



Management of agro-pastoral dams in Benin: Stakeholders, institutions and rehabilitation research

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ARTICLE INFO

Article history:

Received 30 September 2011

Accepted 27 June 2012

Available online 27 August 2012

Keywords:

Multiple resource use

Water pollution

Complex conflict

Crocodiles

ABSTRACT

Agro-pastoral dams are waterholes constructed to provide water for livestock and for agricultural development. In Benin, agro-pastoral dams are managed by dam management committees. This study seeks to (1) characterize the stakeholders involved in agro-pastoral dam use and management, (2) identify important institutional and technical impediments and opportunities related to dams as perceived by the stakeholders, and (3) identify a coherent set of domains for research in support of improved dam management and ecosystem rehabilitation. The study was carried out in the Nikki District in northern Benin. The data were collected through focus group discussions, semi-structured interviews, participant observations and participatory exercises with diverse stakeholders. The results show that the dams are used for multiple purposes such as providing drinking water for livestock and people, fish production, vegetable production, swimming, bathing, washing, house construction, food crop production and cotton farming. All these practices involve diverse stakeholders with different interests, backgrounds, knowledge, and assumptions. In addition, the dams are the main habitat for crocodiles, which thus can also be seen as key stakeholders. The use and management of the dams create conflicts among the stakeholders who all tend to reproduce their own 'truth' and to shift the responsibility for solving conflicts to others. Moreover, the water is becoming seriously polluted, which impinges on every stakeholder's interests. The analysis indicates five domains for further research: (1) the way agro-pastoral dam water quality can be improved, (2) the mechanism through which to improve agro-pastoral dam fish production, (3) the way stakeholders in different contexts do frame crocodile behaviour and habitat use, (4) the characterization of crocodile behaviour and habitat use in agro-pastoral dams, and (5) the way to promote an inclusive agro-pastoral dam management.

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Abbreviations: APD, agro-pastoral dam; CeCPA, communal centre for agriculture promotion (Centre Communal de Promotion Agricole); CoGes, dam management committee (Comité de Gestion du barrage); DGFRN, department of forests and natural resources management (Direction Générale des Forêts et des Ressources Naturelles); DGR, agricultural engineering service (Direction du Génie Rural); FCFA, Franc – Communauté Financière d'Afrique (Franc – Financial community of Africa); FAD, development aid fund (Fonds d'Aide au Développement); FGD, focus group discussion; MAEP, ministry of agriculture livestock farming and fisheries (Ministère de l'Agriculture de l'Elevage et de la Pêche); MEHU, ministry of environment housing and town planning (Ministère de l'Environnement de l'Habitat et de l'Urbanisme); PADPPA, participative artisanal fisheries development programme (Programme d'Appui au Développement Participatif de la Pêche Artisanale); PDEBE, Project of Livestock farming in East-Borgou (Projet de Développement de l'Elevage Borgou Est); PDRT, Roots and Tubers project (Projet de Développement des Racines et Tubercules); PESB, South Borgou Project of livestock farming (Projet d'Elevage Sud Borgou); SNV, Netherlands Development Organization; SSIs, semi-structured interviews; UCOPER, communal union of herders (Union Communale des Producteurs et Eleveurs de Ruminants); UNCDF, United Nations Capital Development Fund; UNDP, United Nations Development Programme.

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1. Introduction

Water access and availability are emerging as critical challenges to sustainable development in the 21st century [1,2]. Water plays a key role in society in terms of food, energy, and industrial activities. It also plays a critical role in physical and biological processes, through runoff, groundwater flows, soil moisture replenishment and other ecosystem functions [3]. Pressure on water resources and ecosystems, resulting from urbanization, population growth, land use change, increased irrigation, construction of dams, pollution, climate change and other impacts related to human activities and economic growth need to be addressed urgently at both local and global level [4–6].

In Benin, the water and grazing requirements for livestock [7] are the major impediments for the development of livestock production. The severe drought of 1970, which caused high ruminant (cattle, sheep and goats) mortality compelled the government to promote agro-pastoral dams (APDs), managed by dam management committees (CoGes) in order to provide additional drinking water for livestock and agricultural development [8]. The promotion of waterholes is one of the priorities identified by the Benin government for improving production systems [8]. The waterholes are open for public use and thus are considered a common good [9–11] by a multiplicity of actors. APD management thus has become a complex issue [12–14]. The present situation could be characterized as exemplifying the tragedy of the commons [11]. Trying to achieve a solution by means of centrally imposed taxes or quotas may fail in part because central authorities misunderstand the local situation.

In recent efforts to optimize the management of the APDs in northern Benin, the invasion of the dams by crocodiles, which are considered by some stakeholders to be one of the main hindrances to fish production and to the sustainable use of the dams, has been pinpointed as a major constraint [8,15,16]. At the same time, the northern Benin crocodile species are considered by national and international experts to be in danger of extinction [16,17], leading to demands for their protection [17]. So the challenge is to find innovative ways to optimize dam use and management from the perspective of integrated water resources management, taking into account social, environmental, technical and institutional aspects and the interests and practices of all actors involved, including the crocodiles. This seems likely to require forms of water management decision-making that are flexible, holistic, and environmentally sound [13].

An exploratory study conducted in northern Benin in 2009 confirmed that the dams have multifunctional uses and identified a number of technical, institutional and ecological issues [15] that appear to be at the root of the problems relating to multi-user water management in this region. Water management responsibilities were found to be fragmented, with little regard for either the conflicts or complementarities among the stakeholders' diverse, social, cultural, economic, ecological and environmental objectives. On the basis of that study, the justifications for an in-depth diagnostic study were identified.

The aim of this diagnostic study is to provide the first description of the so far unexplored situation and develop research priorities that aim to contribute to the design of an innovation process for improving the situation at grass roots level. The focus is on managers' and users' practices and perceptions, taking into account both formal and informal institutions that might enable or hinder innovation. The specific purposes of this study are (1) to characterize the stakeholders involved in agro-pastoral dam management, (2) to identify their practices and perceptions in relation to dam use and management, (3) to identify important institutional and technical impediments and opportunities, and (4) to identify a set

of researchable domains to support effective and sustainable dam use and management.

2. Methodology

2.1. Framing change and innovation

The methodology of our study is framed by the idea that innovation is a collective process that involves the contextual re-ordering of relations in multiple social networks [18]. Such a re-ordering cannot be usefully understood in terms of 'diffusing' ready-made solutions. In the development and design of innovation, everyday communicative exchanges and self-organization amongst actors are likely to be of critical significance in connection with the re-ordering.

