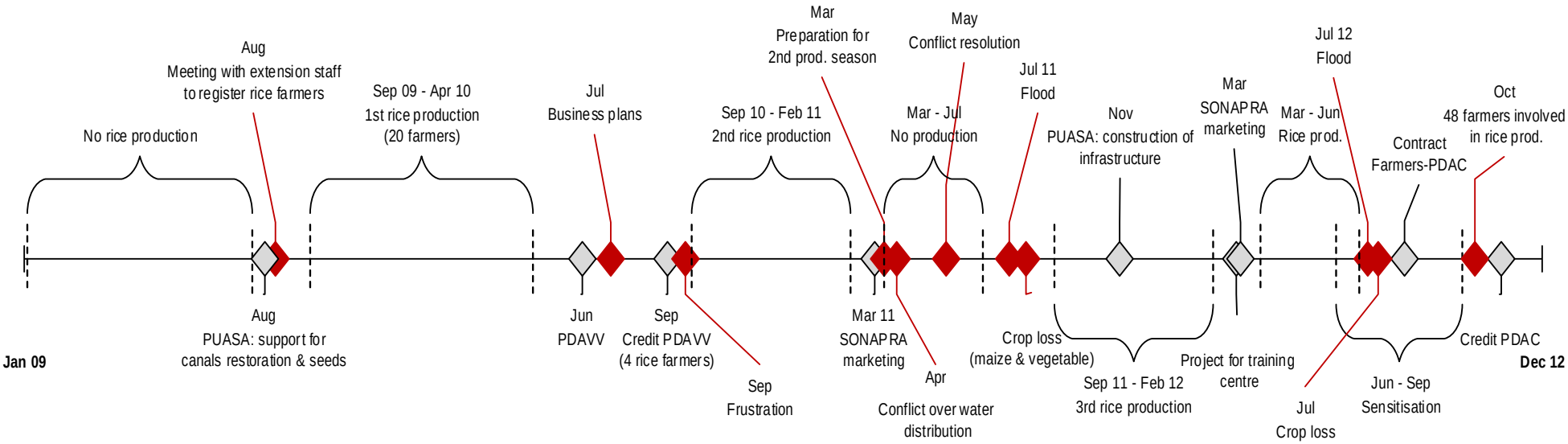


Figure 5.3: Timeline of critical events in the change process in Zonmon

5.5.3 From growing vegetables and maize only to growing rice in Zonmon

In Zonmon, the major distinguishing change relates to the shift from growing vegetable and maize only to a combination with rice production. The critical events that facilitated this change are described in Figure 5.3.

Rice production resumed in Zonmon in 2009 with the PUASA programme, which provided support for irrigation infrastructure rehabilitation and seed. The extension staff suggested that farmers should seize this chance. These interventions motivated 20 farmers to start rice production.

During this first growing season (2009), there was no formal credit available for farmers because the local banks did not extend credit to newly established rice producers. Therefore, most of the farmers turned to local lenders. Because of farmers' complaints about the high interest rate charged by these lenders (up to 150%), the extension officers recommended that they should apply to the PDAVV programme for credit. All 20 farmers applied, but only four of them were funded for the pilot phase. Three-quarters of the farmers interviewed mentioned that the selection of only a few of them was on the one hand frustrating, but on the other hand motivated them to intensify their rice production.

In 2011, the four farmers who received the PDAVV credit enlarged their plots from 0.5 to 1.5 ha. The others who did not receive the credit cultivated an average of 0.5 ha each. SONAPRA bought all 15 tons of paddy harvest in bulk and paid the farmers spot cash. With this market outlet and because they expected to receive the credit the next time, 10 of the rice farmers (including the four who received the credit from PDAVV) decided to produce during two growing seasons per year.

The second cropping season in 2011 coincided with the period when the other farmers grew maize and vegetables. A conflict arose when a group of maize farmers diverted the irrigation water flow at the head of the scheme. This unauthorised cut caused a severe scarcity of water at the tail section where rice was grown. With the mediation of the community development committee, solutions were explored in discussions between the two groups. The committee suggested that maize farmers would leave 2 m of farmland around the main canal and not till near the canal. In compensation, rice farmers would pay the equivalent of €150, corresponding to the damage they caused in the maize plots. During this second season however, 80% of the farmers were unable to produce rice because of the delay in finding this solution to the conflict, and they feared that, if they sowed at this time, there could be a risk of flooding at harvest time. They then decided not to pay any compensation to the maize and vegetable farmers as suggested.

In July 2011, a flood occurred in the command area, whereas floods used to take place between August and September, when there were no crops in the lowlands. It caused an estimated 80 to 90% crop loss. Maize and vegetable plots were the most affected, and these crops were the main income source for almost 85% of the community. Because of the flood, five maize and vegetable producers chose to produce rice instead, because this crop would survive the floods better in the following rice growing season (September 2011–February 2012). As three of the five new rice farmers were involved in the water conflict, this shift contributed to pacifying the conflict.

To facilitate post-harvest activities and rice harvest conservation, the PUASA programme constructed a rice drying area and a 100 metric ton capacity warehouse for the farmers. In February 2012, the president of Benin chaired its launch and the inception of an agricultural programme in the village aimed at young entrepreneur training. The municipal council used the construction of the infrastructure and the president's visit as arguments to sensitise more farmers to produce rice. At a meeting, one of the local leaders explained to farmers that the infrastructure and the agricultural programme would benefit the community in terms of improved roads, availability of clean water, electric power and increased employment opportunities, if they would produce more rice. The local leaders expected that the construction of the new infrastructure combined with the SONAPRA intervention could motivate new farmers to start producing rice.

In March 2012, SONAPRA bought all the paddy harvest in bulk, directly in the village for the second time. The guaranteed rice market stimulated most of the farmers to produce rice in the potential three

cycles per year. In April 2012, we observed 29 farmers, including the 20 farmers who started in 2009, the five maize producers who cultivated rice after the flood and four other new maize producers. The nine farmers combined both maize and rice production in the lowlands. During this growing period, there was no conflict over water distribution.

> *We are all interested in rice production because of the market outlet facility that SONAPRA offers. During the previous seasons, the local traders bought our harvest at a low price, and we could not complain, because there was no other option for us. The price that SONAPRA offers for our rice motivated many people to produce.* (A rice farmer from Zonmon, field interview, November, 2012).

In July 2012, flooding again occurred earlier than expected, damaging farmers' crops. Therefore, producing only maize or vegetables was no longer a secure option for the farmers. The floods again motivated the farmers to combine rice and other food crops instead of relying on maize and vegetables only. Then, when formal credit was made available to all the rice farmers with the PDAC programme in addition to SONAPRA's market outlet, 19 farmers started rice production. In September 2012, there were 48 farmers producing rice in the area.

> *I lost all my harvest in two consecutive years. I found that it may be more secure for me to combine rice and the other food crop. I do not produce because people from the municipality asked me to do so! I do it because rice now seems profitable: there is market available, fertiliser, seed and also credit.* (A new rice farmer from Zonmon, field interview, November, 2012).

5.6 Analysis and Discussion

5.6.1 Interplay between interventions and local agency

In the rice value chain, we observed changes in practices of rice production, selling, financing and water management across the three areas studied. Beyond these direct outcomes, there were also some indirect effects. From the analysis of the three case studies, we conclude with Long (2001) and Verbole (2000) that, in their encounter with external interventions, the local actors transformed the interventions to fit their own needs. In the context of the three areas, we saw that farmers drew on the external interventions to create new opportunities, which in the normal course of their operations may not have happened. For instance, in Bamè, farmers used the framework of the PDAVV programme to move to the uplands, hence resolving the land conflict that existed in the lowlands. The existence of a formal market outlet and credit motivated farmers in Koussin-Lélé to themselves set new regulations for effective participation in canal cleaning.

However, we also saw an interaction between interventions and the physical context. At Zonmon, the increase in the number of farmers engaged in rice production was linked not only to the new rice market outlet and credit facility, but also to the floods occurring unexpectedly early. In Bamè, the existence of available upland area was another important additional condition for the positive outcome of the interventions. The timelines show in addition that the extension officers played broader intermediation roles than in classic extension (Klerkx et al., 2010) by facilitating the interaction between rice farmers and programme staffs.

Moreover, the analysis of the chronological events shows that the conflicts had different roles. In Bamè and Zonmon, the conflicts that emerged among the farmers can be interpreted as the consequence of the interventions for market outlet and input facilities, creating new inequalities between the farmers (Rothstein, 2005: 91). In Koussin-Lélé however, the PUASA intervention provided conditions to resolve the existing water distribution tension.

Farmers' strategies, the role of conflicts and physical conditions are further discussed in the next section in which we draw some lessons by comparing the three cases.

5.6.2 Factors shaping diversity of outcomes

This section explores the factors influencing the diverse patterns of responses to the external interventions in the three areas.

Subsistence strategy influencing diverse responses

Rice does not have the same importance in all three areas. In Koussin-Lélé and Bamè, rice is the main source of income, whereas in Zonmon farmers have many other income-generating activities (maize, vegetables, etc.). Hence, farmers' expectations regarding rice production are not the same. This difference influenced farmers' choices. According to Feeny (1983), smallholder farmers are subsistence-oriented, prioritising safety and reliability over long- or short-term profit. They then organise their resources by adapting external interventions to fit their subsistence strategy (Hasselskog, 2009). In Koussin-Lélé and Bamè, farmers used the opportunities offered by the external interventions to overcome some local constraints (canal cleaning, tension over land use in the command area). By doing so, farmers are strategic and solve their problems in ways that make sense for their interest (Stroosnijder, 2012). Darré (1999) argues that people react to new interventions depending on their own experiences, expectations and needs.

In the case of Zonmon where rice production was not a crucial source of household revenue, the external interventions did not have, at first, any indirect effects, beyond the expected programme outcomes. However, when subsistence strategies were hindered by the floods for two years consecutively, the farmers adapted their production practice to this changing context and turned to rice production in addition to vegetables and maize. Richards (1989) shows how small farmers adjusted their farming practices repeatedly to adapt to changing agricultural conditions. The farmers' need to guarantee their subsistence shapes the way they interact with external interventions, managing to deal with their daily needs and problems. The small farmers accommodated the external interventions in their local structures and subsistence strategies (Hasselskog, 2009).

Tensions as catalyst for change

In all three areas, there were conflicts among the farmers relating to collective resources. This observation urges further exploration of the role of conflicts in the interaction between interventions and local actions.

There were long-lasting social tensions among the elites and the regular farmers. Although the regular farmers can be seen as less powerful actors in Koussin-Lélé for instance, they initiated the rule change relating to collective canal cleaning (Long, 2001). Although the term conflict is often associated with negative encounters (Labianca et al., 1998), in the three areas the conflict played an important role in the changes that happened. Power differences and conflicts did not hinder farmers' ability to cope with the challenges they faced. Instead, they created new opportunities for the farmers. When the farmers engaged in a conflict, this fostered awareness about the existence of a problem among those who did not suffer from it. A positive effect of the conflicts was that they involved outsiders (extension agents, traditional leaders and community development committee) to seek solutions for the existing problems (Cosier and Dalton, 1990).

In the three areas, the conflicts played different roles: in Koussin-Lélé, the water conflict emerged before the external intervention. Then, the intervention was used to resolve the existing tension. However, in Bamè and Zonmon, the conflict emerged as a manifestation of the interventions creating new inequalities between the farmers. The way the conflicts were managed in the three areas contributed to the different outcomes of the interventions. In Koussin-Lélé, the water conflict was addressed by re-

arranging the rules for individual canal cleaning. In Bamè, farmers did not reach such a consensus, probably because of the hierarchical relationship and the importance of traditional norms in the village. Moreover, the fact that in Bamè all the farmers are from the same village did not give much room to change the institutional rules and solve the problems of land allocation in the lowlands. Instead of changing the local rules for land allocation, the conflict was pacified by using the alternative of the uplands for rice production. In the Zonmon case, the conflict was appeased when the vegetable farmers who had cut the water flow became involved in rice production.

Alternative production options and natural circumstances as elements of difference

The study has shown that farmers in the three areas do not have the same rice production options and are not dealing with the same natural context. The availability of land, apart from the lowlands, and the occurrence of floods differed in the three areas.

In Koussin-Lélé, farmers produced during the first and the second seasons in the lowland area. They hired the land surrounding the irrigated area to produce during the third growing season because they were not able to produce in the lowlands during the floods which frequently occur from July to September. In the dry season, from December to March the discharge capacity of the canals and the velocity of water flow decrease and water becomes scarce, irrigating only 63% of all the plots sufficiently (Totin et al., 2012). These characteristics contrast with Bamè where the inland valley is divided into two areas: (1) a lowland part, which allows gravity irrigation and (2) an upland part where no natural source of surface water is available and a groundwater pump is required. The rice farmers had the alternative of producing either in the lowlands or the uplands. Often, from July to September almost three-quarters of the lowlands is flooded, and farmers still have the alternative to produce in the upland part. However, in Zonmon, the farmers produced rice only in the lowlands. Because of its topography, the command area is frequently inundated, mainly from July to September. During this period, farmers were not able to produce rice at all because all the irrigated area was inundated and farmers did not have upland alternative.

The analysis of the chronological events in Zonmon shows that the flood that happened during two consecutive growing seasons, damaging the food crops, triggered the farmers to look for an alternative and reliable production option by combining rice with other crops. It seems that the market and credit facilities provided to rice farmers were not the main motivation for the 28 new farmers to start producing rice.

Hence, the physical conditions of the occurrence of floods and the availability of land in addition to the lowlands help to explain the different outcomes of the governmental programmes in addition to the importance of rice for farmers' livelihoods and the different ways in which tensions between the farmers were managed.

5.6.3 Implications for evaluating external interventions

The analysis elucidates that external interventions are in a constant process of interaction with local actions (Bierschenk, 1988). The change is not only the outcomes of the interventions, but rather a process that involves many actors who continuously reshape and transform the interventions to fit their goals and interests (Mongbo, 1995: 222; Verbole, 2000). Therefore, the investigation of intervention outcomes needs to focus not only on programme goals and planned activities, but also on social relations, actions and interactions (Bagozzi and Dholakia, 2002). Marsh (1978) presents goal-oriented evaluation as an objective and reliable approach for assessing changes. It focuses on the activities implemented to assess whether the goals and the objectives identified as important by the programme staff have been achieved or not (Horkoff and Yu, 2012). A weakness of the goal-oriented approach for evaluating external interventions is that it may underestimate the potential of local actions that also facilitate the expected changes (Binnendijk, 2000; Thurston and Potvin, 2003).

This study shows that changes should not be seen from a single perspective. Taking into account local actors' and interventionists' perspectives provided insight into the combined effect of several intervention programmes, local actions, tensions and intermediaries' roles. Many authors advocate the use of participatory evaluation approaches, such as responsive evaluation (Kouevi et al., 2013; Visse et al., 2012) or most significant change (Dart and Davies, 2003), because they promote collective agenda setting and shared expectations (Holte-McKenzie et al., 2006; Parkinson, 2009; Quintanilla and Packard, 2002; Scarinci et al., 2009). During the investigation, the interventionists often explained the changed local practices as a direct outcome of their activities without acknowledging the role of the farmers. However, although the farmers themselves mentioned actions they had undertaken over time, they did not attribute the changes to their own actions. In view of this latter observation, we doubt whether involving people in the evaluation as advocated in participatory approaches is a sufficient condition for a deep understanding of the changes.

5.7 Conclusions

The new generation of rice intensification policy in Benin has provided external institutional conditions for farmers to change their practices for rice production, selling, financing and water management and ultimately contributed to an increase in their incomes. The government programmes mitigated the main institutional barriers that hindered the rice farmers in the three research areas and allowed them to deal with the problems of ineffective water management, inequitable land allocation and discriminatory participation in canal cleaning.

The study shows that the generic interventions provided not only institutional conditions for rice intensification, but also room to change local rules that had previously hindered effective water management. We conclude that analysing the chain of events meticulously with a timeline, by triangulating interviews and informal conversations with field observations, is a good way to explain different outcomes of generic policy and sheds light on interactions with farmers' actions and local conditions.

Chapter 6

Synthesis

Synthesis

6.1 Introduction

This thesis aimed to investigate how institutions shape rice production in inland valleys in Benin. The research was conducted in the framework of the Convergence of Sciences, Strengthen Innovation System (CoS-SIS) research programme (see pages 159-161). The central assumptions of this programme are: 1) smallholders are aware of (bio-technical) opportunities to raise productivity, but 2) institutional changes are needed to create the enabling conditions for farmers to use these opportunities.

