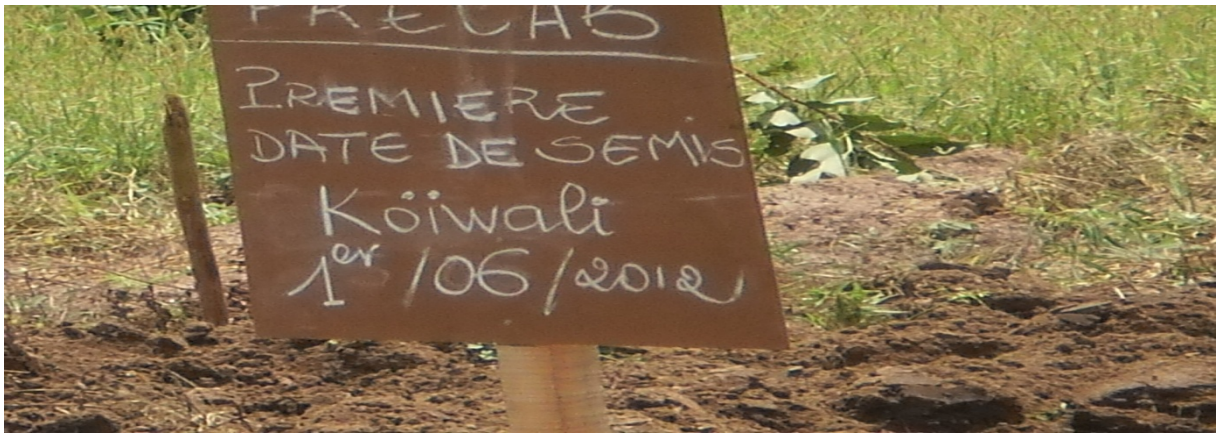
Climate Learning for African Agriculture: Working Paper No.5

Innovation Systems for Agriculture and Climate: Analysis of Three Case-Studies from Benin



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Climate learning for African agriculture

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Foreword

The project "Climate Learning for African Agriculture", funded by the Climate and Development Knowledge Network, and led by the Natural Resources Institute (NRI) of the University of Greenwich, the African Forum for Agricultural Advisory Services (AFAAS) and the Forum for Agricultural Research in Africa (FARA), is very pleased to present this Working Paper on Benin written by Dr Ismail Moumouni and his collaborator Latifou Idrissou. The paper builds on Working Paper No.3, by the same authors, which presented a systematic tour of the policies and institutions which form the context for agricultural adaptation to climate change in Benin, and noted the lack of *policies* that are specifically and realistically oriented to helping small farmers adapt to climate change.

The present paper focusses on the potential for innovation for adaptation at the *project* level, and specifically on three projects in Benin, led respectively by a university department, the Benin National Institute of Agricultural Research, and an NGO, that have set out to assist farmers in adapting to climate change or climate variability. Dr Moumouni discusses the experience of the three projects in terms of *innovation systems* and in terms of *learning processes*. Each project, responding to the erosion of livelihoods through climate variability, has encouraged the interaction, at a local level, of farmers, researchers and other stakeholders in developing agricultural responses to climate variability, and to an extent has used participatory methodologies for developing and disseminating those responses. There has been success in the adoption of new seed varieties, new sowing dates, and a shift to a more drought-resilient form of agriculture in the *bas-fonds*. But Dr Moumouni shows that the learning processes could and should have been more reflexive – encouraging farmers to think about their own learning as well as about specific technologies - and more holistic – addressing institutions and value chains as well as production. Without such orientations there is a risk that project benefits will be lost when projects end, and that the necessary task of empowering farmers to develop their own climate adaptations will not be fulfilled.

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List of Acronyms and Abbreviations

Aldipe	Association de Lutte pour un Développement Intégré et pour la Protection de l'Environnement	Association for the Struggle for Integrated Development and for Environmental Protection
BF-CC	Projet de la gestion durable des terres agricoles dans les bas-fonds dans un contexte de changements climatiques au Sud-Benin	Project on Sustainable Management of Agricultural Land in the *Bas-Fonds* in the context of Climate Change in Southern Benin
CeCPA	Centre Communal pour la Promotion Agricole	Commune Centre for Agricultural Promotion
CeRPA	Centre Régional pour la Promotion Agricole	Regional Centre for Agricultural Promotion
CIMMYT		International Centre for the Improvement of Maize and Wheat
CPV	Conseiller en Production Végétale	Crop Production Adviser
CRAN	Centre de Recherches Agricoles Nord	Northern Agricultural Research Centre
DFID		Department for International Development of the United Kingdom
DPQC	La Direction de la Promotion de la Qualité et du Conditionnement des produits agricoles	Department of Promotion of Quality and Packaging of Agricultural Products
DTMA	Maïs tolérant a la sécheresse en Afrique	Drought Tolerant Maize for Africa
FFS		Farmer Field Schools
IDID	Initiatives pour le Développement Intégré Durable	Initiatives for Sustainable Integrated Development
IDRC	Centre de Recherches pour le Développement International	International Development Research Centre
IITA		International Institute of Tropical Agriculture
INRAB	L'Institut National de Recherche Agricole du Benin	Benin National Institute of Agricultural Research
PARBCC	Projet de renforcement des capacités d'adaptation des Acteurs Ruraux Béninois face aux Changements Climatiques	Project for Strengthening Rural Adaptive Capacity for Climate Change in Benin
PRECAB	Projet de Renforcement des connaissances économiques et de la Capacité d'Adaptation face aux changements climatiques au Bénin	Project to Strengthen Economic Knowledge and Adaptive Capacity in the face of Climate Change in Benin

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1. Introduction

An analysis of the institutional environment created to manage climate change in Benin (Moumouni and Idrissou, 2013) showed that efforts are being made to follow the established international guidelines. However, the mechanisms to co-ordinate the actions of the Ministry of Environment and Ministry of Agriculture have to be strengthened, within each ministry and between ministries, to produce a more visible result at grassroots level. To strengthen the actions of government agencies directly responsible for the management of climate change, many other organisations (NGOs, development projects, farmers' organisations, research and training centres) are mobilising international funding for the development of specific activities to mitigate the effects of climate change or improve the adaptive capacity of various stakeholders.

