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Coherence, Specification and Effectiveness of Agricultural Innovation Systems in Benin

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Aims: This paper explores possible approaches of assessing the effectiveness of AIS with the main hypothesis that ex ante analysis of advisory service systems integrating local perspectives can help for early evaluation of their chance of success.
Study Design: The AIS developed by the Cotton Boosting Project and the District Center for Agricultural Promotion were selected as case studies in Bembereke District in Northern Benin. We focused on advisory services provided by these institutions to farmers to better cope with soil fertility decline and the mortality of small ruminants.
Methodology: We constructed an analytical framework based on organizational theories of agricultural services, structured around the concepts of level of (i) intern and extern coherence, (ii) specification and (iii) effectiveness of AIS. We conducted systematic field observations and semi-structured interviews with farmers and agricultural projects leaders to collect qualitative data on the components of AIS, their level of accuracy, the relations between these components, their appropriateness with the intervention contexts, farmers' perceptions and satisfactions.
Results: The AIS we investigated displayed lack of coherence between objectives, services provided, human and material resources deployed and assets of targeted groups. Specific characteristics of the intervention environment such as rick factor were not often sufficiently considered by project leaders. Objectives and target groups were the less specified components.

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The low levels of harmony and accuracy between/of the components of the AIS were proportional to their unsatisfactory level of achieved performance, displayed by the persistence of soil degradation and the mortality of small ruminants.
Conclusion: The levels of coherence and specification between/of the components of AIS can tell a lot about its probable level of effectiveness. Such an ex ante analysis may complement usual approaches used to assess the effectiveness of AIS.

Keywords: Agricultural innovation systems; Benin; coherence; effectiveness; specification.

ABBREVIATIONS

AIS : Agricultural Innovation System
CeCPA : District Center for Agricultural Promotion
CeRPA : Regional Center for the Promotion of Agriculture
PARFCB : Cotton Boosting Project

1. INTRODUCTION

Assessing the effectiveness of agricultural innovation systems (AIS) is an important challenge. Agricultural innovation is a process in which co-evolution of technology, practices and institutions takes place at multiple and sometimes overlapping scales [1]. As part of AIS, agricultural advisory services are usually part of wider development projects with many interconnected components. However, the assessment of the effectiveness of agricultural advisory services is important to provide donors with evidence of usefulness. The innovation system is a network of organizations, enterprises, and individuals that focuses on bringing new products, new processes and new forms of organization into the economy [2]. AIS is important for efficiency and productivity gains [3] as it is a response to the need for rural competitiveness in a changing economic and social environment [4]. AIS approach has been applied to analyze the organization of technological, social and institutional innovations in agriculture [5]. However, the methods to support and evaluate AIS remain a challenge [6]. Many approaches and models were suggested to evaluate agricultural innovation programs. Deshler [7] identified seven approaches which would provide a sufficient choice for most extension evaluation situations: the (i) expert model relying on expert judgment; (ii) goal-free model which supposes that the evaluators have to uncover what is actually happening relative to farmers' interests regardless of stated goals and intentions, (iii) model of objectives attainment assuming that the success of an AIS can be determined by measuring its outcomes against its own objectives; (iv) management decision model aiming at providing decision makers with relevant information as a management tool; (v) naturalistic model which assumes that an AIS is a natural experiment and that the purpose of evaluation is to understand how it is operating in the natural environment; (vi) experimental model which aims at determining whether changes were due to the contributions of the AIS; (vii) and the participatory evaluation model whose purpose is for AIS leaders and farmers themselves to initiate a critical thinking on their activities. The goal-free model and the naturalistic model differ from the others for being less normative. Indeed, results frameworks, including normatively indicators for monitoring and evaluating the relationships between activities and outputs, are usually the starting point for evaluating outcomes and impacts of AIS [8,9]. Consistent with these normative frameworks, the well-known criteria such as relevance, effectiveness, efficiency, impact and sustainability are commonly applied for evaluating AIS. Operational definitions of these criteria and results frameworks vary importantly according to organizations, contexts and purposes [10]. However, most evaluation approaches are ex-post oriented and tend to be normative [11]. This paper explores possible approaches of assessing AIS with the main hypothesis that less normative and ex ante analysis of advisory service systems can help for early evaluation of their chance of success. Less normative evaluation approach, by valuing local knowledge and perspectives, is more likely to foster the co-creation of useful technical information and knowledge.