The starting point of this research was the outcome of a scoping study conducted on smallholder rice farmers in Benin (Saïdou and Kossou, 2009). The major outcomes of the scoping study were that: 1) the productivity and income of smallholder farmers are low, 2) one of the main reasons for this is the lack of water due to failure to clean the communal irrigation canals and 3) the high potential of inland valleys is underutilised. Three contrasting irrigation schemes in the inland valleys of the Agonlin Plateau (Koussin-Lélé, Bamè and Zonmon) were selected as case studies on the basis of this scoping study that screened 18 rice producing villages located throughout Benin. The following research questions were addressed:

1. What are the constraints in the local rice value chain and the opportunities for innovation in the research areas?
2. How and to what extent does the new generation of interventions create space for rice production in the research areas and overcome the shortcomings of previous interventions?

This chapter provides answers to these targeted research questions and reflects on how the results of the thesis contribute to the wider debate on the importance of institutions in agricultural innovation as a pathway to understand agricultural innovation processes better. It ends with the key conclusions and the implications of this research finding for policy, practice and further research.

6.2 Major findings

The main findings of the thesis are presented in this section. They concern the major constraints in the local rice value chain, the opportunities that exist for innovation, and the interrelation between external institutional changes and farmers' local actions.

6.2.1 Constraints and opportunities

The research shows in Chapters 2 and 3 that the overall barriers in the local rice value chain are not only technical, but also social and institutional. Moreover, the institutional barriers to innovation exist both at the local level and at supra-local level. The existing multiple constraints hinder farmers from taking better advantage of the existing opportunities. The constraints and opportunities are further described below.

Chapter 2 describes the main problems in local rice production and explains them from both a technical and an institutional perspective. It indicates that the first interventions to promote rice in Benin relied on technical changes to boost production, by introducing high-yielding varieties and irrigation technologies. This strategy placed little emphasis on the institutional conditions for change and therefore had limited success. Chapter 2 also provides a further understanding of how the economic reforms hindered the development of the rice sector. With the market liberalisation reforms in the 1980s, the private sector was allowed to import rice, and consequently the market for local rice shrank (Abiassi and Eclou, 2006; Adegbola and Singbo, 2005).

Furthermore, with economic liberalisation, production input distribution was opened up to private agents. The distribution of inputs (fertiliser, insecticide, herbicide and so forth) used to be under the control of public companies. After the reforms, only a few private businessmen had the monopoly on input

distribution. To make a better profit, they imported mainly inputs for cotton crop production because rice was not an official crop with a guaranteed collection system. Each rice farmer thus had to search for production inputs, each year. If they managed to access the input, they were asked to pay spot cash because, unlike cotton producers, they did not have access to credit facilities. Moreover, the type of fertiliser specifically adapted to rice and the inland valley conditions was not available, and farmers were obliged to use cotton fertiliser for their rice crop.

In the absence of an adequate formal credit system, most rice farmers tended to turn to local traders for loans, despite high interest rates of up to 150%. Since there was no guaranteed market outlet for the farmers to sell their rice harvest, their dependence on local traders increased, and they did not have any control of the rice selling price. These institutional conditions affected rice farmers' returns. In Koussin-Lélé, the most successful rice production area, a farmer's return on rice was only about 39% of the current minimum wage level in Benin (31,625 F cfa). In Bamè, the return per farmer was 11% of the minimum wage level, and only 8% in Zonmon. The chapter revealed that insufficient access to irrigation water also affected the rice outcomes in the three research areas. Even though farmers have other sources of income, these figures indicate the modest contribution of rice to income generation as a result of the constraining production conditions.

The lack of access to irrigation water is another main problem hindering rice production. It was established that faulty maintenance of the irrigation canals caused the farmers' insufficient or variable access to irrigation water. In spite of the existing regulations, farmers do not always comply with the rules, and therefore the canals are often insufficiently cleaned. The privileged farmers (group leaders, traditional chiefs and landowners) predominantly escaped from the canal cleaning duty. In response to the discriminatory participation in canal cleaning, the regular farmers chose to clean the canal less well than they were supposed to. They also deliberately took more time than the prescribed one day, to act out their frustration with the leaders.

Chapter 3 adds to the understanding of the water problem by explaining the main factors influencing individual farmers' participation in the collective maintenance of the canals and the difference that exists between the three case studies. The findings draw attention to the nature of the resource, the characteristics of the user group and farmer-based institutional arrangements as the key variables explaining the farmers' contribution to canal cleaning. The areas differ in the balance between water supply and demand, and farmers do not feel the need to enhance the water supply to the same extent. In Koussin-Lélé and Zonmon, farmers suffer from lack of water because of the large size of the command areas under rice cultivation, whereas in Bamè, there is seemingly a year-round abundance of water in the lowlands given the small area under rice cultivation in this part (4.5 ha). In Bamè, the farmers have the option of producing in the upland part of the inland valleys. In Koussin-Lélé and Zonmon, farmers do not have this facility, and they produced only in the lowlands.

Moreover, the difference between the three areas in the farmers' contribution to collective canal maintenance reflects the fact that rice does not have the same importance in all three areas. In Koussin-Lélé and Bamè, rice is a vital source of household revenue. In Zonmon however, farmers have many other income-generating activities. Another difference between Koussin-Lélé and the other areas is that the production area is not tied to a specific village. Koussin-Lélé is a production area used by farmers from different villages, and this adds an extra element of diversity. Indeed, the diversity of farmers' groups in Koussin-Lélé is conducive to cooperation. It creates a need for organisation and institution building. We observed that the degree of farmer discipline is strong in this irrigation area, resulting in relatively high levels of cooperation. In Bamè and Zonmon however, the irrigation schemes are located in the boundaries of the villages under the control of the traditional governance structures, whereas in Koussin-Lélé decisions are not made by the traditional chiefs alone (as is the case in Bamè and Zonmon), but also by the group committees and the board of the farmers' association.

The analysis in Chapter 4 complements the technical perspective by highlighting the inadequacy of the current irrigation schemes – an inadequacy that is not taken into account by the rice intensification interventions. In fact, the irrigation schemes in the three research areas were designed in the 1970s when rice was produced only in the most favourable cropping season, during which the command area received enough water flows to meet the crop's water needs. The local rice intensification policy, however, expects multiple cropping (up to three crops a year), but the same 'old' irrigation schemes have not been redesigned to suit a multiple cropping pattern.

After identifying the main constraints limiting the development of the local rice production chain, the study identifies the potential opportunities that exist for innovation in the rice chain. Chapter 2 shows that, from a bio-technical perspective, in the three irrigation schemes, the actual rice output remains far below the estimated potential of the command areas, given the water and land available in the inland valleys. It establishes that there is room for a considerable increase in rice production and associated incomes. For instance, in Koussin-Lélé and Bamè, farmers have lands in the uplands as well as the lowlands. Less than 10% of the potential land was used for rice production because of the lack of functioning irrigation facilities. Among the several options to help improve soil moisture in the uplands, mulch application was experimented with in collaboration with the farmers from the three areas and an extension agent (Chapter 4). Chapter 4 provides an operational option to improve soil moisture in the uplands to extend rice production in that part of the valleys.

Economically, Chapter 2 shows that the reduction in rice imports consequent to the rice crisis combined with the rapidly growing consumer demand, especially in urban areas, are potential opportunities for the improvement of domestic rice production. The higher international prices appeared to increase the competitiveness of domestic producers.

Chapter 3 adds an institutional dimension to opportunities by showing that traditional rules and formal institutions work against each other. Therefore, a *bricolage* of both traditional and formal institutional arrangements may be important for rule enforcement in the irrigation areas. Consequently, rice production and rice farmers' incomes may increase by re-negotiating the institutional arrangements to promote active cooperation among farmers in the three rice production areas.

The various programmes introduced by the Beninese government after the rice crisis in 2007 also created opportunities for the farmers to improve rice production in the research areas. In the following section, the outcomes of these government programme interventions are further discussed.

6.2.2 Effectiveness of rice policy

The first generation of interventions initiated between 1970 and 1990 targeted the construction of large irrigation schemes to stimulate rice production. Chapters 2 and 3 provide reasons for the limited success of these interventions. In contrast to these first interventions, which mainly disseminated irrigation technologies and high-yielding rice varieties, the new intervention programmes initiated after 2007 addressed some of the specific bottlenecks in local rice value chains such as market and credit facilities and subsidies for fertiliser and seeds. Chapter 5 shows that the programmes initiated after 2007 are quite effective in addressing the shortcomings of the first interventions and mitigate the major barriers that hindered the rice value chain. In all three areas, these intervention programmes have been successful in providing access to formal credit and markets for most rice farmers. Chapter 5 indicates that, between 2009 and 2012, total rice production increased in all three areas. Additionally, the total average amount of rice sold and farmers' rice return improved. Besides these direct outcomes relating to local rice intensification, the chapter investigates the role of these generic interventions in the change process. It is shown that the interventions provided not only institutional conditions for the intensification of local rice production, but also room for the farmers in Koussin-Lélé to change the local rules that had hindered effective water management. Farmers drew on the external interventions to create new opportunities for

themselves. For instance, in Bamè, farmers used the framework of the government intervention programmes to move to the uplands, hence resolving the land conflict that existed in the lowlands. In Koussin-Lélé, the existence of a formal market outlet and credit system motivated farmers themselves to set new regulations for effective participation in canal cleaning.

Chapters 4 and 5 indicate that the institutional settings created by the governmental programmes play an important role in shaping farmers' practices in the local rice value chain. As can be seen in Table 5.3 however, although the changes in some social practices were rather similar, others were more diverse in the three areas. The governmental intervention programmes facilitated changes in social practices relating to rice production (more cycles per year) and financing and rice selling in a formalised market system. In this respect, expected changes in social practices occurred in all three areas. Beyond these similarities, there are some obvious differences between the three areas. The most obvious ones are the change from limited collective canal cleaning to individual canal cleaning in Koussin-Lélé, the use of pumps in upland areas in Bamè and farmers who changed from growing vegetables or maize alone to growing rice in combination with these in Zonmon.

The timeline analysis in Chapter 5 shows that farmers' responses to external interventions are not only affected by the above local level institutions. Other factors, such as the importance of rice in satisfying subsistence prerequisites and alternative production options like available uplands, also influence farmers' responses. These interdependent factors explain the diverse patterns of responses to external interventions in the three areas.

6.3 Discussion

The findings highlight the important role of institutions in the local rice value chain. The numerous interventions undertaken to increase local rice production between 1970 and 1990 yielded limited success because they underestimated the socio-institutional context. Since the crisis of 2007, the new generation programmes have started by acknowledging the benefit of the institutional dimension for a successful intensification of local rice production. In this section, the reflection is organised around three key elements. First, the current rice policy and its sustainability are further discussed. Second, the dynamic of collective action, which is expected to allow smallholder farmers to improve their livelihood more than by operating individually (Barham and Chitemi, 2009; Markelova et al., 2009), is debated. While doing so, we reflect on why farmers in these areas are so hesitant about collective action. Finally, the CoS-SIS programme recommends innovation platforms of key multi-stakeholders as an option to stimulate and facilitate institutional changes (Hounkonnou et al., 2012). This suggestion is contextualised within the three research areas, where intensification of local rice production has occurred without an innovation platform in place. We discuss the relevance of innovation platforms for institutional changes.

6.3.1 Limits of the rice intensification policy

Rice production has increased as a result of the governmental programmes between 2007 and 2012 from 47,000 to 96,000 metric tons in Benin (Index-Mundi, 2012). Although current rice policy thus seems to be effective, rice production is still below its potential (Sohinto and Akomagni, 2008). Moreover, although these programmes address some of the major constraints as identified in our findings as well as in other studies (Dalohoun et al., 2009; Labitan, 2010), their sustainability could be questioned. Below, the sustainability of the policy and other challenges for a further intensification of rice production are analysed from three angles: (1) the current rice policy, (2) water management policy and (3) the complexity of inland ecosystem for rice production.

New rice policy

Since 2007, the policy approach to intensify local rice production has been successful in providing various institutional conditions for farmers, through different programmes. As discussed earlier, facilities such as market outlet development, credit access and subsidies on seeds and fertiliser have been provided to farmers to stimulate an increase in local rice production. However, doubts can be raised about the profitability of the government interventions. The government invests more than it gets in return. For instance, from the farmers' responses in the three areas and the calculation in Chapters 2 and 5, the farmers' public company (SONAPRA) bought the paddy from the farmers for between 160 and 175 F cfa per kg, and sold the milled rice at 200 F cfa per kg. An average of 1.43 kg of paddy (which may cost at least 228 F cfa) is used to produce 1 kg of milled rice sold at 200 F cfa. As a consequence, the programme loses at least 28 F cfa per kg of milled rice sold. The fertiliser is also subsidised for the rice farmers at 10,500 F cfa per bag, instead of 12,750 F cfa, the official price. The credit is provided to rice farmers at an interest rate of 9% per year, whereas the banks charge an average of 24%. In addition, the government provides extra funding for training the rice farmers. Given that these interventions cost money, they can be expected to raise political resistance at some point, even though this may be compensated elsewhere in the macroeconomic chain (e.g., through taxes).

According to authors including Leeuwis (2004a: 142) and Schot and Geels (2008), for innovations to become sustainable, it is important that a "protected space" for experimentation and development is temporarily provided. In that sense, the current government facilities provided for the rice farmers can be seen as a protected space aiming at stimulating the intensification of local rice production and ensuring food security. However, at a certain point the rice production will have to prove itself and 'survive', without, or with less, support. The question then is whether the local situation will have sufficiently matured to allow the new practices to continue without government protection. There is no guarantee that the success observed in the local rice sector will remain after the support provided by the government programmes has ended. Most of these current programmes are funded through loans (CARD, n.d.). The sustainability of these interventions needs a financing mechanism that allows the government to support the subsidies on the inputs and the credit system, each year. These conditions cannot be guaranteed when the funding is on a loan basis.

The current government will come to its end in 2016, and the new government may no longer view rice production as a priority. The same thing happened in the palm oil sector where a previous government invested to facilitate the expansion of industrial oil palm plantations in Benin, until the 1990s. When the socialist regime came to an end and with the structural adjustment policies imposed on African governments in the 1990s, most of the oil palm industrial complexes were privatised and the national policy for expansion of industrial plantations changed its focus (Carrere, 2010: 18–20). As policy priorities tend to shift along elections cycles, the same may occur for the rice policy.

Another problem with the rice policy relates to the restrictive credit system. The rural banks provide credit for rice production only, not for other crops such as maize and vegetables. However, farmers produce different crops in order to mitigate the effect of climate uncertainty. The farmers still turn to local traders and lenders for money, at high interest rates, as observed in the three research areas (Chapter 5). In such conditions, the farmers may not escape the dependence on local traders who demand high interest rates.

In all, despite its success, there are several doubts about the suitability of the new rice policy. There is no guarantee that rice intensification can continue when the support ends.

Water management policy

The reforms in the irrigation sector aimed to reduce government spending by creating autonomous entities for the maintenance of irrigation infrastructures. The reforms require farmers to take over the operation

and maintenance responsibilities, with little provision from the irrigation department to ensure maintenance. These reforms have allowed a new category of actors to emerge, the farmer elites. They organise their peers by collecting fees from individual farmers to ensure the maintenance of infrastructures and to deal with other agricultural problems (e.g., facilitate efficient access to irrigation water for all farmers, manage conflict over water distribution). One of the main weaknesses of the transfer process is that no initiative was taken to strengthen collective action among farmers and to train them in the maintenance of irrigation infrastructure. As a result, the power of the elites is merely strengthened (Mehmood et al., 1999).

Another limitation of the rice policy relates to the use of 'old' irrigation schemes. The irrigation schemes were designed in the 1970s, mainly in order to develop food crop production, especially rice cultivation in the valleys, with the purpose of reducing the country's cereal shortfall (African Development Bank Group, 1988). At that time, the cultivation of one rice-crop season (the most favourable season) supplemented with imports was enough to satisfy demand, since rice was not a common food and consumed only on special occasions. Gradually the context of rice has changed. Because of urbanisation, rice has become a common staple food (AfricaRice, 2011). The demand for rice grew from 25,000 to 346,000 metric tons between 1977 and 2012. The same infrastructures built for one rice-cropping season are still used for rice intensification with plural production cycles per year, without being redesigned. Clearly, the space for change of the current rice intensification policy is limited by the old configuration of the irrigation schemes, designed in a different rice context.

Complexity of inland valleys

Rice is mainly grown throughout Benin in inland valleys. Numerous authors explain that inland valleys offer high potential for rice production because the soil is very fertile in the lowlands, where the farmers can obtain a high yield with less input (e.g., chemical fertiliser) (Abe et al., 2009; Andriesse and Fresco, 1991; Andriesse et al., 1994). However, despite the potential of the inland valleys, rice production is a very complex activity in this ecosystem.

Poor water control is one of the main constraints in the inland valley. For instance, the soils in the lowland part in the three research areas are flooded for almost three to four months each year, hindering production activities in the lowland part of the valley. In the case of Zonmon, almost 85% of community members produce in the lowlands, be it maize, vegetables or rice. During the flood periods, farmers are not able to produce in the lowlands. Moreover, when the floods occur earlier than expected, damaging the crops produced, (local) food security is affected.

