American Journal of Humanities and Social Sciences Research (AJHSSR)
e-ISSN :2378-703X
Volume-5, Issue-6, pp-440-454
www.ajhssr.com
Research Paper Open Access

Innovation platforms in the yam value chain in Ivory Coast and Burkina Faso: display or filter for endogenous innovations?

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ABSTRACT : This paper aims to contribute to the development of existing knowledge on the structural-functional analysis of innovation systems by examining the interdependence between the systemic parameters of an innovation platform and its contribution to the emergence or filtering of endogenous innovations. It analyzes the innovation platforms of Léo (Burkina-Faso) and Tiéningboué (Ivory Coast) built within the framework of the YAMSYS project for the development of the yam value chain. Studies on the agricultural innovation system (AIS) illustrate that agricultural innovation results from interactions between actors, institutions and artifacts. The cross-analysis of narrative data from members of each innovation platform allowed us to understand six major functions of the AIS in Léo and Tiéningboué, that underlie the process of emergence of endogenous innovations The circulation of information and the exploitation of knowledge have led to the establishment of relationships between actors; the dynamism of actors and their active participation in collective activities have generated learning organizations that have led to the formation of markets and mutations in the forms of transactions that have become win-win in Léo. On the other hand, at the Tiéningboué site, the weak collaboration of actors and the socio-historical and cultural context explain the weak incentive for the appearance of learning organizations and innovation.

KEYWORDS: *endogenous innovations, Innovation platform, Léo, Tiéningboué, yam*

I. INTRODUCTION

The United Nations Economic and Social Council report estimated that there were approximately 795 million undernourished people in the world in 2017, or 1 in 9 people. The majority live in developing countries and the rural world. In Asia and sub-Saharan Africa, small farms produce more than 80% of the food. However in sub-Saharan Africa, nearly 25% of the population is undernourished [1][2][3]. The issue of food security is becoming very crucial for achieving the Sustainable Development Goals 2 in 2030 [3]. The Food and Agriculture Organization of the United Nations (FAO) states that, "Food security is a state in which all people at all times have guaranteed physical and socioeconomic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" [2]. Thus, food crops in particular roots and tubers are shown to contribute more to food security [4]. Yams are produced in Burkina Faso and Ivory Coast to different degrees. The yam sector faces several structural, functional and institutional difficulties.

In Burkina Faso, yam is classified as "other crops" by the structure in charge of agriculture. As a result, it is virtually absent from the institution's agricultural development projects and programs. With the adjustment program applied to agriculture, groups of yam producers and later the Union of Tuber Producers appeared. They did not manage to respond efficiently to the needs of producers. Moreover, scientific investigations focused on yam are weak. Agronomic and virological work was done in the 1990s. In the early 2000s, the "regional

cossettes project" on the valorization of yam for urban markets (VALIMA) in collaboration with the National Institute of Agronomic Research (INERA) and the Institute of Applied Sciences and Technology (IRSAT) led to interdisciplinary action research on yam production and processing. It was not until 2015 that yam was once again in the focus of research through the YAMSYS project. In addition to this complex institutional context, yam crop yields have been between 5 and 8 t/ha since 2015. Indeed, the current practice of yam production indicates that its cultivation is extensive, benefits from little investment and is subject to climatic hazards.

In Ivory Coast, however, yam is the most widely cultivated non-cereal food crop, with 63.7% of the area, feeding 2/3 of the Ivorian population and cultivated in all regions of Ivory Coast[5]. Despite this prominent position, its production falls short of expectations (with 7 to 12t/ha) and is subject to climatic hazards. Like Burkina Faso, traditional yam cropping systems are confronted with diseases (virus), declining soil fertility, post-harvest losses, and unsuitable planting material with the use of very few inputs. Added to these complex contexts is the low degree of interaction and synergy between actors in the yam value chains [6].

The low appropriation of technologies by potential users such as producers developed by research partly explains the low yields. It is also a function of the capacity for large-scale adoption of innovations [7]. Several works have shown that linear-type innovation diffusion systems are inadequate for large-scale adoption of innovations. These strategies neglected the importance of local and traditional knowledge and perceived innovation as a technology that excludes any possibilities of integrating social processes during its operation. It has been shown that innovation is a process that results from the integration of ideas (technological and otherwise) and knowledge coming not only from scientists, but also from users, intermediaries and other societal agents. In other words, innovation does not only consist of new technical devices, but also of new social and organizational arrangements, such as new rules, perceptions, agreements, identities and social relations [8] [9]. This implies the intervention of several stakeholders who operate in different interdependent and evolving networks. As a result, adjustments of various kinds are required, even re-conceptions or the destruction of pre-existing conditions and frameworks. Hence the need to resort to the innovation system, which applied to agriculture is an effective tool to analyze the ecosystem and support mechanisms and infrastructures that facilitate agricultural innovation [10]. Knowledge transfer, learning processes, and transformation of farmers' practices involve concerted strategies to improve their living standards [11]. The "innovation platforms" (IP) are one of the means of implementation and operationalization of the innovation system for a development of agri-food value chains in developing countries [12][13]. Their use has enhanced agricultural productivity through the adoption of specific technologies and promotion of agricultural networks, improved livelihoods of smallholder farmers, and enhanced development of interactions between actors and thus co-learning within an agricultural innovation system [13] [14] in order to fight poverty and ensure food security in these developing countries. From the above, it is clear that any innovation process occurs in a context and in the presence of a multitude of actors that goes beyond those directly involved [15]. Thus, whether it is the decisions, actions, behaviors, or choices of actors, they have various sources of external and internal influences. These lead actors to react in various ways. In other words, in the context of the yam value chain, it is necessary to look at the analysis of IP as a driver or not of the endogenous innovation process. Hence, the question that underlies this study, namely, how do actors in the development of the yam value chain manage to create room for maneuver and opportunities in a context of rigidity of existing structures, whether indigenous or external? What is the capacity of local actors in the yam system to innovate in the presence of external intervention through the implementation of an IP? The work of Pamuk et al [16] points to the importance of the pre-existing environment for the implementation of IPs in sub-Saharan Africa in particular, as the social, economic or institutional context affects the performance of IPs. Those of [7] [14] illustrate that the low diversity and disengagement of actors, the poor management of stakeholders in terms of selection and support, the absence of the facilitator, and the low capacity of members to provide solutions to all identified problems limit the process of creation and/or adoption of innovations. Given the persistence of food insecurity, it seems essential to understand the contribution of IP to the socio-economic and institutional transformation process of the yam system for sustainable development. Moreover, if IP is an opportunity to facilitate exchange, collaboration and co-learning, would it not also be a source of motivation for endogenous (local) initiatives?