2. MATERIALS AND METHODS

2.1 Analytical Framework for Analyzing Agricultural Innovation Systems

We constructed an analytical framework based on organizational theories of agricultural services for analyzing agricultural innovation systems. “Innovation systems are complex, open and

dynamic human activity systems in which actors (individuals, groups, organisations) apply their minds, energies and resources to innovation in a particular domain of human activity" [12]. Agricultural innovation system can be defined at small, medium and larger scale [13,8]. We focused on the local level. AIS can then be characterized by the accuracy of its components and the consistency of the relations between its components. The main components of AIS are the objectives, target groups, services provided, resources allocated, intervention methods and environment (Fig. 1).

Our analytical framework is then structured around the concepts of level of (i) specification, (ii) intern and extern coherence and (iii) effectiveness of advisory service systems. AIS is said to have low level of intern cohesion when the system lacks consistent between objectives, services, characteristics of the target group, allocated resources and organizational arrangements. AIS with low extern or contextual cohesion would not consider enough the socio-economic and agro-environmental contexts of intervention, i.e. availability of natural resource for example, required for the implementation of innovations. AIS with low level of specification would attempt to provide all services to all target groups with the same organizational arrangement everywhere. Specification of the components of the AIS is important to ensure its coherence. Finally, effective AIS should be able to address successfully the concerns of the target groups.

2.2 Study Area and Case Studies

To analyze the impact of the levels of coherence and specification of AIS on its effectiveness, we selected two case studies in Bembereke district (3,348 km², 77,354 inhabitants) in Northern Benin. In this area struck by soudano-guinean climate (1000-1200 mm rainfall per year) occupied principally by Batonu and Fulani ethnic groups, about 75% of people practice agriculture (farming and husbandry) as main occupation. Main crops are maize, bean, groundnut and cotton. The main small ruminants reared are sheep and capra [14]. Many development organizations provided assistance to farmers in the District. The agricultural innovation systems developed by the Cotton Boosting Project (PARFCB) and the District Center for Agricultural Promotion (CeCPA-Bembereke) were selected as case studies. Both institutions have been very active in extension service provision to farmers early and mid 2010s. We focused on advisory services that these organizations provided to farmers to better cope with soil fertility decline (PARFCB) and the mortality of small ruminants (CeCPA). Many studies identified both constraints as major factors affecting negatively farmers' yields in Bembereke and mentioned as such in the district development plan [14]. The soil fertility decline is mainly due to overuse of lands and inappropriate agricultural practices and leads up to 30% of yield reduction. Anthrax and food intoxication are the main causes of the mortality of small ruminants and can provoke the loss of a whole herd.

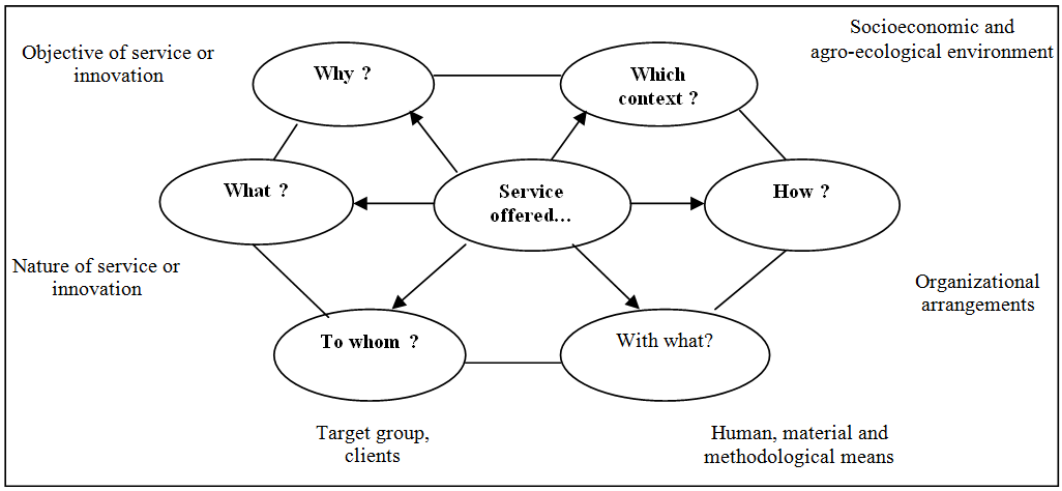

Fig. 1. Framework for analyzing agricultural innovation systems
Source: The author