This report aims to present an analysis of some case studies. These case studies were selected following the exploratory phase conducted at national level and which allowed the drawing up of an "inventory" of innovation systems concerned with agriculture and climate (Moumouni and Idrissou, 2013). Case-studies were selected to capture a range of: types of organisation (NGO, public, private, farmer-led, project); geographical locations (to cover at least two agro-ecological area of the country); and the nature of the learning process in terms of diversity and of the level of involvement of stakeholders. The three case studies examined here are:

- The project on Sustainable Management of Agricultural Land in the *Bas-Fonds*[1] in the context of Climate Change in Southern Benin (BF-CC) implemented by the Faculty of Agronomy of the University of Parakou,
- The Drought Tolerant Maize in Africa (DTMA) Initiative implemented by the Benin National Institute of Agricultural Research (INRAB), IITA and CIMMYT,
- The Project to Strengthen Economic Knowledge and Adaptive Capacity in the face of Climate Change in Benin (PRECAB) implemented by the NGO Initiatives for Sustainable Integrated Development (IDID).

The objective of these case-study analyses of innovation and collective learning processes is to characterise these processes to highlight their achievements and challenges. These case studies were devised and conducted to support the innovation and learning processes under investigation. Such an approach aims to sharpen awareness and stimulate reflection on the effective management of agricultural information and knowledge in the face of climate change.

[1] Small wetlands used seasonally for agriculture, a term common in francophone Africa

2. Analytical and Methodological Framework

2.1. Analytical framework

Climate change has now become a major concern in all sectors and all over the world. The effects of climate change are a particular concern for developing countries where agriculture, particularly rainfed agriculture, is the main livelihood. To maintain food security, all the components of the agricultural innovation system must incorporate planning for adaptation. Agricultural advisory services, which have among other objectives learning and technical innovation among smallholders – through information, training, exchange, facilitation, etc. – deserve special attention. Organisations supporting development (research, agricultural advisory services) and farmers, as well as other stakeholders involved in the innovation system, have developed (and continue to develop) climate knowledge that needs to be built up, validated and shared.

In this study, we therefore conceptualise an innovation system as a collective learning process within a group of stakeholders gathered around a common issue. The complexity of climate change and the various specificities of farmers make collective learning in the field even more relevant. An innovation system can be defined as a dynamic network of organisation or stakeholders in a given political and institutional framework to produce and to use new knowledge in order to improve their performance (World Bank, 2006). The performance of an innovation system can thus be defined not only in terms of the results produced but also in relation to what the stakeholders in the system learnt and how they learnt (Daane, 2010). Learning is the process whereby knowledge is created through the transformation of experience (Kolb, 1984). To be complete, it generally takes place in two loops (Argyris and Schön, 1978). For example, when a person is confronted with a problem, he or she develops strategies to resolve it, based on his or her current knowledge which is used for hypothesis formulation. The reflection process to explain the results obtained through the implementation of defined strategies constitutes the first loop. The person enters the second loop when he or she returns back to relate the results obtained to the original assumptions, in order to confirm, qualify or reconsider, and identify better assumptions. Learning thus appears as a process of introducing change in the terms of reference (values, beliefs, norms, etc.) of an individual or a group of individuals and can thus lead to behavioural transformation (Mezirow, 1997). When it is collective, learning should enable the stakeholders involved in the innovation process to learn from each other, to learn from the process, and to produce new knowledge. This study sets out to be a commentary on, and support to, processes of collective learning.

Based on the important role played by the farmers in the innovation process, Biggs (1987) identifies;

- Contractual participation where farmers are only contracted to provide land and labour necessary for the implementation of experiments,

- Consultative participation where farmers are consulted to obtain information about their constraints, challenges and priorities for production, etc.,
- Collaborative participation, much more of a two-way process, as the farmers are involved in decision-making,
- Collegial participation where decisions are taken collectively by stakeholders in the process including the farmers, and
- Participation through self-mobilisation of farmers.

On the basis of these theoretical contributions, we have developed an analytical framework of innovation and collective learning processes. It allows analysis of the subject of innovation or learning, the interactions of stakeholders, and the operation and performance of the process, and identifies challenges and opportunities (Table 1)

Table 1: Analytical Framework of the Collective Learning Process in the Case Studies.

Factors	**Aspects**
Subject of innovation or learning	Case presentation: location, history, etc.
	Problems that underlie the initiation of the process.
	Relevant crops
	Main technology or innovation involved
Stakeholders involved in the process	Stakeholders involved in the innovation and learning process (researchers, extension agents, farmers, input suppliers, traders, etc.)
	Relationships between stakeholders (roles, complementarity, synergy, antagonism, indifference, etc.)
	Perception of the problem and innovation by various stakeholders (perception of problem to be solved, solutions, innovation/learning system, approach to participation, etc.)
Operation of the process	Type of information/knowledge promoted (information on climate change, technologies for mitigation and for adaptation, knowledge of the institutional and economic environment, knowledge of management etc.)
	Mechanisms of knowledge exchange (awareness-creation, internal and external exchange visits, etc.)
	Learning mechanisms (training, workshops, field schools, demonstrations, trials, etc.)
	Communication channels used in the circulation of information and knowledge relevant to innovation (visits, radios, posters, TV, phones etc.)
	Mechanisms for funding the network (contributions of different stakeholders, flow of resources, etc.)

Analysis of the process performance	Level of learning of the stakeholders (knowledge improvement, changing awareness of climate change, agricultural practices, values and norms in relation to management of natural resources, etc.)
	Stakeholders' perception of the performance of the process (solution or not of the original problem, sustainability of achievements, etc.)
Challenges and prospects	Identification of challenges, strengths, weaknesses, opportunities and constraints of the learning system.
	Identification of the trends and future prospects of learning systems.

2.2 Methodological framework

The projects selected as case studies cover several Communes[2] and villages. In order to explore in depth the learning systems, we have chosen specific intervention sites, all at the level of villages:

- Alahé in the Commune of Za-kpota, Zou Département in southern Benin, for BF-CC
- Koïwali in the Commune of Bassila, Donga Département in the northwest of Benin for PRECAB
- Ina in the Commune of Bembéréké, Borgou Department in the northeast of Benin for DTMA.

Based on the analytical case study framework we have deepened the literature review, conducted interviews and focus groups in villages and organised workshops for collective learning. In each case-study:

- We conducted semi-structured interviews with two to three leaders of organisations involved (staff of projects, public research and extension services) with additional key informant interviews,
- We made five field trips, during which site visits were held (*bas-fonds* under development, improved maize fields and trial plots),
- Two focus groups were organised with farmers involved in the process,
- Two mini-workshops bringing together eight to fifteen people, with different backgrounds and roles, were organised.

A final workshop brought together various stakeholders from the three case studies to share experiences and key lessons. During this meeting, the commonalities and contrasts of the projects were brought out. These elements have enabled us to make a comparative and analytical synthesis across the projects.