Innovation studies suggest that complex interdependencies and regularized interaction (including communication) patterns tend to constrain the space for meaningful innovation, not in the least since a number of the actors in a network are likely to have a vested interest in maintaining the existing situation. Such vested interests are expressed in the prevailing formal and informal societal rules and arrangements that actors draw upon and reproduce in their interaction [19,20]. Despite such constraints, and despite the experience that deliberately designed change is not easily achieved, we see that societal relations change continuously – and quite radically at times. Self-organization i.e., the emergence of order without external control [21], plays an important role in bringing about patterns of change. The term self-organization does not mean that change happens automatically and without human intentionality; change emerges as the unintended outcome of numerous intentional actions that interact and interfere with each other in complex ways [22–25]. This perspective suggests that latent opportunities for change always exist (even if unacknowledged) and that societal contexts and structural conditions are not only constraining but also enabling [19]. In this framing it is relevant to think about the space for innovation [26]; in a general sense, this might be thought of as the room for manoeuvre that exists or emerges in a network of interactions occurring at multiple social interfaces.

This approach to change and innovation is connected to theories of complexity [27]. The behaviours of people are positioned as conditioned by numerous variables and we cannot count on linear serials of causes and consequences to explain the change dynamic. We assume in this paper that each activity associated with the dams involves numerous stakeholders interacting with each other in diverse ways leading to either co-operation or conflict among them and that improved dam management can be found only if the actors take into account the system of interactions as a whole [18,28].

2.2. Research setting

The study was carried out in three villages (Nikki, Sakabansi and Fombawi) in Nikki District, which lies in the Borgou Department in north-eastern Benin (Fig. 1).

Nikki District covers an area of 3171 km² and houses 20 agro-pastoral dams [8]. The main sources of livelihood of the local communities are crop production, livestock farming, fishing and trade of agricultural products [8]. The three main dams are:

1. The Nikki agro-pastoral dam, constructed in 1972 and renovated in 1996 by the United Nations Capital Development Fund (UNCDF). It has a capacity of 257,000 m³; the surrounding watershed is 120 km² [8]. It is located within the boundaries of Nikki town. The annual influx of livestock gives rise to conflicts

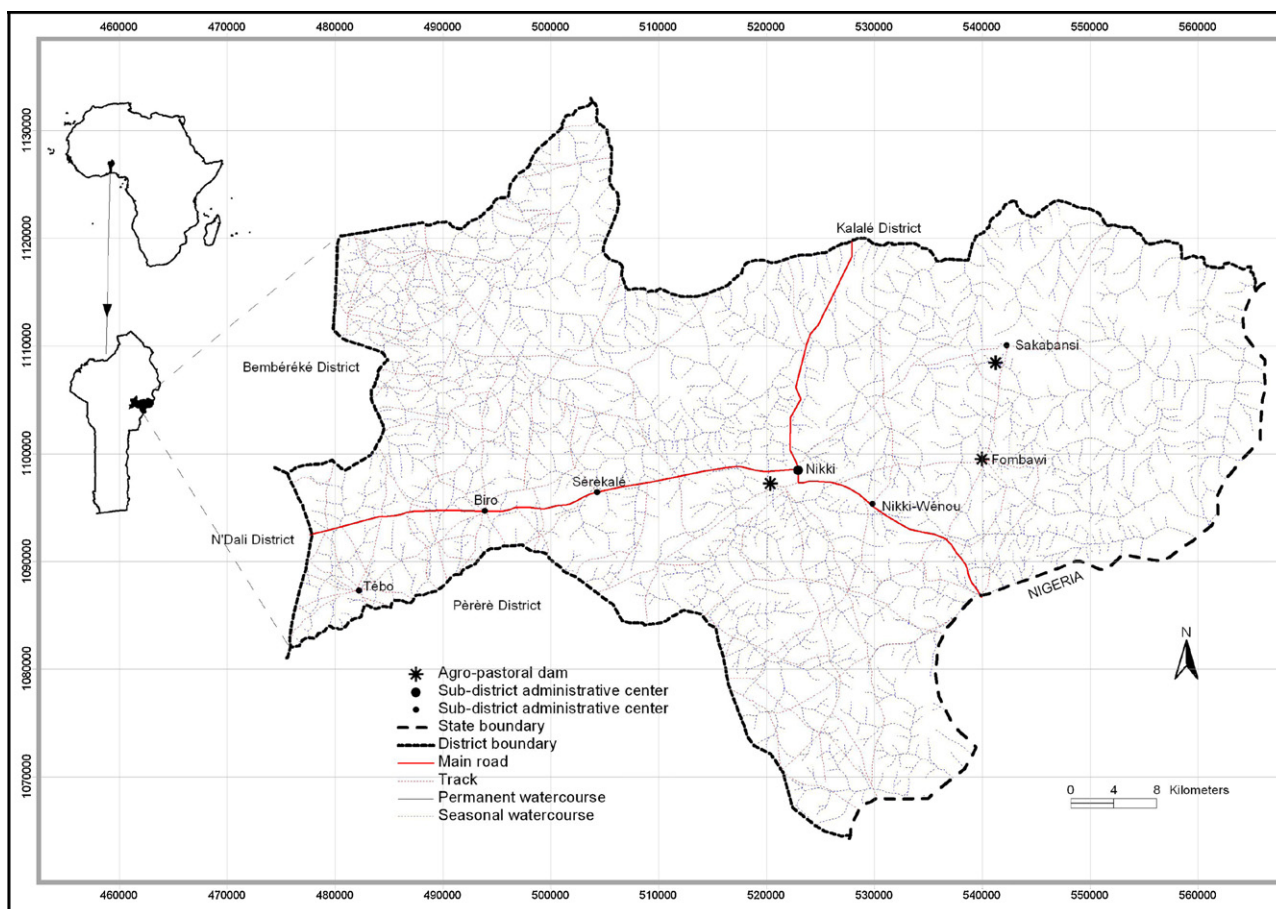


Fig. 1. Location of the Nikki, Sakabansi and Fombawi agro-pastoral dams, Benin.

Source: Map designed by G.N. Kpéra.

between herders and farmers. Fishing is carried out at least two times a day. Crocodiles live in the dam and are regarded as an impediment to fish farming.

2. The Sakabansi agro-pastoral dam. The dam has a surface area of 1 ha, has a capacity of 200,000 m³ and is surrounded by a watershed of 20 km². It was constructed in 1985 by the Development Project of Livestock East-Borgou (PESB) with the financial support of the Development Aid Funds (FAD) [8]. Because of its geographical position the dam is mainly used to provide additional drinking water for livestock. It lies at crossroads for transhumant herders from the bordering districts and countries, and conflicts between herders and farmers are common. Fish production is a secondary activity that also is hindered by the presence of crocodiles.
3. The Fombawi agro-pastoral dam, constructed in 1989 under the financial support of the United Nations Development Programme (UNDP) and under the East-Borgou Development Project of Livestock (PDEBE) in Benin. The dam has a capacity of 17,000 m³ and is surrounded by a watershed of 2.4 km² [8]. Its geographical position means that it is used by national and international transhumant livestock and this periodically intensifies farmer–herder conflicts. Fishing takes place only once a year because of the high number of crocodiles that hinders this activity. Unlike the Nikki and Sakabansi dams, here the crocodiles are honoured because they represent the cultural identity of the local people, who protect them by means of traditional institutions and have developed considerable knowledge related to the ecology, behaviour and endogenous conservation of crocodiles.

