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Status of Agricultural Innovations, Innovation Platforms and Innovations Investment in

Mali

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Status of
Agricultural Innovations, Innovation Platforms and Innovations Investment

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STUDY BACKGROUND

Science and technology remains the fulcrum for development over the ages. There is hardly any national development in contemporary history that is not based on consistent efforts from the science and technology sector. The spate of development in agriculture follow suit; the state of efficiency in science and technology generation correlates highly with the development of agriculture. In Africa, agriculture is considered as the sector with the best potential to lead the socioeconomic development of countries on the continent. However, the sector is bedevilled with many constraints that could be categorized as technological, socio-cultural, institutional, infrastructural, and economical. The poor productivity of the enterprise stream in the sector is clearly seen from its contribution to a country's GDP versus the number of active workers engaged in the sector. Africa's agriculture currently engages about 65% of the working population and its average contribution to GDP still stands at 22.9%.

The crave to develop Africa has received good attention in recent years, starting with the political will of the heads of states, under the auspices of the Africa Union Commission, to develop and implement the Comprehensive Africa Agricultural Development Programme (CAADP), the Science Technology and Innovation Strategy (STISA). The Forum for Agricultural Research in Africa (FARA) also came up with a handful of continental initiatives, such as the Sub-Saharan Africa Challenge Programme (SSA CP), *Strengthening Capacity for Agricultural Research and Development in Africa* (*SCARDA*), Dissemination of New Agricultural Technologies in Africa (DONATA) and several others. The different initiatives aim to foster change by addressing specific issues that constitute constraints in the path of progress in Africa agriculture. The notion that African agricultural research system has generated a lot of technologies with great potentials, but which are not realized due to different institutional and organizational constraints—more specifically, the way agricultural research and development systems is organized and operated—is prevalent among stakeholders in the sector. Indeed, this notion appeals to reasoning. However, there is no known cataloguing or documentation of existing technologies and their veracity in delivering broad-based outcomes. The possibility of finding some documentation in annual reports of research institutes, journal articles and thesis in the universities is known, but this will not meet an urgent need.

Thus, the Programme of Accompanying Research for Agricultural Innovation (PARI) commissioned the three studies reported in this volume to provide a compressive analysis of the state of agricultural technology generation, innovation, and investment in innovations in the last 20 years in selected countries in Africa.

Study 1 is the "situation analysis of agricultural innovations in the country" and provides succinct background on the spate of agricultural innovation in the last 30 years. It provides useable data on the different government, international and private sector agricultural research and development interventions and collates information on commodities of interest and technologies generated over the years. It also conducted an assessment of the different interventions so as to highlight lessons learnt from such interventions, with regard to brilliant successes and failures.

Study 2 concerns a "scoping studies of existing agricultural innovation platforms in the country". It carried out an identification of all the existing Innovation Platforms (IP) in the country, including identification of commodity focus, system configuration, and partnership model. The study provides an innovation summary for each IP for use in the electronic IP monitor platform. It further synthesises the lessons learnt from the agricultural IPs established through different initiatives in the country in the last ten years.

Study 3 was an "Assessment of the national and international investment in agricultural innovation". It is an exhaustive assessment of investments in innovation for agricultural development, food and nutrition security in the country. It collates updated data on investment levels in the past and present, including a projection for the next decade requirement to assure food and nutritional security in the country.

The three studies form the comprehensive collation on the state of agricultural innovation in the 12 countries where the PARI project is being implemented. It is expected that these studies will benefit all stakeholders in Africa's agricultural research and development, including the users of technologies, research stakeholders, extension system actors and, more importantly, the policymakers.

STUDY ONE

Inventory of Agricultural Technological Innovations (1995 to 2015)

INTRODUCTION

One of the major challenges for agricultural research in sub-Sahara Africa is the implementation of innovations, which allow sustainable improvement in food security and the nutrition of the continent's increasing population without damage to the environment. Increasing rural poverty and decreasing per capita food production negatively affect sustainable production systems. Sustainability is also threatened by continuing soil degradation, increased use of marginal lands, biodiversity lost and recurrent pest and natural disasters. In the bid to increase production and productivity, agricultural producers undertake certain activities which, when coupled with environmental events, reduce nutritional and economic benefits and prevent opportunities for international trade.

Therefore, to overcome production problems, food insecurity concern and the poverty challenge, a coherent framework for exchanging knowledge and information between researchers and innovation users should be elaborated. In this line, research and rural development institutions, the private and public sectors should work together to overcome the challenges to develop and diffuse technologies at the lowest cost. This can be achieved through the creation of adequate institutional agreements, making sound decisions and facilitating environments that support agricultural productivity and profitability.

IER (Institut d'Economie Rurale), the agricultural research institute in Mali is decentralized in 6 regional centres. It includes 17 research programmes, partitioned between 6 research domains (rainfed crops, irrigated crops, animal production, forestry resources, fisheries, production systems and natural resources management and value chain economics), central laboratories and a genetic resources unit. With such a structure, IER contributes significantly to improving productivity of different crops and generating innovations for different end-users. This improvement has pushed ahead production frontiers of many crops. IER has also contributed to the empowerment of its different partners through capacity building, individual and group training of NGOs, the private sector and other development agents through workshops, seminars and field visits for diffusing innovations.

IER developed several innovations which are incorporated into genetic materials, in tools and soil fertility management practices, and soil and water conservation, as well as improving human capacities. Despite the generation of several innovations,

however, food insecurity and poverty continue to thrive in the country. This situation could, in part, be explained poor adoption practices and/or poor dissemination techniques with regard to information on agricultural innovations. Besides, many innovations are kept on the shelves because of the lack of means to diffuse them.

Despite poor adoption of innovations generated by research in sub-Sahara countries, many studies have found that return on investment in research in these countries are positive (Masters et al., 1998; Yapi et al., 2002; Alene et al., 2009). However, the level of investments in research generally remains weak, especially in the areas of increasing agricultural productivity and reducing poverty (Alene et al., 2006). This situation often changes when a government and its partners adopt a new orientation in development politics. To understand how the phenomenon has changed in Mali, it is necessary to document major innovations developed through research and create a technical database which can be used as reference.

In agricultural development, the government of Mali elaborated a priority investment programme for its major crops: millet, sorghum, maize, rice, livestock and fisheries. In each of these value chains, therefore, this study aims to identify stakeholders in innovation development as well as document the effects and impacts of the innovations on the end-users. The main objective of this study is to conduct an in=depth situation analysis of agricultural innovations in Mali and generate reliable information in this regard. The questions guiding the measurement of this objective are:

1. What are the main value chains in the target countries (crops, livestock, fisheries, etc) in line with the Malian agricultural development plans?
2. Who are the stakeholders involved in agricultural innovations in the identified value chains?
3. What types of innovations have these stakeholders generated and what are their socioeconomic benefits on the target beneficiaries?

Historical Background to Malian Agriculture

This section provides information on events that impacted on the agricultural sector in Mali, from independence to the present. These included:

- 1960 (independence): The First Republic had a centralized government structure following the socialist model; creation of national agricultural research institute: Institut d'Economie Rural (IER);
- 1970 – 1974: There was the Sahelian drought, followed by a large influx of donor support, leading to 1972's "Operations de Dévelopement" to achieve regional food self-sufficiency; creation of parastatals responsible for regional development (CMDT for Southern Mali; Office de Niger);

- 1985: Start of a large-scale World Bank's structural adjustment programme
- 1990: Start of World Bank-guided national extension project (PNVA), following the training and visit model;
- 1992: First democratic elections for presidency, parliament and local government; start of "decentralization" policies and increased emphasis on democracy;
- 1994: There was 50% devaluation of the Franc CFA;
- 1995: General liberalization of land use (important impact on Office de Niger); start of new World Bank-sponsored Agricultural Research Project (PNRA) and introduction of "Regional User Committees" (CRU);
- 1995 – 2001: Further withdrawal and reduction of public sector services (including CMDT and Office de Niger); increased responsibility of the private sector;
- 1998: End of World Bank-sponsored PNVA project;
- 2001: End of PNRA;
- 2002: Start of a new comprehensive World Bank-coordinated agricultural development project (PASAOP): increased privatization of research and extension services;
- 2009: This marked the end of PASAOP;
- 2010: Start of new World Bank programme (PAPAM).

Generally, the Malian society has always functioned under centralized government, taking directives from it—this started with the colonial period and through to the independent First and Second Republics. With a reduced public sector and increased decentralization during the Third Republic came, however, new centralized, large-scale and "donor-imposed' policies towards agricultural development became associated with large multilateral projects.

METHODOLOGY

The study was conducted by a team of researchers, who met with the major stakeholders (CNRA, IER, DNA, SG 2000, CNU and ICRISAT/ICRAF/AVRDC /ILRI, CIRAD) in Bamako. Farmers' organizations and regional agricultural services were questioned during field visits. The field tour covered the Sikasso, Segou and Koulikoro regions and the district of Bamako. The Sikasso region, where rainfall ranged between 800 and 1100 mm, in southern Mali, represented the cotton-based systems and was served by the Sikasso Regional Research Centre of Agriculture (CRRA-Sikasso). The Segou region, with 500 – 750 mm of rainfall, had two different systems: the rainfed millet/sorghum-based systems and the irrigated rice-based systems of the Office de Niger and Office Riz Ségou. The region was served by the

CRRA of Niono. The CRRA of Sotuba, which served the region of Koulikoro and the district of Bamako, was visited for discussion on thematic areas. The overview of the study area is presented below.