In addition, access to irrigation water becomes critical during the dry season. The water discharge decreases, making irrigation not possible in all plots. In short, the water supply is unreliable in inland valleys. Farmers are aware of the complexity of the inland areas. They have developed ways to allocate carefully their limited resources to produce and meet their livelihood needs and mitigate the effects of uncertainty. In Koussin-Lélé, two out of three farmers located in the tail section of the command area apply mulch in their plots to the exposed soil surface in order to maintain the desired soil moisture level. In Bamè, farmers prefer to cultivate their upland plots with IR-841, a rice variety that is only recommended for use in the lowlands. That rice cultivation practice goes against the recommendations of the extension staff, as shown in Chapter 4. In Zonmon, to cope with the unreliability of the irrigation water in the lowlands, the farmers start transplanting the rice nursery following the retreat of the water level after flooding, so that they harvest before the dry season.

Flooding is not possible in the upland area, but, in this part of the inland valleys, rice production depends mainly on rainfall. Given the uncertainty of rainfall, the high water demand of rice crops requires the resource-poor farmers to find a supplemental water source for irrigation, like the pumping system. The pumping irrigation system incurs considerable extra costs (for the pump, fuel and maintenance) and,

accordingly, increases rice production costs in the uplands. Farmers are aware of the extra costs of production in this part of the valleys. As this study shows, it was only when a better rice price was offered through SONAPRA's guaranteed market outlet that the farmers were motivated to move into the upland part and invest in a pumping system.

Inland valley rice production furthermore requires extensive labour, especially for land cleaning and ploughing, mainly because the clay soil is hard to work on when it is wet. The smallholder farmers deal with the complexity of the inland valley ecosystems by adapting their cropping practices (Obalum et al., 2011). Illustratively, in Zonmon, after two years of early floods, farmers adjusted their practices by combining rice production with maize and vegetables.

In sum, inland valleys are a potential area for rice production but suffer from continuous uncertainty about water supply. Smallholder farmers are therefore required to allocate the available resources carefully. This may provide an additional explanation as to why less than 8% of the potential of the national inland valleys in Benin has been used (Adegbola and Singbo, 2005).

6.3.2 Collective action

The research started from the assumption that, if farmers in the lowlands cleaned the canals collectively, they could increase rice production and their related income. In addition, collective action was required in order to obtain credit from the formal banks, which did not provide credit for individual farmers before the new credit system. In all three areas however, there was rather little cooperation among farmers. In this section, some of the reasons behind this limited cooperation are discussed.

In the three research areas, as in most cases in Benin, farmers produce rice in groups. However, the research shows that most farmers prefer to work individually, for themselves, even though they are organised in groups. Tiffen (2003), Lussier (2010) and Bandyopadhyay and Green (2013) explain that many communities in Africa are famous for their solidarity networking. Rauch gives an illustrative example of cooperation and self-organisation among traditional communities to reduce the food risks of their vulnerable people (Rauch, 1999: 124). If as many communities in Africa were famous for their solidarity as currently claimed, why nowadays do most rice farmers, for instance, prefer to produce individually and prefer individual solutions to cooperation, as shown in Chapter 3?

Scholars support the hypothesis that cooperation is more difficult in larger groups, but Chapter 3 indicates that the larger farmer groups with more than 200 farmers cooperate more effectively. This result contributes to the wider discussion about collective action theory by contrasting with the findings of other authors, including Fujiie et al. (2005). Another interesting feature of this study is the unexpected pattern observed with respect to group diversity. It is commonly assumed that people from heterogeneous communities are less likely to cooperate (Olson, 1965; Dayton-Johnson and Bardhan, 2002; Fujiie et al., 2005). However, Chapter 3 challenges this theoretical hypothesis by showing that the diversity of a community can also be conducive to cooperation. The study reveals that, although institutions play an important role in cooperation, they can compete with one another. The tension between traditional and formal institutions affects farmers' participation in collective canal cleaning.

The lack of collective action with regard to maintenance of irrigation canals and the desire to produce individually as shown in Chapters 2, 3 and 5 illustrate the rise of individualism (Christopher Earley and Gibson, 1998; Young and Stretton, 1991). Individualisation has both advantages and disadvantages. Illustratively, in Koussin-Lélé, effective maintenance of the canals was observed with the new individual cleaning rules. Additionally, opting for individual production allows farmers to buy their individual pumps in order to have better control of irrigation water. Because the farmers no longer depend on one another to produce, they are likely to invest more in their rice activities. Moreover, it prevents the free-rider problem associated with collective action (Lerman, 1998).

However, individualisation among communities is also often associated with major economic disruptions (Zacher, 1988; Rauch, 1999). From a farming perspective, the collapse of the collective labour groups due to the rise of individualisation and labour out-migration has led to labour shortage and thus to an increase in the cost of labour (Woolcock and Narayan, 2000).

In all, we see that the biophysical and the institutional contexts create both incentives and disincentives for cooperation. Although there may be many advantages in cooperation, an interesting phenomenon in the three areas is that farmers prefer the individual solution, when the situation allows it. Apparently, individualisation has progressed and has led to an increase in rice production. It also allows farmers to invest more in their rice activities.

6.3.3 The need of innovation platforms

It is widely recognised that innovations can only emerge and grow out of interactions among various stakeholders (Tenywa et al., 2011; World Bank, 2007). Innovation involves multiple actors, and is not an individual process. It is assumed that direct interaction helps to forge stronger linkages among involved stakeholders (Nederlof et al., 2011: 14). Because of the collective nature of innovations, a mechanism is needed to bring all relevant stakeholders together, to stimulate and facilitate the interaction among them. To enhance such interaction among different stakeholders, a number of recent initiatives are suggested, such as an innovation platform, as a space for interaction and coordination among multi-stakeholders (Badibanga et al., 2013; CORAF/WECARD, 2012). Warner (2005) and Devaux et al. (2009) highlight coordination and interaction as some of the key characteristics of a platform.

The CoS-SIS programme, within which this research was conducted, is based on the premise that an innovation platform is important for facilitating interaction among key stakeholders and stimulating institutional changes (Hounkonnou et al., 2012). In the case of water management in Benin, an innovation platform was set up in 2010. However, the actors initially invited to participate in the platform did not include any of the stakeholders in the rice value chain, except farmers. Subsequent efforts to invite onto the platform a stakeholder from the mill and advisory service failed (CoS-SIS, 2013: 28). Moreover, many of the activities planned by the platform had already been undertaken by the programmes operating in the areas. Consequently, the platform was not very active in the rice value chain.

Notwithstanding the lack of an innovation platform active in rice production in inland valleys, the rice farmers did change their practices in such a way that they produced more rice and gained a better return. As shown in this study, the conditions for this were provided by the government with two major rice intensification programmes.

The coordination between these interventions takes place via the staff of the government programmes. For instance, the credit programme (PDAC) cooperates with SONAPRA to enable deduction of the loan given to the farmers at the beginning of the growing seasons. The extension agents are involved in coordinating and facilitating, at farmers' level, a realistic use of credit and fertiliser. SONAPRA provides fertilisers to farmers and intervenes at the end of the growing season to buy the resulting paddy. The cost of fertiliser and the loan are deducted before farmers are paid for their paddy. This deliberate interaction among staffs of the programmes strengthens their individual interventions and helps them to prevent default on loan repayment.

Hence, although in the three research areas the platform was not active in the rice value chain, some of the key characteristics such as cooperation, coordination and orchestration inherent in platforms are at work within as well as among the different government programmes. These programmes and the way they cooperate with one another, as presented in Chapter 5, can be considered as a dynamic platform that enhances the performance of the conditions set for the intensification of local rice production. The interrelation/coordination that exists between these different programmes leads to the observed changes (e.g., market outlet, credit, seed and input facilities).

Hence, a platform does not need to be a formalised space where different stakeholders meet and interact in a concerted way to carry out activities (Nederlof et al., 2011: 14; Kilelu et al., 2013). From the experience in this study, it is possible for innovation to take place, with a self-coordination of the key stakeholders, even when there is no physical meeting space. The innovation platform cannot therefore be reduced to a formalised space for meetings. What is important is the interaction among the stakeholders. The coordination/interaction among the different stakeholders makes room for innovation to take place.

6.4 Recommendations for policy and further research

For more than three decades, scientific communities, developers, donors, policymakers and private entrepreneurs have spent large amounts of money on initiatives to improve rural livelihoods in the developing world (Lundy and Gottret, 2006). In the rice production sector in Benin for instance, since 1972, successive governments have initiated many programmes aimed at increasing rice production. Despite the expenditures and the works of researchers, local production has remained low. This research shows that disseminating technologies alone cannot facilitate an increase in rice production. Institutional conditions such as market, credit, seed and fertiliser facilities to support the technologies are also important in influencing rice production. On the basis of this finding, some specific options are suggested to support the increase in domestic rice production.

6.4.1 Policy: private and civil sectors

The government programmes are making visible efforts to increase domestic rice production and reduce rice imports, in the medium term. These programmes have been successful in all three research areas. However, these interventions may not be sustainable, as described in the previous sections. These concerns have to be addressed to adequately promote domestic production. Actions aimed at the sustainability of the rice sector could target either strategies for reducing production costs (see below) or options for a financial mechanism to guarantee the self-functioning of the rice value chain. We have seen in Chapter 5 that more attention is now given to credit and input facilities, but there is as yet not enough focus on the improvement of the quality of local rice, and on capacity building for more cooperation among farmers. It was further explained in Chapters 1 and 2 that local rice cannot compete with imported rice because of its poor standard and the lack of market information. These institutional problems have not yet received full attention. Government interventions need also to target and solve these problems as well as develop a wider market opportunity for local rice.

Reduction of rice production costs

For local rice to be competitive, it is important to reduce the production costs. Chapter 2 shows that farmers receive only a small income from rice production, so if production costs could be reduced, farmers may be able to improve their returns. Several options exist to reduce the cost of producing rice. Some of them are discussed below.

The government is promoting new hybrid high-yielding rice, early maturing and disease resistant varieties to boost rice production. The use of the improved and high-yielding varieties may decrease rice production costs. This research has shown, however, that sometimes farmers rationally choose the lower-yielding rice varieties (Chapter 4). The question that then emerges is: what conditions are needed to make hybrid varieties really profitable for the smallholder farmers?

Expanded and improved irrigation systems in inland valleys may be needed to decrease the unpredictability of the gravity system. Interventions (e.g., construction of small-scale irrigation schemes and dams) to provide irrigation access to farmers could allow them to have better control of the irrigation water and hence help to reduce production costs.

There is scope to reduce the production cost by working on the credit system. Public–private partnership could be a valuable option to facilitate farmers' access to agricultural inputs. In that context, rice production should not be viewed in isolation, but as a component of the whole agricultural system. Input suppliers, including banks, perceive the risks of facilitating the cultivation of other crops (maize, vegetables and so forth) as being much higher. For example, there is no guarantee that farmers will repay loans in the event of crop failure – a scenario that is due mostly to natural factors, beyond the control of farmers. The government could set up a guarantee fund to help cover the risk faced by farmers and private input suppliers. This initiative would encourage the private inputs sellers and banks to make the needed inputs available for other crops as well, at a correct price and at the right time. This could help all farmers to have access to formal credit at a reasonable interest rate and to improve their crop yields, consequently reducing their production costs.

Improve local rice quality

The diagnostic study shows in Chapter 2 that the locally milled rice is of poor quality and does not meet the requirements of urban consumers, whose incomes are higher. Local rice is mainly consumed in the rural areas. Chapter 2 indicates that rice processing is constrained by inadequate and inappropriate processing equipment, especially for post-harvest operations, such as milling, de-stoning and polishing. The inability to provide and use improved technologies in rice processing has led to the production of poor quality domestic rice that is not competitively marketable. In most rice production areas, farmers themselves mill the rice. However, they have no machines to remove stones properly from the rice and no processing skills. This contributes to the poor standard of local rice. Improved post-harvest technologies to help in the production of uniform rice without stones, for seed or consumption, would contribute to improving the standard of local rice.

Set up effective market information services

Chapter 2 shows that, because the farmers do not have access to market information, they are left to the mercy of local traders who define the rice selling price. Up-to-date market information is needed for rice farmers to guide them in their decision-making process. It may be important for them to know which kind of product to sell, whether paddy, parboiled or milled rice, where and when to sell it, and under what conditions. The lack of market information creates an unequal playing field between (local) traders and farmers. Arinloyé (2013) makes the same observation in the context of the pineapple chain in Benin. Information asymmetry affects the terms of trade for smallholder farmers and leads to the poor integration of markets across space and time. The government, the NGOs and the projects intervening in the agricultural sector in Benin could assist the farmers to have better access to information about rice prices, the different opportunities in existing market outlets and the price of inputs. Such an information system would provide incentives for farmers to produce at the best periods and to improve their incomes consistently. In the current system, because farmers do not have access to information, they all produce in the same period. Moreover, because they have to sell their harvest at the same time, the price goes down. Improved communications technologies, mainly the mobile phone, largely adopted by the farmers, could be used as appropriate channels to assist farmers to access market information.

6.4.2 Suggestions to support innovation platforms and cooperation

Innovation platforms are becoming a booming topic for both the research community (e.g., universities, CGIAR, FARA) and development workers (NGOs) (Tenywa et al., 2011; Hlamalani and Hagmann, 2011; Kilelu et al., 2013). However, the attention given to innovation platform use is more focused on bringing people together and search for practical ways to advance their livelihoods and create space for interaction among different stakeholders (Nederlof et al., 2011; Nederlof and Pyburn, 2012; Hounkonnou et al., 2012). Strong

focus on the 'bringing people together' dimension may overlook many other valuable aspects that affect the success of an innovation platform such as interaction, trust, confidence, understanding etc. (CORAF/WECARD, 2012). This research shows that innovation platforms should not be restricted to a formal meeting space (Kilelu et al., 2013). It explains that some key characteristics of innovation platforms (Warner, 2005; Devaux et al., 2009) that trigger institutional change can also take place without any formal meeting of platform members.

On the other hand, the research shows that, in the three areas, there is a rise of individualisation, and most farmers prefer individual solutions to collective options. Among other things, this indicates that the tension between traditional rules and formal institutions hinders cooperation. We estimate that an institutional *bricolage*, integrating both traditional and formal rules, could contribute to enhancing cooperation among the farmers.

6.4.3 Suggestions for a research agenda

More farmers are now involved in rice cultivation in Benin mainly because of the enabling institutional conditions provided by the government programmes. Therefore, it is clear that designing technology for rice production (e.g., seeds, irrigation patterns and so forth) is one thing, but it is also important to create conditions for the designed (new) technology to be used.

It has been established that institutions play a central role in the rice production chain, but it is important to realise that other factors such as history, the biophysical context and the importance of rice income for livelihoods also all influence farmers' practices. From the findings of this research, some new challenges have emerged that can be further explored. Future research could investigate some of the following key points. Since 2007, a new generation of interventions has been in place to boost local rice production. It may be interesting to explore (1) how the national agricultural research agenda is embedded in this new rice policy implemented since 2007 to enhance innovation in rice value chain. Regarding the gap that exists between research activities and their concrete contribution to the development of communities, it might be interesting to further reflect on (2) how to articulate (agricultural) research demands and objects to make research activities relevant for development and research users, in a changing institutional context.

This research raised some concerns about the sustainability of the government intervention programmes, mainly whether the local situation will have sufficiently matured to allow the new practices to continue without government protection. Therefore, future research may be needed to address the question of (3) what kind of institutional *bricolage* can enable the sustainability of the government interventions in rice production in Benin. Regarding the tension between local and formal rules (Chapter 3), institutional *bricolage* was also suggested to improve cooperation. It may be useful for further research to investigate (4) how to achieve a *bricolage* to improve collective action.

6.5 Conclusion

The aim of this thesis was to analyse the role of institutions in rice production, especially in the inland valley context of Benin. The research shows that institutions indeed played an important role in the local rice production chain. Illustratively, the first generation of interventions to promote local rice production in Benin, between 1970 and 1990, did not pay much attention to this dimension and hence had limited success (Adegbola and Singbo, 2005). In contrast to these first interventions, the new government programmes started in 2007 by providing institutional conditions for farmers to improve local production. In only five years (between 2007 and 2012), local rice production doubled, increasing from 47,000 to 96,000 metric tons because of the facilitating conditions that were created. The research shows that investment in the institutional context really matters. It can stimulate the innovation process and enhance

agricultural outcomes in a relatively short time. This finding confirms Werle's (2012) analysis of the interplay between technology and institutions. He explains that institutional arrangements influence the uptake of technology. In this rice production study, it was observed that the institutional conditions that the government programmes created stimulated the increase in local rice production. However, the government interventions may not be sustainable or complete because some institutions are better supported than other. For instance, they have focused on credit and market issues, with less attention being given to capacity building to strengthen cooperation.