2.3 Sampling and Data Collection

We conducted semi-structured interviews with three leaders of service organizations (one staff and two field team members) for each case study to collect qualitative data on the components of AIS which are the objectives, target groups, services, resources, methods and environment. Semi-structured interviews were also conducted with 90 farmers. This random stratified sample includes 50 people supported by PARFCB (soil fertility decline) and 40 people supported by CeCPA (mortality of small ruminants). This sample includes both female and male farmers from different education levels, different main occupations and status with regard to access to credit (Table 1). We collected data on (i) the characteristics of households and farms, (ii) farmers perceptions and satisfaction with regard to service provided to them. A coding process led to the extraction of quantitative, nominal or ordinal variables which are the age of farmers, sex (male and female), ethnic group (Batonu and Fulani), formal education (no formal education, primary school and secondary school), size of household, size of farms, main activity (agriculture, other activities), access to credit (access, no access), perceptions of the appropriateness of services to their context (too resource-demanding, too time demanding or not) and the satisfaction with services (disappointment, satisfaction).

2.4 Data Analysis

Our analyses addressed three focal points which were the coherence, specification and effectiveness of AIS at the grassroots level. More specifically, we looked at (i) the accuracy of the components of systems, (ii) the relations between the components of the agricultural innovation systems, (iii) their appropriateness with the socio-economic and agro-environmental contexts, and (iv) the farmers' perceptions and satisfaction with the services. The avoidance of normative evaluation requires looking for criteria at the interface between the characteristics of the AIS and the socioeconomic conditions of farmers. We assumed therefore that the perception of farmers of the requirements of the service or innovation is a synthesis variable reflecting the way they experience the levels of specification and coherence of the AIS. This perception results from the confrontation of farmers' own characteristics (age, sex, education, experiences, size of farm, resource available, etc.) with the characteristics of the innovation (levels of specification, intern and extern coherence). We used descriptive statistics to capture the diversity of target groups, farmers' perceptions and satisfactions. Correlation test was used to analyze some aspects of the coherence of the AIS. We used Khi2 test to analyze the relations between the farmers' perception of services and their satisfaction.

3. RESULTS AND DISCUSSION

3.1 PARFCB Case Study

PARFCB is was four years project launched by Benin Government and the Cotton Inter-professional Association (including cotton ginners, input suppliers and farmer organization) to boost the cotton industry through technical and organizational supports to farmers. PARFCB was implemented by an independent management unit and aims at improving the cotton yield (up to1500 kg/ha) and production (400.000 ha in 2012). Cotton was the most important cash crop in Benin. Cotton production systems, using mainly chemical pesticides and fertilizers, are seen as unsustainable. Soil fertility decline combined with organizational problems led to the decrease of cotton production in the second half of the 2000s. PARFCB proposed the approach of integrated soil fertility management in response to the soil fertility decline. The dissemination of the integrated soil fertility management was one of the key activities conducted by the project team. Promoting the integrated soil fertility management consisted in disseminating a technological package including preparation and use of compost and manure, fallow and crop rotation. The adoption of the whole package was expected to promote sustainable farming systems.

3.1.1 Specification of PARFCB's agricultural innovation system

The level of specification of PARFCB's AIS varied according to components (Table 2). The analysis of the specification of these components shows that the innovation, its nature, usefulness and some aspects of human and material resources allocated for this mission were well specified. However, the objective, the target group, the terms of the institutional arrangement with the CeCPA (public extension organization) needed all to be more accurate. In addition, there was a need for PARFCB to better consider the specificities of the intervention areas.