2.3. Research methodology

The study seeks to provide an in-depth understanding of the on-going dynamics in stakeholders' relationships at the interface between the formal arrangements and self-organized initiatives governing their interaction. Because case studies enable the development of richly textured information they may be used to explain complex causal links in real-life situations and to describe the real-life context in which interventions take place [29,30], a comparative case-study approach has been chosen as the overarching research design.

Case study methods involve an in-depth, longitudinal examination of a single instance or event: a case. A case study provides a systematic way of looking at events, collecting data, analysing information, and reporting the results. The researcher may gain a sharpened understanding of why the instance happened as it did, and of what is important to look at more extensively in future research. Case study research also has limitations: generalizations cannot be made and the results are not widely applicable. However, case study research may allow analytical generalization.

Because of the diagnostic nature of our study largely qualitative methods were used. We started with a desk study leading to archival data collection from various departments with responsibilities for water and livestock management at the Ministry of Agriculture, Livestock Farming and Fishery (MAEP), the Department of Forest and Natural Resources Management (DGFRN), the Agricultural Engineering Service (DGR) and the Hydraulic Service. Data on stakeholders' perceptions of the management and use of

the dams was obtained through 19 focus group discussions (FGD) [31] whose members were drawn from amongst each of the stakeholder categories identified in the three study villages (yielding 7 FGDs in Nikki, 7 in Sakabansi and 5 in Fombawi). A stakeholder analysis [33] was carried out to identify the stakeholder categories. The analysis also allowed the researcher to develop a preliminary understanding of stakeholders' behaviour, intentions, and interests. The snowball technique was used to identify representatives of each stakeholder category and these were invited to join the focus group discussions. The snowball technique yields a sample based on referrals made by people who share, or know others who present the characteristics that are of research interest [34].

The resultant focus groups consisted of seven to nine men and women who were involved in one of the following specific focus activities: vegetable farming, herding, non-vegetable farming, fishing, and membership of a dam management committee. Members of the town council, women washing kitchenware and clothes around dams, and children who swim in the dam were also included. The focus group method surfaces and explores meanings and rationalities with respect to water practices at the group level and in interaction between the researcher and the participants [32].

The snowball technique was used also to identify male and female respondents in each stakeholder category, with whom twelve, eight and seven individual semi-structured interviews (SSIs) were held in respectively Nikki, Sakabansi and Fombawi, in

order to obtain more detailed information on their experience of activities, impediments and opportunities.

The discussions in the focus groups and the individual interviews were tape-recorded and transcribed. In addition, participant observation and participatory exercises (brainstorming and problem analysis), as well as numerous natural interviews, were used to identify additional impediments and opportunities. Finally, two stakeholder meetings with representatives of each category of stakeholders from Nikki, Sakabansi and Fombawi were organized in Nikki. The first meeting was attended by 22 participants and the second by 28 participants, and included herders, vegetable farmers, food crops and cotton farmers, dam management committee members, members of the town council, daily users of the APDs, fishermen, dam security guards, local officers of MAEP and of the local union of herders (UCOPER). At each of the two meetings the researcher first presented the preliminary findings, which were then discussed. The participants also listed and prioritized further items for research and intervention.

The data and information were analysed manually by comparing and contrasting the stories of the stakeholders in order to find patterns, such as the interdependence amongst activities related to stakeholders' diverse interests and backgrounds, and explanations for the identified conflicts and problems.

Table 1 summarizes the methods, the target respondents and the number of respondents per village.

Table 1
Objectives and methodology for data collection and analysis in the Nikki, Sakabansi and Fombawi agro-pastoral dam areas.

Objectives	Tools/methodology	Targeted respondents	Number of respondents		
			Nikki	Sakabansi	Fombawi
Characterization of stakeholders involved in the agro-pastoral dams management	Desk study: archival data collection Focus group discussions Stakeholder analysis Snowball technique Tape-recording of interviews and transcription	Food crops and cotton farmers, herders, vegetable farmers, fishermen, dam management committees, Council of Nikki, women who wash kitchenware and clothes around the dams and children who swim in the dam, Agricultural engineering service (DGR), workers of the communal centre for agriculture promotion) (CeCPA)	56	56	45
Identification of stakeholders' practices and perceptions related to dam use and management	Focus group discussions Individual semi-structured interviews Participant observation Participatory exercises (brainstorming and problem analysis) Tape-recording of interviews and transcription	Herders, vegetable farmers, food crops and cotton farmers, dam management committee members, town council, daily users of the dams, fishermen, dam safe guards, local officers of the Ministry of agriculture, livestock farming and fisheries, UCOPER, SNV, PADPPA	56	56	45
Identification of important institutional and technical impediments and opportunities to dam use and management	Focus group discussions Individual semi-structured interviews Participant observation Natural interviews Tape-recording of interviews and transcription	Herders, vegetable farmers, food crops and cotton farmers, dam management committee members, town council, daily users of the APDs, fishermen, dam safe guards, CeCPA, UCOPER, SNV, PADPPA	68	64	52
Identification of a set of researchable questions to support effective and sustainable dam use and management	Stakeholder meetings Tape-recording of interviews and transcription	Herders, vegetable farmers, food crops and cotton farmers, dam management committee members, Council of Nikki, daily users of the dams, fishermen, dam safe guards, CeCPA and UCOPER	28	16	10

3. Results

3.1. The stakeholders in agro-pastoral dam use

The stakeholders in dam use or management are diverse. Two main categories were identified: (1) the users of the dams' ecosystem services (herders, vegetable farmers, food crops and cotton farmers with a farm near the dams, daily users of the dams, fishermen and crocodiles), and (2) governmental officers at local and at national level. We first describe their perceptions and practices related to dam use and management, including the problems and impediments they experience.

3.1.1. Users

Based on information from the focus groups and interviews, our study shows that the diverse stakeholders use the agro-pastoral dams (APDs) for different goals and purposes. These sometimes allow other uses and goals to be respected but often exclude them, leading to conflict. The main stakeholder groups include herders, vegetable farmers, food crops and cotton farmers, daily users, fishermen, dam management committee members and crocodiles.

3.1.2. Herders

In all the areas studied, both farmers and herders are involved in livestock farming. The herds typically are mixed, consisting of cattle, sheep and goats, and belong to four sub-categories of stakeholders: (1) local farmers, (2) local herders, (3) herders from districts bordering Nikki and Segbana, and (4) herders from countries bordering Benin (Nigeria, Niger and Burkina Faso). Typically, the farmers own 2–10 animals, and local herders 50–500 animals, whereas herders from the bordering districts and countries own 500–1000, mostly cattle. In the latter case, shortages of water and grass, particularly during the dry season, recurrently force the herders to migrate with their livestock over long distances from Niger, Nigeria and Burkina Faso into Benin.