The study highlights in Chapter 3 that providing institutional conditions is neither a panacea nor a miracle solution, because the influences of the diverse institutions influencing people's practices do not go in the same direction. Idrissou et al. (2013) made the same observation in the case of natural resources management. The tension between formal and traditional rules creates room for distrust and conflict among the natural resource users (Idrissou et al., 2013). The findings in the rice areas also show the existence of a tension, among others, between the local rules grounded in tradition and the external rules designed by the extension workers for canal maintenance. A better integration of both traditional and formal rules (an institutional *bricolage*) at the local level could improve the cooperation in the management of the collective irrigation infrastructure. However, the thesis also makes clear that the setting of new institutional conditions (such as market and credit conditions) creates space for negotiation of new social relations and arrangements that can bypass existing institutions (e.g., traditional leadership). It thus demonstrates the complex interrelation between higher level institutional changes and local institutional dynamics.

As stated earlier, the research indicates that institutions play an important role in the local rice value chain, but other factors such as history, the biophysical context including technology, and the importance of rice income for livelihoods all influence farmers' choices.

Another implication of this research relates to the way institutions influence practices. They do not directly affect people's practices; rather, they create new conditions that stimulate changes in practices. Other studies have come to similar conclusions (Battilana et al., 2009; Garrett and Lange, 1995). The changes happened through the interplay between external actions and beneficiaries' own initiatives. This has implication for evaluation studies. Often, researchers or interventionists claim the changes as the outcomes of their activities only, overlooking the capacity of the local community to influence the change process as well: their agency. In practice, change is not possible without beneficiaries' own initiatives and depends on the complex interrelation between external interventions and people's local actions.

In all, the thesis shows the how institutions have influenced rice production and water management. Many institutional studies are about social issues (Arts and Buizer, 2009; Behera, and Engel, 2006). One of the main contributions of this thesis relates to the points it established by linking institutional issues with technical dimensions. Chapters 3 and 4 explain the interrelations between institutions and technologies used for water management. The experimental procedure described in Chapter 4 was grounded in the institutional context but also had a technical purpose (e.g., identifying water use options that allow the expansion of rice production in the uplands).

References

Abe, S.S., Oyediran, G.O., Masunaga, T., Yamamoto, S., Honna, T., Wakatsuki, T., 2009. Soil Development and Fertility Characteristics of Inland Valleys in the Rain Forest Zone of Nigeria: Mineralogical Composition and Particle-Size Distribution. Pedosphere 19, 505-514.

Abiassi, E., Eclou, S., 2006. Etude sur les instruments de régulation des importations commerciales de riz au Bénin. CCR-B/FUPRO.

Adegbola, P., Singbo, A., 2005. Impact de l'importation du riz sur la competitivite et la rentabilite de la production nationale au Benin, Communication à l'atelier régional de l'ADRAO sur le thème : "Politique et stratégies pour la promotion de la production rizicole et la sécurité alimentaire en Afrique subsaharienne", Cotonou.

Adeniyan, B.O., Ojeniyi, S.O., Awodun, M.A., 2008. Relative Effect of Weed Mulch Types on Soil Properties and Yield of Yam in Southwest Nigeria. Journal of Soil and Nature 2, 1-5.

Adjei-Nsiah, S., Kuyper, T.W., Leeuwis, C., Abekoe, M.K., Cobbinah, J., Sakyi-Dawson, O., Giller, K.E., 2008. Farmers' agronomic and social evaluation of productivity, yield and N-2-fixation in different cowpea varieties and their subsequent residual N effects on a succeeding maize crop. Nutr Cycl Agroecosys 80, 199-209.

African Development Bank Group, 1988. Oueme Valley Irrigated Agricultural Development Project: Project Performance Evaluation Report (PPER). African Development Bank Group, Operations Evalution Department, p. 27.

AfricaRice, 2011. Boosting Africa's Rice Sector: A research for development strategy 2011-2020. Cotonou, Benin.

Ahmed, I. and Lipton, M., 1997. Impact of Structural Adjustment on Sustainable Rural Livelihoods: A Review of the Literature. Brighton (UK): Institute of Development Studies and Poverty Research Unit, University of Sussex (IDS). Working Paper 62, pp. 33.

Andriesse, W., Fresco, L.O., 1991. A characterization of rice-growing environments in West Africa. Agriculture, Ecosystems & Environment 33, 377-395.

Andriesse, W., Fresco, L.O., Van Duivenbooden, N., Windmeijer, P.N., 1994. Multi-scale characterization of inland valley agro-ecosystems in West Africa. Netherlands Journal of Agricultural Science 42, 159-179.

Araral JR, E., 2009. What explains collective action in the commons? Theory and evidence from the Philippines, World Development 37, 687-697.

Araya, A., Stroosnijder, L., 2010. Effects of tied ridges and mulch on barley (*Hordeum vulgare*) rainwater use efficiency and production in Northern Ethiopia. Agricultural Water Management 97, 841-847.

Araya, A., Stroosnijder, L., Girmay, G., Keesstra, S.D., 2011. Crop coefficient, yield response to water stress and water productivity of teff (Eragrostis tef (Zucc.). Agricultural Water Management 98, 775-783.

Arinloye, D., 2013. Governance, marketing and innovations in Beninese pineapple supply chains. A survey of smallholder farmers in South Benin. Wageningen University, p. 193.

Arowolo, D., 2010. The effects of Western civilisation and culture on Africa. Afro-Asian Journal of Social Sciences 1, 1-13.

Arts, B., Buizer, M., 2009. Forests, discourses, institutions: A discursive-institutional analysis of global forest governance. Forest Policy Econ 11, 340-347.

Asbury, J., 1995. Overview of focus group research. Qualitative Health Research 5, 414-420.

Ashby, J., Pretly, J., 2006. Commentary: Participatory research for sustainable agricultural research and development. International Journal of Agricultural Sustainabilty 4, 97-98.

Atidégla, S., Agbossou, E. K., Braima, J., 2010. Étude comparée des modes d'irrigation dans les exploitations maraîchères urbaines et péri urbaines de la commune de Grand-Popo au Bénin. Annales des Sciences Agronomiques 13, 41-67.

Badibanga, T., Ragasa, C., Ulimwengu, J., 2013. Assessing the effectiveness of Multitakeholder Platforms: Agricultural and Rural Management in the Democratic Republic of the Congo, Development Strategy and Governance Division. International Food Policy Research Institute (IFPRI), Washington, p. 32.

Bagozzi, R.P., Dholakia, U.M., 2002. Intentional social action in virtual communities. Journal of Interactive Marketing 16, 2-21.

References

Bandaragoda, D.J., 2001. A Framework for Institutional Analysis for Water-Resources Management in a River Basin Context, in: Bruns, B., Bandaragoda, D.J., Samad, M. (Eds.), Regional Workshop on Institutional Strategies for Improving the Productivity of Agricultural Water Management. International Water Management Institute, Malang, Indonesia, pp. 3-18.

Bandyopadhyay, S., Green, E., 2013. Nation-Building and Conflict in Modern Africa. World Development 45, 108-118.

Barham, J., Chitemi, C., 2009. Collective action initiatives to improve marketing performance: Lessons from farmer groups in Tanzania. Food Policy 34, 53-59.

Battilana, J., Leca, B., Boxenbaum, E., 2009. How Actors Change Institutions: Towards a Theory of Institutional Entrepreneurship. The Academy of Management Annals 3, 65-107.

Baxter, P., Jack, S., 2008. Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. The Qualitative Report 13, 544-559.

Behera, B., Engel, S., 2006. Institutional analysis of evolution of joint forest management in India: A new institutional economics approach. Forest Policy Econ 8, 350-362.

Biernacki, P., Waldorf, D., 1981. Snowball Sampling: Problems and Techniques of Chain Referral Sampling. Sociological Methods & Research 10, 141-163.

Bierschenk, T., 1988. Development projects as arenas of negotiation for strategic groups: A case study from Bénin. Sociol Ruralis 28, 146-160.

Biggs, S., 2007. Building on the positive: an actor innovation approach to finding and promoting pro-poor institutional and technical innovations. International Journal Agricultural Resources, Governance and Ecology 6, 144-164.

Biggs, S., Smith, G., 1998. Beyond methodologies: Coalition-building for participatory technology development. World Development 26, 239-248.

Binnendijk, A., 2000. Results based management in the development co-operation agencies: A review of experience. The Development Assistance Committee (DAC) Working Party on Aid Evaluation, Paris.

Brewer, M. B. and Kramer, R. M., 1986. Choice Behaviour in Social Dilemmas: Effects of Social Identity, Group Size, and Decision Framing. Journal of Personality and Social Psychology 50, 543-549.

Bricas, N., Sauvinet, R., 1989. La diversification de la consommation: une tendance de l'évolution des styles alimentaires au Sahel, Les Espaces Céréaliers Régionaux en Afrique de l'Ouest, Ouagadougou, Paris, CILSS-OCDE-Club du Sahel, p. 25.

Brydon-Miller, M., Greenwood, D., Maguire, P., 2003. Why Action Research? Action Research 1, 9-28.

CARD (Coalition for African Rice Development) no date. Fiche d'informations sur le projet/programme riz dans les pays du deuxième groupe de la CARD. Retrieved from http://www.riceforafrica.org/new/index.php?option=com_content&view=article&id=1130%3Bj-28&Itemid=209 (accessed March, 2013).

Carrere, R., 2010. Oil palm in Africa, past, present and future scenarios, World rainforest movement series on tree plantations, p. 68.

Carter, M.R., 2008. Knock, knock: Where is the Evidence for Dangerous Human-Caused Global Warming? Economic Analysis & Policy 38, 177-202.

Chambers, R., 1994. Paradigm shifts and the practice of participatory research and development. Institute of Development Studies, UK.

Chambers, R., and Jiggins, J., 1987. Agricultural research for resource-poor farmers. Part I: Transfer of Technology and Farming Systems Research. Agricultural Administration and Extension 27, 35-52.

Chambers, R., Ghildyal, B.P., 1985. Agricultural research for resource-poor farmers: The farmer-first-and-last model. Agricultural Administration 20, 1-30.

Chizema, A., Buck, T., 2006. Neo-institutional theory and institutional change: Towards empirical tests on the "Americanization" of German executive pay. International Business Review 15, 488-504.

Christopher Earley, P., Gibson, C.B., 1998. Taking stock in our progress on individualism-collectivism: 100 years of solidarity and community. Journal of Management 24, 265-304.

Cleaver, F., 2002. Reinventing institutions: Bricolage and the social embeddedness of natural resource management. The European Journal of Development Research 14, 11-30.

CORAF/WECARD, 2012. Integrated Agricultural Research for Development (IAR4D)- Innovation Systems: Innovation Platforms (IP) of Agriculture Value Chains. CORAF/WECARD, Dakar, Senegal, p. 19.

Cosier, R., Dalton, R.D., 1990. Positive effects of conflict: A field assessment. International journal of conflict management 1, 81-92.

CoS-SIS, 2013. CoS-SIS with one year to go: What is it? What has it achieved so far? Convergence of Sciences, Wageningen, The Netherlands, p. 69.

Cousins, J.B., MacDonald, C.J., 1998. Conceptualizing the successful product development project as a basis for evaluating management training in technology-based companies: a participatory concept mapping application. Evaluation and program planning 21, 333-344.

Cunha, P.M., Cunha, R.C., 2003. The interplay of planned and emergent change in Cuba. International Business Review 12, 445-459.

Dalohoun, D.N., Hall;, A., Mele., P.V., 2009. Entrepreneurship as driver of a 'self-organizing system of innovation': the case of NERICA in Benin. International Journal of Technology Management and Sustainable Development 8, 87-101.

Darré, J-P., 1999. La production de connaissance pour l'action. Arguments contre le racisme de l'intelligence. Maison des Sciences de l'Homme, INRA, Paris.

Dart, J., Davies, R., 2003. A Dialogical, Story-Based Evaluation Tool: The Most Significant Change Technique. The American Journal of Evaluation 24, 137-155.

Dayton-Johnson, J. and Bardhan, P., 2002. Inequality and conservation on the local commons: a theoretical exercise. The Economic Journal 112, 577-602.

de Sardan, J.-P.O., 1995. Anthropologie et développement: Essai en socio-anthropologie du changement social. APAD-Karthala, Paris.

De Schutter, O., 2009. Rapport du Rapporteur Special sur le droit à l'alimentation. Cotonou Office du ONU, pp. 22.

Devaux, A., Horton, D., Velasco, C., Thiele, G., López, G., Bernet, T., Reinoso, I., Ordinola, M., 2009. Collective action for market chain innovation in the Andes. Food Policy 34, 31-38.

Dick, B., 2006. Action research literature. Action Research 4, 439-458.

Direction Générale des Prévisions et des Statistiques Agricoles-DGPSA, 2008. Restrictions à l'exportation du riz : risque de pénuries dans les pays fortement importateurs, in AgriAlerte (Ed.), Alerte sur la situation de la campagne agricole des régions-Burkina-Faso-N°021-02/04/2008 www.sosfaim.be/pdf/fr/dajaloo/references/riz/risques_penuries_riz_agrialerte_n021.pdf (available online on January 2011).

Djagba, J.F., 2006. Etude des expériences d'aménagement hydro-agricole des vallées de l'Ouémé et du Zou à Zagnanado et Covè, Département de Géographie. Université d'Abomey-Calavi, Benin, Abomey-Calavi, p. 152.

Dormon, E.N.A., Leeuwis, C., Fiadjoe, F.Y., Sakyi-Dawson, O., van Huis, A., 2007. Creating space for innovation: the case of cocoa production in the Suhum-Kraboa-Coalter District of Ghana. International Journal of Agricultural Sustainability 5, 232-246.

Douthwaite, B., Keatinge, J.D.H., Park, J.R., 2001. Why promising technologies fail: the neglected role of user innovation during adoption. Research Policy 30, 819-836.

Douthwaite, B., Keatinge, J.D.H., Park, J.R., 2002. Learning selection: an evolutionary model for understanding, implementing and evaluating participatory technology development. Agricultural Systems 72, 109-131.

Duggleby, W., 2005. What about focus group interaction data? Qualitative Health Research 15, 832-840.

Edquist, C., 1997. Systems of innovation: Technologies, institutions and organisations. Pinter, London and Washington.

Edquist, C., 2011. Design of innovation policy through diagnostic analysis: identification of systemic problems (or failures). Industrial and Corporate Change 20, 1725-1753.

Eek, D. and Biel, A., 2003. The interplay between greed, efficiency, and fairness in public-goods dilemmas. Social Justice Research 16, 195-215.

El-Basyouny, K., Sayed, T., 2011. A full Bayes multivariate intervention model with random parameters among matched pairs for before–after safety evaluation. Accident Analysis & Prevention 43, 87-94.

Fagade, S.O., 2000. Yield gaps and productivity decline in rice production in Nigeria. Pp. 15-37, in: FAO (Ed.), Proceedings of the Expert Consultation on Yield Gap and Productivity Decline in Rice, Rome, Italy.

Feeny, D., 1983. The Moral or the Rational Peasant? Competing Hypotheses of Collective Action. The Journal of Asian Studies 42, 769-789.

References

Fish, R.D., Ioris, A.A.R., Watson, N.M., 2010. Integrating water and agricultural management: Collaborative governance for a complex policy problem. Science of The Total Environment 408, 5623-5630.

Flyvbjerg, B., 2006. Five Misunderstandings About Case-Study Research. Qualitative Inquiry 12, 219-245.

Freeman, S., Gnayem, N., 2004. Use of plasticulture for strawberry plant production. Small Fruits Review 4, 21-32.

Fujiie, M., Hayamib, Y. and Kikuchic, M., 2005. The conditions of collective action for the local commons management: the case of irrigation in the Philippines, Agricultural Economics 33, 179-189.

Garrett, G., Lange, P., 1995. Internationalization, institutions, and political change. International Organization 49, 627-655.

Gaudin, R., 2012. The kinetics of ammonia disappearance from deep-placed urea supergranules (USG) in transplanted rice: the effects of split USG application and PK fertiliser. Paddy Water Environ 10, 1-5.

Gautam, A.P., 2007. Group size, heterogeneity and collective action outcomes: Evidence from community forestry in Nepal, International Journal of Sustainable Development and World Ecology 14, 574-583.

Geels, F.W., 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Research Policy 31, 1257-1274.

Gerber, J.M., 1992. Farmer participation in research: A model for adaptive research and education. American Journal of Alternative Agriculture 7, 118-121.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., Trow, M., 1994. The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies. SAGE Publications Ltd, London.

Giddens, A., 1984. The Constitution of Society: Outline of the Theory of Structuration, Berkeley. University of California Press.

Giddens, A., Audet, M., 2005. La constitution de la société: éléments de la théorie de la structuration. Presses universitaires de France, Paris.

Gopalakrishnan, S., 2005. Collective action in the management of common-pool resources: is there an alternative to the rational choice model? East Lansing: Michigan State University, Department of Agricultural Economics, working paper, pp. 62.