Table 1. Characteristics of the sample

Variables	Modalities	Frequencies		Percentages (%)	
		PARFCB	CeCPA	PARFCB	CeCPA
Sex	Female	6	4	12	10
	Male	44	36	88	90
Formal education	No formal education	30	19	60	47.50
	Primary and secondary school	20	21	40	52.50
Main occupation	Agriculture and husbandry	40	31	80	77.50
	Non agricultural occupations	10	9	20	22.50
	Total	50	40	100	100

Source: The author

Table 2. Analysis of the specification of PARFCB's agricultural innovation system

Components	Level of specification
Objective of innovation	PARFCB provided farmers with technical support for integrated soil fertility management. The objective was to foster yield improvement and sustainable farming systems The objective was quantitatively not specified.
Nature and usefulness of innovation	PARFCB disseminated the technological package encompassing the preparation and use of compost and manure, fallow, crop rotation, as solution to soil fertility decline. The nature and usefulness of the innovation was specified.
Target groups, clients	Cotton farmers of the district were all targeted. Although all those farmers may be concerned by soil fertility decline, the reasons for that were different from one farmer to another. In some farms (40% of the sample), soil fertility decline was due to inappropriate use of chemical fertilizers; while in others (45%) this came from inappropriate crop rotation. In addition, the sizes of farms varied too much, from 2.5 ha to 72 ha. Target groups needed more specification.
Human, material and methodological resources	Three field workers were recruited and endowed with motorcycles to conduct sensitization events and training sessions in the district. Human and material resources allocated for this mission were clearly defined but insufficient. PARFCB developed an institutional arrangement with the district public extension organization to make up the shortage. Fuel vouchers should be monthly allocated to public extension workers involved in PARFCB's activities. The allocation of vouchers stopped suddenly. Resources needed to make this arrangement functional were not enough clearly defined.
Institutional or organizational arrangements	The three field workers recruited are placed under the responsibility of a public extension officer. In addition, PARFCB solicited public extension field workers to increase its coverage rate. No clear contract defined the responsibilities of the parties. Moreover, public extension workers and officers were very busy with their own agenda. The terms of the institutional arrangement were not enough good specified.
Socioeconomic and agro-ecological contexts	The integrated soil fertility management strategy proposed by PARFCB included intensive use of compost, manure, fallow and crop rotation. Not all of these techniques were appropriate to socio-economic and agro-ecological contexts of any farmer. For instance, farmers complained for land scarcity to making fallow in some areas of the district while in others, farmers had limited access to water to make compost. There was a need for PARFCB to better consider the specificities of the intervention areas.

Source: The author

3.1.2 Coherence of PARFCB's agricultural innovation system

To capture the level of intern coherence of PARFCB's AIS, we focused of the coherence between service and target group, and between target group and resources allocated. The suitability of the innovation to the agro-ecological conditions and socio-economic environment are prospected to account for the extern coherence (Table 3). The analysis of the intern coherence of the AIS developed by PARFCB reveals that

some components of the technological package were appropriate to some categories of farmers and inappropriate for the others. The human and material resources made available were insufficient to reach the entire target group. With regard to the extern coherence, some technologies of the package were suitable for the agro-ecological conditions and the socio-economic environment of some farmers and not for those of others.

3.1.3 Effectiveness of PARFCB's agricultural innovation system

The satisfaction of farmers with regard to the service provided to them is an indicator of the effectiveness. Farmers' gave various reasons to explain their level of satisfaction with regard to AIS of PARFCB. These reasons are related to the innovation (in the sense of technology) as well as the innovation process. 58% of the interviewed farmers expressed dissatisfaction while 42% said to be satisfied of the AIS (Table 4).

Between farmers arguing that the integrated soil fertility management is too resource demanding and those stressing that PARFCB did not give much support, who were mostly satisfied with PARFCB's AIS? Both categories of farmers differed from the point of view of their satisfaction (chi2=6.65; p-value=.01). 76% of people who found the innovation too resource demanding were dissatisfied while 60% of farmers who complained about the lack of assistance from PARFCB were satisfied with the AIS. The specification status of the components of AIS impacted on farmers in terms of (in)sufficiency of support because the resources needed and the institutional or organizational arrangements to cover the size and diversity of the target groups were not enough accurate. This low level of specification made it difficult to ensure the coherence of the AIS. This coherence status of the AIS was felt by farmers in terms of resources constraints for using the technology because of the lack of adequacy mainly between the technology, the target group and the natural and socioeconomic contexts. The farmer with limited resource is then more likely to reject the integrated soil fertility management approach.