Sikasso Region

Agricultural Production Systems

The Southern Mali/Sikasso region is broadly characterized by cotton-based system, with maize, sorghum and millet as major traditional staple cereal crops—the relative importance of each in the system varies with the agro-ecological sub-zones. Throughout, the sylvo-pastoral system is closely integrated /associated with this cropping system. In addition, there are localized pockets (mostly the bas-fonds) where rice is grown traditionally as women's crop, and/or where farming has limited to the cultivation of non-traditional crops like potatoes and a range of vegetables, mainly as peri-urban systems. Fruits, particularly mango and citrus, constitute a major commodity. The entire region is in transition from a largely subsistence, traditional to an increasingly intensified commercial farming system.

Institutional context and development

Within Mali, the southern region of Sikasso is the cotton belt and, therefore, one of the major pillars of the national economy. Since independence in 1960, the comprehensive development of the region – including aspects of health, education, agriculture, infrastructure and construction- has been dominated by one single institution: the CMDT. While initially this has accelerated the development process and cotton production in particular, it has also had some distinct drawbacks that, over time, become increasingly clear. These are:

- The monopolisation in terms of institutional development delayed a balanced evolution towards the wider array of support institutions. An active private sector necessary for a diversified market-driven agricultural development is currently in place to develop the erstwhile subsistent cotton-dominated systems.
- Some important sectors of considerable economic potential, such as fruits (mango and citrus) and vegetables (in particular, potatoes) in peri-urban agricultural systems were neglected.
- The presence of an effective CMDT has provided attractive opportunities for investment by foreign donors and with it the broad introduction of certain "external" development concepts. A major one has been the introduction in 1995 of the local and regional user committees (CRUs) to provide the users/producers with a communication and demand mechanism to signal constraints and service requirements from the various support institutions (research and extension services).

The ongoing large scale restructuring of CMDT (since 1999) and its reorientation and narrowing of mandate to cotton-based systems leaves presently a confused situation. The resulting institutional gaps need to be filled by a host of new players, such as DRA, as extension service providers for all non-cotton commodities, the "Chambre d'Agriculture", the private commercial sector and the relatively young CRUs, as well as some NGOs and foreign projects like the Swiss-supported organization "Gestion et Developpement des Resources Naturelles" (GDRN). The GDRN plays an important facilitating role in the complex communication between CRU and producer organizations, on the one hand, and the research – development / extension organizations, on the other, to clarify, translate and eventually fund issues and demands raised through CRUs.

Research Impact and constraints

There are several available technologies emphasizing soil and water management for Southern Mali. Till date, however, these technologies are only partially adopted by farmers. The adoption rate differed by agro-ecological zone and the population dynamics (population pressure). Within a village, the adoption differed also by type of household—CMDT classified households into A, B, C and D, by equipment level. So the picture of the impact of research could be different for the major commodities. Moreover, the type of bottleneck (technical, socio-cultural, organizational or institutional) as linked to different groups of stakeholders were different for each commodity.

The various actors generally agreed on the significant impact of research on cotton, maize and commercial rice production. There has been very minimal impact on sorghum and millet farming in spite of several years of research efforts. All the improved sorghum and millet varieties developed had proved low adaptation, in terms of maturity cycles, and have led to severe grain disease incidents and excessive bird damage (ESPGRN, 2001).

For vegetables, particularly Irish potatoes, there had been wide-scale impact, especially where the producers are well organized. This is less true for the fruits sub-sector, which has not been especially productive due to drought and livestock mobility—this has complicated the situation because of socio-cultural issues and land tenure rights. The CRU represents users from the non-cotton-based systems (not supported directly by CMDT), whose problems mainly concern postharvest processing, improved conservation and storage of especially fruits and vegetables (Irish potatoes).

Constraints at the CRRA of Sikasso

The two major constraints related to the change in donor-support system along with the introduction of the "research project/contract" system were:

a. The new "research project contract" seemed to lead to a disruption within the research programme, with lead scientists being more preoccupied with projects they had submitted personally at the expense of a collaboration as core in the programme.
b. The costs of field visit were high, with a fare of 300 FCFA/km. This shot up the project implementation costs where scientists had to spend considerable and regular periods of time in the field to communicate directly with producers and other actors, and to monitor/ supervise implementation by technicians. The various thematic/commodity teams (research programmes) were made up of technical/biological disciplines. For a research system which has a development oriented mandate and a "user-demand" strategy, this was a fundamental handicap.

Segou Region

Agricultural Production Systems

Two major production systems prevail: (1) located in the Northern Sudanian and Southern Sahelian zones, where rainfall is more erratic than towards the South, the prevailing rainfed systems are millet-based, with cowpea as an important secondary crop, and sorghum cultivated in lower, wet and heavier soils. Throughout this zone, livestock (cattle and small ruminants; both settled and nomadic) are an important component of the mostly "traditional" cereal-based systems; (2) the irrigated rice-based systems along the Niger River and on the vast plains of the "Office de Niger", located North of Segou and around Niono. Under the influence of land use and trade liberalization, as well as diversification policies, rice production has greatly increased (from 1 to 1.5 ton/ha during the 1980s and 5 to 6 tons/ha at present) and, simultaneously, off-season vegetable production has boomed with shallots in particular.

Institutional Context and Development

Like Southern Mali, this region is dominated by the "Office de Niger" for the vast irrigated planes north of Segou and around Niono. After the Sahelian drought, some donors provided considerable supports to develop, rehabilitate and level the land through collective, state-run farms in the irrigation structures to intensify rice production. The big production boom came when land use and production were liberalized. Presently, responsibilities of the "Office de Niger" have been trimmed

down to the engineering and maintenance aspects of the irrigation facility and water management.

By contrast, rainfed farming areas showed a slower evolution, partly because of the environmental risks of droughts and poor soil conditions. Considerable public sector extension efforts, through the PAPAM project, were undertaken during the last 10 years. The PAPAM project combined elements of the T&V system of extension with an increased user-demand orientation through service contracts with research and the private sector. It was complemented by large-scale rural development projects (FIDA), as well as by more localized interventions from national and international NGOs (Voisins Mondiaux, World Vision, CARE, Save the Children, Winrock International, SG 2000, etc). Obviously, the major institutions involved in the development process (public and private sectors; bilateral projects and NGOs) operated from different perspectives. While, with proper coordination, their respective activities could be very complementary, there were also substantial risks of duplication and contradictory approaches and recommendations.

Research Impact and Development Constraints

Depending on the area, research and agricultural development impact patterns were different for the rainfed and irrigated systems. In both systems, there were changes, research impact and failures, but these were more spectacular for the rice-based systems. For rice, the impact was particularly striking:

- the introduction of high-yielding, short straw varieties since the 1980s,
- the change in cultivation practices from broadcast seeding (using up to 120kg seed/ha) to transplanting practices of 40 to 50kg seed/ha,
- the liberal use of mineral fertilizers (ammonium phosphate and urea), recently complemented with potassium.

These intensification practices came, however, with a great increase in pest and disease outbreaks of catastrophic proportions, especially for rice-yellow mottle virus (RYMV) in 1995/6 and increased pyriculariose. This required the rapid introduction of new resistant / tolerant varieties and adjusted management practices that later paid off, given the extent of the RYMV damage. Farmers' responses to other introduced technologies have been much less favourable. Such technologies included:

- the introduction of varieties having "improved grain quality" was not favourable for their lack of related price incentives,
- the use of pre-germinated seeds in direct seeding techniques,
- the use of chemical herbicides,

- the integration of a legume fodder crops to provide supplementary livestock feeding,
- the use of azolla as supplementary source of nitrogen (50 kg N/ha), and
- the composting of rice straw.

As it was in the case of Sikasso, there was great potential for research impact in the irrigated vegetable sector, but has not been realized. Several benefits are accruable from the introduction of improved, adapted varieties (shallots and tomatoes) that are resistant to major diseases; and from improved postharvest technologies (in terms of storage, conservation and transformation). The transfer of improved vegetable technologies can be constrained by the poor producer organizations and the extreme fragmentation of individual producers up to the level of individual family members, each marketing his/her produce separately.

For the extensive rainfed millet-based system, the development and technology impact pattern is distinctly different. In recent years, new millet and sorghum varieties and some cultural practices with respect to legumes have been introduced at farmers' level. The considerable risks associated with erratic rainfall, land degradation and the poor economic status of producers constrained investment in innovations. These risky conditions also made producers more prudent and reluctant to changes.

In the rainfed systems, innovations are being adopted at a slower rate than in the irrigated systems. It is difficult to trace adoption of some improved crop varieties (millet and sorghum) because the materials become fully integrated into the system under local names. Adoption of pesticides (Apron Plus and/or Apron Star) is widespread; investments in improved soil fertility practices (through FYM, compost with or without NP mineral fertilizer micro-dose) move slowly because of the risk of achieving negative impact in drought years. Locally, the improved cowpea intercrop grown in alternating rows with millet is adopted as an animal fodder crop that is stored and sold in the dry season to the peri-urban livestock sector. Other spontaneous changes, such as increased storage of crop residues as fodder and the large-scale adoption of animal-drawn carts can be noticed in the more densely populated areas near Segou and Niono.