This study aims to understand the influence of IP on the innovative capacity of stakeholders in the yam value chains in Burkina Faso and Ivory Coast based on the framework of analysis of the functions of the innovation system. In other words, it aims to identify, explain and compare the interaction effects of IP structure and functioning parameters on the creation process of yam value chain stakeholders in each of the two countries that are beneficiaries of the YAMSYS project. The project is entitled "Biophysical, institutional and economic determinants of sustainable land use in yam production systems for improved food security in West Africa". Indeed, several works on yams have shown the strong contribution of its production in the sustainable fight against poverty, in improving the living conditions of rural households [17][18] and in maintaining the social cohesion of rural communities [19]. Several actors in the yam sector derive their source of income from it [20] [21] such as producers, traders, processors, traditional pharmacopoeia actors and the pharmaceutical industry.

The paper is organized as follows. The second section gives a brief description of the conceptual and analytical framework starting from the definition of the concepts used to end up on the theoretical framework allowing to operationalize in a systemic way the structural and functional analysis of IP as a lever of endogenous innovation processes. Section 3 presents the data collection and analysis process. The fourth section presents the results organized with reference to each of the three areas of IP analysis. Section 5 provides a more in-depth analysis of how endogenous innovations may or may not have emerged with reference to the functions of an innovation system in Burkina Faso and Ivory Coast. The study is concluded in the sixth section.

II. THEORETICAL FRAMEWORK

2.1 Innovation in agriculture

Innovation is complex and defined in a broader way than what is commonly reduced to technique and its transfer or even what is called "the technical package". Innovation can be a new way of doing or organizing. According to [22], "an innovation is essentially a new practice, a new way of doing things, which may have a material support (a new product, a new material, etc.) or which may be immaterial (a new way of thinking, in particular). Innovation is in the social domain. Thus, the results of research have led to methods of making it available to practitioners that sociologists have analyzed through innovation adoption curves. These curves made it possible to distinguish user profiles [23]. Next, agricultural innovation was apprehended from the perspective of the transformations it brought about in the social and technical organizations of the countryside, as illustrated by the analysis of Mendras in 1967 in his work "The End of the Peasants. It illustrates that technical innovation has a multidimensional character with simultaneous technical, economic and social aspects. For the sociology of translation, innovation is understood as a reconfiguration of a hybrid network associating men and technical objects[24] [25] and not as a coupling between an invention and its adoption by users that some have named "socio-technical"[26] [27] [28]. The cross-analysis of these works shows, on the one hand, that the different authors consider innovation in its exogenous aspect although it is no longer perceived as a thing but as a process and, on the other hand, that the appropriation of innovation is also a process requiring creativity that contributes to the improvement of the living conditions of small farmers and thus to development. Otherwise, development would have an endogenous dimension.

The notion of imitation is used as one of the antonyms of innovation. The innovator is an initiator, a creator, a promoter and not an imitator, a reactionary, a conservative. Thus a novelty coming from outside, so that it passes from the state of "ab-novation" to that of in-novation there is need for an active process of appropriation[29]. This active process of appropriation grants the endogenous dimension to innovation. For several decades, sociological theories in agriculture have focused on the growing involvement of users in the production of innovation, which is perceived as both a process and a system. This has been the development of innovation for and by users (User-led innovation) [30]. With reference to agriculture, several authors make explicit the capacity of farmers to impel a "dynamic of within" and to bring about various changes in a given environment [31] [32]. Endogenous innovation can be seen both as a desire to optimize innovative activity by capturing the voluntary creativity and knowledge of users and as an imperative posed to users to direct innovation to meet the specificity of their needs. Exchanges between designers and users have always existed in design, as demonstrated by Akrich's work, which is in line with the sociology of science. Indeed, they contribute to defining approaches known as "co-evolution" in the understanding of the complexity of the multiple interactions between technologies and the different components of systems that co-evolve over time. This leads Demeulenaere to stipulate "that no one has the capacity to apprehend the complexity of the world, that everyone has a partial and partial knowledge of it, and that the resolution of concrete problems - even more so in a situation of scientific uncertainty - requires the mobilization of a plurality of concerned actors"[33]. Thus, each component of the yam value chain is a system and their overall approach is seen as a meso-system referred to in this study as IP. The IP offers this mobilization of actors whose functioning could contribute to the emergence of innovations adapted to specific environments where the environments are not virgin. This consolidates the idea that the emergence of innovation in agriculture can occur because of the existence of effective networks between agricultural enterprises and basic research, between the different functions of the enterprise, between consumers and producers. [34][35][36]. This innovation process can induce solutions to problems because stakeholders in the networks have collaborated, learned from each other, shared resources, and responded to changing economic, environmental, social, and technical conditions. The endogeneity of innovation refers to the capacity of organizations to become learners because of their capacity for permanent observation of nature, their practice of exploration and experimentation, their strategy of cooperation and negotiation [37]. This combination of new and old knowledge contributes to the construction of solutions that are more adapted to their needs. These are referred to in this study as endogenous innovations. Consequently, it is imperative to take into account the perspectives, knowledge and practices of local actors, hence the interest of the agricultural innovation system [38] [39].