[2] Benin is divided into 12 Départements and 77 Communes

3. The Case Studies

3.1. Sustainable Management of Agricultural Land in the *Bas-fonds* in the context of Climate Change in Southern Benin (BF-CC)

3.1.1. The innovation process in BF-CC: context and stimulus

Farmers suffer the harmful effects of fluctuation in rainfall through, among other ways, reduced maize yields on plateau land. Maize is the main staple food in the village. Rainfed agriculture leaves farmers at the mercy of variable rainy seasons. It is difficult for them to know when to carry out sowing for a good harvest. Subsistence is becoming increasingly difficult. But farmers have not understood the significant wealth represented by the nearby *bas-fonds* where water is always available. It was into this context, where farmers were facing existential challenges, that the BF-CC project brought a new perspective. This project is based on the research finding that the perceptions of small farmers, and their strategies for adaptation to climate trends such as decrease in rainfall, depend on their access to water resources (Akponikpè *et al*., 2010). Thus, farmers near water resources such as rivers and *bas-fonds* demonstrate perceptions and adaptive strategies different from those of farmers on the plateau facing changes in rainfall régimes. In this way, BF-CC started from the assumption that the profitable exploitation of the *bas-fonds* might be limited by the low level of farmers' knowledge and their lack of access to inputs and markets for agricultural production. This could of course be a major cause of their vulnerability in the context of climate change. BF-CC thus aims to contribute to the proper management of the *bas-fonds* of South Benin in order to improve food security in the context of climate change.

The project was launched on November 21st 2011 through a workshop that was held in Bohicon. After the launch workshop, a scoping study was conducted on six *bas-fonds* in Central and Southern Benin which led to the selection of four *bas-fonds* in four different villages. Among the selected cases, two were traditionally exploited by farmers with little outside intervention (Dogbanlin and Gankpétin) and the other two using more "modern" techniques (Alahé-Centre and Houimga-Houégbé). These contrasting cases were selected to evaluate the suitability of different *bas-fonds* management models for water use in the context of climate change. Following consultation with project managers, the CLAA study focused on the village of Alahè-Centre.

3.1.2. Stakeholders involved in the innovation process of the BF-CC project

Several stakeholders are involved at various levels in the implementation of the project, most importantly Aldipe, researchers of the Faculty of Agronomy of the University of Parakou, farmers' groups, landowners, the Commune Centre for Agricultural Promotion (CeCPA), seed banks and traders.

- The Faculty of Agronomy of the University of Parakou: Following the initiative of the University of Parakou in collaboration with the University of Abomey-Calavi, BF-CC is financed under a START Grant for Global Environmental Change Research by the US

National Science Foundation, the Climate and Development Knowledge Network, and the Climate Change, Agriculture and Food Security programme of the CGIAR.[3] Its mission is to investigate the potentials of *bas-fonds* in Benin, particularly in the Départements of Zou, Collines and Mono. For implementation, Aldipe, an NGO which was already active in the area of intervention, became a partner. The project, by exploring *bas-fonds* available in these Départements, has identified sites under greater or lesser degrees of management. Socio-economic studies were carried out in these selected sites, which include Alahé village, in order to provide information on the factors determining farmers' participation in the management of *bas-fonds* and to analyse the cost-effectiveness for farmers.

- Aldipe: Located in the village since 2006, Aldipe works to promote community development. It is mainly funded by the Belgian organisation DBA (Défi Belgique Afrique). Its four components, namely community health, child nutrition, literacy and food security, are carried out in most of the other villages in Za-kpota Commune. It is through the last component that the NGO identified the operation of the *bas-fonds* as a reliable alternative for the management of climate change impacts, particularly the declining fertility of plateau lands, and for poverty reduction in the village.
- Farmers' groups: To faciliate their more active involvement in the learning process on exploitation of *bas-fonds*, several farmers' groups have been created according to crops farmed in these *bas-fonds*. While there were originally several separate groups, we noted that there are currently two main ones, specifically for rice and horticulture. The Alahé rice producers' group, for example, has about 40 rice farmers, each farming between 0.25 ha and 0.5 ha, with a total of around 10 ha being cultivated each season. Each farmer individually operates his or her plot. Technical packages taught to farmers are put into practice on the plots. Soil preparation, installation of nurseries, transplanting, and the other farming operations use family labour and only rarely wage labour. Production remains based on laborious manual techniques.
- The landowners: The property rights of the owners of the *bas-fonds* are crucial in the development process, whether or not they are villagers, or relatives of farmers involved. Ownership rights have been acquired mostly through inheritance. Owners' attitudes range from indifference to co-operation. Some owners immediately agree to provide their *bas-fonds* for development whereas some agree only after tough negotiations; others simply refuse, or go back on their favourable decisions after a period of operation. The attitude of landowners may thus be a favourable or unfavourable factor, depending on the circumstances, for the innovation process.
- The Za-kpota Commune Centre for Agricultural Promotion (CeCPA): This is the public organisation in charge of agricultural development in the Commune. Aldipe acts as the mediator and facilitator between this public service and the farmers of Alahé in

[3] Consultative Group for International Agricultural Research

supplying the latter with fertilisers. This facilitation is informal and does not take place easily, in a national context of non-availability of specific fertilisers for food crops. The NGO does not always manage to source the amount of fertilisers demanded by the farmers, even though it is ready to pay in cash. The fertiliser obtained is distributed on credit by the NGO which collects repayment at the end of each season. The involvement of the Za-Kpota CeCPA in the process is not limited to input supply. In collaboration with INRAB, on-farm trials of rice variety IR841 are jointly monitored by the NGO.

- Seed Banks: Rice seed used by farmers comes from seed banks located in Glazoué Commune. This seed is obtained through Aldipe. Farmers often provide themselves with seed through exchange between farmers, gifts, selections from growing rice plants, etc..
- Merchants: After the rice harvest, farmers carry out the husking process at the mini processing centre set up by Aldipe, before marketing. Sales are directly made by farmers' wives or by farmers themselves in local markets or neighbouring towns. An attempt at collective marketing by the National Office for Food Security failed due to the unattractive prices offered to farmers by the buyer.

3.1.3. Operation of the innovation process in the BF-CC project

In the BF-CC project, the Faculty of Agronomy, Aldipe, the Alahé farmers' group, the owners of the *bas-fonds*, and the secondary stakeholders such as the CeCPA and seed banks interacted to develop a response to the effects of climate disruption on farmers. This interaction made possible (i) development of a shared understanding of the phenomenon of climate change, (ii) a collective awareness of the opportunities available, through natural resource management, to ensure food security in the context of rainfall disturbances and (iii) implementation of concrete actions for technical learning on the exploitation of these natural resources. Those actions were principally awareness-creation of the possibilities of exploiting the *bas-fonds*, training in tillage of *bas-fonds* and in selected crop production techniques, monitoring, and management advisory support delivered through Aldipe's literacy component.