3.2 CeCPA Case Study

The Disctrit Center for the Promotion of Agriculture (CeCPA-Bembereke) was the representative of the ministry of agriculture providing farmers with organizational and technical supports in the district. The center hierarchically depended on the Regional Center for the Promotion of Agriculture for the Borgou Department (CeRPA-Borgou). CeCPA provided until recently agricultural advisory services to all farmers. The technical staff of the center included matter specialists and field workers with various backgrounds (animal breeding, crop production, natural resource management, food quality control, nutrition, etc.). In this study, we focused on the AIS established by the CeCPA to address small ruminant mortality, with the aim of making traditional husbandry systems more intensive. As solution of the mortality of small ruminants, CeCPA suggested to breeders to build animal house, to feed animals with self-produced fodder instead of straying and regular vaccination of animals.

3.2.1 Specification of CeRPA's agricultural innovation system

The level of specification of CeCPA's AIS varied according to components (Table 5). The analysis of the level of coherence of CeCPA's AIS showed that the nature, the usefulness of the innovation and the functioning mechanism of the intervention design were well specified. However, there was a need to define more accurately (i) the quantitative objective of the AIS, (ii) the size and characteristics of the target group, (iii) the human and material resources to invest to reach the objective, and (iv) the socioeconomic and agro-ecological contexts in which people undertake husbandry (Table 5).

3.2.2 Coherence of CeRPA's agricultural innovation system

To analyze the intern coherence of CeCPA's AIS, we focused on the consistency between the technological and the target group and between the target group, organizational arrangement and resources allocated. For the extern coherence, we addressed the suitability of the technological package to agro-ecological conditions (Table 6). The assessment of the level of coherence of CeCPA's AIS reveals that the intervention approach (sensitization approach) and the innovation (animal house model and fodder cultivation) were appropriate for some breeders and not for others. The coherence between target group, organizational arrangement and resources allocated needed improvements. Although the agro-ecological context is favorable for cultivating fodder, many farmers thought that grass production would be competing with human food production.

Table 3. Analysis of coherence of PARFCB's agricultural innovation system

Components	Level of coherence
Intern coherence	Coherence between service and target group: The target group of PARFCB was heterogeneous with regard to many important factors such as the size of farms. 52% of the interviewed farmers had less than 10 ha. The size of farms is highly correlated (0.64 significant at .05) with farmers' perceptions of the requirements of the solution suggested to them in response to soil fertility decline. The larger is his farm, the more the farmer perceived the soil fertility management strategy of PARFCB as resource (manure and time) demanding. In opposite, this requirement was less relevant to very small holders with less than 5 ha. For them, the practice of fallow appeared as impossible as it requires some land assets they do not have. To sum up, some components of the technological package are appropriate to some categories of farmers and not to others. Coherence between target group and resources allocated: PARFCB recruited only three field workers to conduct sensitization and training in a district where 77.354 people living in rural area. These field workers thought that the motorcycle given to them could not reach remote area in rain season because trails were deteriorated. They all complained for insufficiency of fuel allocation. The half of the interviewed farmers emphasized that PARFCB did not give them much support (lack of personal, lack of visits, etc.). 28% of the interviewed farmers found it very hard to meet PARFCB's agent who was expected to cover their area. Human and material resources available for this mission were insufficient to reach the entire target group.
Extern coherence	Suitability of the innovation for agro-ecological conditions: Fallow is not appropriate for farmers with land scarcity concerns (50% of the interviewed farmers) as the use of manure is not suitable for large scale farmers (42% of the interviewed farmers having more than 10 ha). 45% of the interviewed farmers thought that the integrated soil fertility management strategy proposed by PARFCB required natural resources (land or water) they can't access to). Some technologies of the package are suitable for the agro-ecological conditions of some farmers and not for those of others. Suitability of the innovation for socio-economic environments: Farmers who used credit to finance some agricultural activities such as plowing, hoeing and harvest (30% of the interviewed farmers) considered the integrated soil fertility management strategy proposed by PARFCB to be too risky. Some difficulties to get sufficiently manure and compost, for time constraints for example, might result into low yield which can hamper credit reimbursement. Moreover, some of them got the credit in nature, i.e. they get chemical fertilizers on credit. For them, giving up the use of chemical inputs made it hard to access to credit. The technological package is suitable for the socio-economic environment of some farmers and not for those of others.