A participant of one FGD noted that the local herders have contributed to the construction of the APDs because the APDs were perceived to be very beneficial to them: they could water their livestock year-round without walking long distances. *If our dam disappears, humans and livestock will suffer a lot and our livelihood will be negatively affected* (FGD, August 2010).

From 2001 onward the local herders have been organized by UCOPER (Union Communale des Producteurs et Eleveurs de Ruminants), a union open to herders from the whole district. According to both herders and UCOPER managers, UCOPER's main interest is to manage the conflicts between farmers and all four of the herder sub-categories, defend herders' interests, improve water quality and become highly involved in APD management. UCOPER participates also in the setting of national and international transhumance corridors that all categories of herders must follow to access the waterholes and pastures. However, according to farmers and other stakeholders, herders do not make use of these corridors because they want to escape the grazing-tax collectors. In addition, both local and transhumant cattle (i.e., cattle from districts bordering Nikki and Segbana and from countries bordering Benin) are herded by children who let the animals access the dams from all sides. The animals drink for 20–40 min and then graze around the dams on farmers' land where fresh grass is available even during the dry season. In addition, herders find the corridors too long and therefore they prefer to shorten the journey by passing across farmers' land. According to the farmers, this results in cattle and other animals destroying the farmers' crops and eating their grass. The herders, in turn, blame those farmers who, in order to extend their land, deliberately decide to obstruct the livestock corridors. During the rainy season, the conflicts are less: few livestock visit the dams

because water is available from small ponds and rivers around the villages.

All the herders we talked claimed that the main impediments to the use of the APDs are the recurrent conflict between farmers and herders, water pollution, and the silting up of the dams. They blame the farmers for impeding access to the dams as well as the council of Nikki for taking a position favourable to the farmers. According to them, both native and transhumant herders are considered as strangers whose interests do not necessarily have to be taken into account. Moreover, several herders (70%) shared the following view: we herders do not like politics. *As the town council knows that it cannot count on our vote to win elections, we are usually marginalized in favour of the farmers during conflict resolution* (Mama Sambo, Sakabansi, October 2010).

As far as water pollution is concerned, the herders do not see themselves to be the agents of the poor water quality. They shift the responsibility by saying: *the daily users of the APDs pollute water by washing and swimming in the dams, by defecating and by leaving household waste at the water edge. Vegetable growers and farmers of food crops and cotton around the APDs also pollute the water by using inorganic fertilizers and pesticides* (Djodi Adamou, Fombawi, October 2010).

3.1.3. Vegetable farmers

Vegetable growers are organized in associations of farmers who grow vegetables around the APDs in the villages. At Nikki, two vegetable farmer associations exist: *Ansouroukoua association*, initiated in 1990 with 20 members and now consisting of 150 members (130 women and 20 men), and *Donmarou association*, created in 2007 and consisting of 50 members (10 men and 40 women). Vegetable farming at Nikki is carried out mainly in the dry season. The cropping area is located about 800 m upstream from the dam i.e., they do not use directly the water from the dam but instead dig small wells of 2–3 m deep. A large variety of vegetables is grown, among which the most common are: red amaranth, sesame, okra, tossa jute, hot pepper, African eggplant, roselle, silver cock's comb, wild cabbage, lettuce, tomato, carrot and onion. Individual plot size varies from 200 m² to 800 m². To fertilize the soil animal manure is used by 61% of the respondents; 39% use inorganic fertilizers because these are considered to be more effective than animal manure. We noticed people also making use of a bio-pesticide made locally from neem seeds and leaves and that the highly toxic synthetic pesticides Endosulfan and Lambda Cyhalothrin C-Profenofos – which formerly were recommended for use on cotton and currently are forbidden in Benin – are being used on the sly by vegetable growers.

At Fombawi, 32 women have organized themselves into an association for vegetable farming, called *Angara debu*. Their main crops are red amaranth, sesame, okra, tossa jute, hot pepper, roselle, melon, lettuce and tomato. The plots are located downstream of the dam and the women draw water manually from the dam by using bowls. Animal manure is used as fertilizer and – although the women complain about its ineffectiveness – also plant ash is applied as a bio-pesticide. Since 2009 the women have stopped vegetable farming in Fombawi, because, as they said, their garden fence and their products were many times destroyed by cattle. In addition, their products were destroyed by bush fires lit by 'dishonest people seeking giant field mice', which are considered an important delicacy.

The vegetable farmers association of *Ankua mon* at Sakabansi was created in 1998 and counts nowadays 30 members (29 women and one man). The association was restructured in 2004 on the initiative of a support of the Roots and Tubers project (Projet de Développement des Racines et Tubercules), which helped the members to obtain seeds and trained them in cropping techniques. As at Nikki, the vegetable plots are located upstream. The farmers cultivate the same vegetables as in Fombawi. Compared

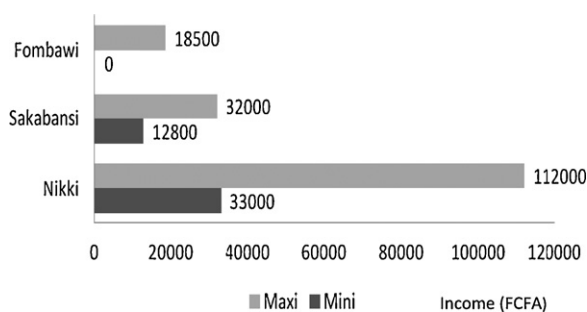


Fig. 2. Average maximum and minimum income per person per season of women vegetable growers in Fombawi ($n = 26$), Sakabansi ($n = 23$) and Nikki ($n = 21$) villages. Sources: interviews with vegetable producers, 2010, and survey in Nikki Sakabansi and Fombawi, villages, 2010.

with Nikki and Fombawi, the farmers' plots are very small. Instead of getting water directly from the dam they dig small wells near their plots. Animal manure is used as fertilizer and plant ash as a bio-pesticide. Because they greatly appreciate vegetable production, they are motivated to remove the impediments to production in order to improve their income.

The vegetable farmers' main concern is to get water and materials for their activity.

During the FGDs with the vegetable farmers, and at the two stakeholder meetings, a number of technical impediments were listed, such as the decrease in vegetable yield because of diseases and pests, the lack of inorganic fertilizers, the lack of materials and seeds and, at Fombawi, the destruction of fences by cattle. The harassment in accessing credit and the difficulty in accessing potential markets for their products were also mentioned. Because only registered associations have easy access to the micro-credit allocated by the government and by non-governmental organizations all vegetable farmers have become members of an association.