Two sets of preliminary studies, technical and socio-economic, were conducted in a participatory manner by researchers of the Faculty of Agronomy, members of Aldipe and farmers. The farmers contributed in providing information, and were extensively consulted throughout the studies.

- Technical studies: Rapid pre-development diagnosis and a study of the hydraulic and hydrological operation of the *bas-fonds* had to be carried out to identify the types of development advisable for each *bas-fonds*. Rapid pre-development diagnosis had to be conducted to determine whether the initial development scheme for the selected *bas-fonds* was feasible in view of rainfall variability. However the hydrological data required for the determination of the decadal flow and a modelling-based historical

reconstruction were not available. In order to perform a test on the hydraulic and hydrological functioning, data on surface water (rainfall, infiltration, evaporation, stagnancy, streaming, and water flow) and the surface water dynamics (piezometry) were measured. The results obtained were used to propose structures for managing underground and surface water dynamics in the *bas-fonds*.

- Socio-economic studies: Two preliminary studies were conducted in a participatory manner by researchers of the Faculty of Agronomy, members of Aldipe and farmers. The first study focused on the perceptions of climate change (causes, manifestations and consequences) and farmers' adaptation to climate change. Through an analysis of the effects of climate change on farmers' incomes, the second study allowed a view on how the exploitation of the *bas-fonds* could become an adaptive strategy. It has also allowed process stakeholders to identify the factors that determine access to the *bas-fonds* and to compare the benefits of production in the *bas-fonds* and production on the plateau.

Several awareness-creation activities, capacity-building of stakeholders, and dissemination of information on best management options for the *bas-fonds* in the context of climate change were held.

- Information and awareness-creation: Awareness-creation took place during meetings and through the presentation of photos showing examples of neighbouring villages or other regions of the country that have benefited from the exploitation of their *bas-fonds*. It is mainly through the project that the farmers have discovered the usefulness and importance of *bas-fonds*. Thus, the exploitation of the *bas-fonds* has become for them an alternative to try, en route to realising the cost-effectiveness compared to other forms of farming.
- Building capacity of farmers for better adaptation to climate change in the *bas-fonds*: This training workshop organised by the village focused on the best practices for the exploitation of the *bas-fonds*. It involved the participation of around thirty farmers. Discussions revolved around three main issues, namely (i) climate change (explanation of the phenomenon, its manifestations, its causes, projections for the future), (ii) agricultural adaptive strategies (and the general need for them) and (iii) better practices for sustainable management of the *bas-fonds* in the context of climate change. The relevance of this training lies not only in the knowledge conveyed but also in the learning process adopted. The themes were introduced in sequence, starting from the knowledge (perceptions) of farmers on climate change, with the opportunity to improve the *bas-fonds* as a reliable alternative for the management of its adverse effects. Training was based on the presentation of images with commentary by farmers themselves and accompanied by field visits.
- Radio shows and dissemination of information through posters: These sessions were held in French and local languages to share information with the public. The information disseminated in the village concerned explanations of climate change

and its impacts on agriculture, the advantages of improved techniques for management of the *bas-fonds,* and technologies adapted to climate change (technologies to reduce the effects of floods and droughts, effective techniques of soil and water conservation, soil fertility planning adapted to the *bas-fonds*, improved high-yielding cultivars). On the same themes, posters (A0 and A3) and pamphlets were also made and distributed to different stakeholders.

- Visits to exchange experiences and knowledge: The BF-CC project, by the fact that it also works in other Départements, particularly Mono to the Southwest, has favoured visits to exchange experiences and knowledge between farmers for the improvement of *bas-fonds* in different areas of the country.
- Training of young researchers: Three agronomy students conducted their final-year research projects, for the University of Parakou, the University of Abomey-Calavi and the Burkina Faso Institute of Water and Environmental Engineering, with the BF-CC project. The project gave them scientific, technical and financial support during their research.

Now in its most active phase, the Aldipe field team is promoting the producers' organisation, implementing the development of the *bas-fonds* with the technical support of the university researchers, and assisting farmers in almost all phases of the development process. The producers' organisation has facilitated the choice of appropriate types of development, and secondly the involvement of different groups in the improvement works particularly the construction of small dykes. The development of the *bas-fonds* is based on the aspirations of farmers in terms of crop choices but takes account mainly of the physical properties of the *bas-fonds*. After the exploratory phase (identification of areas, measuring the slope, the source, size and width of flow, the period during which the site is flooded), the technicians employed by the NGO plant lines of stakes following the contours. The farmers also participate in these operations, particularly the construction of small dykes. The cultivation process is not very different from the agricultural production systems familiar to farmers. It involves the preparation of soils, the procurement of inputs (seeds, fertilisers, etc.), sowing, maintenance operations, harvest and post–harvest operations (processing and marketing).

The NGO plays a mediating role between the farmers and the suppliers of various services, particularly the input suppliers. On one hand, it ensures for farmers the availability of seeds that it buys in seed banks (e.g. the seed bank at Glazoué). On the other hand, it ensures the supply of fertilisers through the CeCPA. For the post-harvest operations, the NGO has acquired a husking machine for the rice producers.

The principal stakeholders of the agro-climatic innovation system developed around the improvement of *bas-fonds* in village Alahé coordinate their actions for the management of the impacts of climate change and improvement of living conditions of rural people within a

relationship of complementarity. Each stakeholder retains a certain autonomy in financial matters and in their work.

3.1.4. Performance of the innovation system in the BF-CC project

Discussions of the results of the technical and socio-economic studies, the exchange workshops and the intense interactions which have accompanied the development process of the *bas-fonds* have allowed all stakeholders involved to get new ideas, knowledge and experiences on the links between climate change and *bas-fonds*.

The collaboration between the Faculty of Agronomy, the NGO and the farmers was fruitful profitable for all:

- Improvement of knowledge in terms of, on the one hand the clear and shared comprehension of climate change, and on the other hand the learning and adoption of new crops, specifically rice and horticulture. The orientation of production activities towards the development of the bas-fonds indicates a shift in beliefs about natural resources. This has resulted in a change in relations between the people – who were accustomed only to traditional maize cropping on the plateau land – and their physical and institutional environment. Similarly, the production of rice which has for a long time been considered a commodity for purchase, changed dietary habits. Rice is now available to farmers and prepared when needed.
- Aldipe has further established itself in the community, as its services are highly appreciated by the villagers. Study findings also represent for the NGO, planning as it does to work in the village for several more years, a database for future decision-making.
- University researchers have a better understanding, through this experience, of relations between people and their natural, socio-economic and institutional environment that can enhance the results of their research. In particular, the involvement of young researchers in the project helped to raise awareness and train them on the issues of management of effects of climate change through development of the bas-fonds.