Source: The author

Table 4. Reasons for (dis)satisfaction of farmers with regard to PARFCB's AIS

	Reasons for (dis) satisfaction	Frequencies	Percentages	Total (%)
Dissatisfaction	Innovation is inappropriate	15	30	
	Innovation process was top-down and did not considered local knowledge	14	28	58
Satisfaction	The innovation has visible advantages	12	24	
	Innovation process is a pleasant socio-technical learning	9	18	42
Total		50	100	100

Source: The author

Table 5. Analysis of the specification of CeCPA's agricultural innovation system

Components	Level of specification
Objectives of the innovation	CeCPA aimed at reducing the mortality of small ruminants to increase the productivity of small husbandries and the availability of good quality meat-based products in the district. The objective was qualitatively clear but lacked quantitative accuracy.
Nature and usefulness of innovation	CeRPA organized sensitization campaigns to make breeders aware of the importance of protecting (house) and the vaccinating small ruminants. CeRPA trained breeders on principles and techniques for building animal house, cultivating fodder and follows up the implementation. The nature and the usefulness of the innovation were well specified.
Target groups, clients	The target group of CeCPA included all the small ruminant breeders in the district. However, this target group was heterogeneous from various prospects. 48% of the interviewed people had no formal education. 55% of the interviewed breeders did not know the causes of the small ruminant mortality while 27% could describe them accurately. The sizes of herd varied from 33 to 135 animals. In addition, the husbandry of small ruminants was not the main occupation for 23% of the interviewed breeders. The size and characteristics of the target group should be made more accurate.
Human, material and methodological resources	CeCPA had two (2) field workers specialized in animal husbandry (called advisors on animal husbandry) and endowed with motorcycles. They were expected to cover the whole district. There was a need to define better the human and material resources required to reach the objective.
Institutional or organizational arrangements	The advisers for animal husbandry were members of a larger team including advisors for other issues such as crop production, natural resource management, food and nutrition. They got update training from matter specialists. In a given area, one adviser for farm management supervised and coordinated the team work. Vaccination campaigns were planned at the departmental level by the CeRPA. The information came at district level to the CeCPA. Both advisors for animal husbandry should transmit the information to all small ruminant breeders. The district rural radio was used for broadcasting information. The functioning mechanism of the design was well specified.
Socioeconomic and agro-ecological contexts	The target group included people geographically scattered. The socioeconomic and agro-ecological contexts in which they undertook husbandry need specification. Knowledge of the natural endowments of each area is required to suggest appropriate model of animal house. Breeders could then valorize local resources to build cheaper houses.

Source: The author

3.2.3 Effectiveness of CeCPA's agricultural innovation system

As mentioned before, the satisfaction of farmers with regard to the service provided to them is an indicator of the effectiveness. Farmers' gave various reasons to explain their level of satisfaction with regard to CeCPA's AIS. These reasons concern the technological package and the innovation process. 77.50% of the interviewed farmers expressed dissatisfaction while 22.50% said to be satisfied of the AIS (Table 7).

The category of farmers who thought that the technological package made of animal house, fodder cultivation and animal vaccination was too expensive differed from the one stressing the lack of attention and support from the CeCPA with regard to their satisfaction (chi2=5.95; p-value=.02). 65% of people who found the AIS too financial resource demanding were dissatisfied while 78% of farmers who complained of insufficient assistance from the CeCPA were satisfied with the AIS. Therefore, the specification status of the components of AIS impacted on farmers who felt lacking support because the human and material resources needed to cover the target groups were not enough accurate. The coherence status, characterized by the lack of consistency mainly between the technology and the target group, was felt by farmers in terms of financial constraints for using the technological package.