Constraints to CRRA, Niono

The situation was generally similar to that of Sikasso; but particular constraints ranged from water management, through soil structure and fertility management, to market access and prices. On the other hand, the efforts to document ideas on various issues

relating to the technology transfer process and to factors that impede rapid adoption of new technologies demonstrated a clear progression in research attitudes.

Bamako and Koulikoro Region

In this region, sorghum is the dominant crop; followed by maize and cotton. Rainfall ranges between 600 mm and 1000 mm yearly. There are major concerns on diminishing soil fertility and the resulting degradation of the natural vegetation cover. This is further compounded by increased exploitation of communal forest resources for firewood and charcoal production. The agricultural development activities in the zone are carried out by "Operation Hautes Vallées de Niger" (OHVN). Development activities have reached the rural communities, while agricultural innovations have been adopted unevenly in the villages. Due to large agro-ecological diversities, technological packages, recommendations and the processes of technology transfer are difficult. The impact of agricultural research varies according to commodities and locations.

Constraints at the CRRA of Sotuba

The different meetings with thematic groups of scientists (such as, maize and sorghum programmes, soil and water laboratories, GIS and agro-climatic units, the SPGRN team, and food technology laboratory) are becoming difficult with regard to technology generation and transfer. The research teams worked independently in different locations, which emphasizes the division between disciplines and between thematic and systems' units. Like in Sikasso, the new rules for transport fares constitute a considerable share of limited research/project budgets.

Overall analyses

Most important to agricultural development in Mali is the creation of a favourable national policy environment that attracts donors, NGOs and the private sector. The World Bank supports the Malian agriculture through funding development and research programmes/projects.

The Malian case is complicated by the considerable differences between the country's regions with respect to the development actors and the present transition period between two major multi-lateral donor projects (coordinated by the World Bank). In the south, CMDT had dominated the development scene, as did the Office de Niger in the area north of Segou. In the other agro-ecologically, more marginal regions, the actors have been more divers, often a combination of public sector extension, NGOs and various development projects.

The impacts of research have been considerable for cotton-based systems and for irrigated rice, while for most of the "traditional" production systems, it has been marginal. One domain where the liberalization process has had a most pronounced impact has been in the non-traditional vegetable production sector, mainly concentrated in peri-urban areas. This sector is highly profitable and probably could become even more lucrative if the producers were organized, instead of each operating individually.

PNRA led to the creation of CRUs in an effort to increase user influence and operate demand-driven approach to research. Considerable funding went into the built up and functioning of different (national, regional, district, community) administrative structures, while the anchorage at the local community level remained weak. Currently, the majority of farmers remain unaware of the existence and functions of CRU and/or consider its composition non-representative. Do researchers spend an important part of their time on-farm generating sound innovations that benefit farmers? Are frequent research and extension, tests and survey meetings with farmers convenient for them? Innovation generation should include human and social aspects and interventions must be coordinated.

Main Value Chains in Line with Malian Agricultural Development Plans

Numerous crop and livestock commodities are produced in Mali, some of which have been subjected to continuous research, while others are neglected. Table 1 lists the commodities produced in Mali by type.

Table1: Agricultural commodities by type in Mali

Type	Commodities
Cereals	Millet, sorghum, maize, wheat, fonio
Roots and tubers	Cassava, sweet potatoes, potatoes, yam
Pulses	Cowpea, bambara pea
Oil crops	Groundnut, sesame, soybean
Fibre crops	Cotton, sisal
Fruits	Mangoes, banana, citrus
Vegetables	All vegetables
Livestock	Cattle, sheep, goat, camel, pigs, horses, donkeys, poultry
Fisheries	All river fishes
Forestry	All Sahelian trees

Source: Authors own experience

Significant efforts have been made to set up institutions and mechanisms that support the development of market-oriented agriculture in Mali. Indeed, food security is high on the country's political agenda, with strong emphasis on the agricultural sector to

encourage increased food production and economic growth (Duncan et al., 2010). Accordingly, the government set the Strategic Framework for Growth and Poverty Reduction (CSCRP), which provides the overall framework for all public investment planning aimed at promoting economic growth and poverty reduction. In CSCRP, the priority is to facilitate public investment for evolving from subsistence to commercial farming. The Framework defines three strategic areas: (i) promoting accelerated and sustainable growth that benefits the poor and creates jobs and revenue; (ii) reinforcing the long-term bases of development and equitable access to good-quality social services; and (iii) strengthening institutions and governance. Government-funded projects are required to be embedded in these strategic areas to support social and economic development in the country. In order to foster rural sector development and natural resources management, the government has set other specific agricultural development policies, such as:

- **The Agricultural Framework Act** (*Loi d'Orientation Agricole,* LOA), which establishes a long-term vision for the agricultural sector based on the promotion of a sustainable, modern and competitive agricultural sector that is primarily anchored on family farms;
- **The National Food Security Strategy** (*Stratégie Nationale de Sécurité Alimentaire,* SNSA), which lays out a vision of long-term sustainable food security, based on improved food availability, access, utilization and stability, and establishes a set of tools to deal with transitory food crises. SNSA also lays out a strategy to move from just managing short-term crises to sustainable food security on a broad-based agriculture-led economic growth and creation of market-compatible social safety nets;
- **The National Agricultural Investment Plan** (*Plan National d'Investissement du Secteur Agricole,* PNIA) was developed with the guidance of Economic Community of West African States (ECOWAS) and the New Partnership for Africa's Development (NEPAD). In this framework, a 5-year priority investment plan, called *Plan National d'Investissement Prioritaire dans le Secteur Agricole* (PNIP-SA), was elaborated in 2010. The PNIP-SA focuses on strategic investments in some key value chains, including rice, maize, millet and sorghum, inland fisheries, and livestock products (both meat and dairy). It also includes cross-cutting activities aimed at strengthening nutrition education throughout the country. The PNIP-SA is supposed to serve as a roadmap for improving agricultural productivity by aligning various donors' efforts around the prioritized sectors; and
- **The Agricultural Land Tenure Framework Act** (*Loi sur le Foncier Agricole*) and the General Agricultural Census Management Act (*Loi régissant le Recensement Général Agricole*), both being currently discussed in Parliament and

aiming to support the implementation and monitoring of the Agricultural Framework Act by lifting constraints towards equitable and secure access to land, modernization of the agricultural sector, and assessment of its strengths and weaknesses.

Priorities for addressing vulnerability and adaption to climate change hold an important position within Mali's national policy documents; agriculture is identified as one of the most vulnerable sectors. Food sovereignty is adopted at political level as a food policy objective both in Mali (the Agricultural Act) and at ECOWAS (ECOWAP). It relies on three key elements: (a) enhancing local production of main food crops, whose demand would highly increase in the coming years to reduce dependence on imports; (b) strengthen food security through increased availability and economic accessibility to food by augmenting production drawn by productivity, reduction of trade costs, and increased incomes of stakeholders in the value chain; (c) improve population nutrition through key nutrients' production and a better nutritional education.

The National Plan of Priority Investment was built around 5 programs covering 6 value chains which provide better chances to reach CADEP objectives. The selected value chains are: rice, maize, millet/sorghum, livestock, milk and fisheries/aquaculture; they were selected because of their real potential to expand, the important number of concerned poor people and their importance for food security and nutrition. The value chains are also those on which the government and regional programmes (such as ECOWAP) focus intensively since the food price volatility of 2007/2008. The fisheries/aquaculture value chain was particularly targeted because of its role in animal protein intake by the segment of the population with low income, and in women income generation.

Stakeholders in Agricultural Innovations

IER, as the research institute, is engaging various partners to deliver on its responsibility. These partners include local and international NGOs and donors, bilateral and multilateral organizations, and country missions supporting the Malian government in improving agricultural research and development processes. The strategies and interventions of the various partners are aligned with Mali's CAADP approach and the National Plan of Priority Investment in the Sector of Agriculture (PNIP-SA), GOM's five-year agricultural development policy, as its guiding principle for agricultural development. The roles and capacities of each actor's category and the governance mechanism are discussed below.

Government

The current institutional context of agricultural sector is characterized by the presence of several ministries directing public interventions in the sector. They are: ministry of agriculture, ministry of livestock and fisheries, and ministry of environment and sanitation. Indeed, there is the food security commissariat, whose mission consists of elaborating and insuring the implementation of the National Food Security Policy. Specifically, the ministries in charge of rural development are responsible for elaborating and implementing subsector policies in their domains in synergy with other respective ministries. A weak synergy between ministries, institutional instability and poor human resources management are still serious challenges.

Territorial Collectivism

The country has 703 communes, with 96 urban, 49 'Conseils de Cercle' and 8 'Conseils Régionaux' having responsibilities over the development of their localities. By this, they elaborate, implement and evaluate in concert with the agricultural services, the management and development frame and of the agricultural space in their territories, and development programmes of their communities.