Hall, A., Rasheed Sulaiman, V., Clark, N., Yoganand, B., 2003. From measuring impact to learning institutional lessons: an innovation systems perspective on improving the management of international agricultural research. Agricultural Systems 78, 213-241.

Hanatani, A., 2010. Exploring the causal mechanism of collective action for sustainable resource management. A comparative analysis of rural water supply systems in Senegal Tokyo: JICA Research Institute, pp. 55.

Hargrave, T., Andrew, J., and Van De Ven, H., 2006. A collective action model of institutional innovation. Academy of Management Review 31, 864-888.

Hasselskog, M., 2009. Development Intervention on the Ground: Inherent rationales of aid and their encounter with local dynamics in three Cambodian villages. Peace and Development Research, School of Global Studies. University of Gothenburg, Göteborg, Sweden, p. 311.

Hawkins, J.D., Guo, J., Hill, K.G., Battin-Pearson, S., Abbott, R.D., 2001. Long-Term Effects of the Seattle Social Development Intervention on School Bonding Trajectories. Applied Developmental Science 5, 225-236.

Henrich, J., McElreath, R., 2002. Are peasants risk-averse decision makers? Current Anthropology 43, 172-181.

Hlamalani, N., Hagmann, J., 2011. Making innovation systems work in practice: experiences in integrating innovation, social learning and knowledge in innovation platforms. Knowledge Management for Development Journal 7, 109-124.

Hill, D., 2000. Assessing the Promise and Limitations of Joint Forest management in an Era of Globalization: the Case of West Bengal, Paper presented at the Eighth Biennial Conference of the International Association for the Study of Common Property "Constituting the Commons: Crafting Sustainable Commons in the New Millennium", Bloomington, Indiana, USA, May 31st-June 4th.

Holte-McKenzie, M., Forde, S., Theobald, S., 2006. Development of a participatory monitoring and evaluation strategy. Evaluation and program planning 29, 365-376.

Holzinger, K., 2008. Transnational common goods: Strategic constellations, collective action problems, and multi-level provision. New York : Palgrave Macmillan, St. Martin's Press.

Hounkonnou, D., 2001. Listen to the Cradle: Building from local dynamics for African Renaissance, case studies in rural areas in Benin, Burkina Faso and Ghana. Wageningen University, p. 267.

Hounkonnou, D., Kossou, D., Kuyper, T., Leeuwis, C., Nederlof, S., Röling, N., Sakyi-Dawson, O., Traoré, M., van Huis, A., 2012. An innovation systems approach to institutional change: Smallholder development in West Africa. Agricultural Systems 108, 74-83.

Hugon, P., 2007. Méso analyse de filières et politiques publiques, illustration par les filières cotonnières en Afrique. Université Paris X Nanterre.

Idrissou Latifou., van Paassen, A., Aarts, N., Vodouhè, S., Leeuwis, C., 2013. Trust and hidden conflict in participatory natural resources management: The case of the Pendjari national park (PNP) in Benin. Forest Policy Econ 27, 65-74.

IFAD, 2008. Climate change and the future of smallholder agriculture: How can the rural poor people be part of the solution to climate change? Proceedings of the Governing Council Round Tables: Challenges and opportunities for smallholder farmers in the context of climate change and new demands on agriculture. IFAD, Italy.

Index-Mundi, 2012. Retrieved from http://www.indexmundi.com/agriculture/?country=bj&commodity=milled-rice&graph=production (accessed June 2013).

Isaac, W.A.P., Brathwaite, R.A.I., Cohen, J.E., Bekele, I., 2007. Effects of Alternative Weed Management Strategies on Commelina diffusa (Burn) Infestations in Fair trade Banana (Musa spp.) in St. Vincent and the Grenadines. Crop Protection 26, 1219-1225.

Issaka, R.N., Buri, M.M., and Wakatsuki, T., 2008. Importance of rice to Ghana's economy. Pp. 1-5 in Buri, M.M., Issaka, R.N., and Wakatsuki, T. (Eds), The "SAWAH" system of rice production, Higashi-Osaka.

Jacob, E., 1998. Clarifying Qualitative Research: A Focus on Traditions. Educational Researcher 17, 16-24.

Janssen, S., van Ittersum, M.K., 2007. Assessing farm innovations and responses to policies: A review of bio-economic farm models. Agricultural Systems 94, 622-636.

Jiggins, J., 2012. Diagnostic research in support of innovation. Njas-Wagen J Life Sc 60-63, 115-121.

Kanbur, R., 2003. Development economics and the compensation principle. International Social Science Journal 55, 27-35.

Kefasi, N., Pali P, Fatunbi A.O, Olarinde L.O, Njuki J, Adekunle, A.O., 2012. Stakeholder Participation in Innovation Platform and Implications for Integrated Agricultural Research for Development (IAR4D) International Journal of Agriculture and Forestry 2, 92-100.

Khavul, S., Chavez, H., Bruton, G.D., 2013. When institutional change outruns the change agent: The contested terrain of entrepreneurial microfinance for those in poverty. Journal of Business Venturing 28, 30-50.

Kiepe, P., 2009. Integrated Watershed Management: Connecting people to their land and water. Exp Agr 45, 236-236.

Kilelu, C.W., Klerkx, L., Leeuwis, C., 2013. Unravelling the role of innovation platforms in supporting co-evolution of innovation: Contributions and tensions in a smallholder dairy development programme. Agricultural Systems 118, 65-77.

Kilelu, C.W., Klerkx, L., Leeuwis, C., Hall, A., 2011. Beyond knowledge brokering: an exploratory study on innovation intermediaries in an evolving smallholder agricultural system in Kenya. Knowledge Management for Development Journal 7, 84-108.

Kitzinger, J., 1994. The methodology of Focus Groups: the importance of interaction between research participants. Sociology of Health & Illness 16, 103-121.

Klein Woolthuis, R., Lankhuizen, M., Gilsing, V., 2005. A system failure framework for innovation policy design. Technovation 25, 609-619.

Klerkx, L., Aarts, N., Leeuwis, C., 2010. Adaptive management in agricultural innovation systems: The interactions between innovation networks and their environment. Agricultural Systems 103, 390-400.

Klerkx, L., van Mierlo, B., Leeuwis, C., 2012. Evolution of systems approaches to agricultural innovation: concepts, analysis and interventions, in: Darnhofer, I., Gibbon, D., Dedieu, B. (Eds.), Farming Systems Research into the 21st Century: The New Dynamic. Springer Netherlands, pp. 457-483.

Kolb, D.A., 1984. Experiential learning: experience as the source of learning and development. Prentice Hall, Englewood (New Jersey).

Kollock, P., 1998. Social dilemmas: the anatomy of cooperation. Annual Review of Sociology 24, 183-214.

Koné, B., Ettien, J.B., Amadji. G., Diatta, S., 2008. Caractérisation de la tolérance de NERICA a la sécheresse de mi-saison en riziculture pluviale. African Crop Science Journal 16, 133-145.

References

Kouévi, A.T., van Mierlo, B., Leeuwis, C., Vodouhe, S.D., 2013. The design of a contextualized responsive evaluation framework for fishery management in Benin. Evaluation and program planning 36, 15-28.

Kristjansona, P., Placeb, F., Franzelb, S., Thornton, P.K., 2002. Assessing research impact on poverty: the importance of farmers' perspectives. Agricultural Systems 72, 73-92.

Kwesi, J., 2007. Intégrer les autorités traditionnelles dans les systèmes de gouvernement démocratiques: le défi de la réforme de la dualité. In: Sy, O., Sauquet, M. and Vielajus, M. (Eds.). Entre tradition et modernité, quelle gouvernance pour l'Afrique? Actes du colloque de Bamako du 23 au 25 Janvier 2007, pp. 174-179.

Labianca, G., Brass, D.J., Gray, B., 1998. Social Networks and Perceptions of Intergroup Conflict: The Role of Negative Relationships and Third Parties. Academy of Management Journal 41, 55-67.

Labitan, C., 2010. Evaluation of the necessary of agriculture public expenditure for poverty reduction and food security in Benin. Zhongnan University of Economic and Law, p. 23.

Lançon, F., Erenstrein, O., 2002. Potential and prospects for Rice production in West Africa, Presentation at "Sub-Regional Workshop on Harmonization of Policies and Co-ordination of Programmes on Rice in the ECOWAS Sub-Region", Accra, Ghana 25-28 February 2002, p. 23.

Laurier, E., 2008. Participant observation, Working paper. University of Glasgow.

Le Coq, J.-F., Trebuil, G., 2005. Impact of Economic Liberalization on Rice Intensification, Agricultural Diversification, and Rural Livelihoods in the Mekong Delta, Vietnam. The Southeast Asian studies 42, 519-547.

Leeuwis, C., 2004a. Communication for Rural Innovation. Rethinking Agricultural Extension. 3 rd ed., Blackwell Science, Oxford, p. 426.

Leeuwis, C., 2004b. Innovation as a process of network building, social learning and negociation-Implication for transdisciplinary research collaboration, Communication presented at Trans-KARST2004- International Transdisciplanary Conference on Development and Conservation of Karst-Region, Hanoi.

Leeuwis, C., Aarts, N., 2011. Rethinking communication in innovation process: creating space for change in complex systems. The Journal of Agriculture Education and Extension 17, 21-36.

Lerman, Z., 1998. Does land reform matter? Some experiences from the former Soviet Union. European Review of Agricultural Economics 25, 307-330.

Long, N., 2001. Development sociology: Actor Perspectives. Routledge, London & New-York.

Lundy, M., Gottret, M. V. and Ashby, J., 2005., Learning alliance an approach for building Multi-Stakeholder innovation Systems, ILAC Brief n°8.

Lundy, M., Gottret, M.V., 2006. Learning alliances: An approach for building multi-stakeholder innovation systems.

Lussier, D.N., 2010. From solidarity to division: An analysis of Lech Wałęsa's transition to constituted leadership. The Leadership Quarterly 21, 703-715.

Lustiger-Thaler, H., Maheu, L., and Hamel, P., 1998. Enjeux institutionnels et action collective. Sociologie et sociétés 30, 53-63.

MAEP, 2007. Dossier technique d'exécution des travaux d'aménagement des bas-fonds et périmètres irrigués du département du Zou, Rapport de consultation. Ministère de l'Agriculture de l'Elevage et de la Pêche Cotonou, Benin, p. 37.

MAEP, 2010. Strategie nationale pour le developpement de la riziculture au Benin. Ministère de l'Agriculture, de l'Elevage et de la Pêche. Retrieved from www.riceforafrica.org/new/downloads/Countries/benin/benin_WW1.pdfaccessed February on June 2011).

Markelova, H., Meinzen-Dick, R., Hellin, J., Dohrn, S., 2009. Collective action for smallholder market access. Food Policy 34, 1-7.

Marsh, J.C., 1978. The goal-oriented approach to evaluation: critique and case study from drug abuse treatment. Journal of Evaluation and Program Planning 1, 41-49.

McCown, R.L., 2001. Learning to bridge the gap between science-based decision support and the practice of farming: Evolution in paradigms of model-based research and intervention from design to dialogue. Australian Journal of Agricultural Research 52, 549-571.

Mehmood, U.H., Memond, Y., Hamid, A., 1999. Returns to Facilitating Farmers' Organisations for Distributary Maintenance: Empirical Results from a Pilot Project in Southern Punjab. The Pakistan Developmen Review 38, 253-268.

Minot, N., Kherallah, M., Soule, B.G., Berry, P., 2001. Impact des réformes agricoles sur les petits agriculteurs au Benin resultats des Enquêtes des Petits Agriculteurs, des Communautés, et des Groupements Villageois. International Food Policy Research Institute (IFPRI), p. 299.

Mondegnon, K.M., 2012. Effet du système SAWAH sur la production du riz et la productivité de l'eau dans le bas-fond de Bamè au Benin, Département d'Aménagement et Gestion des Ressources Naturelles. Université de Parakou, Benin, p. 126.

Mongbo, R.L., 1995. The appropriation and dismembering of development intervention: Policy, discourse and practice in the field of rural development in Benin. PhD thesis. Rural Sociology. Wageningen University, Wageningen.

Morgan, L.M., 2001. Community participation in health: perpetual allure, persistent challenge. Health Policy and Planning 16, 221-230.

Moseley, W.G., Carney, J., Becker, L., 2010. Neoliberal policy, rural livelihoods, and urban food security in West Africa: A comparative study of The Gambia, Côte d'Ivoire, and Mali. Proceedings of the National Academy of Sciences 107, 5774-5779.

Nederlof, E.S., Röling, N., van Huis, A., 2007. Pathway for Agriculture Science Impact in West Africa. Lessons from the Convergence of science Programme. International Journal of Agricultural Sustainability 5, 247-264.

Nederlof, E.S., Wongtschowski, M., van der Lee, F., 2011. Putting heads together: Agricultural innovation platforms in practice, Bulletin 396, Development, Policy & Practice. KIT Publisher, Amsterdam, p. 192.

Nederlof, E.S., Pyburn, R., 2012. One finger cannot lift a rock: Facilitating innovation platforms to trigger institutional change in West Africa. KIT Publishers, Amsterdam.

North, D.C., 2005. Understanding the Process of Economic Change. Princeton University Press, Princeton.

Nyakudya, I. W., Stroosnijder, L., 2011. Water management options based on rainfall analysis for rainfed maize (Zea mays L.) production in Rushinga district, Zimbabwe. Agricultural Water Management 98, 1649-1659.

Nyikahadzoi, K., Pali, P., Fatunbi, A.O, Olarinde, L.O, Njuki J, A.O, A., 2012. Stakeholder Participation in Innovation Platform and Implications for Integrated Agricultural Research for Development (IAR4D) International Journal of Agriculture and Forestry 2, 92-100.

Obalum, S.E., Nwite, J.C., Oppong, J., Igwe, C.A., Wakatsuki, T., 2011. Comparative topsoil characterization of sawah rice fields in selected inland valleys around Bida, north-central Nigeria: textural, structural and hydrophysical properties. Paddy Water Environ 9, 291-299.

OECD, 2011. The 2008 rice crisis: shock and new challenges, p. 12.

Ojha, H. R., Hall, A., Sulaiman, R. V., 2013. Adaptive collaborative approaches in natural resource governance: an introduction. Pp. 1-19 in: Ojha, H. R., Hall, A.,Sulaiman, R. V. (Eds), Adaptive collaborative approaches in natural resource governance: Rethinking participation, learning and innovation, Routledge London and New-York.

Olson, J. M., 1965. The logic of collective action, public goods and the theory of groups, Cambridge: Harvard University Press.

Ostrom, E., 1990. Governing the commons: the evolution of institutions for collective action, Cambridge: Cambridge University Press.

Ostrom, E., 2000. Collective action and the evolution of social norms. Journal of Economic Perspectives 14, 137-158.

Ostrom, E., 2003. How types of goods and property rights jointly affect collective action. Journal of Theoretical Policies 15, 239-270.

Ostrom, E., 2004. Collective Action and Property Rights for Sustainable Development: Understanding Collective Action. Focus 11, Brief 2 of 16, February 2004. Available from http://www.ifpri.org/sites/default/files/publications/focus11.pdf [Accessed October 2011]

Ostrom, E., 2009. A general framework for analyzing sustainability of Social-Ecological Systems, Science 325, 419-422. Available from www.sciencemag.org [Accessed March 2012]

Ostrom, E., 2011. Reflections on “Some Unsettled Problems of Irrigation”. American Economic Review 101, 49-63.

Pain, R., Francis, P., 2003. Reflections on participatory research. Royal Geographical Society, Area 35, 46-54.

Pal, S., Joshi, P.K., Saxena, R., 2002. Institutional reforms for agricultural development under new economic and technological environment. Indian Journal of Agricultural Economics 3, 507-518.

Paquet, M., Savard, L., 2009. Impact of Informal Re-exports between Benin and Nigeria: A CGE analysis Groupe de Recherche en Économie et Développement International/Université de Sherbrooke, Canada, p. 28.

References

Parkinson, S., 2009. Power and perceptions in participatory monitoring and evaluation. Evaluation and program planning 32, 229-237.

Paul, S., 1987. Community participation in development projects, the World Bank experiences. World Bank, Washington, p. 52.

Pijnenburg, B., Nhantumbo, I., 2002. Participatory Development Interventions in Mozambique. Development in Practice 12, 192-199.

Pimbert, M., 1994. The need for another research paradigm, Seedling, July 1994.

Poteete, A., Marco, R., Janssen, A. and Ostrom, E., 2009. Working together: collective action, the commons, and multiple methods in practice, United Kingdom: Princeton University Press.

Poteete, A., Ostrom, E., 2004. Heterogeneity, Group Size and Collective Action: The Role of Institutions in Forest Management. Development and Change 35, 435-46.

Purdon, S., Lessof, C., Woodfield, K., Bryson, C., 2001. Research methods for policy evaluation, Department for Work and Pensions Research Working Paper No 2. National Centre for Social Research, p. 44.