The main opportunity for vegetable farmers is that they are close to Nigeria, which is a large centre of commercial food crop marketing, but currently only the Nikki farmers take advantage of this market. However, they do not look to the town council in Nikki for support in opening up this market; rather, the council is seen by the vegetable farmers as a threat. According to the farmers themselves, the council has accused the farmers of contributing significantly to the silting problem and to water pollution through their activities. Attempts made by the dam management committee and the council of Nikki to expel the vegetable farmers from their upstream to new downstream sites have not been successful for the following reasons as expressed by the farmers themselves: *there is no infrastructure downstream; the new place is stony and dry and water is not easily available.* (Ibouraima Maimou, Sakabansi, November 2010), and: *we are not the ones polluting the dam and this place is for everybody. We have the right to use it like we want. Even if you come here with a crane; we are not going to move* (Aboudou Mamatou, Sakabansi, November 2010).

Once more, it can be noticed that it is 'the other stakeholders' who are blamed for the pollution and other problems.

Fig. 2 presents women vegetable growers' minimum and maximum incomes in Nikki, Fombawi and Sakabansi. The income is higher in Nikki where vegetable growers have access to local markets and to a market in Nigeria (Tchikanda).

Regarding the sustainability of the dams, vegetable farmers are aware of the grounds for concern in all the three cases. However, they say that everybody is trying to use the dams' resources to the maximum because what is important for them is their day-to-day life.

3.1.4. Food crops and cotton farmers

The food crops and cotton farmers who have a farm near the APDs are growing mainly maize, groundnut, soya bean, millet, sorghum, yam and cotton. It is common to see farms located at only 50m from the edge of the water in the dams. The cropping system is characterized by the use of authorized inorganic fertilizers and pesticides. However, several farmers also use the prohibited organochlorine pesticides Endosulfan (Benzoepin), lindane (gamma-hexachlorocyclohexane), and DDT (dichlorodiphenyltrichloroethane). They indicated to us that they buy these chemicals from the Chikandou Market in Nigeria (located at 22 km from Nikki) because they are cheap.

Thirty-five percent of the farmers interviewed honestly recognized that they are contributing to the silting up of the dams and to water pollution. However, the majority (65%) of the respondents blame the herders, who allow livestock to urinate and defecate into the water. They also blame the daily users of the APDs for polluting the water by their activities: *livestock urinate and defecate into the water, polluting the water. In addition, users wash and clean their things directly in the water* (Guerra Issa, Fombawi, November 2010).

In all the three dam areas, the production of non-vegetables takes place in a radius of 1 km from the water's edge. A decision to displace these farms from this land has been taken by Nikki town council. The farmers have been informed about this decision but it has not yet come into force. The farmers claim that land scarcity is the reason that they are cultivating this land and why they do not want to leave. In addition, they refer to their grandfathers' land rights, which extended into the area now covered by the dam. According to the town council, however, the area belonged in the past to certain families who voluntarily offered it to the village to accommodate the dams. The Council of Nikki recognizes that these donations unfortunately were made without a formal act supporting their land rights.

3.1.5. Daily users

Every day, people visit the APDs for various purposes such as collecting water for drinking and domestic uses, washing (kitchenware, clothes, motorbikes and cars), swimming and bathing. As the APDs have no organized entrance or exit, access is free for everyone who wants to make use of the water.

During the dry season, finding water for domestic uses is an ordeal for many people. Most of the wells dry up and the only water available is drawn from ground wells by hydraulic pumps, which are costly to buy and operate; however, access to the APDs is free. The women in Sakabansi and Fombawi use water from the dams for cooking, for other domestic uses and for drinking for two reasons as they say: (1) they are too poor to buy the clean water supplied by commercial water sellers; and (2) because everyone uses the water it would be fairer if everyone paid for using it. Others argue that they continue drinking the water of the dams simply because they have done so for many years without experiencing any problem. However, others seriously doubt the quality of the dams' water and see this practice as a health risk.

In addition, at Nikki the water is used in the construction of houses and roads and in Sakabansi and Fombawi in house construction. The Nikki town council has decided that those who use the water for construction must pay 2000 FCFA (€3.05) per house under construction. The money is supposed to be collected by the treasurer of the dam management committee, who sends the amount collected to the Nikki town council account. At Nikki, it is a guard who is responsible for collecting the payment as he is living near the dam. However, some people refuse to pay the money, arguing that the town council is doing nothing to improve the quality or allocation of the dam water and as long as the dam water is treated as a common good they too have the right to use it freely.

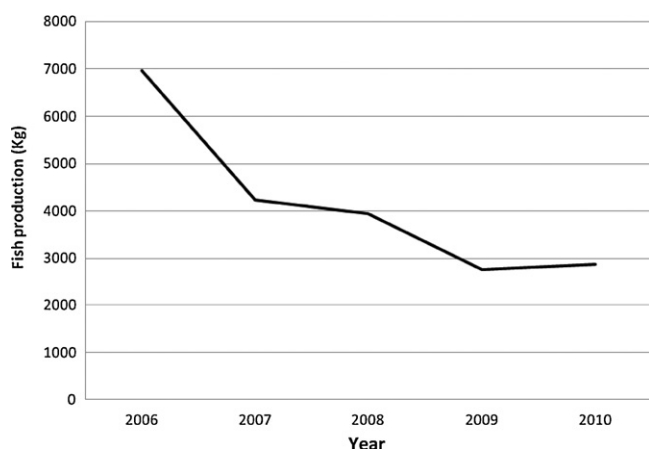


Fig. 3. Fish production in Nikki District between 2006 and 2010.

Source: CeRPA, Nikki, 2010.

The daily users' main interest is to continue to have free access to the dams. The presence of crocodiles is experienced as an impediment to access. In all the villages the silting up of the dams and the water quality are highlighted as additional problems in daily use.

3.1.6. Fishermen

Fish farming is not open to everybody: the Council of Nikki employs registered fishermen who live in Nikki town or who come from Niger for temporary work. The fishermen receive 1/3 of their fish catch; 2/3 is in principle reserved for the council. The fishermen's main interest is to intensify fish production because their incomes depend on the fish yield. They also fish for themselves in the Niger River and the Ouémé River i.e., their livelihood does not completely depend on the APDs.

The fishermen claim that there has been a strong decrease in fish yield, caused principally by the silting up of the APDs, by longer drought periods, water pollution, and the lack of attention paid to these trends. Between 2006 and 2010, fish yield decreased in the whole district of Nikki, as illustrated by Fig. 3. They also mentioned the invasion of the dams by aquatic plants and the lack of fishing equipment.

At all the three dam sites, crocodiles were identified both by fishermen and the dam users as one of the main hindrances to fish farming because of their high predation on three valuable fish species: the Nile tilapia (*Oreochromis niloticus*), the Guinean tilapia (*Tilapia guineensis*) and the African sharp tooth catfish (*Clarias gariepinus*). They claimed also that the crocodiles destroy fishing nets and the dam's infrastructure (by digging holes into the dyke). At Nikki and Sakabansi the crocodiles are hunted and killed and their meat, organs and skins sold. However, in Fombawi local people accept the presence of crocodiles and have created rules and behaviours that seem to allow them to live in peaceful co-habitation with the crocodiles.