Civil Society Organisations (OSC)

The agricultural civil society organisations (OSC) attend the implementation of the agricultural development policy. The NGOs are important actors to the promotion of rural areas, the agricultural development and food and nutrition of vulnerable populations. However, there is still the challenge of a weak synergy with state technical services.

Chambers of Agriculture and APCAM

The chambers of agriculture and APCAM are consulted by the government on questions relating to agriculture. By this, they give their votes as requested by the government or formulate suggestions at their own initiative on agriculture-related questions, in such areas as:

- Prices, incomes, credit and agricultural products trade policies;
- rules relating agriculture, pastoralism, forestry, fisheries, fiscal and custom activities;
- legislations related to labour rights of agro-sylvo-pastoral enterprises and those relating to land rights in rural area;
- training in agricultural profession;
- means to implement programmes for increasing agricultural development.

Despite the significant progress made during these last years, the network of chambers of agriculture lack resources to implement development programmes and hold regular meetings. But there are coordination problems.

Agricultural Vocation Bodies

These agricultural bodies include public establishments with moral and financial autonomy, working in the agricultural domain. They are mainly public establishments with agricultural vocation and have administrative characteristics which make them professionals, scientific, technological, industrial and/or commercial. They are consultative bodies for agricultural and rural development in their intervention zones. But they are constrained by insufficient financial resources and aging personnel.

Professional Agricultural Organisations (OPA)

Professional agricultural organizations are agricultural groups which decide to get together to defend their interests against the government and others for supplying goods and services to their members. The OPA include cooperatives, associations, unions, federations, confederations, foundations, and labour unions. There is often challenges with governance structure and funding. Since the comprehensive agricultural law, a ruling frame has been implemented to favour inter-professional associations.

Farms

Estimated in 2005 to be more than 805,000 units, farms are the first actors of agricultural development. Also, family farms and farm enterprises are integral parts of the private sector. Family farms are characteristically small, have low equipment level and face general funding problem.

Service Providers

They are from the private sector and group the inputs and equipment suppliers and the financial institutions (banks, micro finance). They play a key role in agricultural development through the partnership with public sector. Input suppliers and micro finance institutions are poorly qualified and have funding problems.

Technical and Financial Partners (*PTF*)

This group contributes to the funding of agriculture and brings their technical expertise in the implementation of agricultural development programmes and projects. But there is the need for a better coordination of their activities, so that they can harmonize their support to the development sector.

Types of Innovations Generated and their Socioeconomic Benefits

Several innovations have been generated by IER in collaboration with the stakeholders in the diverse domains; the most recent ones related to prioritized value chains are presented in table 2.

Table 2: List of technologies and innovations during the last 20 years in Mali

Research programmes / laboratories	*Technology/ innovation*	*Year of generation*	*Year of registration in the catalogue*	*Reference project of the technology/innovation*	
				Title	*Total Budget*
Millet	Variety NKOxTC1	2010	2011	Participatory development and assessment of millet varieties potentially productive, adapted to north Guinean, Sudan and sahelian zones of Mali (*Project PASAOP*) :2006-2010	32,070,600
	Variety Guéfoué 16	1995	1998	1994-2001 (Plan Stratégique 1994-2005) Projet Syngenta	
	Variety Indiana 05	2001	2002	(Plan Stratégique 1994-2005)	135,032,000
	Synthétic Variety 006	2005	2007	Implementation of adapted and high yield potential varieties for sahelian, and north Guinean zones of Mali (*Project PNRA*) : 1994-2005	
Sorghum	Variety Tiandougoucoura		2010	Development and utilization of dual purpose sorghum hybrids and genetic diversity conservation of sorghum varieties in Mali (Project PASAOP) : 2006-2010	34,072,220
	Variety Grinkan		2010		
Maize	Variety Sotubaka (introduction : SUWAN1 SR)	1995	1995	Project PNRA 1994-1995	10,000,000
	Variety Dembanyuma (introduction : Obatanpa)	1995	1998	Project PNRA 1994-1995	10,000,000
	Variety Tcheba (origine IITA)	2009	2012	Project PASAOP 2005-2010	20,000,000
	Variety Brigo	2011	2012	Project PASAOP 2005-2010	35,000,000

Cowpea	Variety Jiguiya		2011	Project PASAOP	-
	Variety Wilibali		2011	Project PASAOP	-
	Variety Korobalen (introduction : IT69KD-374)	1993	1998	Project PDUNE	-
	Variety Sangaranka (introduction : IT89KD-245)	1993	1998	Project PRONAF	-
	Variety Ganashoni (CZ1-94-23-2)	2010	2011	Project PASAOP (2006-2010)	19,399,600
	VarietyDunanfana (PBL 112)	1986	1998	Project PRONAF	-
	Variety Yèrèwolo (PRL 73)	1986	1998	Project PDUNE	-
	Variety Cinzanatélimani (CZ 11-94-5C)	2010	2011	Project PASAOP (2006-2010)	19,399,600
Irrigated rice	Variety Wassa (introduction : IR 32307-107-3-2-2)	1995	1998		33,046,373
	Variety Nerica L1 (WAS122-IDSA-1B-IER-18-6)	2004	2007	Project PASAOP	12,941,018
	Variety Nerica L2 (WAS161-IDSA-3-WAS-B-FKR-IER-2-4)	2004	2007	Project PASAOP	12,941,018
Low land rice	Variety DUNKAFA-P17	2010	2011	Project PASAOP (2006-2010)	29,922,325
	Variety DUNKAFA-P27	2010	2011	Project PASAOP (2006-2010)	
	Variety DUNKAFA (SIK 385-B-57-2-12-2-2-1-2)	2010	2011	Project PASAOP (2006-2010)	

Fruits/Vegetables	Vitro plants de bananier				
Poultry	Wassachiè	2000	2003	Improvement of Potential Genetics of local chicken and guinea-fowl	21,742,400
Agricultural Mechanisation	Semoir philippin	2011	2013	Support project to accelerate diffusion of the seeder Philippine poly-range type Asiatic (WAAPP)	65,768,500

Socioeconomic Benefits of the Innovations

The process of assessing the impact of investments in agricultural innovations involves combining farm-level information with data on research and extension costs and related economic parameters, to produce a number of quantitative indicators of profitability, efficiency, and food-security impact. For estimating the benefits of research investment, the study used the example of sorghum hybrids in Mali. This section sets the premises for estimating returns on investments and evaluates the indicators of the impact of such investments.

Estimation of research and extension service costs

For the purpose of this study, IER and the CGIAR partners are considered the main research collaborators, and DNA the government agency that diffuses technologies (innovations) under study. The contribution of any other collaborating institution is accounted for under IER or DNA. As mentioned earlier, NGOs have contributed in the diffusion of improved technologies in many areas of Mali. But for the purpose of this study, the costs incurred by NGOs and other partners are treated as composite of IER or DNA costs. Data on the annual costs of research were obtained from IER scientists and administrators completed by ICRISAT scientists for sorghum. This information is presented in tables 3 and 4.

Table 3: Costs incurred by low land rice variety generation and diffusion

Year	*Cost*	*Activity*	*Donor*
2002	3000$	Prospection	Rockefeller Foundation
2004-2007	72000$	Variety development	Rockefeller Foundation
2007-2010	185000$	Variety selection & +investment/ Vehicle	AGRA
2011-2014	120000$	Technology diffusion	AGRA
2015-2018	58000$	Seed production and dissemination	AGRA

Source: Fosseyni (2015)

Table 4: Costs incurred by sorghum hybrid generation and diffusion

Years	*Source*	*Purpose*	*Amount USD*
2000-2003	Rockefeller Foundation Guinea Hybrids	Research: develop parents/hybrids	530 000
2003-2005	Rockefeller Foundation Guinea Hybrids	Research: develop parents/hybrids	280 000
2005-2009	Rockefeller Foundation Guinea Hybrids	Research: develop parents/hybrids	289 000
2009-2011	McKnight Foundation Seeds Project	Research: on-farm testing	40 000
2011-2012	BMGF-HOPE	Research: on-farm testing, mini-pack	50 000
2011-2012	BMGF-HOPE	Training: Hybrid seed production	20 000
2012	Dryland Cereals	B-line development	23 000
2013	BMGF-HOPE	Training: Hybrid seed production	15 000
Total			1,247,000

Source: Rattunde et al. (2013)

Table 5: Area and production estimates for main cereals in Mali from 2006/2007 to 2014/2015

Produc	*Units*	*2006*	*2007*	*200*	*200*	*201*	*2011*	*201*	*201*	*2014/15*
Rice	Area	4084	3918	626	665	686	830	679	604	684 185
	product	9604	1082	160	195	230	1 74	1 91	2 21	2 166
Maize	Area	4124	4099	403	558	523	924	598	640	803
	product	6768	6899	740	147	140	1 29	1 71	148	1 744
Wheat	Area	3565	3430	541	510	9	9844	10	690	10 176
	product	8565	8585	131	151	237	33	40	27	45 353
Sorghum	Area	9170	1090	104	152	122	1 68	1 24	937	1 271
	product	1128	9007	104	146	125	1 19	1 21	819	1 204
Millet	Area	1495	1586	159	172	146	2 28	1 87	143	1 743
	product	1175	1175	136	139	137	1 46	1 77	115	1 715
Fonio	Area	4577	4647	721	623	668	65	43	34	55 704
	product	2624	2869	407	354	523	51	21	22	37 284
Total Cereals	Area	3283	3528	374	453	3 97	5 79	4	366	4 501
	product	3 693	3 885	481	633	6 41	5 77	6 67	5 73	6 980

Source: Ministry of Agriculture's annual report (2015)

Premises of the evaluation

The assessment of returns on investments over agricultural innovations and diffusion was based on the following premises:

Base-level production: These were computed on the basis of national agricultural statistics. Since, complete information was not available on regional level; benefits evaluation was restricted to an aggregate analysis. Base-level production figures are averages for the periods 2006 - 2015. This is to avoid using extreme values which may be associated with actual production data for a particular year.