2.2 Agricultural innovation system (AIS)

The innovation process at its origin was conceptualized through the "linear model" whose major limitation was the absence of feedbacks (Klime and Rosenberg, 1986 cited by [36]. In response to this limitation, the chain linkage model of Klime and Rosenberg, was proposed. According to this approach, there are feedback loops between the different stages of the innovation process. In the early 1990s, other works combined several strands of thought by focusing on institutions and using the chain model, showed that they are key elements for supporting innovation because of the interactive properties between firms and basic research, between different functions of the firm, between consumers and producers [34][36]. Thus, the chain linkage model presents innovation as a process of interactions. These approaches recognize the existence of innovation systems. The latter can be defined as "a network of organizations, firms, and individuals focused on the economic exploitation of new products, processes, and organizational forms, as well as the institutions and policies that influence their behavior and performance"[40]. In the literature, the innovation system (IS) is defined in several ways and can also take several forms depending on the actors and the analytical framework used. The agricultural domain is an example of the field where IS is applied to explain the process by which innovation develops and can be initiated [35]. Hence, the concept of AIS. According to [41] an IS is a multi-actor arrangement set up to facilitate and undertake various activities around innovation challenges and opportunities identified at different levels in agricultural systems. It serves to facilitate interaction and collaboration across networks of farmers, agricultural input suppliers, traders, food processors, researchers, government officials, and by providing a space for experimentation, learning and negotiation [42] [41][43] [44][45. Within the SIA framework, "innovation is not only about technical innovation such as the adoption [of the Mini-sett practice in yam cultivation]. It also encompasses organizational innovation such as organizing farmers into clusters and institutional innovation such as addressing sustainable land management processes through the operationalization of the Land Degradation Neutrality (LDN) process[46]. With the advent of Integrated Agricultural Research for Development (IAR4D), IP is advocated as the operational mechanism for achieving change and co-evolution in agricultural systems[47][13].

2.3 Innovation platform

The innovation platform is composed of around 20 to 25actors; where each plays an active role [48]. He/she contributes to the process of creation, organization, and achievement of the platform. To do this, the actor has his own resources or those granted to him by his environment composed of facilitators, experts, elected officials, civil society, donors, traditional leaders to name a few. As for the innovation platform, it "is presented as a framework for reflection or discussion allowing actors to exchange, co-learn, negotiate and reach win-win solutions to a common issue (problem or opportunity) of a complex nature. It is therefore a mechanism for resolving a problematic situation through social learning and negotiation, which requires a medium- or long-term approach" [42]. This multi-scale exchange mechanism can be observed: (i) between professionals on the expectations of the different actors, (ii) between researchers and actors on scientific representations and methods, on technologies or on organizational modes favorable to collective action and finally (iii) between researchers on research methods and organization [49] [50]. IP conceptualized as a grouping of stakeholders in a value chain around a common goal, offers them a space to negotiate their own interests through processes of collaboration and cooperation. From this point of view, IP is very useful for smoothing out differences between groups of actors, resolving conflicts and co-constructing a new vision. It would promote exchanges of experience and learning and take into account the individual expectations or needs of actors in complementary professions. These exchanges are a function of the prerogatives, roles and responsibilities that each group of actors expresses when solving the problem of common interest [51] [13][52]. IP, conceptualized from interactionist thinking, makes explicit the adoption and creativity of innovations through the relationships between endogenous knowledge, science, practice, policy, etc. from the complex social system of human actions. Otherwise, stakeholders are constructed in their relationships with their environment (human, affective, material, and moral) [53]. Within the framework of the YAMSYS project, the innovation platform was designed to contribute to a transition from the unsustainable yam systems existing in each project intervention area to more sustainable production systems. It should, in close cooperation with the involved biophysical researchers, develop options for techniques and organizational modes based on the specificities of each research area.

III. ANALYTICAL FRAMEWORK

Several factors influence the functioning of the IP, which in turn induces reactions at the level of the stakeholders. These stakeholders pursue innovation objectives while creating new relationships that allow them to mobilize material, energy and financial resources [54]. IP is an arena of power play that each component exploits through conflict and negotiation to change the "rules of the game." As IP is an operational tool of the AIS, to understand its contribution or not to the emergence of endogenous innovations, it is imperative to exploit the IS analysis framework [55] that takes into account the dynamic process of technological and social change. The analysis proceeds by systemically mapping the activities that take place in IS and that lead to change. The function of these activities is to contribute to the objective of the IS, which is the generation and diffusion of innovations. The processual approach

based on functions, adopted in this study, allows us to avoid the institutional determinism that affects the IS analysis framework. It allows for a better understanding of the underlying mechanisms that determine the evolution of both technological and social innovations over time. The notion of function also makes it possible to identify, understand and compare the crucial activities of IS specific to technologies. It provides insight into the dynamics and possible patterns of evolution of related practices, markets, institutions and innovation processes [55]. To conduct the analysis, Hekkert and colleagues defined seven functions. The first one, entrepreneurial activities, shows how the potential of new knowledge, networks and markets are transformed into concrete actions to realize value. The second is knowledge development, which is fundamental for innovation, and the ability to develop new knowledge. The third is related to the diffusion of knowledge through networks, platforms to develop and adapt knowledge and innovations. The fourth function corresponds to the orientation of research, which consists in creating a vision of the innovation system through multiple interactions, to orient other functions such as entrepreneurial activities and the development of knowledge in the system. The fifth function responds to the formation of the market for new products or for existing products produced in different ways and with new attributes. The sixth function corresponds to resource mobilization involving the basic financial and human capital needed to undertake all activities in the AIS. Finally, the seventh function contributes to creating legitimacy and overcoming resistance to change. In the YAMSYS project, entrepreneurial activities, knowledge development, diffusion of innovations through IP, mobilization of human and financial resources and market formation are the ones that best fit the achievement of its intended objectives and thus appear to be the most important for the study.

The figure below indicates that three categories of variables are interactive and can be understood through various parameters. The structural elements are the basis for the implementation of IP. They clarify the internal organization of an IP and the different categories of context within which the IP operates and which influence power relations, including the flow of resources and information between groups of actors. They also provide an understanding of the relevant objectives of the project that designed it and the key issues to be resolved. The divergent interests of the links are expressed in the ways in which information is explored and used. The nature and importance of the information contribute to the construction of their perception and their attitude towards the risk linked to the process of innovating and making a change. Face-to-face discussions during IP activities and physical visits are elements that contribute to the interrelationship of stakeholders. These interactions will be consolidated with the cooperation and coordination processes. This networking capacity will have variable effects, and will be a source of trust and participation in collective actions due to its dynamic nature. Consequently, the interaction between these different parameters contributing to the functioning of the IP could also induce or not endogenous innovations.