3.1.7. Dam management committee

Each dam is maintained by a dam management committee (CoGes: Comité de Gestion du barrage) consisting of seven to nine members, comprising farmers, herders and vegetable growers, who are considered the main dam ecosystem users. The main functions of the CoGes are to clean periodically the dams and the surrounding area, open transhumance corridors, prevent robbery of the fish, and control activities that contribute to the silting up of the dams and to water pollution. The CoGes members are selected by the Nikki town council at a general assembly. The CoGes' powers are limited to the dam they are in charge of. The actual state of the APDs leads to serious doubts whether there is a sufficient performance

of their functions. According to the members of the CoGes who were interviewed in this study, the informal deal is that the management committees take care of the dams and in compensation benefit from a kickback (amounting to 2/3 of the fish production per fishing session). The CoGes members confessed that they are not motivated to perform their official role because the informal deal is not respected.

3.1.8. Crocodiles

Several species of wild animals occupy the dams, including snakes, monitor lizards, turtles and crocodiles. Crocodiles appear to be the most impressive of these animals both in number and in size, and people give them full attention. They occur in all the three dams but in different numbers. According to local people, crocodiles are rare in Nikki (less than 20), common in Sakabansi (20–100) and abundant in Fombawi (more than 200). Two crocodile species are said to occur in the dams: the Nile crocodile (*Crocodylus niloticus*) and the Dwarf crocodile (*Osteolaemus tetraspis*). However, only the first species was observed during this study. Most of the interviewed dam users stated that the invasion of crocodiles took place after the construction of the dams. In earlier times, old people testified, there were large numbers of crocodiles in the rivers and ponds and in their experience crocodile numbers had decreased. They related the perceived decrease in the number of crocodiles to the longer drought periods in the area, the destruction of the crocodiles' natural habitats because of urbanization, poaching for meat and organs, and the lack of motivation from the stakeholders to undertake dam management for the conservation of ecosystem functions, including the protection of the crocodiles.

Although, as we have noted, many stakeholders think that the crocodiles are a problem, in all the three villages people seem to have a particular relationship with the crocodiles. Respondents framed the crocodiles as lying at the heart of the APDs because, according to them, the availability of water depends on the crocodiles, because they maintain the water in the dams by digging holes so that the ground water can be reached. At Nikki and Sakabansi, crocodiles are considered wild animals but with the particular additional assumption that: *it is not good to kill crocodiles because this can bring misfortune* (Seidou Karim, Nikki, July 2009).

This assumption, however, does not prevent people from hunting the crocodiles, because they are thought to eat too much fish and because they are considered good bush meat. According to respondents in Nikki and Sakabansi the crocodiles also destroy fishing equipment and they attack their dogs and sometimes even their sheep. According to local press reports, in the period March 2010 to July 2011, two dogs at Nikki, four at Fombawi and six at Sakabansi were killed by crocodiles. In the same period, respondents stated that a child was bitten by a crocodile in Fombawi dam when it was swimming. Such incidents lead people to reason as follows: *We know that crocodiles are natural resources and part of our biodiversity. We have to protect them for new generations. In many villages, crocodiles disappear because of poaching. It is a pity for young people. In this village, we do not kill them all. We just kill adult crocodiles that cause damage and leave sub-adults and young animals in the dams to grow. We do not have any solution apart from killing them because they affect our means of living* (Abou yacoubou, Sakabansi, December 2009).

This analysis shows that there is an ambivalent attitude towards crocodiles: people do not feel comfortable about killing them; however, they do not want them in their dams. In Nikki we talked to a crocodile hunter who argued that God gave him the talent to fight the crocodile (which is considered to be extremely difficult) so that he was obliged to do so. This could be interpreted as a rationalization that allowed him to kill the crocodiles without taking the responsibility for doing so.

At Fombawi, crocodiles are conserved for their specific role in the local culture: crocodiles are thought to be holy, protecting people from bad luck. Old people interviewed in Fombawi explained: *We have a great chance to have some specimens of crocodiles in our village and we thank God for that* (Boco David, October 2009).

Neither killing crocodiles nor collecting them to give them away as pets is allowed in Fombawi. There is considerable local respect for the crocodiles and, as a result, most people have learned to peacefully live together with them by sharing fish and water. The rules and behaviours for sharing are reinforced in celebrations and rituals and handed down to children in folk tales. Many people in Nikki and Sakabansi blame the people from Fombawi because they assume that the crocodiles present in their own dams have come from the Fombawi dam.

3.2. Stakeholders in government at different levels and in a non-governmental organization

In this section we explore the role of the governmental stakeholders and a non-governmental organization that is supporting the rational evolution in the use and management of the dams.

The council of Nikki represents the local government, following the decentralization reforms that started in 2005. The council consists of 17 town councillors elected by popular vote and the town councillors in turn elect the Mayor. The council employs workers to provide various services that impact the dams and their use. These workers, the councillors and the Mayor together form the staff of the council of Nikki.

In the decentralization process all the 20 APDs in Nikki District that were formerly under the control of the Communal Centre for Agriculture Promotion (CeCPA: Centre Communal de Promotion Agricole) are now under the control of the council. According to the town council respondents, the income from fish production for all the 20 dams was estimated in total to be one million FCFA (€ 1527) in 2010 and 1.5 million FCFA (€ 2290) in 2011. This revenue should contribute to local development. The council's main interest is to raise more financial resources for local development by maximizing the dams' incomes, and to increase their power in decision making. However, the council has been blamed by the CoGes and users of the three dams for a prejudiced mismanagement of the dam income, giving use to a feeling of frustration amongst all the stakeholders. People reason as follows: *The Council of Nikki collects money from herders and they also sell fish. But they use the money for their own business* (Sani Imorou, Sakabansi, November 2010).

CeCPA represents and provides a service at district level on behalf of the MAEP that consists of advising and helping farmers and herders in relation to various agricultural practices. Before decentralization, CeCPA managed the APDs. Nowadays, CeCPA only intervenes in dam management as an advisor. As stated by the workers interviewed, CeCPA's interest is to help to improve fish production in the dams and to advise users and managers on the sustainable management of the APDs. However, as noted in the field, co-operation between CeCPA and the Nikki council seems to be weak.

The department of forests and natural resources management (DGFRN: Direction Générale des Forêts et Ressources Naturelles) falls under to the Ministry of Environment, Housing and Town planning (MEHU: Ministère de l'Environnement de l'Habitat et de l'Urbanisme). At district level, the service is represented by a forester in charge of the preservation of natural resources (mainly fauna and flora). The forester explained that this service mainly assists in choosing valuable trees for the reforestation of the water edges and ecosystem rehabilitation. The forester always disagrees with the daily users, especially women who cut trees around the dams so as to use for cooking food, and the herders who allow the livestock to destroy the young trees.