Farm cost structure: On the basis of the survey data, the cost structures of cereal production using traditional and improved varieties were computed. The additional costs associated with the use of new technologies were mostly in the areas of land preparation, farmyard manure and its application, harvesting, seeds, insecticide application, and farm equipment rental. There were no additional land preparation costs between farmers' practices and innovations. The unit variable cost reduction was mainly due to the level of yield; since hybrids have higher yields, even where production costs are not significantly different, they recorded the lowest production cost (tables 6-8).

Table 6: Traditional sorghum variety farm budget

Items	*Unit*	*Quantity*	*Unit cost*	*Value*
Labour				
- *Field preparation*	Man days	4	1500	6000
- *Ploughing*	Man days	2	1500	3000
- *Manure application*	Man days	1	1500	1500
- *Sowing*	Man days	3	1500	4500
- *Weeding1*	Man days	6	1500	9000
- *Weeding2*	Man days	6	1500	9000
- *Harvesting*	Man days	8	1500	12000
- *Threshing*	Man days	5	1500	7500
- *Hauling*	Man days	3	1500	4500
Seeds	Kg	10	100	1000
Farm yard manure	Ton	3	10000	30000
Insecticide	Litre	0	600	0
Fertilizer	Kg	0	250	0
Equipment rental	Days	4	5000	20000
Total variable cost	CFA/ha			118000
Output per Ha	Kg/ha			950
Unit variable cost	CFA/kg			125
Unit variable cost reduction	CFA/kg			-

Table 7: Improved sorghum variety farm budget

Items	*Unit*	*Quantity*	*Unit cost*	*Value*
Labor				
- *Field preparation*	Man days	4	1500	6000
- *Ploughing*	Man days	2	1500	3000
- *Manure application*	Man days	1	1500	1500
- *Sowing*	Man days	3	1500	4500
- *Weeding1*	Man days	6	1500	9000
- *Weeding2*	Man days	6	1500	9000
- *Harvesting*	Man days	8	1500	12000
- *Threshing*	Man days	5	1500	7500
- *Hauling*	Man days	3	1500	4500
Seeds	Kg	8	400	3200
Farm yard manure	Ton	3	10000	30000
Insecticide	Litre	2	600	1200
Fertilizer	Kg	150	250	37500
Equipment rental	Days	4	5000	20000
Total variable cost	CFA/ha			158900
Output per Ha	Kg/ha			1500
Unit variable cost	CFA/kg			105
Unit variable cost reduction	CFA/kg			20

Adoption rate projection: Sorghum hybrid adoption rates were estimated for 2015 and projected backward and forward using the logistic function. Following Yapi et al. (2000) for the projection, the study used adoption ceiling rate of 40% for hybrid varieties. The rationale for setting this ceiling rate was twofold: first, it was believed that their early-maturity and high yielding characteristics will help their adoption to spread and reach 40%; second, given the pressing need for food security in an ever-demanding environment, farmers would shift to new varieties for fulfilling their future food requirements. Changing this rate will require a strong political will to address major innovation adoption constraints facing farmers in the country. Such political commitment is unlikely in an environment characterized by government budget reduction and privatization (Yapi et al., 2000).

Table 8: Hybrid sorghum farm budget

Items	*Unit*	*Quantity*	*Unit cost*	*Value*
Labour				
- *Field preparation*	Man days	4	1500	6000
- *Ploughing*	Man days	2	1500	3000
- *Manure application*	Man days	1	1500	1500
- *Sowing*	Man days	3	1500	4500
- *Weeding1*	Man days	6	1500	9000
- *Weeding2*	Man days	6	1500	9000
- *Harvesting*	Man days	8	1500	12000
- *Threshing*	Man days	5	1500	7500
- *Hauling*	Man days	3	1500	4500
Seeds	Kg	8	800	6400
Farm yard manure	Ton	3	10000	30000
Insecticide	Litre	2	600	1200
Fertilizer	Kg	150	250	37500
Equipment rental	Days	4	5000	20000
Total variable cost	CFA/ha			162100
Output per Ha	Kg/ha			2500
Unit variable cost	CFA/kg			65
Unit variable cost reduction	CFA/kg			60

Indicators of research impact

Three basic parameters were used as indicators of the impact of sorghum and pearl millet research in Mali. They were: food security, technical efficiency, and profitability.

a. *Household food supply (household food supply):* The use of improved sorghum hybrid varieties under farmers' conditions brought significant yield gains to the adopters; also, yield increases over the checks were higher for hybrid varieties. For example, adopting farmers gained an additional 1000 kg/ha using sorghum hybrid varieties. These gains should not be viewed as the effect of using improved seeds alone, but rather as the result of using a whole package (planting techniques, fertilizer usage, etc).

b. *Technical efficiency:* Cost analyses of sorghum production indicated that, by adopting improved and hybrid varieties, farmers were able to achieve substantial reduction in per unit cost of production. For improved sorghum hybrids, the gain was CFA 60,000 per hectare (about US$120), rather than farmers' best checks.

c. *Financial returns and benefits:* The study has shown high returns on investments in sorghum improvement research in Mali. At a 10% discount rate, and supply and demand elasticities of 0.5 and -0.75 respectively, the total surplus of these investments was estimated at US$206 million ($83 million for consumers and $123 million for producers). This represented an average internal rate of return (IRR) of 65%.

Table 9: Summary statistics for simulations results

	TS	IRR	CS			PS		NPV
			Value	share		value	share	
Maximum	206	410%	83	40%		123	60%	201
Minimum	-48	0%	-24	-50%		-24	-50%	-53
Mode	17	50%	7.5	44%		2.5	14%	14
Standard deviation	26	45%	10	38%		16	62%	26
Mean	30	65%	12	40%		18	60%	25

Conclusion

The study was an ex-post evaluation of the potential economic impact of first Guinea-race sorghum hybrids introduced to farmers in the Sudanian Savanna of Mali. Based on the economic surplus model, it compared the hybrids with best available varieties. The parameter assumptions were designed to reflect the approach to on-farm selection and farmer-managed seed supply that has been encouraged in Mali since 2000.

The findings indicated that research investment in sorghum hybrids in Mali is sound, particularly when combined with earlier on-farm selection and farmer-based mechanisms for disseminating seeds. However, the findings also illustrate the predicted variability of economic benefits to the cost advantages of hybrid seeds under the current research paradigm. The variability in predicted total surplus appeared to depend very much on the price elasticity of supply, yield advantages and, thus, on the performance of the materials introduced, as well as on the responsiveness of producers to price signals in the market.

The conclusion concerning the superiority of the current paradigm reflects a contextual reality: despite the many years of ICRISAT's efforts at liberalizing the seed system in Mali, the seed system for sorghum remained largely farmer-based. Development and introduction of new materials by the national research programme had been successful and frequent enough, but farmers tended to absorb these new materials into their own systems and rely on each other more than on external sources.

There is, therefore, the need to strengthen the research system for continued generation of improved technologies, including new improved varieties, integrated crop management technologies, as well as pre and postharvest management technologies. This involves enhancing genetic gains, capacity building (research facilities and personnel) for utilizing advanced technologies and enhancing efficiency (e.g. molecular technologies), strengthening collaboration between research programmes in the region and beyond. Demand driven and participatory technology generation has shown to be promising and is important for developing farmer- and end-user-preferred technologies for higher impact.

Furthermore, the impact of climate change on Africa's agricultural sector is a reality and the scenario is likely to worsen. Research outputs are thus needed to mitigate the challenge. Breeding for heat-resilient genotypes will be needed to sustain and enhance production; breeding for short duration varieties would also help avoid end-of-season moisture stress. Research on land and water management needs to be enhanced to develop options (including ground water management); organic inputs are needed to mitigate excessive use of agricultural inputs that endanger the health of the ecosystem (rivers, livestock, etc).

A huge gap existed between realized yield in farmers' fields and the potential yield recorded for improved varieties. Seed system is weak and a lot is needed both in terms of creating demand for improved varieties and also in making sure adequate quantities of appropriately improved seeds are available, accessible and affordable to smallholder farmers in different agro-ecological regions of Mali. The lack of mechanization in operations during production and postproduction phases is an important gap that needs to be addressed for significant impact, particularly in processing approaches for reducing Fe and Zn losses during food preparation. Moreover, there is the need to strengthen linkages between value chain actors (including input suppliers and agro-dealers) and to improve the capacity of research and extension personnel for developing technology packages and disseminating same to smallholder farmers for higher agricultural outputs.