The analysis of the mapping of relations between the parameters of the structure and functioning of the IP is done at specific moments in the innovation process. This time is multiple and interactive, discontinuous and localized, because it is indexed to contexts that themselves evolve at their own pace, and therefore acts differently throughout the realization of the IP's activities. Each parameter is part of an environment with which it interacts and which transforms it, modifying its power of impact in the chain. The analytical approach is based on methods related to innovation systems and the processual analysis of functions[40] [55]. It will make it possible to identify the functions of the innovation system defined by Hekkert and, in turn, to understand the drivers of the innovation process in the yam value chain. Thus, the integration of the different parameters of the innovation system reveals the reality of the links and the value chain, which is understood in a narrative principle since reality is itself organized on this narrative principle [56].

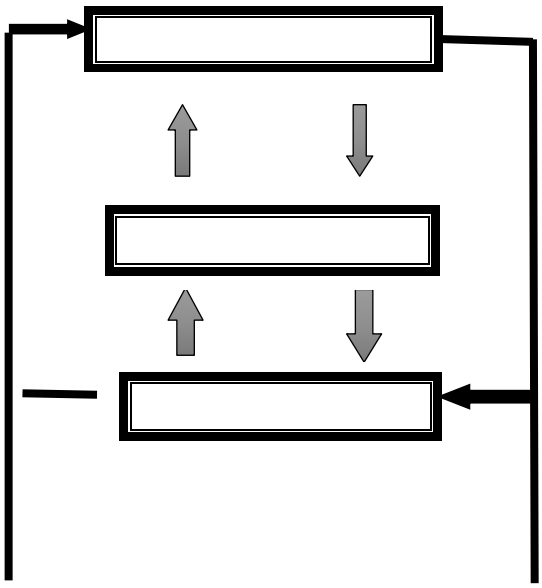

Figure 1: Analytical framework of the YAMSYS IP project

Source:inspired by the work of [55] and [7]

IV. METHODOLOGY

4.1 Brief description of the YAMSYS project

In order to induce changes in the current practices of yam value chain actors, the YAMSYSproject established innovation platforms (IPs) in each of these sites. In keeping with the common structure of innovation platforms, YAMSYS also involved institutions concerned with improving yam production and value chain development, as well as enhancing ownership of technical packages. A first appropriation of this exogenous innovation structure by local actors consisted in the attribution of a name to each of these platforms, "Pia kakila kio" or "the star of the yam has appeared" in the local Nouni language in Léo, Burkina Faso, and "Djiguissêmê" which means "Hope" in the local Koro language in Tiéningboué, Ivory Coast. Léo and Tiéningboué belong to two agro-ecological zones: the Sudano-Sahelian zone for Léo, with five villages, and the Sudanese-Guinean zone for Tiéningboué, with seven villages (Table 1).

Table 1: Communes and villages where YAMSYS IPs are installed by country

Agro-climatic zone	Country	Municipality/subprefecture	villages
Sudanese-Guinean	Ivory Coast	Tiéningboué	Dabakalatou, Menemenetou, Moussatogoda, Niangourala-Kamagaté, Lamakamagaté, Ninakiri et Tiéfindougou
Sudan-Sahel	Burkina Faso	Léo	Nadion, Hélé, Outoulou, Onliassan et Bénaverou

Source: Léo and Tiéningboué activity reports 2015

4.2 Study Area

The study is based on the case of the IPs of Léo and Tiéningboué. The importance of yam productivity for supplying consumer markets guided the choice of these study areas. Léo is a border town, located 15 km from Ghana, and is crossed by a national road, making it easily accessible. The Léo market is the supply point for large urban centers such as Ouagadougou, Koudougou and Ouahigouya. It is an agro-climatic zone of the Sudano-Sahelian type bordered by the 900 mm and the 1100 mm isohyet [57]. In the past, yam was produced exclusively by the Gourounsi peoples, grouping the Sissala and Nuni. But currently, it is also produced by other ethnic groupswho coexist on the village land with these indigenous people, namely the Peuhls, the Dagara-dioula, the Mossis and the Silmi-mossis. As for the commune of Tiéningboué, it is located in the transition zone of the forest, in the northwestern region of Ivory Coast, between the isohyets 900 mm and 1700 mm. The climate is characterized by two seasons, a long dry season (October - April) and a rainy season (May - September). The population is made up of indigenous Koro people and a large number of non-indigenous people (Sénoufo, Baoulé, Koyaka, Odiennéka) and non-indigenous people from the region (Peulhs, Malians, Burkinabé, Guineans).

4.3 Data collection and analysis

The methodology used is a mapping exercise of the agricultural innovation system functions. Data collection covered the period from IP initiation (August 2015) to the close of IP activities (October-November 2020) as shown in Table 2. The data are from structured, semi-structured interviews, participant observations during IP consultation activities, stakeholder testimonies, and facilitator debriefings. The data relate to the understanding of the structuring of IPs, i.e., the actors (their profile, the evolution of their numbers, the types of relationships developed, their roles, their expectations, their attitudes, their perceptions, their financial capacity and their practices). As for the understanding of the functioning of IPs, the data concerned the activities carried out (entrepreneurial, learning, dissemination of innovations, investments, markets developed, mobilization of human, financial and material resources, lobbying by interest groups, and the mode of governance), the difficulties encountered and the approaches to solutions developed.