According to the farmers themselves, the socio-economic advantages of development of the *bas-fonds* are very important. As Madam X, member of the rice producers' group reported:

> *This experience is very beneficial. Today, the rice that is usually difficult for us to buy on the market is available on our doorstep. We only need to prepare it for the children and they can set off for school. Also we have not seen a situation where we have to sell our maize harvest then cannot afford to buy it back. Instead, with more frequent production cycles, we are able to have food and ready cash to solve our little problems. We can honestly say that this ''project'' has, ever so slightly, resolved our insecurity.*

On the other hand, the new form of cultivation retains labour power in the village thus resolving a major social issue, specifically rural-urban migration. This was raised by a stakeholder in these terms:

> *A few years ago, the reduction in maize yields which was our main crop, and the wretchedness that reigned in the village, meant that heads of farming households would usually travel to Nigeria to look for jobs. But now, our success in putting our bas-fonds under cultivation has brought back life to our village. Unlike before, people no longer travel for these kinds of reason.*

The success of this approach developed by the BF-CC project comes from its innovative nature, specifically the development of the natural assets of which the villagers were not necessarily aware. This success was reinforced by the value chain approach which meant assisting farmers (with greater or lesser success) in the removal of any constraints (difficult access to seeds, inputs, markets, advice, etc.). The results obtained, however, masked a low level of participation in the strategic decision-making of the project. Even if this level of participation, which may well be described as collaborative (see discussion of Biggs' 1987 schema in Section 2.1 above) has allowed the setting-up of a rice value-chain from the *bas-fonds*, it seems insufficient to empower the population in future initiatives, for example the negotiation (more permanently) of other agricultural services to which the project has allowed them access.

3.2. The Drought Tolerant Maize for Africa Initiative (DTMA)

3.2.1. The innovation process in DTMA: context and stimulus

In northern Benin, maize is both the second-most importance subsistence crop (after vegetables) and the second-most important cash crop after cotton. Like all cereals, its production is severely affected by drought. By 2006, the varieties available were no longer giving much satisfaction to farmers. In this context, the International Centre for the Improvement of Maize and Wheat (CIMMYT) and the International Institute of Tropical Agriculture (IITA) launched in 2006 the Drought Tolerant Maize for Africa (DTMA) initiative in 13 countries including Benin, where INRAB is the national partner. This project is funded by the Bill and Melinda Gates Foundation, the Howard G. Buffet Foundation, USAID and the UK Department for International Development (DFID).

The objective of this project is to reduce hunger and increase the food and financial security of smallholders with limited resources, through the development and dissemination of varieties of maize tolerant to drought. However, adaptation to climate change is not explicitly stated as an objective of the project. Apart from the quality of drought-tolerance, maize varieties from the project are selected for their adaptation to local conditions,

particularly in characteristics such as superior milling and baking quality, and resistance to diseases such as maize streak virus, turcicum leaf blight and maize grey leaf spot.

3.2.2. Stakeholders involved in the innovation process of DTMA.

The key local stakeholders directly involved in the innovation process of DTMA are:

- The Northern Agricultural Research Centre (CRAN): founded in 1930, it is based in the village of Ina in the Commune of Bemberéké, occupying an area of 254 ha. It is one of the three Regional Centres of INRAB, responsible for serving the northern region of Benin. The centre includes Research and Development Teams located in different parts of its intervention area. CRAN has the mandate to lead the DTMA initiative in Benin.
- The Regional Centre for Agricultural Promotion (CeRPA), primarily involved in activities of final testing and dissemination of seed.
- Smallholder seed multipliers: These are volunteers willing to become involved in the learning process.
- The Department for Promotion of Quality and Packaging of Agricultural Products (DPQC), who are responsible for seed certification.
- The seed farms and Seed Producers' Organisation that produce and sell maize seed.

3.2.3. Operation of the innovation process in DTMA

At the start of the process, studies were conducted (i) to characterise maize producing households in the dry savannah area of Benin, (ii) to assess the constraints affecting the production of maize seed, and the approaches used previously for testing seed and disseminating it to farmers, etc. These studies synthesised studies previously carried out in northern Benin to assess the impact of the introduction of improved varieties initiated before the advent of the project. They were used to estimate the level of adoption of these varieties to better understand the process of technology diffusion and to determine the socio-economic and institutional factors that may influence the adoption of future varieties. In general, the range of improved varieties of various maturing times had been expanded. Despite the relatively acceptable rate of adoption of these varieties, the negative effects of drought could not be circumvented because of a lack of varieties tolerant to abiotic factors. In addition, an adequate supply of agricultural inputs (fertiliser, seeds, herbicides, etc…) is necessary for the development of improved varieties of maize, but had been compromised by lack of availability in the vicinity and by high transportation costs on bad roads.

The project is implemented through:

- Greenhouse trials: this component involves submitting different varieties of maize to water stress in the greenhouse to detect those that are more tolerant to drought.
- Performance trials: trials are done on-station to detect the best varieties from a performance point of view. These varieties are then given to the 12 smallholder seed

multipliers trained by CRAN. These smallholders grow the varieties for 2 to 3 years to detect the best, which are sent for final seed testing.

- Seed production: the best varieties selected are multiplied by CRAN and made available to the CeRPA for dissemination.

The smallholder multipliers receive seed and inputs then carry out the rest of the work themselves, specifically the preparation and the maintenance of the seed fields installed on their plots. CRAN technicians in collaboration with the Crop Production Advisers of the CeRPA ensure continuous monitoring of field activities. At harvest, assessments are made jointly by all stakeholders involved and the crop is returned to the farmers. The best varieties should undergo a stability test by the Research and Development Teams, and be sent back to CRAN for further work. But this link in the seed chain does not yet seem to function properly due to lack of resources.

Once the seeds are certified by the DPQC, pre-basic seed is produced at CRAN. At the moment, it is hoped that the Department of Agriculture of MAEP can take charge of the next step through its seed farms. But this division of labour does not yet seem to work properly either. In its absence, CRAN relies on the seed producers' organisations. These organisations, that have already existed for about a decade, need strengthening of their organisational and managerial capacity to improve the quality of their services. Specific intervention proposals are sometimes developed and implemented to support seed production and to improve the professionalism (entrepreneurial and management ability) of these seed producers' organisations.

In the implementation of the project, information is exchanged through various meetings organised within the framework of project activities. Thus, exchange of information takes place between researchers and farmers during awareness-creation, open days and farmer-to-farmer exchange visits, which are opportunities for farmers to discuss their problems in order to find joint solutions and share their experiences with other stakeholders in the process. Learning about seed production is carried out during training workshops, demonstrations and trials. Posters, technical leaflets, audio-visual materials, reports and publications allow sharing of new knowledge, beyond the stakeholders directly involved in the implementation of the project.