Quintanilla, G., Packard, T., 2002. A participatory evaluation of an inner-city science enrichment program. Evaluation and program planning 25, 15-22.

Ramakrishna, A., Tam, H.M., Wani, S.P., Long, T.D., 2006. Effect of mulch on soil temperature, moisture, weeds infestation and yield of groundnut in northern Vietnam. Field Crops Research 95, 115-125.

Rauch, T., 1999. Food Security in the Context of Global Markets, Agricultural Policy and Survival Strategies of Rural People in Sub-Saharan Africa, in: Kracht, U., Schulz, M. (Eds.), Food Security and Nutrition, The Global Challenge. Spektrum, New-York, pp. 107-130.

Reckwitz, A., 2002. Toward a Theory of Social Practices: A Development in Culturalist Theorizing. European Journal of Social Theory 5, 243-263.

Remigio, R., 1995. L'espace actif: une réponse paradigmatique des régionalistes au débat local-global, Colloque International de l'Association de Science Régionale de Langue Française - "Dynamiques Industrielles, Dynamiques Territoriales".

Renault, D., 2004. Rice and water: a long and diversified story. Rome: FAO. Available from http://www.fao.org/rice2004/en/f-sheet/factsheet1.pdf [Accessed March 2012].

Richards, P., 1989. Agriculture as a performance, in: R. Chambers, A. Pacey, Thrupp, L.A. (Eds.), Farmer First: Farmer Innovation and Agricultural Research. Intermediate Technology Publications, London, pp. 38-43.

Röling, N., 1988. Extension science: Information systems in agricultural development. Cambridge University Press.

Röling, N., Hounkonnou, D., Kossou, D., Kuyper, T.W., Nederlof, S., Sakyi-Dawson, O., Traore, M., van Huis, A., 2012. Diagnosing the scope for innovation: Linking smallholder practices and institutional context Introduction to the special issue. Njas-Wagen J Life Sc 60-63, 1-6.

Röling, N.G., Hounkonnou, D., Offei, S.K., Tossou, R., Van Huis, A., 2004. Linking science and farmers' innovative capacity: diagnostic studies from Ghana and Benin. Njas-Wagen J Life Sc 52, 211-235.

Rollnick, S., Heather, N., Gold, R., Hall, W., 1992. Development of a short 'readiness to change' questionnaire for use in brief, opportunistic interventions among excessive drinkers. British Journal of Addiction 87, 743-754.

Rosemeyer, M., Viaene, N., Swartz, H., Kettler. J., 2000. The effect of slash/mulch and alleycropping bean production systems on soil microbiota in the tropics. Applied Soil Ecology 15, 49-59.

Roy, A.C., Wanki, S.B.C., Takow, J.A., 1988. Use of green manure in rice farming systems in West and Northwest Cameroon. Pp. 333-342 in: I.R.R. Institute (Ed.) Sustainable agriculture: Green Manure in Rice farming, Proceedings of a symposium on sustainable agriculture. The role of Green Manure Crops in Rice Farming Systems, Rome.

Saïdou, A., Kossou, D., 2009. Water management for enhancing land productivity in Benin: Exploring opportunities for enhancing land productivity by smallholder farmers through water management, in: van Huis, A., Youdeowei, A. (Eds.), Towards Enhancing Innovation System Performance in Smallholder African Agriculture, Proceedings of the First CoS-SIS International Conference, CoS-SIS Programme. CoS-SIS programme, pp. 48-52.

Sandler, T., 2004. Global collective action. Cambridge: Cambridge University Press.

Scarinci, I.C., Johnson, R.E., Hardy, C., Marron, J., Partridge, E.E., 2009. Planning and implementation of a participatory evaluation strategy: A viable approach in the evaluation of community-based participatory programs addressing cancer disparities. Evaluation and program planning 32, 221-228.

Schatzki, T.R., 2002. The Site of the Social: a Philosophical Account of the Constitution of Social Life and Change. The Pennsylvania State University Press, Pennsylvania, USA.

Schot, J., Geels, F.W., 2008. Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. Technology Analysis & Strategic Management 20, 537-554.

Sharma, R., 2001. Present situation and challenges of agricultural support services in Asia and the Pacific, in: Sharma, R. (Ed.), Strengthening Agricultural Support Services for Small Farmers. Asian Productivity Organization, Japan, 4-11 July 2001, pp. 12-29.

Shay, S., 2008. Researching assessment as social practice: Implications for research methodology. International Journal of Educational Research 47, 159-164.

Sinzogan, A.A.C., J. Jiggins, S. Vodouhè, D.K. Kossou, E. Totin and A. van Huis, 2007. An analysis of the organisational linkages in the cotton industry in Benin. International Journal of Agricultural Sustainability 5 213-231.

Sinzogan, A.A.C., van Huis, A., Kossou, D.K., Jiggins, J., Vodouhe, S., 2004. Farmers' knowledge and perception of cotton pests and pest control practices in Benin: results of a diagnostic study. Njas-Wagen J Life Sc 52, 285-303.

Sodjinou, E., Adegbola, P., Zinsou, J., Oloukoi, L., 2008. Projet de Stratification Riz et Maïs au Benin. Cotonou: INRAB-ADRAO Rice policy and Development Program, pp. 129.

Sohinto, D., Akomagni, L., 2008. Analyse de la rentabilité économique de la chaîne de valeur joutée riz. MAEP, Programme de Conservation et Gestion des Ressources Naturelles, p. 87.

Soulé, B.G., Blein, R., 2008. Revue et analyse des mesures engagées à court et moyen terme en réponse à la hausse des prix alimentaires en Afrique de l'Ouest. FARM, p. 4. Retrieved from www.fondation-farm.org/zoe/doc/confprix_lares_resume_mp.pdf.(accessed January 2011)

Strengers, Y., 2010. Conceptualising everyday practices: composition, reproduction and change. Centre for Design, RMIT University and University of South Australia, Australia, p. 21.

Stroosnijder, L., 2012. Myths in Land Degradation and Development. Farewell address upon retiring as Professor in Land Degradation and Development, Wageningen University, 36p.

Stroosnijder, L., Moore, D., Alharbi, A., Argaman, E., Biazin, B., van den Elsen, E., 2012. Improving water use efficiency in drylands. Current Opinion in Environmental Sustainability 4, 1-10.

Tenywa, M.M., Rao, K.P.C., Tukahirwa, J.B., Buruchara, R., Adekunle, A., A. , Mugabe, J., Wanjiku, C., Mutabazi, S., Fungo, B., Kashaija, N.I., Pali, P., Mapatano, S., Ngaboyisonga, C., Farrow, A., Njuki, J., Abenakyo, A., 2011. Agricultural Innovation Platform As a Tool for Development Oriented Research: Lessons and Challenges in the Formation and Operationalization Learning Publics Journal of Agriculture and Environmental Studies 2, 117-146.

Thurston, W.E., Potvin, L., 2003. Evaluability Assessment: A Tool for Incorporating Evaluation in Social Change Programmes. Evaluation 9, 453-469.

Tiffen, M., 2003. Transition in Sub-Saharan Africa: Agriculture, Urbanization and Income Growth. World Development 31, 1343-1366.

Ton, G., 2012. The mixing of methods: A three-step process for improving rigour in impact evaluations. Evaluation 18, 5-25.

Totin, E., Stroosnijder, L., Agbossou, E., 2013. Mulching upland rice for efficient water management: A collaborative approach in Benin. Agricultural Water Management 125, 71-80.

Totin, E., van Mierlo, B., Saidou, A., Mongbo, R., Agbossou, E., Stroosnijder, L., Leeuwis, C., 2012. Barriers and opportunities for innovation in rice production in the inland valleys of Benin. Njas-Wagen J Life Sc 60-63, 57-66.

van der Ploeg, J.D., Long, N., 1994. Heterogeneity, actor and structure: towards a reconstitution of the concept of structure, In: Rethinking social development, D. Booth (ed.). Longman Group Ltd, Harlow (1994) 62-90.

van Huis, A., D. Hounkonnou and N. Röling, 2008. CoS-SIS research design. Convergence of Sciences Project.

van Huis, A., Jiggins, J., Kossou, D., Leeuwis, C., Röling, N., Sakyi-Dawson, O., Struik, P.C. and Tossou, R.C., 2007. Agricultural research to reduce rural poverty: can convergence of sciences support innovation by resource-poor farmers in Benin and Ghana? International Journal of Agricultural Sustainability IJAS 5, 91-108.

van Koppen, B., Namara, R., Safilios-Rothschild, C., 2005. Reducing poverty through investments in agricultural water management, synthesis of Sub-Saharan Africa Case Study. International Water Management Institute.

van Mierlo, B., Arkesteijn, M., Leeuwis, C., 2010a. Enhancing the Reflexivity of System Innovation Projects With System Analyses. American Journal of Evaluation 31, 143-161.

van Mierlo, B., Leeuwis, C., Smits, R., Woolthuis, R.K., 2010b. Learning towards system innovation: Evaluating a systemic instrument. Technological Forecasting and Social Change 77, 318-334.

Velded, T., 2000. Village politics: heterogeneity, leadership and collective action. Journal of Development Studies 36, 105-134.

Verbole, A., 2000. Actors, Discourses and Interfaces of Rural Tourism Development at the Local Community Level in Slovenia: Social and Political Dimensions of the Rural Tourism Development Process. Journal of Sustainable Tourism 8, 479-490.

Vincent, L.F., Roth, D., 2013. Analysing water control: interdisciplinarity, socio-technical approach, and institutions in water management, in: Roth, D.D., Vincent, P.d.L.F. (Eds.), Controlling the water. Matching technology and institutions in irrigation management in India and Nepal. Oxford University Press, New Delhi, India, pp. 30-58.

Visse, M., Abma, T.A., Widdershoven, G.A.M., 2012. Relational responsibilities in responsive evaluation. Evaluation and program planning 35, 97-104.

Vodouhè, D., 1996. Making rural development work. Cultural hybridization of farmers' organizations: The Adja case in Benin. Wageningen University: Published doctoral dissertation, pp. 204.

Vredeseilanden, 2011. Promotion of the rice value chain in Benin: Cooperation between Beninese farmers' organisations, the Belgian retailer Colruyt and the NGO. Veco, Leuven, p. 26.

Wade, R., 1988. Village republics: Economic conditions for collective action in South India, Cambridge, UK: Cambridge University Press.

Walters, B., Cadelina, A., Cardano, A., Visitacion, E., 1999. Community history and rural development:

Walters, C.J., Holling, C.S., 1990. Large-scale management experiments and learning by doing. Ecology 6, 2060-2068.

Warner, J., 2005. Multi-stakeholder platforms: integrating society in water resource management? Ambiente and Sociedade 8, 4-28.

Waters-Bayer, A., Bayer, W., 2009. Enhancing local innovation to improve water productivity in crop-livestock systems. The Rangeland Journal 31, 231-235.

Weiermair, K., Peters, M., Frehse, J., 2008. Success factors for public private partnership: cases in alpine tourism development. Journal of Services Research Policy 3, 7-21.

Werle, R., 2012. Institutions and Systems: Analysing Technical Innovation Process from an Institutional Perspective, in: Bauer, J.M., Lang, A., Schneider, V. (Eds.), Innovation Policy and Governance in High-Tech Industries, The Complexity of Coordination. Springer-Verlag, Berlin, pp. 23-47.

Woodhill, J., 2008. Shaping behaviour-How institutions evolve. Broker 2008 (10): 4-8 (www.thebrokeronline.eu, accessed online on December, 2011)

Woodhill, J., 2010. Capacities for Institutional Innovation: a complexity perspective. IDS Bulletin 41 (3): 47-59.

Woolcock, M., Narayan, D., 2000. Social Capital: Implications for Development Theory, Research, and Policy. The World Bank Research Observer 15, 225-249.

World Food Programme, no date. Rice crisis, market trends, and food security in West Africa. Accessed at http://www.oecd.org/swac/publications/47853480.pdf on November 8, 2012

World-Bank, 2007. Enhancing agricultural innovation: How to go beyond strengthening agricultural research systems. Washington DC the World Bank, Washington.

Wynne, B., 1991. Knowledge in Context. Science, Technology, & Human Values 16, 111-121.

Yanow, D., 1995. Built Space as Story. Policy Studies Journal 23, 407-422.

Yanow, D., Schwartz-Shea, P., Freitas, M.J., 2010. Case Study Research in Political Science. Encyclopedia of Case Study Research. SAGE Publications, Inc. SAGE Publications, Inc., Thousand Oaks, CA.

Yin, R.K., 2004. The case study anthology. Sage, Thousand Oaks; London.

Young, J., Stretton, H., 1991. Individualism and collectivism: how will sustainability affect the roles of the public and private sectors? Science of The Total Environment 108, 103-110.

Zacher, H.F., 1988. Traditional solidarity and modern social security harmony or conflict?, in: von Benda-Beckmann, F., von Benda-Beckmann, K., Casino, E., Hirtz, F., Woodman, G.R., Zacher, H.F. (Eds.), Between Kinship and the State, Social Security and Law in Developing Countries. Foris Publications, Dordrecht (Holland), pp. 21-38.

Summary

This thesis is part of the wider debate about the role of institutions in agricultural innovation processes. It investigates how institutions shape rice production in inland valleys in Benin. It starts from a scoping study (prior to this research) on smallholder irrigation in Benin, which indicated irrigation water stress as one of the main problems in the rice production chain. The authors explain the water scarcity as the consequence of poor maintenance of the irrigation canals, whereas others think that is a direct manifestation of climate change. It appears that a mono-technical explanation cannot give a deep enough understanding of the existing water problem, which has various dimensions. The thesis therefore assumes that an institutional perspective would provide a better insight into the barriers that hinder the efficient use of irrigation water in the rice production chain.

Chapter 1 introduces the main problems teased out in the book. Between 1976 and 1990, the Benin government initiated numerous interventions to increase local rice production. These different interventions were ineffective because of the many innovation barriers that existed in the rice chain. Therefore, the first research question addressed in this research is: what are the constraints in the local rice value chain and the opportunities for innovation in the research areas?

After the 2007 rice crisis, the government introduced a new generation of interventions which prioritised the institutional facilities (e.g., subsidies for seeds and loans for fertiliser, market facilities and so forth) to support the intensification of local rice production. There have been successful outcomes in terms of increased rice yield, rice production and farmers' income. So, this research is interested in studying the effectiveness of the two generations of interventions in the rice value chain. The following research question is also addressed: how and to what extent does the new generation of interventions create space for rice production in the research areas and overcome the shortcomings of previous interventions?

Which factors hinder the effective use of irrigation water and the development of the local rice value chain in the three research areas are further explored in a diagnostic study and described in Chapter 2. The diagnosis indicates that it is not only technical constraints that hinder the local rice production chain; rather, a combination of technical and institutional factors affect the development of rice production. Moreover, both local and higher level institutional barriers influence negatively the local rice value chain. The barriers to innovation include: unclear division of responsibilities for canal maintenance between local farmer groups and the government, lack of effective local rules for the distribution of the available water and maintenance of the irrigation infrastructures, distrust among farmers and the constraining formal and informal credit systems and uncertain market outlets. These constraints reduce rice output and farmers' incomes.

After identifying the main economic, institutional and technical constraints that limited the development of the local rice production chain, the study also describes the potential opportunities that exist for innovation in the chain. Chapter 2 shows that, from a bio-technical perspective, in the three irrigation schemes, the actual rice output remains far below the estimated potential of the command areas, given the water and land available in the inland valleys. It establishes that there is room for a considerable increase in rice production and associated incomes. For instance, in Koussin-Lélé and Bamè, farmers have lands in the uplands as well as the lowlands. Less than 10% of the potential land is used for rice production. Chapter 4 shows an option to improve soil moisture in the uplands and extend rice production in this part of the valleys.

In the research areas, there are differences in the extent to which the rules for collective activities are set and followed. The farmers cooperate, for instance, to collectively purchase inputs, make collective credit requests or sell collectively the harvested rice. At the start of the study however, not all the farmers contributed to the collective cleaning of the canals to increase the water discharge that serves all of them. To further understand why the collective maintenance of the irrigation infrastructure is so problematic

among the farmers, a comparative analysis of the three research areas was conducted, using a framework to highlight key contextual differences such as the nature of the resource, the characteristics of the user group and farmer-based institutional arrangements in the geographical areas. The findings of the case studies, reported in Chapter 3, draw attention to the balance between water demand and availability, the existence of inequities and privileged positions within the groups and the strength of farmers' group organisation and the ability to sanction uncooperative behaviour. The existence of alternative sources of livelihood also influenced cooperation. Contrary to our expectations, the analysis shows that the largest and most diverse group of farmers appeared best organised and equipped to engage in cooperation. Large, diverse farmer groups allow the emergence of institutional arrangements that can overcome social dilemma situations and demotivation emanating from customary privileges and exemptions.