STUDY TWO

Inventory and Characterisation of Innovation Platforms

INTRODUCTION

In sub-Saharan Africa as well as in Mali, a vast majority of the population depends directly or indirectly on agriculture for their livelihoods, so that any positive change in the sector would affect millions of lives (Makini et al., 2013). The agricultural sector faces challenges relating to production, postharvest handling, marketing, information/knowledge exchange between stakeholders and policy frameworks. To reduce poverty and improve food and nutrition security, efforts are often undertaken to transform agriculture with a view to reducing environmental degradation. In Mali, technologies to improve agriculture are generated through research and diffused through government technical services, such as DNA (Direction Nationale de l'Agriculture), projects and NGOs. Technological adoption level is relatively low due to such constraints as: illiteracy, insufficiency of means to cover targeted zones, low adaptability of technologies, high cost of adoption, and poor farmer organizations, among others.

Many approaches have been used to improve technologies adoption rates by farmers. One of such methods is the Farmers Field School. The limit of the approach is that it does not include all actors of the value chain; only the production side is concerned, while other aspects are left for the market to drive.

Innovation platforms are considered fora established to foster interaction among a group of relevant stakeholders around a shared interest. The stakeholders are different but play complementary roles in the development, diffusion and adoption of technologies for socioeconomic benefits (Makini et al., 2013). Innovation platforms seek to harness innovations related to technology processes, institutional and social-organizational arrangements. To promote these innovations, partnerships along and beyond agricultural value chains must be fostered to bring on board actors with special mix of skills (World Bank, 2011). These skills are complemented with functional expertise, since the new ways of working require a mix of scientific, technical, managerial and entrepreneurial skills.

In Mali, due to the diversity of production systems and crops cultivated, many platforms are implemented by donor projects to foster commodity value chains. Many of these IPs are at their beginning stages, with different objectives and development mechanisms to achieve impact. The projects aim to produce better crop seeds, supply markets with quality processed product, reduce cost, and to integrate agriculture with small ruminants, among others. The projects are meant to benefit every member of the platform in a win-win collaborative mechanism.

According to Adekunle et al. (2010), stakeholders in a platform should interact to jointly identify problems and opportunities, seek and apply solutions, learn, reflect and source more solutions for the innovation process to continue. However, many stakeholders are confused by the diversity of notions, such as cooperative, platform, commission board, incubation centre and value chain. Indeed, information and training through workshops often help their comprehension of innovation platforms. Most of IPs are market-oriented and target local, national and international markets; a few are production-oriented, such as having access to better seed quality at reduced cost. The majority of IPs are formed to provide access to information on commodities prices or inputs. The main challenge is how to ensure sustainable functionality of IPs after the projects that helped implement them are ended.

According to the United Nations**,** Mali ranks 173 out of 177 countries on the Human Development Index and 151 out of 157 on the Gender Development Index. Approximately 51% of the population live under the poverty line, while 28% of the population is undernourished. Beyond the constraints faced by smallholder farmers, there is a history of systemic under-investment in agriculture, especially in new technologies. The government of Mali recently started subsidy initiatives (a 50% fertilizer subsidy in 2008; a 1,000 tractor subsidy at half cost in 2015). The country has different agro-ecological areas with rainfall ranging from 100mm in the north to 1200mm in the south. The 'Office du Niger' and the flooded areas of the country are suitable for rice production, whereas the uplands are appropriate for cereals and other crop production. This study is carried out in three administrative regions: Sikasso, Segou, and the Bamako and Koulikoro regions.

Sikasso region is broadly characterized by cotton-based systems with maize, sorghum and millet as major traditional staple cereal crops of which the relative importance of each in the system varies with the agro-ecological sub-zones. In addition, there are localized pockets (mostly the bas-fonds) where rice has been grown traditionally as women's crop and/or where farming is intensified to cultivate non-traditional crops like potato and a range of vegetables mainly as peri-urban systems. Fruits (in particular, mango and citrus) constitute a major commodity. The entire region is in transition from largely subsistence and traditional to an increasingly intensified commercial farming system.

Two major production systems prevail in Segou. The prevailing system in the northern Sudanian and southern Sahelian zones, where rainfall (500-750 mm) is more erratic than towards the south, is millet-based, with cowpea as important secondary crop and sorghum cultivated in lower wet and heavier soils. Throughout this zone, livestock

(cattle and small ruminants; both settled and nomadic) is an important component of the mostly 'traditional' cereal-based system. But where rainfall ranges between 350 and 500mm, there is the irrigated rice-based system along the Niger River and on the vast plains of 'Office de Niger', located north of Segou and around Niono. Under the influence of land use and trade liberalization, as well as diversification policies, rice production has greatly increased (from 1 - 1.5 ton/ha in the 1980s to 5 - 6 tons/ha at present); off-season vegetable production has also boomed, with shallots in particular.

In the Bamako and Koulikoro Region, sorghum is the dominant crop; followed by maize and cotton. Rainfall ranges between 600 mm and 1000 mm yearly. Major concerns exist on diminishing soil fertility and the resulting degradation of the natural vegetation cover. This process is compounded by the increased exploitation of communal forest resources for firewood and charcoal production. Development activities have reached the rural communities differently and agricultural innovations have been adopted unevenly in the villages. Due to large agro-ecological diversity, technological package recommendations and the processes of technology transfer are becoming difficult.

Most important to agricultural development in Mali has been the creation of a favourable national policy environment that attracts donors, NGOs and the private sector. In the south, CMDT dominates the development scene, as did the Office de Niger in the area north of Segou. In the other agro-ecologies and more marginal regions, the actors have been more divers, including a combination of public sector extension, NGOs and various development projects. Many technologies (innovations) have been introduced in cotton-based and irrigated rice systems; while for most of the "traditional" production systems, it has been marginal. However, overall rates of adoption are low and varied by crop and agro-ecology. One way of improving technology adoption rates is to implement a value chain dependant platform. This explains why WAAPP in Mali have encouraged the implementation of several platforms in the different regions of the country.

Objectives

The main objectives of this study are to identify operational platforms in the regions visited, discuss the constraints they face and the perspectives. To achieve the above objectives, a team of researchers met with stakeholders in Bamako, and farmers' organizations and regional agricultural services in Koulikoro, Segou and Sikasso.

Innovation Platforms Formation

The establishment of platforms comes from the WAAPP project, which uses the IAR4D approach to develop commodity value chains. The innovation platforms include researchers, development agencies, farmers and policymakers. They aim at enhancing learning between stakeholders to increase productivity and access to market, reduce poverty and improve environmental conditions. Due to the multiplicity of actors who started with diverse objectives and expectations, management of platforms is complicated. Platforms in the visited regions can be categorized as follow:

Seed innovation platforms

- Irish potatoes seed
- Sorghum/groundnut seed in Kolokani
- Maize seed in Siramana

Rice and fonio platforms

- Low land of Doumanaba
- Low land of Bamadougou
- Parboiled rice of Zangaradougou
- White rice of Kourimary
- Fonio of Mandela
- Maize Mali

Livestock innovation platforms

- Dairy of try
- Small ruminants of Didiéni
- Small riminants of N'Golobougou
- Goats of Yorobougoula

The innovation platforms identified are thematic, geographic, sectoral or value-chain related. They are formal in character and possess rules to define how decisions are made, conflicts are dealt with and how to be a member. Table 1 provides the name, location, region and targeted activities of the platforms.

Table 1: Location and target product of platfroms

N°	*Name of the platform*	*Location*	*Region*	*Product/ target activity*
1	Parboiled rice	Zangaradougou	Sikasso	Parboiled rice for local, national and international markets (Burkina and Guinea)
2	Fonio	Mandela	Sikasso	Fonio grain and rocessed fonio for local market of Sikasso, national and international market (Burkina)
3	Local Irish potatoes seeds	Niono et Koulikoro	Ségou and Koulikoro	Local Irish potatoes seed for local and national market
4	Milk (dairy)	Try	Sikasso	Cattle milk to provide local plants of Koutiala town
A	Low-land	Bamadougou	Sikasso	Irish potatoes and low land rice consumption: local, national and international markets (Togo, Ghana, Burkina)
6	Low-land	Doumanaba	Sikasso	Irish potatoes and low land rice consumption: local, national and international markets (Togo, Ghana, Burkina)
7	Small ruminants	Didieni	Koulikoro	Agriculture and small ruminants Integration (Guera goat), local and national market
8	Small ruminants	N'Golobougou	Koulikoro	Agriculture and small ruminants Integration (Guera goat), local and national market
9	Seeds (sorghum, groundnut)	Kolokani	Koulikoro	Certified seeds of sorghum and groundnut for national seed enterprises
10	Seeds (maize)	Siramana	Sikasso	Certified maize seeds for local producers, national seed enterprises and to promote agriculture and livestock integration
11	Platform 'White rice'	Kourimari (Diabaly)	Niono	White rice for local, national and international markets (Mauritania and Sénégal)

All platforms are funded and implemented by the WAAPP project. Activities to be carried out are discussed during a workshop, where members plan and schedule activities. Most of the IPs were established in 2015 with the availability of funding from the project. Activities achieved by the IPs in 2015 are presented in table 2.