3.2.4. Performance of innovation system of DTMA project

Varietal selection has led to the development of several varieties that have been tested with respect to their resilience to climate change.

These varieties are divided into four groups:

- Extra-early-maturing varieties (75 days)
- Early-maturing varieties (90 days)
- Medium-maturing varieties (105 days)

- Late-maturing varieties (120 – 125 days)

Many groups of seed producers are producing and distributing at scale drought-tolerant maize varieties. Many producers have learnt the technical packages for production of these maize varieties. This shows that participatory research is an important tool of collective learning. In this case, it has united several stakeholders around a common challenge, which is to respond to the effects of climate change. In this project, the level of participation of farmers is sometimes contractual (as in the case of the farmer multipliers), sometimes collaborative (in the case of seed producers' organisations). A development whereby farmers take ownership of the seed value chain (at least a collegial level of participation) is very much a goal of the national organisations supporting DTMA, because it is perceived as a guarantee of sustainability.

The performance of the system is impaired by the absence or the failure of important links in the seed value chain, particularly the seed industries, and the distributors of inputs. This situation could be explained by the fact that the project, externally funded, collaborated only with a limited number of stakeholders. The DPQC which should check and certify the seeds, the Department of Agriculture which should give support in the multiplication and distribution of seeds, the Research and Development Teams who should be actively involved in the trials of varieties in rural areas have all found it difficult to collaborate fully. Similarly, the weak involvement of the private sector, including the seed industries and farms seems to be the crucial link that could jeopardise the sustainability of the achievements of the innovation system. We can then state at this point that the improvement of the efficiency of the innovation system requires a matching progress in all its links.

3.3. Project to Strengthen Economic Knowledge and Adaptive Capacity in the face of Climate Change in Benin (PRECAB).

3.3.1. The innovation process in PRECAB: context and stimulus

The agricultural population of Bassila, like that of the surrounding Communes, are facing several problems related to delayed onset of the rains, excessive rainfall, and violent winds. Repeated delays in the rains in particular cause problems in so far as people no longer know when sowing should be carried out during the campaign. Furthermore, soil erosion following abundant rain has contributed to the reduced maize yield. It is under these conditions that the Project to Strengthen Economic Knowledge and Adaptive Capacity in the face of Climate Change in Benin (PRECAB) was initiated by the NGO IDID in 2011, following its Project for Strengthening Rural Adaptive Capacity for Climate Change in Benin (PARBCC) executed between 2007 and 2011. PARBCC was financed by the Climate Change Adaptation in Africa programme which was a joint initiative of the International Development Research Centre (IDRC) and DFID.

The overall objective of this project is to improve the adaptive capacity and resilience to climate change of the local communities in order to manage the negative impacts on food security and rural poverty in Benin. With IDRC as principal funder through the African Adaptation Research Centres Initiative, PRECAB has been implemented in six Départements and in 35 Communes. We have closely examined the innovation and learning system developed by PRECAB in the village of Koïwali in the Commune of Bassila where the issue of identifying the right sowing date is crucial. We focused on the process of identification of sowing dates for maize as well as the introduction of *mucuna* (a herbaceous legume) that are both appropriate to new climate conditions. *Mucuna* is offered to farmers as a cover crop to minimise on the one hand erosion caused by excessive rains and on the other the drying out of soil caused by exposure to burning sun.

3.3.2. Stakeholders involved in the innovation process of PRECAB.

The stakeholders involved in this process of identifying new sowing dates for maize with *mucuna* in Bassila are mainly the members of IDID, agricultural advisers and farmers.

- IDID: IDID is represented in the field by a field agent hired for the implementation of the project, serving as a communication channel between the management of the NGO and other grassroots stakeholders, including farmers.
- Researchers: Research activities are conducted by researchers from INRAB through its Programme for Agricultural Policy Analysis, and from the Universities of Parakou and Abomey-Calavi. The research protocols used in the project were developed by INRAB researchers. The latter participate in field visits whose objective is to observe the progress of trials and suggest necessary improvements.
- Agricultural advisors: Alongside the Bassila CeCPA, the public agricultural advisory body, IDID also intervenes in agricultural advisory services in Bassila. The Crop Production Advisers (CPVs) of the CeCPA, who are familiar with the farmers, are involved in the identification of pilot farmers. The CPVs also provide technical support for the ongoing activities.
- Farmers: Farmers constitute the target or beneficiary population for PRECAB. Among them there are those who play a more active role than others, the “pilot farmers”. Once selected, they each in turn identify four partner farmers who will participate in the Farmer Field Schools.

3.3.3. Operation of the innovation process in PRECAB.

Exchange of knowledge and learning take place in general through information, awareness-creation, training and workshops.

- Information and awareness-creation: Awareness-creation of farmers on *mucuna* is mainly done through Farmer Field Schools (FFS). The communication channels are, among others, written information on development and climate change, television programmes to share information relevant to climate change, posters used during

field sessions, and community radio. An early-warning and agro-meteorological information system, active at national, communal and grassroots level, was initiated to assist farmers in agricultural planning adapted to a changing climate. Based on data collected from various sources (African Air Traffic Control Agency – ASECNA, African Centre of Meteorological Application for Development - ACMAD, Benin Meteorological Service bulletins, field observations. etc.), agro-meteorological information is developed and disseminated through bi-monthly bulletins, local radio, the CeCPAs, and pilot farmers during the agricultural season. In general, the beneficiaries, particularly the farmers, hope for an increase in the frequency of information dissemination so as to enable them to plan ahead better in their farming. Farmers appreciate the advice on the management of the maize crop but feel that the information on the management of climate risk remains insufficient. A video documentary was produced and broadcast on TV channels on the experience of the NGO in the context of reducing agricultural vulnerability to climate change in Benin.

- Training: Strengthening of the adaptive capacity of non-farmer stakeholders organised by IDID is especially directed at the extension staff of the CeCPA. These, being primary stakeholders working everyday alongside farmers, have been chosen by IDID to receive training on climate change. This training has been on themes including: climate change, observed impacts, consequences, risks and adaptation, generally and in the context of Benin.
- Workshops: consultation workshops were organised by IDID with other stakeholders. These workshops were to discuss the progress of activities, to see what works and what does not, and to consider together the options for improvement.