Table 6. Analysis of coherence of CeCPA's agricultural innovation system

Components	Level of specification
Intern coherence	Coherence between service and target group: The same sensitization approach should not apply for all categories of farmers, as it was the case, because of the heterogeneity of the target group. For instance, 48% of the interviewed people had no formal education, 41% and 10% had primary and secondary school levels respectively. Farmers' understandings of causes of small ruminant mortality varied according to their education level (r=0.43 significant at 0.05). In addition, the proposed model of animal house was not appropriate to the socio-economic living conditions of many people. 55% of the interviewed breeders complained for being asked to build animal house which was more comfortable than their own house. They found this innovation inappropriate and too demanding in terms of financial resources Finally, investing to cultivate fodder for animal was possible for some breeders, difficult and even unthinkable for others, as they would prefer cultivating food and leaving animals being a stray. To sum up, the sensitization approaches as well as the animal house model were appropriate only for some breeders. Coherence between target group, organizational arrangement and resources allocated: Two field workers were definitively unable to cover the defined target group in a district where 77.354 people live in rural area. 45% of the interviewed farmers complained for that CeCPA did not provide enough advisory advices to them. Moreover, the organizational arrangements based on a hierarchical system was not enough relevant for a scattered target group. Although the district rural radio was used by CeCPA to disseminate the information, many farmers (64%) complained for not getting right information on time. As consequence, they were not able to their animals (usually in divagation) and to mobilize the required vaccination fees gather right on time. The coherence between target group, organizational arrangement and resources allocated needed improvements
Extern coherence	Agro-ecological conditions were favorable for the cultivation of fodder. The soudano-guinean climate made it possible grass production. But small ruminant breeders' socio-economic level was so that fodder production would be competing with human food production.

Source: The author

Table 7. Reasons for (dis)satisfaction of farmers with regard to CeCPA's AIS

	Reasons for (dis) satisfaction	Frequencies	Percentages	Total (%)
Dissatisfaction	Innovation is inappropriate	11	27.50	
	Innovation process was top-down which did not considered local knowledge	15	37.50	65
Satisfaction	The innovation has visible advantages	6	15	
	Innovation process is a pleasant socio-technical learning	8	20	35
Total		40	100	100

Source: The author

3.3 Discussion

The low levels of harmony and accuracy between/of the components of the investigated advisory service systems were proportional to their unsatisfactory level of achieved performance, displayed by the persistence of soil degradation and the mortality of small ruminants. These findings support some research results such as Faure et al. [15] which argued that for an agricultural innovation system to be successful, strong interactions must exist between the different components of the system, i.e. intervention method, financial and human resources available for providing advisory services and the nature of services (internal coherence). For effective co-innovation there is a need for network-level capability and legitimacy,

an understanding of priorities between actors, and adequate resources [16]. The coordination is a key issue because of the diversity of actors and their interactions and because of the progressive co-construction of the service demand and supply [17]. Innovation systems are more likely to build, sustain or enhance food security in situations of change when they are flexible [18,19] enough to address needs of diverse target groups. The performance of innovation systems can be enhanced by creating an enabling (policy, institutional, resources …) environment [12] we refered to as external coherence. This result is consistent with Toillier et al [6] who show that a variety of mechanisms are requested to create enabling conditions for innovation and to provide a step-by-step support to innovation. Therefore, as confirmed by Faure et al [17], networking, facilitation and brokerage functions are crucial across all the phases of the innovation process.

4. CONCLUSION

The analysis of the AIS of both PARFCB and CeCPA showed that the specification of the components of AIS (objective, target group, and institutional arrangements for PARFCB; objective, target group and resources for CeCPA) impacted on farmers in terms of (in) sufficiency of support. Indeed, the resources needed and the institutional or organizational arrangements to cover the size and diversity of the target groups were not enough accurate. These low levels of specification made it difficult to ensure the coherence of the AIS. The coherence status of the AIS was felt by farmers in terms of resources constraints (natural resources for PARFCB and financial resources for CeCPA) for using the technology. Indeed, the AIS lack adequacy mainly between the technology, the target group (CeCPA case study) and between the technology, and the natural and socioeconomic contexts (PARFCB case study) of intervention. The low levels of harmony and accuracy between/of the components of the investigated advisory service systems were proportional to their unsatisfactory level of achieved performance, displayed by the persistence of soil degradation and the mortality of small ruminants.

The authors recommend that these findings have two major implications. First, the study attempted to include farmers' perspectives in understanding the shortcomings of AIS. It provides some evidence that the valorization of farmers' perspectives in agricultural research can lead to the co-creation of useful technical information and knowledge, especially in critical phases of the functioning of AIS such evaluation. Considering local perspectives may make the functioning of AIS less normative and helps understanding the gap between theoretical plan and field reality. Second, the study showed that the levels of coherence and specification between/of the components of an agricultural advisory service system can tell a lot about the probable level of effectiveness of the system, especially with regard to the gap between theoretical logical framework and the reality of the field. Such an ex ante analysis may complement usual approaches used to assess the effectiveness of agricultural innovation systems.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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