Table 2: Achieved activities by the different IPs in 2015

Activities	*Period*
1. Operationnalization for the process of diffusion of proven technologies in Mali	14 - 16 January 2015
2. Initiation for the diffusion of local Irish potatoes seed produced in Mali	13 - 16 May 2015
3. Revisiting of action plans	03 - 08 June 2015
4. Training of actors on concepts and background principles of the approach IAR4D and functioning of IPs	23-26 June 2015
5. Actors' support of IPs on budgeting action plans	25 - 31 July 2015
6. Internal facilitators' capacity building workshop for a better functioning of innovation platforms	27 - 29 August 2015
7. Mandela fonio IP field visit to San and Tominian	25 - 29 October 2015
8. Inter farmers visit of the dairy IP of Try	28-29 October 2015
9. Action plan elaboration of Kourimary (Diabaly)	30 October to 1st November 2015
10. Sharing information meeting on how to produce Local Irish potatoes seed by members	18 -19 December 2015

Visited platforms were at their beginning stages and needed coaching to be able to achieve planed activities. The platforms included mostly producers who functioned as cooperatives, because members of an IP made only one activity together: purchasing inputs. Other activities in the value chain were made individually (sale of products). The poor structure of the IPs did not fully involve such stakeholders as researchers, extension agencies and NGOs. Information was shared in the IPs only during regular meetings (monthly, quarterly or annual meetings). During these meetings, budget balances were also shared; other information relating to markets was kept individually.

All visited IPs had governance rules which were set and translated during a general assembly; these included how to be a member, activities to be carried out, regular fees and investment. To be a member of an IP, the governance rules are to be respected. Decisions were made during general assemblies. A researcher, extension agent or NGO officer worked as facilitator in the IPs. The actions planed by the IP were monitored by the facilitator.

Functioning of IPs

The IPs functioned from an action plan elaborated by the funding project and the members. The project which implemented the platform tended to link different actors in the value chain by organizing workshops where each actor can express needs or requirements. Most IP members did not think of the ownership and did not see that the

role of the project should change from initiator to facilitator. The role of private sector, instead of being collaborative to support farmers' commercial opportunity, was interest-related. Table 3 presents the number of actions planed by IPs in 2015. The performance of IPs was evaluated on the basis of how accurately they had respected their action plans. The criteria used are as follow:

1. evaluation of achievement level of action plans by identifying favourable factors or unfavourable factors and complementary information;
2. importance of innovations diffusion;
3. strategy applied to implement the action plan;
4. communication channel used;
5. main difficulties/constraints;
6. lessons learned in the implementation of action plans.

Table 3: Nature and number of scheduled actions

IP	*Functioning actions*	*Investment actions*	*Garanty Funds*	*Total number of scheduled actions*
Irish potatoes seeds	13	2		15
Sorghum, maize, groundnut Kolokani	13	2		15
Maize seeds, Siramana	13	2	1	16
Fonio				14
Low land IP of Doumanaba	4	9	-	13
Low land IP of Bamadougou	11	8	-	19
Parboiled rice of Zangaradougou	10	4	1	15
White rice of Kouroumary	14	7	1	22
Dairy IP of Try	10	1	1	12
IP of Didiéni	11	2	-	13
N'Golobougou small ruminants	13	2	-	15

Table 4: Total budget of 10 platforms for achieving actions planed (without white rice IP)

Type of budget	*Amount*	*Percentage*
Functioning	461 062 200	18,4
Investment	1 805 885 250	72,2
Garanty funds	235 025 000	9,4
Total Budget of scheduled actions	2 501 972 450	100

Table 5: Achievement level of action plans

IP	*Total number of scheduled actions*	*Number of achieved activities*	*Achievement rates of activities (%)*
Irish potatoes seeds	15	9	60%
Sorghum, maize, groundnut Kolokani	15	8	53%
Maize seeds, Siramana	16	8	50%
Fonio	14	9	64%
Low land IP of Doumanaba	13	8	62%
Low land IP of Bamadougou	19	5	26%
Parboiled rice of Zangaradougou	15	5	33%
White rice of Kouroumary	22	12	55%
Dairy IP of Try	12	5	42%
IP of Didiéni	13	8	62%
N'Golobougou small ruminants	15	5	33%

Only 4 IPs recoreded 50% achievement of their action plan. Many factors explained this result.

Favourable factors

Achieved actions were related to the support of WAAPP-2A project, which provided the fund and monitored the IPs. Other partners had carried out some thematic actions (research, extension) that were in accordance with their mandate in the area where the IP operated. Also, facilitators' capacity to mobilize resources and connecting stakeholders helped achieve positive results. The availability of some local radios in the area also influenced the achievement of actions for each platform.

Non-favourable factors

The lack of financial support was frequently cited as a limiting factor in the implementation of the action plans. Most platforms also stated that they had limited access to information and techniques for mobilizing funds.

Technologies diffused through platforms

Table 6. Importance of technologies diffused by the platforms

Name of innovation platform (IP)	*Diffused Technologies*	*Area or quantity*	*Number of beneficiaries Direct or indirect*	*Number of female beneficiaries*	*Number of youth beneficiaries*
IP 'Parboiled rice' 'low land' Bamadougou and 'low land' Doumanaba	Improved rice varieties (swétasoké, kogoni 91)	640 ha	815	637	458
	Kits for rice parboiled	04 kits	431	425	220
IP 'Fonio'	Improved varieties of fonio (Tongo, Solosso)	1 ha	98	98	84
IP 'White rice of Kouroumary'-Diabaly	NERICA L1, L2 et Wat 310	3057,8ha	3095	27	1117
	Philippino Seeder	30 ha	30	1	19
IP 'Irish potatoes local seed'	Irish potatoes local seed varieties: *Claustar* and *Sahel*	20,575	848	-	-
IP 'Sorghum/ groundnut seeds' of Kolokani	Groundnut improved varieties seeds (Mossi Tiga Fleur 11, JL24)	10 ha	15	2	-
	Sorghum improved varieties seed (Diakumbè, Seguifa, Sangatigui)	60 ha	120	12	20
IP 'Maize seed' Siramana	''association maize/ mucuna'' for maize grain production and forage Technology	17,50 ha	70	25	02
IP 'Dairy of Try'	''Association of maize/mucuna'' Technology	44,5 ha	2000	1020	1200
IP 'Small ruminants' Didieni	Introduce and diffuse varieties of forage crops	43 ha	32000	16320	19200
	Groundnut varieties diffusion (Flower 11, JL24, Mossi tigua)	45 ha	32000	16320	19200
IP 'Small ruminants' N'Golobougou	Diffuse improved varieties of groundnut (Alason et Samékè)	1,25 ha	26700	13617	16020
	Diffuse improved cowpea varieties (Sangaraka et CZ)	1,25 ha	26700	13617	16020
	Diffuse forage maize varieties (Sotubaka)	2,5 ha	26700	13617	16020

Source: WAAPP-2A

Strategies for implementing IP action plans

- Frequent concertations between platform members;
- Participation of actors in trainings on actors' roles and responsibilities;
- Mobilisation of platform members;
- Engagement of platform members;
- Market access facilitation;
- Communication on platform activities;
- Field visits organisation;
- Participation at agricultural fairs for displaying products;
- Actors' sensitizing;
- Radio broadcasting;
- Meeting of leaders, general assembly of actors.

Communication channels used

The following channels were used:

- Portable telephones (sms)
- Nearby radios for media coverage and broadcasting of platform activities;
- Meetings and general assembly of actors;
- Reports and books to register platform events;
- Films/videos

Main difficulties/constraints

- Poor financing of activities due to the lack of knowledge financial resources mobilization procedures;
- Weak technical extension;
- Lack of concertation among platforms;
- Late seed and fertilizer disposal;
- Information deficit on action plans implementation;
- Non disposal of some priority technologies, such as Guera goat, micro-dosage seeder, fonio dehuller kit.

Lessons learned on platforms' implementation

- The determinant role of field visits for innovation systems (discovery and/or better appreciation of innovations during visits);
- Prioritizing of actions which are numerous and diversified;
- Necessity of self-evaluation of IP actors to better situate their strength and weaknesses;
- Importance of value chain approach for better products valorization;

- Necessity for IP actors to adopt ways to mobilize financial resources from different partners;
- Necessity of training IP members in terms of references elaboration to mobilize needed resources for executing activities;
- Necessity of cooperation and mutual learning between different IPs and their actors;
- Innovation platforms constitute an appropriate body for the diffusion of a large pool of technologies;
- Necessity of funding support and technique from other partners;
- Need to mobilize proper financial resources for the implementation of sustainable action plans.