In the active phase of the project, learning took place around agricultural trials organised by Farmers Field Schools over two years. The objective of the trials was to encourage the beneficiary farmers themselves to identify the best sowing dates and the advantages of each of the treatments in the trials, to learn for themselves the most relevant strategies for their day-to-day problems, to replicate them on their own plots and to disseminate them to other farmers. The FFS has provided the framework for assisting farmers in the creation of new knowledge and in learning new practices to solve the problem of declining maize yields. The farmers involved were volunteers, known as pilot farmers, who each brought four other farmers to participate in the FFS. The innovation process was to establish trial plots which incorporated farmers' existing practices and proposed new techniques, and to see together with the farmers the treatment that gives the best yield of maize. Thus at each FFS, 4 sub-plots were established over an area of 400 m^2. Plot T0 served as a control plot, involving existing farmer practice (maize without fertiliser). On T1, maize and *mucuna* were planted, on T2, maize with fertiliser and finally on T3 maize and *mucuna* with fertiliser. *Mucuna* as a cover crop in association with maize is sown preferably at the emergence and early flowering of maize. According to IDID's report on the first year of farmer trials, this technical

option makes it possible to cover the soil and to protect it against exposure to burning sun, maintaining humidity under the cultivated plant. Similarly, the physical and chemical properties of soils are improved. Indeed, the increase in the proportion of organic matter raised the fertility and insured good retention of water in the soil for the medium- and long-term. In terms of maize yield after one season, at the end of the trials carried out in Bassila, plot T2 (maize with mineral fertiliser) outperformed the other plots.

To provide an answer to the question of sowing dates, two experimental plots were established for planting in each of four ten-day periods. The first plot was the reference plot (maize without fertilisers) and the second plot featured maize with fertiliser. The plot dimensions used for each ten-day period and treatment were 5x10 m. The best sowing time for maize identified after the trials in Koïwali runs from 1st June to 20th July, which is later than that previously practised.

The trial plots are monitored carefully from sowing to harvest. Monitoring is always done in the presence of the pilot farmer, his partners and the NGO facilitator. During monitoring, the phenological data from the FFS and socio-economic data on the farmers are collected using a pro-forma in order to analyse costs and benefits later. For the conduct of trials, the pilot farmers provide land and labour. They are responsible for preparing and maintaining the trial plots. The harvest from the plots is theirs. The NGO provides the necessary inputs and expertise.

3.3.4. Performance of the innovation system in PRECAB

The innovation process led by the project PRECAB has allowed farmers to discover *mucuna* as a plant of value in stopping the decline in soil fertility and water erosion, and identifying a new sowing period so as to cope with delays in rain. At the end of the process, the farmers have adopted the new sowing dates, but only in a vague sense the experimental process that generated them. This seems to be the reflection of the low level of participation of farmers. In fact, the latter bring only land and labour and to the best of our knowledge, do not seem to have been effectively brought to enter “the second loop of learning” (see Section 2.1 above). Consequently, it is difficult for them to usefully link the results obtained with the process that generated them. During and until the end of the process, the farmers were not asked why they had not themselves been able to identify more suitable sowing dates or whether they will be able to do so successfully in future, with minimum external support. To the question of how they will face a future problem of unreliable sowing dates, one of them replied: “we will ask the adviser.”

If the farmers seem to grasp and disseminate to each other the new sowing dates for maize, *mucuna* has not yet been used beyond the FFS. The pilot farmers who were supposed to disseminate it at village level do not themselves practice it as they were taught. However, the farmers, not only the pilot farmers, themselves innovated by cultivating *mucuna* in pure stands as a green manure to regenerate particularly poor soils, as manifested by halving of grain yields, significant decrease of tuber sizes or unusually heavy weed growth.

4. Conclusion

4.1. Summary and analysis

The projects BF-CC, DTMA and PRECAB have all addressed the problems created for agriculture by changes in rainfall. The logic of these three projects is to consider climate change as a reality. On the basis of their respective diagnostic studies, they have developed different approaches to adaptation:

- Development within the framework of the BF-CC project of new alternatives for agricultural production through development of natural resources available to manage the negative effects of changes in rainfall on the food security of farmers.
- Identification within the framework of PRECAB of new sowing dates for maize appropriate to current rainfall régimes.
- Development within the framework of the DTMA initiative of new varieties of maize tolerant of drought.

The collective learning processes in the three projects have followed very similar learning cycles. Analysis of these cycles shows stakeholders in dynamic interaction around the production and use of new knowledge. These processes of collective learning in the three different projects studied put stakeholders in interaction with each other: donors, research centres, universities, farmers, local agricultural services etc..

The learning process is based in all three cases on the experiences of farmers which are identified and analysed through the research organised in the different projects. Indeed, the projects have begun by the organisation of diagnostic studies in their respective areas. These studies have been carried out by the researchers involved in the implementation of these projects, with a degree of collaboration by other stakeholders. Thus, in the case of BF-CC, the project has conducted studies on farmers' perceptions on the issues related to climate change and their options for adaptation in the *bas-fonds* of southern Benin. The project also investigated the comparative advantage of the exploitation of *bas-fonds* over the plateau in adaptation to climate change. The studies carried out in the framework of the implementation of the DTMA initiative concerned the maize producers' understanding of maize and its environment and the identification of maize varieties tolerant to drought. As for PRECAB, it studied the climate risks and the autonomous adaptive strategies developed by rural communities themselves to cope with climate change and variability. These studies have revealed both the problems of, and the adaptive solutions to, climate change perceived by farmers in each case. At this stage, the stakeholders, to a greater or lesser degree, are becoming more aware of the phenomenon of climate change or of some of its manifestations and more familiar with the perceptions of other stakeholders on climate change, and are discovering new perspectives of action that they commit themselves to explore.

After the diagnostic phase, the projects focus on the improvement of farmer adaptation strategies through trials. Thus, in the case of BF-CC, the comparative advantage of production in the *bas-fonds* as an adaptive strategy for farmers facing climate change has been proved through the differential benefits generated by production in the *bas-fonds* compared to production on the plateau. For DTMA, the varieties tolerant to drought used by farmers have been improved through varietal improvement and the conduct of performance trials of varieties, and then the best varieties selected have been multiplied by CRAN for dissemination to farmers. PRECAB has meanwhile conducted on-farm trials, through the organisation of Farmer Field Schools, on climate adaptation options that can be offered to farmers. In this context, a new period for sowing maize and its intercropping with *mucuna* were identified and proposed to farmers.

At this level, one can question how reciprocal and thoroughgoing the learning was. Indeed, the projects go to the field with clear goals. The project leaders are often willing, at least in theory, to explore the knowledge and perceptions of farmers. But it is still the case that they have ideas (knowledge, technical solutions, etc.) to promote. Generally the farmers take up the ideas in their own way, without necessarily questioning or understanding the processes of their creation. For example farmers of Koïwali in Bassila Commune have taken up the newly identified sowing dates, without taking on board much of the experimentation process that generated this knowledge (the first loop) and still the question of why they were not able, unaided, to find solutions to the problem of unreliable sowing dates (the second loop). This low level of reflexivity in the innovation and learning processes raises the question of the sustainability of the achievements in that the farmers may still need assistance to resolve their agricultural problems.