Table1: Distribution of respondents by study area and stakeholder groups

IP stakeholders interviewed	Workforce	
	Léo	Tiéningboué
Facilitator	1	1
Representatives of village yam producers	10	8
Retailer Representatives	1	
Representatives of the wholesalers		4
Processor Representatives	1	

Input sales Representatives	1	1
Customary authorities	2	2
The Environmental Protection Department	1	1
Microfinance Representative	1	1
Provincial Directorate of Agriculture/Extension workers	2	1
*Nian Zouè*Federation (FNZ) / Professional organization	1	
Policy makers	2	2
Researchers	2	1
Total	**25**	**22**

Source:based on field data, 2016-2020

Fig. 1 presents the analytical framework for understanding endogenous innovations induced or not by IP in Léo and Tiéningboué. Thus, the cross-analysis of the content of the speeches, observations and reports made it possible to understand the drivers of the innovation process. In order to identify the process and its "added value," it was necessary to combine data from the institutional environment related to yam production, the structure of each IP, and their operations. As a result, the results induced in terms of endogenous innovations correspond to the added value of the IP. These different parameters of analysis serve as a corpus for the results presented below in the study.

V. RESULTS

5.1 Initiation and definition of constraints in the fresh yam value chain

5.1.1 IP initiation

According to the project coordinators, the IP initiation process began with the first activities carried out in mid-June 2015. An exploratory survey at each site identified representatives of potential direct IP stakeholders. The motivation of the respondent to induce change in the yam system was the criteria for selecting these actors. Then, sensitization workshops on the concept of the innovation platform were conducted with the identified stakeholder groups. Next, consultation frameworks (CF) were created with these actors around the "central" links identified, and the members of the IP came from these CF. As for indirect stakeholders, they were identified through the results of the mapping of the yam system in each country, and then sensitized by the site manager with the support of the local project coordinator and his team, on the interest of the IP and the expectations of the project in terms of contribution to the achievement of the objectives. Finally, workshops to structure the platform, to deepen the diagnosis and to plan priority activities were organized with the actors identified in each intervention zone during which the IP's operating document (the team contract) was developed and validated in a participatory manner.

5.1.2 Structure of the Platform

Exploratory studies, consultation meetings with traders, input sellers, yam producers and processors provided information that enabled the identification of major constraints and opportunities in the yam system. The choice of improving the yam production system, particularly healthy seeds, was based on the analysis of the stakeholders' arguments on the constraints. This productivity is based on the principles of integrated soil fertility management. The analysis of stakeholders in the yam system allowed for the identification of three value sub-chains at each site. These are grouped under the heading of the yam value chain and are driven by direct and indirect actors. In Léo, these are the fresh yam sub-value chain, the yam processing and the yam supply sub-value chain. As for Tiéningboué, these are the value sub-chain "late yams for the local market", the sub-chain "Florido yam for export" and finally the processing sub-chain "foutou and French fries". In addition, the analysis made it possible to identify the categories of links present in the IP and their roles.

The direct actors are found in five links of the value chain ensuring the functions of production, processing and marketing, namely

- The supply of inputs and services link is made up of two groups of actors, including mound makers and seed suppliers. These actors work in close collaboration with the producers.
- The production link is made up of small family farmers who produce various varieties of yam.
- The distribution link relates to the distribution of yam tubers and its by-products. It is the essential relay link between the producer and other users of yam products and by-products. It includes collectors, trackers and transporters. The distribution of yams is carried out on the Léo market every Friday, the day of the Léo market, to wholesalers from urban markets. The yams are transported by tricycles and carts to the Léo market. The supply of tubers to the Léo market is also provided by transporters from Ghana. Transporters of 10 and 15 tons trucks, buses, and minibuses transport the tubers to the national assembly markets.

- The marketing link: in this link, retailers constitute the proximity sales points on rural and urban markets. Sales are made by the unit or in piles of three in Léo and Tiéningboué. Semi-wholesalers keep intermediate stocks with a view to reselling them to retailers or wholesalers. Wholesalers are the large merchants located in the large cities. This link is located between the production and processing functions. Indeed, wholesalers have very little contact with producers; they negotiate the price of yam heaps with collectors and trading intermediaries, who are the majority in Léo. The collectors are yam producers who collect within their lineage, their village and the surrounding villages. The trading intermediaries are essentially young women who occupy the market place every market day to negotiate the price of the heaps with the collectors and increasingly with the wholesalers. The yams are sold in heaps of 100 tubers according to their size. The intermediary is paid according to the number of piles supplied. On average, he is paid 2,32 USD equivalent for each heap sold. Léo is a local collection market for yam tubers and a border market.
- The transformation link includes two yam transformation processes in Léo, including traditional and semi-mechanized transformation, with the former predominating because the transformation process is highly manual. In contrast, only traditional processing exists in Tiéningboué. These actors are mainly restaurant owners and agri-food processors. The food processing activity is carried out solely by women, most of whom are organized in groups. It is carried out only during the dry season. The main productsobtained are sold to consumers at the national, regional and international levels by semi-wholesalers and retailers.

Indirect actors provide three functions: support services, financing and regulation. They strongly influence the yam value chain. These are

- The Support services actors are composed of research, extension and agricultural service providers such as suppliers of phytosanitary products and fertilizers, and suppliers of agricultural tools (artisans / blacksmiths / equipment manufacturers). Research is led by national research structures with specialized yam centers, such as the Institute of Environment and Agricultural Research (INERA), theInstitute of Technological Research and Applied Sciences (IRSAT), in Burkina; and the National Institute of Agricultural Research in Ivory Coast (INRA). This forms a network whose main objective is to contribute to the development of the yam value chain and to satisfy the food needs of the populations while preserving the environment. This network is linked to universities, extension and advisory structures, and NGOs. The extension services ensure the dissemination of technological knowledge to producers. As for equipment suppliers, they provide Léo with mechanical crushers and grinding mills for the crushing of yams into flour, and plowing tools on each site. The suppliers of phytosanitary products have formed a formal group in Léo and an informal association in Tiéningboué.
- Financing institutions. Financing needs are observed among all direct actors in the value chain. There are financing needs for cash flow, different economic activities, equipment, social needs, etc., to name a few.
- The actors in the regulation of agricultural activities are the political decision-makers, the administrations in charge of agriculture and the environment, and the professional organizations. There are also community leaders who regulate the chain through standards.
- The consumption link concerns national, sub-regional and international customers. The consumption of yams is increasingly growing and is done in several forms according to the preferences and tastes of these consumers.