Governance and internal functioning of IPs

Governance at each platform level was characterized by the decision-making system and information sharing system through regular meetings (monthly or quarterly), extraordinary meetings, general assemblies, or annual meetings. Meetings were organized by the facilitator who ensured the IP animation. Members paid fees to support the IP's expenditures. Reports were elaborated in local languages or French. Communication channels used included local radios and traditional channels. The strength of governance in the IPs are listed bellow.

a. Elaboration of a communication plan with local radio station (IER support to IPs of parboiled rice, lowlands of Doumanaba and Bamadougou) on parboiled rice and Irish potatoes seed production technologies;
b. Membership fees were correctly paid in most all platforms;
c. Regular periodic meetings even without financial resources (Mandela, N'Golobougou);
d. Smooth members mobilization for periodic meetings (Riz blanc, Petit ruminants N'Golobougou, fonio);
e. Important role of local radios for enhancing IPs (Diabaly rice price change to increase from radio broadcasting on the vision and action plan of platform for quality improvement of white rice. Koutiala, the rural radio 'Ouéssou' facilitated the diffusion of maize/mucuna technology for milk production in peri-urban communes of Koutiala);
f. The fonio IP of Mandela was well perceived by actors at the base after the field visit in San and Tominian; they had good experience in fonio production and processing;
g. IP actors in N'Golobougou and Zangaradougou participated in all activities because of their trust for the president;

Despite these positive points, it is important to noticed that because of the difficulty in mobilizing financial resources for the scheduled activities, some platform leaders thought they lost the trust of members who were expecting immediate funding from donors. The study found the role of facilitators as very important in the governance of each IP; their mode of engagement and personality especially affected the sustainability and effectiveness of the IPs.

Financing the action plan and resources mobilization at IP level

Depending on the configuration of a platform, there was the proposal that it should fund female groups with 10% of members' contribution for light investments, 20% contribution for average investment and 40% contribution for heavy investments. Similar contributions were proposed for mix and male platforms (table 7). The proposed rates for support on investments were adjudged high by platform members; their suggestions are presented in table 8.

Table 7. Investment proposition of platforms

Limits (FCFA)	*Investment categories*	*Support level from donor by gender*	
		Female	*Mix and male*
0 à 499 999	Ligth	90% (10% IP)	85% (15% IP)
500 000 à 1 999 999	average	80% (20% IP)	70% (30% IP)
≥ 2 000 000	heavy	60% (40% IP)	50% (50% IP)

Table 8. Proposed participation in investment by platform members

Platform	*Light investments*		*Average investments*		*Heavy investments*	
	M/F	*F*	*M/F*	*F*	*M/F*	*F*
Maize seeds of Siramana	15%		10%		5%	
small ruminants Didiéni	10%	5%	15%	10%	20%	15%
small ruminants N'Golobougou	10%	5%	10%	5%	10%	5%
Fonio Mandela	0%	20%	0%	15%	0%	10%
Irish potatoes seed	15%	10%	10%	5%	5%	5%
White rice of Kouroumary	20%	15%	15%	10%	10%	5%
Seed sorghum -groundnut Kolokani	10%	5%	10%	5%	10%	5%
Dairy TRY	5%	0	10%	5%	15%	10%
Doumanaba	5%	0	10%	5%	15%	10%
Parboiled rice Zangaradougou	5%	0%	5%	3%	10%	5%
Bamadougou	5%	0%	5%	3%	10%	5%
Mean	9%	5%	9%	6%	10%	7%

Table 9. Mechanism/strategy of acquired equipment management

Platform	*Management Mechanism of Acquired Equipment*
Maize seeds of Siramana	▪ Leasing equipment to make money for the platform
small ruminants Didiéni	▪ Installing a management comity, ▪ Collect leasing fees to ease reimbursement
small ruminants N'Golobougou Fonio Mandela	Seeds ▪ Installing a management comity; ▪ The equipment is leased and the amount is shared as: 25% gas, 25% maintenance, 50% depreciattion cost for renewing the equipment; ▪ Each beneficiary pays the fees.
	Guera Goat ▪ Reception of six units for 3 years, each beneficiary reimburses the goats at a rate of 2 units by campagne.
Irish potatoes seed	▪ Establishment of the management commity; ▪ Lease other equipment owned by the platform; ▪ Share of rice dehulled fees of 500 FCFA to 100 FCFA ofr depreciation and 400 FCFA for maintenance
White rice of Kouroumary	▪ Establish a management commity; ▪ Storage service ▪ Replacement of equipments
Seed sorghum - groundnut Kolokani	▪ Establishing two commities (management commity, consil for management) ▪ Depreciation (rate 35% of rice dehulled fees) ▪ The remaining will serve as operating and maintenance cost
Dairy TRY	▪ Establishment of a monitoring commity in charge of all management activities
Doumanaba	▪ Establishment of a committee to monitor reimbursment
Parboiled rice Zangaradougou	▪ Payment of 50 FCFA fees, leasing for reimbursing received equipments ▪ Establishment of management commitee, ▪ Money flow will be used for reimbursing equipment at (50% depreciaition, 25% maintenance, 25% functioning)
Bamadougou	▪ Prestations (5 FCFA/kg of potatoes): 50% depreciation, 50% maintenance ▪ Establishment of the management commitee for irrigation equipment (motopompe): 20% of purchase cost to pay beneficiary ▪ For the storage houses 500 FCFA per bag: 50% depreciation, 50% maintenance

Major threats

The major threats to the sustainability of the IPs involved the non-competitiveness of the value chains and the mobilization of actors. Each value chain had specific threats, which were not reflected in the initial action plans (table 10).

Table 10. Major challenges as deduced from threats to identified IPs

Platform	*Challenge deduced from identified threats*
Maize seed of Siramana	▪ Accelerate the process of seed certification which affects selling seeds during periods of strong demand ▪ Improve storage and conservation of seeds
small ruminants Didiéni	▪ Mobilizing all members for IP meetings ▪ Improve forage production through forage seed availability
small ruminants N'Golobougou	▪ Satisfying demands for Guerra goats and other improved genotypes ▪ Timely access to seeds of improved varieties
Fonio Mandela	▪ Supplying the market with clean, labeled white fonio
Irish potatoes seed	▪ Reducing Irish potatoes seed lost in storage houses ▪ Transport and in time Irish potatoes from farm to storage place
White rice of Kouroumary	▪ Supplying the market with quality labeled white rice of Kouroumari
Seed sorghum - groundnut Kolokani	▪ Produce enough seeds to sell in the market; ▪ Possessing large funds to get foundation seeds
Dairy TRY	▪ Make available a lot of forage to feed livestock during the dry season and avoid disruption in milk supply of the dairy plant
Doumanaba	▪ Produce enough paddy rice for parboiling
Parboiled rice Zangaradougou	▪ Increase labeled parboiled rice in Zangaradougou market
Bamadougou	▪ Increase availability of parboiled rice

Outcomes of the Innovation Platforms

In Cinzana, where IER had a research station, a multi-actor platform was implemented to disseminate cowpea innovations. The main activity of the platform was the production of certified cowpea seeds. To generate financial resources, the platform will get 10% of total amount facilitated by it. Furthermore, the platform had a written contract for supplying 40 tons of cowpea to the World Food Programme (WFP).

Due to the high yielding characteristics of the varieties and the quality of grains required by buyers, thresher machines were introduced. In terms of food security, the platform helped identify high yielding varieties, resistant to striga and early maturing, as well as adapted to agro-climatic conditions of the Sudan-Savanna zone. These high yielding varieties help ensure food availability to population in August-September when coarse grains are scarce and revenues to smallholders dwindle. Besides, the threshers acquired by the platform had reduced women time for food preparation and made them available for other activities.

Plate 1. Cross-section of actors at the establishment of Cinzana cowpea platform

The cowpea variety Djiguiya introduced by IITA is one of the diffused varieties by the platform of Cinzana. It has the following characteristics: cycle of 55 days; white color grain; tolerant to striga gesnerioides; yield on station of 1.5 - 2 tons per hectare. Due to its characteristics, the variety is on high demand. In effect, the platform produced 5 tons of R1 seed in 2015 and this expanded cultivation land to 500 ha, with a production forecast of 365 tons and a sale of about 182,500,000 FCFA. Also, due to its precocity, the variety can be farmed twice during the rainy season.

The small ruminants platform of Ngolobougou

Ngolobougou is located in an area where rainfall ranges from 800 to 900 mm; farmers grow cotton, maize, cowpea, sorghum and groundnut, as well as rear goats. Their main challenge was how to control goats during the rainy season when crops were grown. The platform helped goat farmers with new legume varieties and improved goat species. In a period of two years, they were able to sell larger goats and had more control on their goats.

The fonio platform in Tominian

Fonio is a cereal whose processing is rather cumbersome. Just to eat fonio, it takes a woman a whole day to dehull, polish, wash, steam and cook it. The most difficult part of the process is dehulling. This platform therefore involved the provision of

mechanical and electrical dehullers to women by the NGO AMEDD. Women are now more organized to process fonio and leave it in its pre-coocked (diouka) or polished form and then sell this to supermarkets.

Conclusion

All visited platforms were initiated by projects; once the project ended, the platform stopped functioning. However, a few platforms still remained even after the funding agency has been concluded its field operation. Among the drivers that encouraged such platforms to continue functioning were: trust for the leaders among the stakeholders, the relevance of the IP's intervention; regularity of the facilitator with beneficiaries; and the quick/ lasting impact of actions.

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