The Participative Artisanal Fisheries Development Programme (PADPPA: Programme d'Appui au Développement Participatif de la Pêche Artisanale) is a programme of the MAEP that is active around the Nikki and Sakabansi dams but not in Fombawi. The programme began working in 2005. Its activities include the reforestation of the water edges, stocking the dams with a total of 5000 young fish (*O. niloticus* and *C. gariepinus*), donation of two fishing nets and two dugout canoes and training fishermen and vegetable growers. PADPPA is helping the town council in the design of a draft of a management plan for the two dams. Unfortunately, the programme ended in 2011 although the management plan for the dams was not yet implemented. The programme managers stressed that the programme's main interest was to find ways to harmonize three goals: (1) to improve fish production in the APDs, (2) to increase local people's income, and (3) to contribute to the sustainable use and management of the dams.

The Agricultural Engineering Service (DGR: Direction du Génie Rural) is a service of the MAEP and is in charge of the construction of the APDs and the monitoring and maintenance of the infrastructures. It advises the CoGes on how to carry out their tasks. According to the official staff interviewed, the budget for the maintenance of the dams is supposed to be financed by the money remaining from the initial construction fund. This money has been used and the service no longer has any money left so that the staff rarely visits the dams and maintenance of the infrastructure hardly takes place. As a result, all the dams are in a highly eroded condition.

The Netherlands Development Association (SNV) is a non-governmental association that is providing considerable support to conflict management. It assists the APDs through the UCOPER and the farmer association by financing conflict-solving meetings and by training farmers and herders on local governance and conflict-solving strategies. Its main interest is to reduce farmer–herder conflicts and to promote sustainable agriculture.

Our observations lead us to believe that the governmental stakeholders at both local and national level and SNV do not seem to be able to realize their ambitions, because of lack of sufficient co-operation with and co-ordination between the stakeholders they depend on to accomplish their own tasks and goals.

Table 2 summarizes stakeholders' main interests, the main impediments they perceive and the tensions that arise through dam use and management. Most respondents perceive that it is the totality of activities that has resulted in the serious and continuous decrease in water quality and the persistence of the problems. They themselves perceive that the tensions and problems are likely to become worse since nobody feels responsible for taking action to change the existing situation.

4. Analysis and discussion

During the focus group meetings and the interviews with the various stakeholder groups the respondents frequently referred to both formal and informal rules related to the management and use of the dams. The formal laws that impact on the use and management of the dams are as follows:

1. Law 97-029, articles 84–107, on decentralization. Since 2005, administrative reform in Benin has been engaged in the implementation of processes of decentralization that aim to give local people the power to manage their own region. As a result, many issues have been left to local councils, such as environmental issues, hygiene, public health and rural infrastructure (including the bas-fonds, agro-pastoral dams, and ground water).
2. Law 2010-44, that relates to water management. It states that all the rivers and water holes including the APDs belong to the public domain. Articles 13 and 14 forbid all types of water

Table 2
Stakeholders' main interests, the main impediments they perceive and the tensions identified.

	Stakeholders	Main interests	Main impediments perceived by stakeholders	Tension
1	Herders/UCOPER	Manage conflict between farmers Defence of herders' interests Improve water quality Involvement in the APD management UCOPER participates in the delimitation of national and international transhumance corridors	Recurrent conflict between farmers and herders Water pollution Silting up of dams	Blaming farmers for impeding access to the dams Blaming the council of Nikki for taking a position favourable to the farmers Herders considered strangers; their interests are not usually taken into account
2	Vegetable farmers	Getting free access to dams	Decrease in vegetable yield Diseases and pests Lack of specific inorganic fertilizers Lack of materials and seeds Destruction of garden fences by cattle Harassment in accessing credit Difficulty in accessing potential markets for products Low organization of vegetable farmers associations	Tension with the council of Nikki that wants to expel them from their present location The council of Nikki is seen as a potential enemy
3	Food crops and cotton farmers	Cropping in the surrounding of the dams	Destruction of crop by cattle Conflict between farmers and herders Problem of land tenure	Tension with the council of Nikki who decided to displace farmers farming in a radius of 1 km from the dams The council of Nikki is seen as a potential enemy
4	Daily users of the dams	Maintaining free access to the dams	Strong decrease in fish yield Silting up of dams Longer drought periods Poor water quality Absence of attention to fish production Aquatic plant invasion Lack of fishing equipment Crocodile predation on valuable fish species	Tension with the council of Nikki
5	Fishermen	Intensification of fish production	Presence of crocodiles The silting up of dams Poor water quality	Tension with the town council
6	Dam management committees (CoGes)	Participation in dam management	Not motivated to carry out their functions	Tension with the council of Nikki
7	Crocodiles	Maintaining access to their habitat and food source in the dams	Poaching	Human–crocodile conflict in Nikki
8	Council of Nikki	Raising more financial resources for local development Maximization of dam income Increasing their power in decision making	Aquatic plant invasion Silting up of dams Poor water quality Invasion of the dams by crocodiles	Tension with vegetable farmers of Nikki Blamed by the CoGes and users Tension for a prejudiced mismanagement of the dam income Feeling of frustration amongst all the stakeholders
9	Communal centre for agriculture promotion (CeCPA)	Advise and help farmers and herders in relation to various agricultural practices	Aquatic plant invasion Silting up of dams Poor water quality	Tension with the council of Nikki
10	Department of Forests and natural resources management (DGFRN)	Assist in choosing valuable trees for the reforestation of the water edge	Deforestation of the water edge Silting up of dams	–
11	Participative artisanal fisheries development programme (PADPPA)	Contribute to ecosystem rehabilitation Improve fish production	Poaching of crocodiles Aquatic plant invasion	–
		Increase local people's income Contribute to the sustainable use and management of the dams	Silting up of dams Invasion of the dams by crocodiles	
12	Agricultural engineering service (DGR)	Maintenance of the dam infrastructure	Silting up of dams Destruction of the dam infrastructure	–
13	Netherlands Development Organization (SNV)	Reduce farmer–herder conflicts Promote sustainable agriculture	Conflict between herders and farmers	–

pollution and article 57 allows for decrees to be issued concerning rules governing agricultural and pastoral activities.

3. Law 2002-016, relating to wildlife. It states that crocodiles are a fully protected species and should not be hunted.

As discussed above, the formal rules are not naturally respected at the local level and decentralization does not mean that local people are enabled to manage their environment; the water in the dams for instance is constantly polluted by the various and mostly daily activities. The only village in which the crocodiles are protected is Fombawi and this is not because of the formal law but because of local beliefs and informal rules that fit these beliefs. A further distinction can be made between (1) informal rules set by the town council, and (2) informal rules that are part of local cultures.