5.1.2.1. Structural evolution of the IP

In Léo, the IP is made up of yam producers, ten of whom come from each of the consultation frameworks of the five Léo project villages until 2019; they are all Gourounsi. In 2020, two other villages were involved in IP activities at the request of producers in these villages. Their participation was influenced by the extension workers and the IP facilitator. Only one person per village participates in IP meetings, and the second is an alternate. They are all indigenous people and men, and at major meetings they are all invited. As for the producer members of the Tiéningboué IP, they come from the consultation frameworks in the villages that discuss their problems. Their representatives, called focal points (one per village), meet and discuss constraints. Then two representatives of these focal points bring the information to the IP. In 2015, there were six members in the IP including one woman. In 2019 this number has evolved to seven members with the departure of one member, and the accession of two new members who arrived in 2018 and 2019. They are mostly Koro. Then come the transporters who have been associated with the activities of the IP only during the first two years of operation. Following this link comes the marketing of yams. These are the retailers who are associated with the Léo IP. On the other hand, in Tiéningboué, wholesalers from the Bouaké wholesale market are members. The representative designated by the president of the yam sector participates irregularly in IP activities. The last link is processing, and only the Léo platform has a processing unit.

The actors in the support services, support and influence of the yam value chain are the most diversified in these IPs. Thus, the Léo IP includes: suppliers of phytosanitary products represented by Mr. L. at the secondary level since its creation following the exchange meetings held with the project team. There are also suppliers of tools (craftsmen/equipment manufacturers). They joined the IP in 2017 following the producers'

request. Microfinance was represented by the Caisse Populaire and the First Microfinance Agency (FMA) in 2015. As of 2017 only FMA is present at the IP, in the person of its first manager. The customary authority is represented by the Canton Chief of Léo and a village chief. They have been members since 2015. Two political decision-makers (mayor and high commissioner). They ensure the implementation of activities and the application of decisions made by the members. A representative of the group of researchers in the person of the regional coordinator resident in Ivory Coast. Three extension workers are present, including two from the public administration in charge of agriculture and a professional agricultural organization, the *Nian Zouè* Federation (FNZ). They are helping to set up and monitor the farmer field schools and son trials and are participating in the guided tours. An agent of the Evangelical Development Radio is a member of the IP. Her role is to ensure media coverage through sensitization and dissemination of information related to the IP. RED has been a member since 2015, in 2018 they changed their representative. A representative of the environmental department whose role revolves around the supervision of producers and input suppliers in the preservation of the environment. This actor has seen two changes due to regular assignments in the function without transferring previous activities to the newcomer by his predecessor. Finally, the facilitator, who organizes and leads IP meetings. As for Tiéningboué, the platform includes: a representative of crop protection product suppliers in the person of Mr. Y.; a microfinance structure called COOPEC, which was linked to the IP in 2017 and represented by the branch manager. As for the agricultural advisors, there were three (3) each linked to ANADER, CIDT and COIC until 2017. Since then, there is only one extension worker affiliated with ANADER and specializing in agricultural advice to producers of perennial crops (cashew nuts). The Directorate of Environmental Protection (Water and Forestry) represented by the Lieutenant of Water and Forestry since 2015. The administrative authorities (the deputy mayor and the protocol of the sub-prefect) are also solicited as local development agents to take part in IP meetings and awareness-raising activities for producers to increase their motivation. In addition, it is up to them to make judicious decisions in the event of conflicts between their populations who are members of the IP. The customary authorities of the various villages are also present at the IP with two (2) delegates of the land chiefs and two (2) delegates of the village chiefs. They were proposed by the producers and customary chiefs to participate in the meetings and to settle disputes or quarrels between the member producers. The group of researchers is represented by the project coordinator to address the concerns of the beneficiaries regarding innovations and other needs. The social center and the gendarmerie are advisory services, and a representative from each structure was involved in the implementation of the IP. The social center targets women, who are made aware of the business opportunities available to them within the projects. But their action within the IP is limited in 2015. The gendarmerie, for its part, ensures the free movement of producers during mobilization sessions and activities within the framework of the project. Finally, like Leo, there is the IP facilitator.

Since the establishment of the IPs, in Léo, seed producers, which can be explained by the use of previous campaign stocks, collectors, trading intermediaries, wholesalers, transporters and consumers are the main absentees, whereas in Tiéningboué, seed producers, trackers, semi-wholesalers, retailers, consumers, transporters and processors are the main absent groups.

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5.2 Identification of endogenous solution options and co-construction of addressing constraints

Actors in the yam value chain are developing strategies to address or adapt to the constraints inherent in their activities. Thus, endogenous or co-constructed solutions through individual and collaborative activities are the subject of this section.

5.2.1. Improving yam productivity

Several local practices are observed on each site. Crop rotation with legumes or maize as a preceding crop would contribute to improved yields. The majority of producers have reduced the area allocated to yam cultivation by half over the last five years. They all invoke the use of rituals to invoke the blessing of the ancestors and the gods of the land, water and bush. Producers affirm that they have made sacrifices and always plant the ancestor of the yam called "*kalédjanè*" first in Léo or let the best producer in the family make the first mound in Tiéningboué. Since productivity is linked to labor, they frequently resort to social labor in order to reduce their costs. In Tiéningboué, this social labor is available with the return of young villagers who temporarily migrated to the forest zone between July and March. This requires a strong integration of the producer into his social fabric. On both sites, they claim to contract agricultural credits, part of which is allocated to the needs of yam cultivation. Those in Léo apply mineral fertilizer in patches over the yam beds, a practice acquired from the cotton cultivation framework. They lobby the authorities in charge of agriculture on every tuber promotion day, while offering them yam variety kits. The multiple interactions between IP actors have led to the practice of seed treatment and mineral fertilization by spraying more in Léo than in Tiéningboué. The latter are still reluctant to use mineral fertilizer on yams.