A collaborative action research approach was used to explore the opportunity to expand rice production in the upland areas. In Chapter 2, it was already established that rice production could be improved for the uplands if there was a better supply of irrigation water. This analysis inspired the action research conducted in collaboration with the rice farmers (from the three production research areas), an extension agent and a researcher to examine the application of mulch (three doses) and the use of a high-yield lowland rice variety to replace an upland rice variety (Chapter 4). Multiple methods suggested by both the researcher and farmers themselves were used to evaluate the trial results: quantitative evidence was combined with qualitative evaluation, using indicators agreed upon by the collaborating group. The results show that the lowland rice variety IR-841 with 10 t ha^{-1} 'rice-straw' mulch allows farmers to better use available water in the upland areas and increase rice yields. Although opting for IR-841 over the specially bred upland variety Nerica-4 is risky because of its high water demand and the uncertainty in rainfall distribution, farmers use IR-841 for profit maximisation. Beyond its technical output, the joint experimentation facilitated the exchange of knowledge, experiences and practices among the involved stakeholders.

Since the rice crisis of 2007, the government of Benin has initiated a variety of short- and long-term programmes aimed at providing access for farmers to agricultural inputs for local rice intensification. Chapter 5 explores the interplay between the external interventions of the government programmes and the local actions of farmers, in the three research areas. Using an actor-oriented perspective combined with the timelines of the chronological events, the study concludes that farmers' local actions interact at diverse junctures with the external interventions. The study shows that it is not only external interventions that trigger changes; rather, the interaction between external interventions and farmers' local actions makes room for changes to happen. Moreover, the investigations show that, although the same institutional conditions (through the different government interventions) were provided to rice farmers in the three study areas, located close to one another, there are similar, but also divergent, hence unexpected outcomes regarding farmers' social practices. The most obvious unexpected outcomes of the programme interventions are the change from limited collective canal cleaning to individual effective canal cleaning in Koussin-Lélé, the use of pumps in upland areas in Bamè and farmers who changed from growing vegetables or maize alone to growing rice in combination with these in Zonmon. The wish to satisfy subsistence livelihood needs, the different production options available and natural biophysical conditions (e.g., floods) are the main factors that contribute to shaping farmers' local actions and explain the diversity of practices in the three research areas, although they all received the same interventions.

Chapter 6 provides answers to the research questions formulated in Chapter 1 and reflects on how the different results from the thesis contribute to the policy debate about how to improve rice production in Benin. Reflection on the sustainability of the current rice intensification policy established that the government interventions constitute a "protected space". However, there is no guarantee that the intensification of local rice production will still continue when the supports provided by the government projects end. Another limitation of the rice intensification policy is that it relies on the use of the irrigation

schemes designed for one cropping season in a context where farmers are now producing up to three cropping seasons a year. The inadequacy of the irrigation design concept for the intensification of rice production might contribute to explaining why some of the farmers are suffering from the lack of irrigation water. Moreover, although the inland valleys in Benin are a potential area for rice production, they are also complex ecosystems with irregular water supply wherein smallholder farmers must carefully allocate available resources.

The thesis shows the importance of institutions in agricultural production. Many institutional studies are about social issues. One of the main contributions of this thesis relates to the points it established by linking institutional issues with technical dimensions. Chapters 3 and 4 explain the interrelations between institutions and water management practices. The experimental procedure described in Chapter 4 was grounded in the institutional context but also has a technical purpose that is, identifying water use options that allow the expansion of rice production in the uplands. By exploring a technical issue like water management from an institutional perspective, the thesis provides clear understanding of the reasons behind farmers' seemingly illogical or irrational water management practices.

Samenvatting

Dit proefschrift maakt deel uit van het debat over de rol van instituties in innovatieprocessen in de landbouw. Het onderzoekt hoe instituties vormgeven aan rijstproductie in 'inland valleys' (beekdalen) in Benin. Het bouwt voort op een brede, verkennende studie voorafgaand aan dit onderzoek naar irrigatie door kleine boeren, die erop duidde dat een tekort aan irrigatiewater één van de belangrijkste problemen is in de waardeketen van rijstproductie. De auteurs van die studie zien het gebrek aan water als een gevolg van slecht onderhoud van de irrigatiekanalen, terwijl andere auteurs menen dat het een directe uitkomst is van klimaatverandering. Zo'n monocausale, technische uitleg geeft onvoldoende inzicht in het probleem rond water, dat diverse dimensies heeft. Het proefschrift veronderstelt daarom dat een institutioneel perspectief een beter inzicht zal geven in de barrières voor een efficiënt gebruik van irrigatiewater in de rijstproductie.

Hoofdstuk 1 introduceert de belangrijkste problemen die centraal staan in het boek. Tussen 1976 en 1990 heeft de overheid vele interventies gepleegd om de lokale rijstproductie te verhogen. Deze interventies waren ineffectief vanwege de vele innovatie barrières in de productieketen van rijst. De eerste onderzoeksvraag van dit onderzoek is daarom: wat zijn de hindernissen in de lokale rijst-waardeketen en wat zijn de kansen voor innovatie in de onderzoeksgebieden?

Na de rijst crisis in 2007, introduceerde de overheid een nieuwe generatie interventies die voorrang gaven aan institutionele faciliteiten (bijvoorbeeld subsidie voor zaad, leningen om te kunnen bemesten, een afzetmarkt en dergelijke) om een toename van de lokale rijstproductie mogelijk te maken.

Welke factoren belemmeren dat het irrigatiewater effectief wordt gebruikt en de lokale rijstproductieketen verder wordt ontwikkeld, is verder verkend in drie onderzoeksgebieden in de diagnose-studie en beschreven in hoofdstuk 2. Deze studie indiceerde dat niet enkel technische factoren, maar een combinatie van technische en institutionele factoren een hindernis vormen voor de ontwikkeling van de lokale rijstproductie. Bovendien, hebben zowel lokale als boven-lokale institutionele barrières een negatieve invloed. Deze barrières betreffen onder meer een onduidelijke verdeling van verantwoordelijkheden tussen boeren en de overheid; een gebrek aan effectieve lokale regels voor de verdeling van het beschikbare water en onderhoud van de irrigatie-infrastructuur; wantrouwen tussen de boeren onderling; en beperkte kredietfaciliteiten en afzetmarkten.

Na het identificeren van de belangrijkste economische, institutionele en technische hindernissen, beschrijft de studie ook kansen in de productieketen voor innovatie. Hoofdstuk 2 toont aan dat, van een biologisch-technisch perspectief en gezien het beschikbare land en water in de beekdalen, de rijstopbrengst ver onder het potentieel blijft in alle drie de gebieden. Er is dus ruimte voor een flinke toename van de rijstproductie en inkomens hieruit. In Koussin-Lélé and Bamè bijvoorbeeld hebben boeren land, zowel in de uplands (de hoger gelegen randen van de beekdalen) als in de lowlands (het irrigeerbare deel van een beekdalen). Minder dan 10% van het beschikbare land wordt gebruikt voor het telen van rijst. Hoofdstuk 4 laat zien dat er een manier is om in de uplands de bodemvochtigheid te verbeteren en de rijstproductie in deze delen van de valleien uit te breiden.

De mate waarin de bestaande regels voor collectieve activiteiten worden opgevolgd, is verschillend in de drie gebieden. De boeren werken onder meer samen bij de aankoop van zaad, het aanvragen van collectieve kredieten en de verkoop van de rijst. Bij aanvang van de studie, droegen de boeren echter niet allemaal bij aan het collectief schoonmaken van de kanalen, ook al zou een toename van de watertoevoer gunstig zijn voor iedereen. Om beter te begrijpen waarom het collectieve onderhoud van de kanalen zo problematisch is voor de boeren, is een vergelijkende studie van de drie onderzoeksgebieden uitgevoerd met behulp van een raamwerk dat de belangrijkste contextuele verschillen belicht, zoals de soort natuurlijke hulpbron, de kenmerken van de boerengroepen en lokale regels in de drie gebieden. De bevindingen, beschreven in hoofdstuk 3 wijzen op het belang van de balans tussen waterbehoefte en –

beschikbaarheid, op ongelijkheden en geprivilegieerde posities binnen de groepen, en op de sterkte van de organisatie van de boerengroepen en hun capaciteit om het afwijken van de regels te sanctioneren. De beschikbaarheid van andere bronnen van bestaan beïnvloedde de samenwerking ook. Anders dan we hadden verwacht, toonde de analyse aan dat de grootste en meest diverse boerengroep het beste was toegerust om samenwerking tussen de boeren te stimuleren. In grote, diverse groepen bestaat ruimte voor het ontstaan van institutionele arrangementen om sociale dilemma's en demotivatie als gevolg van geprivilegieerde boeren te overstijgen.

Om te verkennen of het mogelijk is om de rijstproductie in the uplands uit te breiden is een participatieve actie-onderzoek benadering toegepast. In hoofdstuk 2 was al vastgesteld dat dit mogelijk zou zijn met een beter aanbod van water om te irrigeren. Deze analyse inspireerde tot het doen van actieonderzoek, beschreven in hoofdstuk 4, dat is uitgevoerd samen met de rijstboeren van de drie onderzoeksgebieden, een landbouwvoorlichter en een onderzoeker naar de effecten van het toepassen van mulch (dood gewas materiaal), in drie doses, en een hoge-opbrengst rijst variëteit die normaal in de lowlands wordt gebruikt in plaats van de aanbevolen upland variëteit (Nerica-4). De methoden om de resultaten van het experiment te evalueren waren gesuggereerd door zowel de onderzoeker, als de boeren zelf: kwantitatieve data zijn gecombineerd met kwalitatieve evaluatie met gebruik van indicatoren waar de hele groep overeenstemming over had bereikt. De resultaten tonen aan dat de boeren het beschikbare water efficiënter gebruikten en de rijstopbrengst het hoogst was met de lowland rijstsoort IR-841 met 10 t ha^{-1} mulch van rijststro. Hoewel het verkiezen van IR-841 boven Nerica-4, die speciaal is ontwikkeld voor de upland gebieden, riskant is, vanwege de grote behoefte aan water en de ongelijke, onzekere verdeling van regenwater, gebruiken de boeren IR-841 om de winst te maximaliseren. Naast het technische resultaat, leidde het gezamenlijke experiment tot het uitwisselen van kennis, ervaringen en praktijken tussen de belanghebbenden.

Sinds de rijstcrisis in 2007, is de overheid van Benin diverse korte en lange termijnprogramma's gestart met als doel om boeren beter toegang te geven tot inputs. Hoofdstuk 5 verkent de interactie tussen de externe interventies van de overheidsprogramma's en lokale acties van boeren in de drie onderzoeksgebieden. Met behulp van een perspectief georiënteerd op actoren gecombineerd met een analyse van de chronologie van gebeurtenissen met behulp van tijdslijnen, concludeert de studie dat externe interventies en lokale acties op verschillende momenten interacteren. Het laat zien dat niet alleen externe interventies verandering aanzwengelen, maar dat de interactie tussen externe interventies en de lokale acties van boeren, ruimte maken, zodat verandering plaats kan vinden. Bovendien laat het onderzoek zien dat hoewel de institutionele condities gecreëerd door de overheidsprogramma's vergelijkbaar waren in de drie gebieden, die dicht bij elkaar liggen, er niet alleen vergelijkbare, maar ook onverwachte, verschillende lokale effecten waren in termen van veranderingen in de sociale praktijken van de boeren. De meest opvallende onverwachte resultaten van de programma-interventies zijn de verandering van het beperkte collectieve schoonmaken van de kanalen, naar effectieve individuele schoonmaak in Koussin-Lélé, het gebruik van pompen in de upland gebieden in Bamè en boeren die voorheen alleen rijst of alleen groenten verbouwden, en nu overgingen naar een gecombineerde teelt in Zonmon. De diversiteit in uitkomsten van de generieke interventies, kan worden verklaard uit de verschillen in wijze waarop de boeren in hun levensonderhoud willen voorzien, en de verschillende productie-opties en bio-fysieke condities (zoals overstromingen).

Hoofdstuk 6 geeft de antwoorden op de onderzoeksvragen uit hoofdstuk 1 weer en gaat in op de bijdrage van de onderzoeksresultaten aan het beleidsdebat over het verbeteren van rijstproductie in Benin, met name die in de beekdalen. Reflectie op de bestendigheid van het huidige rijst-intensiveringsbeleid leidt tot de constatering dat het overheidsinterventies een 'beschermde ruimte' bieden. Er is echter geen garantie dat de intensivering van de rijstproductie door zal gaan als de steun van de overheidsprojecten eindigt. Een andere beperking van het huidige beleid is dat het afhankelijk is van irrigatiesystemen die zijn

ontworpen voor één rijstproductie-seizoen per jaar, terwijl de boeren tegenwoordig twee tot drie keer jaar rijst oogsten. De ongeschiktheid van het oude ontwerp van de systemen voor een intensieve rijstproductie kan helpen verklaren waarom sommige boeren nog steeds een tekort aan water hebben. Verder zijn de beekdalen in Benin weliswaar een potentieel gebied voor rijstproductie, maar zijn het ook complexe ecosystemen met een onregelmatige watertoevoer, waarin kleine boeren het beschikbare water en de beschikbare grond heel zorgvuldig moeten benutten.

Dit proefschrift toont het belang van instituties in landbouwproductie aan. Vele institutionele studies gaan over sociale onderwerpen. Eén van de belangrijkste bijdragen van dit proefschrift betreft de punten die gemaakt zijn over de relatie tussen institutionele en technische dimensies. Hoofdstuk 3 en 4 werken de relatie tussen instituties en praktijken van waterbeheer uit. Het experiment beschreven in hoofdstuk 4 was ingebed in de institutionele context, maar had ook een technisch doel, namelijk opties voor watergebruik identificeren om de rijstproductie in de uplands te verhogen. Door een technisch onderwerp als waterbeheer van een institutioneel perspectief te verkennen, biedt dit proefschrift een helder inzicht in de achtergronden van schijnbare onlogische of irrationele waterbeheerpraktijken van boeren.

Résumé

La présente étude contribue à élucider davantage l'influence du rôle que joue le contexte institutionnel dans les processus d'innovations agricoles. L'étude vise ainsi à analyser l'influence du cadre institutionnel sur la chaîne de production du riz au Bénin. La recherche fait suite aux résultats d'une étude exploratoire conduite dans 18 localités du Bénin qui a identifié l'insuffisance d'accès à l'eau d'irrigation comme l'un des problèmes majeurs au niveau de la chaîne de production du riz. Pendant que les auteurs de cette étude exploratoire expliquent le problème de l'eau comme étant le résultat d'un mauvais entretien des canaux d'irrigation au niveau des sites de production, d'autres auteurs pensent que ce même phénomène est une conséquence directe des effets du changement climatique. Ainsi, le problème de l'insuffisance de l'eau d'irrigation dans l'agriculture reste un problème multidimensionnel et une explication mono-technique ne saurait en donnée une compréhension approfondie. La présente étude estime qu'une perspective institutionnelle du problème pourra permettre de mieux élucider les barrières qui empêchent l'utilisation efficiente de l'eau d'irrigation en production de riz au Bénin.

Le Chapitre 1 introduit les principaux problèmes développés dans l'étude. Entre 1976 et 1990, le gouvernement Béninois a initié plusieurs interventions visant à accroître la production locale de riz. Mais la plupart de ces interventions ont eu un impact mitigé sur la production locale, notamment à cause des nombreuses contraintes qui subsistaient au niveau de la filière. A partir de cette première analyse, l'un des objectifs de la présente étude est d'identifier les différentes contraintes qui limitent la promotion du riz local et d'explorer les opportunités d'innovation au niveau du milieu d'étude.

Après la crise internationale survenue en 2007 au niveau de la filière riz, le gouvernement a opté pour une nouvelle politique qui a priorisé la création d'un contexte institutionnel favorable pour susciter l'intensification de la production de riz (subvention sur le prix des engrais, distribution des semences agricoles, facilité d'accès au marché, l'amélioration des conditions d'accès au crédit agricole pour les producteurs de riz, etc.). Ces différentes interventions ont connu du succès et ont permis entre autre une augmentation significative des rendements, de la production locale et une amélioration du revenu des producteurs de riz. En se basant sur ces observations, l'étude s'est aussi intéressée à comprendre comment et dans quelle mesure la série d'interventions après 2007 a-t-elle facilité l'intensification de la production locale de riz et permis de combler les insuffisances des interventions antérieures.

Les différents facteurs qui empêchent l'utilisation effective de l'eau d'irrigation et une promotion de la production du riz sont explorés dans une étude diagnostique présentée dans le Chapitre 2. Cette étude montre que ce ne sont pas seulement des contraintes techniques qui empêchent une meilleure promotion de la filière riz local, mais bien une combinaison des facteurs technique et institutionnel. En plus, il existe des barrières institutionnelles à l'échelle des milieux d'étude mais aussi à une échelle plus élevée (nationale, régionale et internationale) qui influencent le développement de la filière riz local. Entre autre, ces barrières concernent la floue répartition de la responsabilité de l'entretien des infrastructures d'irrigation, l'absence de règles claires en ce qui concerne la distribution de l'eau d'irrigation disponible au niveau des périmètres de production, le manque d'un climat de confiance entre producteurs et l'absence de crédits agricoles adéquats.