The results of these different trials have allowed the identification of adaptation options in each case which are disseminated to farmers and to other stakeholders concerned with questions of adaptation to climate change, within the area of each project. Different channels were used in each case. The project on the *bas-fonds* has organised workshops and has used rural radio to disseminate knowledge on better adaptation to climate change in the *bas-fonds* to farmers, stakeholders in development, early career scientists and final-year students. DTMA trial results have meanwhile been disseminated through the organisation of awareness-creation and knowledge exchange sessions between farmers and project researchers. PRECAB is based on the organisation of Farmer Field Schools for the dissemination of innovations identified by farmers and project researchers. The dissemination of this newly developed knowledge has been successful because the other agricultural services needed by farmers for its implementation (inputs, markets, etc.) were made available. While the knowledge produced by BF-CC has spread very quickly because of the value chain approach adopted (facilitation of access to knowledge, seeds, inputs, husking, marketing, etc.), the dissemination of the new varieties created by the DTMA initiative has been slowed down by the lack or absence of seed enterprises that can make market on a large scale. This finding supports that of Lamboll and Nelson (2012) on the

challenges posed by climate change is in interaction with other major development processes.

What can the projects learn from each other?

The project BF-CC can learn from the experiences of DTMA and PRECAB that participatory trials are a fairly efficient way to improve the process of uptake by farmers. Just as the latter two projects carry out agricultural trials to support technical innovation, it is also possible to carry out institutional experiments to develop new forms of partnerships with various agricultural service providers. In addition, BF-CC can learn from the experience of DTMA that a more active involvement of the public research and agricultural advisory services is necessary to ensure ease of access to services and sustainability of achievements.

DTMA, following the experience of the project BF-CC, can strengthen its conviction that the effective implementation of a value chain approach, with a major involvement of the private sector (including NGOs), can effectively allow the improvement of performance in the innovation system. The experience of PRECAB teaches that the deployment of substantial resources (time, financial resources, material and human) is not the only route. Focussed adjustments in agricultural practices may constitute palliative measures, effective particularly in the short term.

PRECAB, should it refocus its interventions, would benefit from making use of the experiences of DTMA and BF-CC on the effectiveness of the value chain approach and the alternative offered by the exploitation of available natural resources (environmental resources for BF-CC and genetic resources for DTMA). From this realisation, specific approaches for adaptation to climate change can be researched and implemented.

In sum, the collective learning cycle for adaptation to climate change in Benin can be seen as going through three important phases. The projects for adaptation to climate change begin with a diagnostic phase. The results of this diagnostic phase are then enhanced through participatory trials organised with farmers. The projects end with the dissemination of results to the stakeholders. In general, the participation of farmers in these innovation systems is collaborative. They provide land, labour, information and are associated, to a certain level, in the decision-making.

4.2. Challenges and opportunities in adaptation to climate change

Although the different collective learning processes undertaken by the projects studied for farmers' adaptation to climate changes have produced results, challenges remain to improve their performance.

One of the major challenges of collective learning processes is the uptake of the innovations co-constructed by farmers during the process. Indeed, not all the farmers who participate in a collective learning process implement the results. In the case of PRECAB for example, the process does not seem to have passed the stage of demonstration plots established and

jointly followed by farmers and project facilitators in organising Farmer Field Schools. Indeed, few farmers replicate these techniques in their own fields, let alone disseminate them to other farmers.

Collective learning for adaptation to climate change also has to tackle the dissemination of results to other farmers, who have not participated in the process. Indeed, all the projects are limited to a small number of participants in a given zone of Benin due to the limited resources they have. However, there is no guaranteed mechanism for dissemination at scale because the state and private (NGO) structures, that are permanent compared to the time-limited projects, do not take over the dissemination of results. The end of a project often coincides with the end of the collective learning that has led to innovation.

Thus, after the end of these projects, their achievements are not sustained. NGOs involved in the implementation of projects cannot provide continuity for the process due to lack of resources. To improve the sustainability of the impacts of projects, it will be necessary also to aim to develop among farmers a sufficiently reflective attitude, for whatever learning objective. This will allow farmers to better understand their problems and to produce appropriate solutions with minimum assistance.

After this analysis of three projects at different scales and levels of performance, some important lessons can be learned to enhance the practice of agricultural research and advisory services both at national level and across West Africa. For projects that support farmers' adaptation to effects of climate change, it seems important to keep these points in mind:

- An innovation and learning system needs to be *holistic*. An approach consisting solely of strengthening the technical and material capacity of one part of the system quickly runs up against the failure of other components to join the initiative.
- The goal is the improvement and increased sustainability of farmers' livelihoods. Strategies for supporting adaptation to climate change designed with this objective should adopt a value chain perspective and approach.
- External intervention should be conducted with a view to empower farmers or other beneficiaries. This empowerment necessarily takes place through the implementation of a learning process, which beyond the results of technical trials or institutional experiments, brings farmers to take ownership of the logic, principles, approaches and processes of learning.

References

Akponikpè P.B.I, Johnston, P., and Agbossou, E. K. (2010) Farmers' perception of climate change and adaptation strategies in Sub-Saharan West-Africa. ICID+18, 2nd International Conference: Climate, Sustainability and Development in Semi-arid Regions; August 16 - 20, 2010, Fortaleza - Ceará, Brazil.

Argyris, C. and Schön, D. (1978) *Organizational Learning: A Theory of Action Perspective*, Reading, MA: Addison-Wesley.

Biggs, S. (1987) Proposed methodology for analysing farmer participation in the ISNAR OFCOR study. *Agricultural Administration (Research and Extension) Network Paper 17.* London, ODI.

Daane, J. (2010) Enhancing performance of agricultural innovation systems. *Rural Development News 1*. Wageningen.

Kolb, D. A. (1984) *Experiential Learning: Experience as the Source of Learning and Development*. Englewood Cliffs, New Jersey: Prentice Hall.

Lamboll, R. and Nelson, V. (2012) Exploring the links between Climate Change, Agriculture and Development: A Briefing Paper. *Climate Learning for African Agriculture: Working Paper No.1*. NRI, FARA and AFAAS.

Mezirow, J. (1997) Transformative learning: Theory to practice. *New Directions for Adult and Continuing Education* (74): 5–12.

Moumouni I. and Idrissou L. (2013) Innovation Systems for Agriculture and Climate in Benin: an Inventory. *Climate Learning for African Agriculture: Working Paper No.3*. NRI, FARA and AFAAS.

World Bank (2006) *Enhancing Agricultural Innovation: How to go Beyond the Strengthening of Research Systems*. Washington, The World Bank.

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