5.2.2. Countering the disappearance of yam varieties

As local strategies, young producers in both Tiéningboué and Léo offer their labor in exchange for surplus yam seeds from producers with several varieties. Other producers in Léo are bartering yam varieties. Finally, the renewal of seeds is observed through migration to Ghana to purchase varieties that were prized on the consumer market during the previous season. With the collaborative actions of the IP on each of the sites, there is a strong renewal of seeds thanks to the learning of seed multiplication techniques and that of Mini-sett.

5.2.3. Countering the lack of access to credit:

The production of short-cycle food crops such as cowpeas sold as soon as they are harvested in Ghana and ginger in Tiéningboué in order to build up financial funds in July and meet input needs in yam production. From the beginning of IP implementation, the analysis showed that yam producers, processors, traders and input sellers are all linked to MFIs. In Léo, traders, processors and yam sellers had close ties to the Caisse Populaire and FMA officials. They were reluctant to extend credit to yam farmers. With the evolution of the linkages in the IPs, FMA suggested that the experimental producers organize themselves into small groups in order to benefit from loans following the success of the first year (2018) in terms of repayment other groups benefit successively in 2019 and 2020. Producers have seen an improvement in their farm income and have been motivated to deliberately use technical packages, while FMA has increased its clientele. Processors have access to quality yams. Traders report a significant increase in the supply of yams corresponding to the demand for consumer varieties. However, in Tiéningboué, the IP has not been able to instill access to credit due to the persistent lack of trust among its actors. Producers refuse to form a farmers' organization in order to benefit from IP's facilitation of access to credit. This is explained by the difference in social status and the availability of land resources.

5.2.4. Countering rainfall scarcity

Reducing the size of mounds and installing pads are practices that reduce the effect of high sunlight. The pads would help lower the heat in the mound and facilitate the lifting of yam dormancy. The yam planting period in Léo was changed from January to March due to the late onset of rains, and nowadays it is in May-June following the results of activities carried out in the school fields.

5.2.5. Development of different marketing channels and respect for production standards

Each year, during the tuber promotion day in Léo, processors hold tasting sessions for yam-based dishes or yam by-products to encourage their integration into household menus, especially in urban areas. Most of them are also restaurant owners, and at each service contract they propose menus containing yam-based dishes. They participate in training and exchange trips during which new clients are identified. They make purchase contracts with producers in the presence of a witness in order to force the producer to respect the terms. For yam producers, the endogenous solutions encountered were the reconquest of the consumer market by selling yams during the period of low availability of yams from Ghana in September. There is also the creation of the seed market since the realization of the technical activities of the IP. The increasing availability and better quality of yam varieties prized by processors. The organization of the villages of Léo by market days for the equitable supply of yams. Finally, the substitution of yam cultivation by cash crops such as soybeans, sesame and mung bean (cowpea) in Léo and the increasing introduction of cashew plantations in Tiéningboué; remains an endogenous initiative in order to secure the producers' sources of income.

5.2.6. Countering the poor dissemination of knowledge

Yam farmers did not receive any advisory support from the extension and agricultural supervision services. The training activities of the extension workers and the accompaniment of the facilitator in the experimental fields brought about changes in the producers in terms of reflexivity on their current practices and their technical knowledge of yam cultivation. These trainings have also provided more communication tools to the extension workers, who feel more at ease with the producers because they have mastered the subject matter. Thus, between the end of 2018 and 2020, there was an increase in the flow of information from extension workers to producers in Léo. This increasing intensity of interactions is the work of dialogic exchanges during IP meetings. In addition, several students and trainees from different scientific fields such as agronomists, economists and sociologists now constitute a potential human resource needed for the restructuring of the yam value chain in each country. One of the significant changes is the introduction of a practical learning device for the YAMSYS technology packages and an enrichment of the curriculum in 2020, of the agricultural technician training school in Burkina Faso under the initiative of a former student of the project who became a manager in the multipurpose agricultural center of Matourkou. In the training curriculum for future extension workers, there was no module on yam. Following several exchanges between the agricultural center manager, the project coordinator and the center's administration, a module on yams was added to the general agriculture course. A field school was set up with the support of the project. This financial and technical investment could transform the orientation of agricultural policy in the medium and long term, with an evolution in the positioning of yam

cultivation from the "other crops" category to that of a promising sector by government institutions. Since 2018 in Ivory Coast, the Interprofessional Fund for Agricultural Research and Advice through the Solidarity Fund has been funding a project to disseminate the sustainable soil fertility management innovations developed by the YAMSYS project to other sites. This will contribute to the scaling up of technical packages on yam production sites.

VI. DISCUSSION

6.1 Changing linkages between members of the yam VC

The desire to reform the yam system and the decision to develop it through integrated soil fertility management have introduced new relational modes in the fresh yam value chain. Two elements mark important breaks with current practices. The project is co-lead by a global coordinator based at the National Institute of Environment and Agricultural Research (Burkina Faso), who is responsible for the administrative activities of the project, and an African coordinator based at theSwiss Center for Scientific Research(Ivory Coast), who is in charge of the operational activities of the project. This two-headed project coordination structure has introduced a new relationship for the management of activities within the links. It imposes a shared management of the entire process involving the co-construction of knowledge. And the choice of a mix of twenty or so actors per intervention zone to work together on a common problem has also contributed to the emergence of this new relational mode. All of these have allowed a first step in sharing individually held knowledge and developing experiences centered on both the technical object and the forms of relationships. Organizational learning has brought about transformations in the perception of relationships between actors of different hierarchical levels within the same link or between links and between local, national and sub-regional hierarchical levels. It has propelled the creation of legitimacy of knowledge on yam through the signing of conventions in Burkina Faso and Ivory Coast and memoranda in Burkina Faso. The activities of the IPs influence the direction and forms of the interactions. However, the effects of the IP's two-headed structure on interactions between members contributed more to the creativity of yam value chain actors in Léo than in Tiéningboué.