The following informal rules, presented in the results section, were set by the town council:

- anyone who wants to use water for house construction should pay 2000 FCFA (€3.05) per house;
- transhumant herders are to pay 50 FCFA (€0.076) per animal before the animals are allowed to enter the area around a dam;
- access to the dams from the dyke by humans and livestock is banned;
- movement corridors are delimited and livestock should remain within the corridors when accessing the dams;
- opening of farms within 1000 m from the edge of a dam is forbidden;
- vegetable farming is authorized only downstream of the dams;
- it is forbidden to wash and swim in the dams;
- washing is allowed only downstream of the dams;
- vegetation fires may be lit only between 15 October and 30 November;
- fishing is allowed only under the conditions and rules set by the town council;
- the income from fish production is divided between the fishermen, the town council and the dam management committee members; and
- income from the dam is to be used for the purposes of local development.

These informal rules do appear to guide stakeholders' behaviour in the APDs to some extent. We note that they are well known by the dam users. However, this does not mean that they are automatically or universally obeyed.

The traditional rules constituted by Fombawi culture that require that crocodiles are treated in a respectful way include:

- crocodiles are treated as sacred animals;
- every year sacrifices are made to the sacred pond and crocodiles;
- it is forbidden to kill crocodiles in the Fombawi dam; and
- any crocodile that dies is buried only after burial ceremonies headed and conducted by the traditional chief.

When our respondents were asked why they do not always follow the formal and informal rules set by the town council which they appear to know so well, they answered that they see no reason to do so since the town council itself does not meet its promises. This seems to suggest that the notion of a societal contract is latent in people's minds, and that there is a preparedness to act differently only if there were mechanisms to ensure the contract was honoured. This suggests that more attention should be paid to how sanctions are structured and enforced. Since our findings show that the dams are used for multiple purposes, involving diverse practices and stakeholders' interests, backgrounds, knowledge, and assumptions, the creation of an effective regime would seem to

require an active policy of negotiation that includes representatives who can legitimately 'speak for the crocodiles'.

Our results furthermore show that the use and management of the dams creates tension among the stakeholders, each of whom in effect treats the dams as an open access resource [11], to reproduce their own 'truth' about who causes the tensions, and to shift the responsibility for conflict resolution to someone else. The result of this institutional failure is a situation of 'collective irresponsibility' [35]. Meanwhile, the water is becoming seriously polluted and the dam infrastructure is deteriorating – problems that everyone recognizes. Everyone, however, is continuing to intensify exploitation because they receive a direct profit from their activities. Nobody feels guilty about their own contribution to damaging the dams and ecosystems. This might result in both planned and unplanned tipping points that could change the situation radically.

Experience from elsewhere suggests that the sustainability of the APDs would require someone to organize repeated interactions amongst a relatively small number of stakeholders able to develop institutions for monitoring and enforcing a degree of co-operation and that are regarded as legitimate by all stakeholders [9,36–38]. Researchers have identified 10 variables as positively or negatively affecting the likelihood of users' self-organizing to manage a resource such as the APDs: size of resource system, productivity of system, predictability of system dynamics, resource unit mobility, collective-choice rules, number of users, users' leadership/entrepreneurship, norms/social capital of users, knowledge of social-ecological system/mental models of users, and importance of resources for users [39–42]. All these variables are said to interact in a non-linear fashion [39]. So the optimization of use of APDs should start from system thinking that takes into account stakeholders' views and actions, including how these either strengthen or hinder each other, and addressing inter-dependent technical, social and institutional challenges. However, in the absence of strong awareness of the inter-dependency among stakeholders' interests, and their use of the dams, it is difficult to see how 'system thinking' might arise spontaneously.

5. Conclusions and implications for further studies

This study of the stakeholders and the rules of APD management in northern Benin provided insight into the variety of practices and perceptions of problems and impediments related to the use and management of dams in the Nikki District. From our results it can be concluded that the APDs are intensively used by animals, people and crocodiles, for diverse purposes. All stakeholders experience problems related to the use or management of the dams. These problems mainly have to do with access to the dams (for different purposes) and pollution of the water. An important outcome of our study is that the stakeholders involved put different and mostly mutually excluding interpretations on the causes, effects and solutions of the problems and on the impediments, and that there is no appreciation of their interdependency and no mutual accountability. As a result, multiple conflicts among stakeholders persist, with each one pointing to others for causing and thus for solving the problems. They present themselves as victims of the behaviour of others and this reinforces the tension between the stakeholders. This study also reveals that numerous formal and informal rules exist for managing and using the dams in the Nikki District. These rules, however, are differently interpreted and in many cases ignored. The formal rules are not taken into account by the users because according to them the town council does not fulfil its promises and is not able to sanction those who ignore the rules. Also the informal rules that have been negotiated among town council, dam managers and users are ignored, apparently also

without consequences. In contrast, the informal rules concerning the treatment of crocodiles in Fombawi, that are based on strong internalized beliefs about the role of crocodiles in local Fombawi culture are respected, leading to peaceful co-existence with the crocodiles.

In order to deal with the problem of pollution and to organize a more peaceful and sustainable management and use of the APDs a number of lines for follow-up research have emerged:

- identifying a more efficient way to improve agro-pastoral dam water quality (by inviting stakeholders to assess the water quality, quantifying the various threats related to water quality, documenting the local and scientific knowledge on water quality held by local stakeholders, and describing possible innovative solutions in relation to the identified threats);
- developing an institutional mechanism through which to improve fish production (by identifying the biodiversity and productivity of fish in the agro-pastoral dams, how to couple fish production and crocodile conservation, and by developing a more detailed understanding of how crocodile behaviour and habitat use are framed by the stakeholders and of the role of endogenous knowledge, norms, values and beliefs about crocodile habitats and livelihoods);
- the characterization of crocodile behaviour and habitat use in agro-pastoral dams (by identifying the behavioural characteristics of the crocodiles, the conditions in which crocodiles share space with humans in a peaceful way, the triggering of the crocodiles' aggressiveness, the crocodiles species in the dams, and the impacts of crocodile behaviour patterns on human activities); and
- the development and promotion of a more inclusive agro-pastoral dam management (by reviewing with stakeholders the technical and institutional constraints to constructive dam management and the roles of stakeholders in solving the technical and institutional constraints to this management).

Acknowledgements

The authors wish to thank the people of Nikki, Sakabansi and Fombawi in northern Benin who shared their experiences and thoughts with them. We are grateful to Cees Leeuwis and Janice Jiggins for their contribution to earlier versions of this paper. The authors particularly wish to acknowledge the Netherlands Organization for International Co-operation in Higher Education and Research (NUFFIC) through the NPT/146 Project that funded the research and are indebted to the Interdisciplinary Research and Education Fund/Convergence of Sciences – Strengthening Innovation Systems (CoS-SIS) in Benin, Ghana and Mali for training the PhD student in Interdisciplinary Research and for accepting to host this PhD research. The two anonymous reviewers are gratefully acknowledged for their relevant comments on this paper.

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