En mettant en relief ces principaux facteurs économique, institutionnel et technique qui limitent la promotion de la filière riz au Bénin, l'étude explore aussi les opportunités existantes. Ainsi, le Chapitre 2 montre à partir d'une perspective biotechnique que le niveau actuel de la production reste bien en-dessous du potentiel des 3 milieux d'étude. Il existe des atouts pour une augmentation de la production de riz, et par conséquent une amélioration significative des revenus des producteurs. Par exemple, à Koussin-Lélé et à Bamè la production de riz est possible aussi bien dans les bas-fonds que sur la terre ferme. Mais, jusque-là encore, moins de 10% de ce potentiel est vraiment exploité. Le Chapitre 4 présente le paillage comme une

option de gestion de l'eau d'irrigation pouvant permettre l'expansion de la production de riz sur les terres fermes.

Il existe une large différence dans la façon dont les producteurs suivent les règles établies pour l'entretien des infrastructures d'irrigation au niveau des trois milieux d'étude. Bien qu'il soit formellement établi que tous les producteurs doivent participer (équitablement) à l'entretien collectif de leurs infrastructures d'irrigation, dans la pratique ce n'est point le cas. Une analyse comparative des trois milieux d'étude basée des éléments clés du contexte tels que, la nature de la ressource, les caractéristiques des groupes et les règles d'organisation entre producteurs, est faite afin de mieux comprendre les facteurs de motivation des producteurs à participer ou non à l'entretien des canaux. Les résultats de cette analyse comparée, présentés dans le Chapitre 3, montrent que l'équilibre entre la disponibilité de l'eau et sa demande, l'existence de statut de privilégiés et la capacité des groupes à sanctionner les comportements arbitraires restent les principaux facteurs de motivation. En plus, la possibilité d'avoir ou non une source alternative de revenu est aussi un élément fondamental de motivation qui influence les choix opérés par les producteurs. Contrairement aux résultats d'autres études, cette étude a démontré que les plus grands et diversifiés groupes de producteurs sont plus favorables à la coopération. Ainsi, la taille et la diversité des groupes facilitent l'émergence de règles pour prévenir des situations de dilemme social.

Une recherche-action est conduite pour explorer les possibilités d'expansion de la production rizicole sur la terre ferme, où il existe encore de vastes espaces assez propices à la riziculture (Chapitre 4). Il est montré dans le Chapitre 2 que l'extension de la production est possible sur terre ferme tant que l'eau reste disponible. Cette analyse a soutenu la recherche-action qui a impliqué les producteurs de riz des 3 milieux d'étude, un agent de vulgarisation et l'étudiant Ph.D. La recherche a porté sur l'essai de différentes doses de paille en combinaison avec différentes variétés de riz (IR-841 et le Nerica-4). Diverses approches, qualitatives (dérivées des producteurs) et quantitatives émanant du chercheur et l'agent de vulgarisation, sont combinées afin d'apprécier l'efficacité des traitements. Les résultats ont montré que la variété IR-841, bien qu'étant recommandée en production de bas-fond, donne de meilleurs rendements avec une dose de 10 t ha^{-1} de paille en terre ferme, que le Nérica-4. Au-delà des résultats techniques obtenus, cette recherche-action a aussi facilité le brassage de savoirs et l'échange d'expériences entre les acteurs impliqués.

Depuis la crise de 2007 au niveau de la filière riz, le gouvernement a initié une série d'interventions à court et long terme afin d'encourager la production locale. Le Chapitre 5 a analysé les interrelations entre les interventions des programmes du gouvernement et les actions locales des producteurs dans les milieux d'étude. En adoptant l'approche "*actor-oriented perspective*" combinée avec l'analyse chronologique des séries d'évènements, l'étude conclut que les actions locales des producteurs interfèrent à divers niveaux avec les interventions extérieures influençant ainsi les changements de pratiques sociales. L'étude établie ainsi que ce ne sont pas les interventions des programmes à elles-seules qui facilitent les changements de pratiques, mais plutôt la permanente interrelation entre les actions des producteurs et l'intervention des programmes. De façon illustrative, bien que les mêmes interventions aient été faites dans les trois milieux d'étude, il y a eu des changements similaires, mais aussi des mutations diverses, notamment du fait que les producteurs dans ces trois milieux n'aient pas les mêmes capacités d'actions, et n'étant pas aussi confrontés aux mêmes préoccupations (*agency*).

Dans le Chapitre 6, les réponses sont apportées aux questions de recherche formulées à l'entame de l'étude. Ce chapitre montre aussi comment les différents résultats obtenus contribuent aux échanges encours pour accroître la production du riz au Bénin. Les diverses interventions du gouvernement, notamment depuis 2007, visent à mettre en place un cadre favorable à la promotion de la production du riz local. Mais toutefois, l'analyse du contexte créé pour soutenir la production du riz local montre qu'il n'existe pas encore une certitude par rapport à la continuité de l'intensification de la production rizicole, une fois que les appuis apportés par les programmes viendraient à terme. Une autre limite de la politique

actuelle d'intensification de la production rizicole vient du fait qu'elle encourage l'intensification de la production rizicole sur des périmètres qui n'étaient pas aménagés pour supporter le rythme actuel de production. Ceci pourrait d'ailleurs expliquer pourquoi certains producteurs de riz souffrent davantage des problèmes d'insuffisance d'eau d'irrigation au niveau de ces périmètres. En général, bien que le bas-fond soit présenté comme un milieu propice pour la production de riz, il reste aussi un écosystème assez complexe qui demande aux petits producteurs de faire des choix judicieux afin de ne pas compromettre leur sécurité alimentaire.

En se fondant sur l'étude de cas de la production de riz, la présente thèse montre en général l'influence qu'exerce le contexte institutionnel sur les processus d'innovation. L'une des contributions majeures de cette thèse est le lien qu'elle établit entre le cadre institutionnel et les phénomènes techniques. Les Chapitre 3 et 4 montrent en détail les interrelations entre les pratiques de gestion de l'eau d'irrigation et le cadre institutionnel dans lequel opèrent les producteurs. La recherche-action présentée dans le Chapitre 4 a une finalité technique car elle vise à explorer les options qui permettent la production du riz sur terre ferme. Mais avant tout, elle est restée fondamentalement encrée dans le contexte institutionnel dans lequel les producteurs de riz travaillent. En analysant un problème d'ordre technique tel que la gestion de l'eau à partir d'une perspective institutionnelle, cette étude permet d'avoir une meilleure compréhension des pratiques paysannes; pratiques parfois jugées à tort d'irrationnelles parce que souvent décontextualisées du cadre institutionnel dans lesquels elles sont mises en œuvre.

Netherlands Research School for the
Socio-Economic and Natural Sciences of the Environment

C E R T I F I C A T E

The Netherlands Research School for the
Socio-Economic and Natural Sciences of the Environment
(SENSE), declares that

Gnangnimon Gbènakpon Edmond Totin

born on 20 November 1979 in Porto-Novo, Benin

has successfully fulfilled all requirements of the
Educational Programme of SENSE.

Cotonou, Benin, 10 December 2013

the Chairman of the SENSE board	the SENSE Director of Education
Prof. dr. Rik Leemans	Dr. Ad van Dommelen

The SENSE Research School has been accredited by the Royal Netherlands Academy of Arts and Sciences (KNAW)

KONINKLIJKE NEDERLANDSE
AKADEMIE VAN WETENSCHAPPEN

The SENSE Research School declares that **Mr. Edmond Totin** has successfully fulfilled all requirements of the Educational PhD Programme of SENSE with a work load of 48 ECTS, including the following activities:

SENSE PhD Courses

- Environmental Research in Context
- Research Context Activity: Participation in the 'Convergence of Sciences, Strengthen Innovation System (CoS-SIS) programme' and writing a Press Release to communicate PhD research findings
- Qualitative Data Analysis with Atlas.ti - a hands on practical
- Scientific Publishing

Other PhD and Advanced MSc Courses

- Initiation à Atlas. Ti, un outil d'analyse des données d'enquête qualitative
- Facilitating Interactive processes
- Adaptation to Climate Change in Developing Countries
- Graduate School PE&RC weekend
- Competence Assessment
- Mobilising your - scientific - network
- Monitoring and Evaluation Strategies: M&E for learning

Management and Didactic Skills Training

- Co-organization of Concertation and Innovation Group meetings
- Supervision of three BSc and two MSc theses
- Guest lecturer for the course *Diagnostic in Rural Area Tools*, Faculté des Sciences Agronomiques

External training at a foreign research institute

- Training in the use of mulch experiment equipment, Université d'Abomey-Calavi, Benin

Oral Presentations

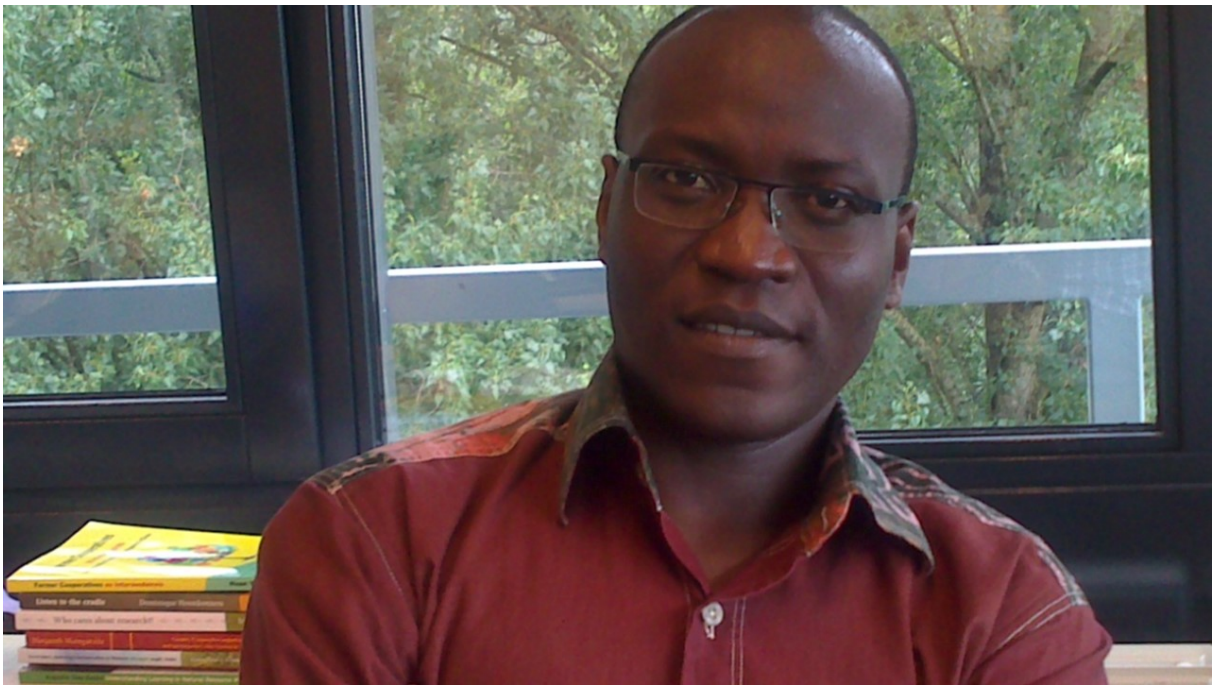
- *Diagnostic investigation on rice production in Koussin, Bame and Zonmon*, Large Int. CoS-SIS workshop, 26 October 2010, Cotonou, Benin
- *Building institutional innovations to support efficient water management in smallholder rice farming in Benin*, Large Int. CoS-SIS workshop, October 2011, Bamako, Mali
- *Drivers of cooperative choice: case of canal maintenance in smallholder irrigated rice production in Benin*, Large Int. CoS-SIS workshop, October 2012, Accra, Ghana

SENSE Coordinator PhD Education

Drs. Serge Stalpers

Curriculum Vitae

Edmond Totin (Gnangnimon Gbènakpon Edmond Totin) was born in Porto-Novo (Benin) on November 20th, 1979. He joined the agronomy school at the *Université d'Abomey-Calavi* where he obtained the Engineer degree in December 2004. In 2005, he worked as research assistant and carried out for the Convergence of Sciences programme, an institutional study on the cotton industry in Benin. From 2006 to 2008 he worked as agricultural extensionnist for an NGO promoting business-led agricultural model. His work included elaboration of farmers' technical training curricula and private entrepreneurs' capacity building. A scholarship from the Belgian government offered him the opportunity to do his MSc. study in Development, Environment and Society at *Louvain-La-Neuve* (Belgium), from 2008 to 2009. In January 2010, he was sponsored by the CoS-SIS programme to carry out an interdisciplinary PhD. at Wageningen University, in the department of Land Degradation and Development, and Knowledge, Technology and Innovation.



The CoS-SIS Research Programme

1.1 Definition and Purpose

Convergence of Sciences-Strengthening Innovation Systems is an action research programme in Benin, Ghana and Mali. It carries out scoping and diagnostic studies, agrarian system analyses and participatory field experiments with innovation platforms at the local, district and national levels. Its purpose is to identify pathways for creating opportunity for smallholder farmers in West Africa. Focusing on the enabling conditions at levels higher than the field and farm, the Programme supports sustainable intensification of smallholder farming for food security.

1.2 Partners and Funding

CoS-SIS is a partnership among the Université d'Abomey-Calavi at Cotonou, Benin; the University of Ghana at Legon, Ghana, and the Instut Polytechnique Rural de Formation et Recherche Appliquée, at Katibougou, Mali; and Wageningen University, and the Royal Tropical Institute in the Netherlands. It is funded to a total of € 4.5 million for six years (end 2008-mid 2014) by Dutch International Cooperation.

1.3 History and future

CoS-SIS is the second phase of CoS. CoS1 (2001-2006) focused on participatory technology development (PTD) in Benin and Ghana. It showed that smallholders can capture only limited benefits from even the best-adapted and appropriate technologies because of their constrained opportunities. Hence CoS1 researchers started to experiment with institutional change (in addition to their agronomic work). Their early results inspired CoS-SIS in that they convincingly demonstrated that institutional change is both important and feasible. CoS-SIS is currently supporting CORAF in implementing its IAR4D strategy with its West African partners.

1.4 Personnel

CoS-SIS employs eight post-doc Research Associates (RAs), recruited part-time from national research organisations and universities, and nine African Ph.D. researchers. Some of the RAs are graduates of the COS1 programme. The RAs facilitate Concerted action and Innovation Groups (CIGs) (multi-stakeholder platforms composed of key actors in an agricultural domain) at the district and national levels to experiment with institutional change. The Ph.D. researchers work at community level with groups of local people to analyse constraints and experimentally develop livelihood opportunities. The doctoral research feeds into the deliberations of the CIGs. The work is overseen by National, Regional and International Programme Coordinators, who together form the Programme Management Committee (PMC). Responsibility for each country programme rests with a Programme Management Team (PMT) composed of senior representatives of universities, ministries, R&D organisations, the private sector, NGOs and FBOs. The PMTs and coordinators are proving to be high-level networkers and important advocates of the institutional change initiated by the CIGs and PhDs.

1.5 Domains reflect national priorities

- *Benin*: cotton, oil palm (inter-cropping oil palm and annual crops, and the oil palm seed system) and integrated water management (agro-pastoral dams in the North, and rice production in valley bottoms in the South);
- *Ghana*: palm oil and cocoa (work in the domain of small ruminants ended when the RA was promoted to another location by his home organisation);
- *Mali*: integrated water management, integration of crop and livestock production (both in the Office de Niger), and shea butter (*karité*).

1.6 Key activities

- Identifying key constraints that specific categories of smallholder farmers and processors experience when trying to improve their livelihoods and incomes through productive or value adding activities.
- Identifying and researching the institutional reasons for the constraints at the local and higher system levels.
- Identifying key actors, networks and mechanisms that maintain the constraints, as well as entry points for action to by-pass, or transform the institutional context to overcome them.
- Assembling multi-stakeholder platforms of key actors who can be expected to engage in institutional change in their respective domains.
- Enabling platform actors to experiment with institutional arrangements.
- Institutionalising achievements in university curricula, the programmes of research institutes, government policies, the structure of agricultural industries, and arrangements among enterprises and services and in value chains.
- Researching the processes of change and the work of the CIGs by means of real-time monitoring and a form of modified causal process tracing, based on two declared theories of change (intervention theory focused on internal and external activities and relationships of the CIGs; and power theory, focused on networks that have power to change or maintain institutional contexts linked to each domain).

Ensuring that the outcomes of the action research are published and disseminated through international scientific media, and shared with local, national, and regional government agencies and political decision makers.