6.2 Emergence of learning organizations

The collective learning activities in the school fields, combined with the annual field visits conducted at specific stages of yam growth, have led to significant changes in the way farms operate. They allowed producers to compare results with those of their previous practices and to draw essential lessons for building their vision. This process was built through trial and error and then reinforced by repetition and transformation of routines that become "natural" or "unconscious. This evolution grants the ability to select available solutions or to create them according to existing problems. It legitimizes the practices to be implemented according to the needs and expectations of the producer or of other groups of actors. This strategy has been consolidated through dialogical interactions that have given rise to interpretations and strengthened the capacity to adopt and appropriate knowledge over time. This is visible in Léo due to the strong diversity of stakeholder groups and the awareness within each group of its causal responsibilities for achieving the shared vision for developing the yam value chain. Indeed, the collaborative actions of yam producers, extension workers and other actors have led to the emergence of learning organizations. In addition, the boundaries that were quite watertight before these collective IP activities have become permeable. This has encouraged actors to initiate autonomous actions whose source of motivation lies in the active participation of these actors.

However, this learning organization is struggling to emerge in Tiéningboué because IP facilitation has not been able to reduce the organizational routines of the yam producers, who are in the majority. The low diversity of actors in the IP is combined with their non-active participation in collective activities, capitalization and knowledge circulation. During its five years of operation, the IP has not been able to generate an alignment of actors in order to develop the capacity of producers to achieve the set goals. Collective action seems to be outlawed due to the failure to take into account differences in social status, ethnicity and gender during the selection of production actors, one of the essential links in the value chain. The Koro producers and landowners have great difficulty collaborating with their Senufo tenants within the IP. They do not have the same interests in yam cultivation or in the sustainable management of the physical environment. In addition, the few female producers who were once widows have become newly married women. As a result, the work is delegated to contract workers and sons who have not benefited from any transfer of knowledge. As a result, IP is a screen for the development of endogenous innovations in Tiéningboué.

6.3 Emergence and formation of markets

The experience-sharing trips between producers and other stakeholder groups at the national and sub-regional levels, as well as the interpersonal interactions between producers and platform facilitators, had an impact on the planning of commercial activities and the definition of yam production objectives according to some yam VC

actors. The participants confronted the shared knowledge with their own practices and experiences. They decided to open up to new partners, discover new environments and reflect on their own reality. Thus, the exchanges were a means of exchanging solutions to (i) common problems such as the sustainability of yams by adopting the practice of tightly packed mounds in a more adapted rotating system and the problem of yam sales by restructuring yam producers into groups with the support of extension workers, (ii) individual problems such as the relationship between traders and producers by integrating the needs of the yam market into production objectives, or (iii) specific, such as the perception of the profitability of medium-sized yams or the recognition of the needs of other direct actors, leading to an adaptation of the tuber planting bed. Most producers are moving from large mounds to medium mounds in order to position themselves on the market as sellers of both seeds and yams for consumption. Like the national-level experience exchanges, they have been a conscious process of both individual and collective learning; and an effective means of information and sensitization.

6.4 Sensitive development of win-win transactions

The exchanges within the IPs allowed each category of actors to understand the negative effects of their weak interaction, which also limited the flow of information that could improve the gain to be made. Thus, transactions in tubers and agricultural inputs were win-lose, especially between traders and producers, between producers and processors, and between producers and input sellers. This shows the asymmetry of power of some over others, which the IPs corrected by facilitating the financing of yam producers in Léo on the one hand, and by promoting a more environmentally friendly technical yam production itinerary and a method of storing and preserving seeds that would improve the quality and volume of tuber production on the other. The majority of producers readapted this technical knowledge based on their prior knowledge, constraints and production objectives. Some producers, in order to achieve their market-oriented production objective, combine the practice of less distant, medium-sized mounds with a strategy of reducing the time spent on crop maintenance. They dilute mineral fertilizers in their crop protection preparation and obtain two products in one. Thus, from fertilizer spreading they move to pumping. Thus, IP has been a catalyst for the emergence of endogenous innovations among direct actors in the yam value chain with the involvement of various actors such as researchers, traders, microfinance institutions, and communication (radio, internet and social networks). They became aware of the importance of their products and activities, which stimulated learning and the adoption of certain technical packages while energizing and expanding interactions. Thus, the leadership of some has been strengthened in terms of defining the terms of transactions of exchange products. The previously disadvantaged are increasingly acquiring decision-making autonomy and could reverse the direction of future transactions in a sustainable win-win manner. This acquisition of leadership is both the result of IP's actions and individual actions that are internally and deliberately sourced.

VII. CONCLUSION

The present study specifically relied on the functions of the technological and organizational innovation system to analyze the innovation platform as a lever for the creation or not of endogenous and/or co-innovation innovations in the yam value chain in Léo and Tiéningboué. These results confirm the strong influence of the structural parameters of the agricultural innovation system on the capacity of the innovation platform to contribute to co-innovation in the yam value chain. Namely, (i) the ability and capacity of knowledge-using actors to engage in the process of finding solutions to existing constraints. (ii) In a given historical and cultural context, the presence and quality of interactions combined with the presence of institutions that govern these interactions that an innovation can emerge, diffuse and be adopted through IP. (iii) Knowledge (research and extension), financial (MFIs) and physical (telecommunication networks, roads, transportation) infrastructures affect the quality of endogenous innovation creation. Both IPs have contributed to changes in the perception of existing organizational routines. In Léo, as in Tiéningboué, they have led to the emergence of fivemajor functions of the innovation system, namely:(1) the creation of legitimacy through the integration of technical packages in a training center and the effectiveness of the partnership between research and agricultural extension structures through the signing of agreements and memoranda; (2) the mobilization of human (multidisciplinary researchers) and financial resources; (3) the formation of the seed, consumer and processing markets; (4) dissemination of knowledge through field schools, guided tours and exchange tripsand (5) the development of knowledge and entrepreneurial activities through the training of students, technical supervisors and direct actors in the value chain. However, they have not been able to support the development of sustainable solutions to all the problems present in the yam value chain. This implies the existence of systemic problems in some of these identified functions that would be interesting to analyze in another study.

VIII. Acknowledgements

The authors would like to thank all the actors involved in this study. Special thanks go to the YAMSYS project and the Laboratory of Analysis of Social Dynamics and Development Studies (LADyD) for their financial, technical and scientific assistance during data collection and analysis.

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