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Understanding innovation platform effectiveness through experiences from west and central Africa

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ABSTRACT

Innovation platforms (IPs) are a way of organizing multistakeholder interactions, marshalling ideas, people and resources to address challenges and opportunities embedded in complex settings. The approach has its roots in theories of complexity, the concept of innovation systems and practices of participatory action research. IPs have been widely adopted across Africa and beyond in recent years as a "must have" tool in a range of "for development" modes of agricultural research. Our experiences with establishing and facilitating nine IPs in local settings in west and central Africa contribute to understanding factors that impact on their effectiveness.

The nine IPs were variously focused on developing dairy, crop and/or meat value chains by strengthening mixed crop-livestock production systems or seed systems. Using case study methods, we identified variables that contribute to explaining the performance of these IPs in relation to six domains of change in the agricultural system and the sustainability of changes. Thematic analysis was guided by a conceptual framework which grouped variables into four categories (context, structure, conduct, and process) that interact to influence IP performance.

Stronger market connections and value chains were generated through some of these IPs but the most prevalent changes overall were in farm productivity and technical knowledge of producers. The structures evolved in some IPs, akin to those of producer collectives, suggested they were filling an institutional gap locally. The effect of the IPs on deeper level institutions that influence agricultural systems and food security was modest, constraining prospects for the IPs to generate impact at scale. Impacts from the IPs on research and development organisations were uncommon but had transformative significance.

Our conceptual framework did not offer optimal guidance to understanding how the many variables that contributed to performance of these IPs combined and sequenced, but the pattern of interactions was consistent with increased social capital being the prime mediator for change. Achieving greater prospects for transformational

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change and impact at scale warrants at least equal attention to three other interconnected change pathways: through markets, institutions and innovation capacity. Important factors for increased impact are individuals and organisations with capacity to purposefully build and manage inter-organisational and cross-scale networks, early diagnostic studies of the institutional landscape, and adaptive processes of critical reflection and learning that continue beyond the short term.

1. Introduction

Although Innovation Platforms (IPs) only recently joined the toolkit of agricultural research for development programs in sub-Saharan Africa, they are being widely used as a core part of strengthening agriculture productivity, smallholder farmer livelihoods and agricultural innovation systems (e.g. Adekunle and Fatunbi, 2014; Kilelu et al., 2013; Schut et al., 2015). Establishment of IPs aims to counter weaknesses in agricultural innovation systems by building interaction amongst different kinds of actors, promoting change in institutions, and garnering resources to augment and/or effectively deploy available capitals (Adekunle and Fatunbi, 2014; Schut et al., 2015). The approach builds on the well-established association between networks and innovation (Egbetokun, 2015; Pittaway et al., 2004).

Agricultural innovation systems are complex since they are characterised by extensive interconnections across multiple levels of system organisation, amongst multiple actors who are influenced by varied institutions and capacities (Foran et al., 2014). Indeed, an innovation system is this very network of actors, institutions and technologies. It comprises components, relationships amongst components and the varied attributes or properties of these components and relationships (Carlsson et al., 2002). Such systems develop through 'functions' that involve and interrelate structural elements: entrepreneurial activities, knowledge development, knowledge diffusion, guidance through vision and targets, market formation, resource mobilisation and development of political legitimacy (Suurs et al., 2010).

Consistent with their complexity, innovation systems cannot be directed or controlled by any specific actor(s) (Bergek et al., 2008). In contrast, researchers have high control over design and implementation in the technology supply-push approach to change in agricultural systems that has dominated in sub-Saharan Africa, in which research outputs are provided to farmers through extension services (Hounkonnou et al., 2012). The failure of research and development agencies to make a difference to the low productivity of African agriculture has been attributed to this tightly directed pathway (e.g. Adekunle and Fatunbi, 2014). Even with the use of participatory methods, researchers face considerable challenges in reducing their level of control (Hocdé et al., 2008).

The need to overcome limitations of this top-down paradigm for achieving locally beneficial social economic and natural resource management change led to Integrated Agricultural Research for Development (IAR4D), an innovation system framework, being developed for the Forum for Agricultural Research in Africa (Adekunle and Fatunbi, 2014; Hawkins et al., 2009). IAR4D principles (Hawkins et al., 2009) highlight and promote complexity by calling for increased interconnection amongst stakeholders, and between analysis, action and change across sectors, spatial scales and organisational levels. IAR4D, in common with other innovation systems, emphasises diversity in actors, relationships and processes whereas antecedent approaches tended to focus mainly on engaging research and development actors with farmers (ISPC, 2016).

IPs are advocated as the prime operational mechanism for achieving the change in agricultural systems that IAR4D calls for in sub-Saharan Africa (Adekunle and Fatunbi, 2014). They are also being used in agricultural development programs and projects where the specific influence of IAR4D is not apparent (e.g. Kilelu et al., 2013; Swaans et al., 2013a). A variety of different terms are used for entities in other contexts that have a comparable focus on knowledge brokering amongst diverse interdependent stakeholders, building relationships and connectivity to foster systemic change. These include living labs (Dhakal et al., 2013), business clusters (Rosenfeld, 1997), collaborative planning forums (Innes and Booher, 2010), communities of practice (Ison et al., 2014) and adaptive governance networks (Chaffin et al., 2014). Such entities can prepare systems for change by connecting actors in ways that allow them to make shared sense of a situation, develop a new vision, and generate momentum to progress toward the vision (Moore et al., 2014).

By establishing IPs and supporting their activities, projects seek to catalyse change (Struik et al., 2014) with livelihood benefit to smallholder farmers often being the priority for donors (Van Paassen et al., 2014). IPs that engage agricultural domain actors at district or national level, are facilitated by innovation champions, and experiment with changing institutions have been effective in creating an enabling environment for farmers to innovate (Struik et al., 2014). The impact of IPs may extend beyond the stakeholders that are directly involved if action within the IP 'niche' (Schut et al., 2015) catalyses change in deeper-level institutions resulting in impact at broader scales. IPs at various levels and scales are advocated (e.g. Adekunle and Fatunbi, 2012; Nyikahadzoi et al., 2012), with interactions at strategic times (Hall, 2005) to ensure that institutions are sufficiently aligned to enable that kind of transformational (Moore et al., 2014) change.

Operational guides to working with IPs (e.g. Adekunle and Fatunbi, 2012; Kebbeh et al., 2014; Makini et al., 2013) portray IPs as physical, virtual or mixed-mode networks that involve a mix of private and public sector stakeholders who have individual interests in a shared issue; who interact and have a range of direct and ongoing dialogues outside the strictures of formalised sectoral structures; and who collaborate to bring mutually desirable changes in a commodity value chain or natural resource management system, including by improving the functioning of their own organisations and enterprises. IPs are portrayed as temporary structures, involving selected key actors relevant to an issue or purpose, whose establishment is facilitated but which may start to act independently (Hounkonnou et al., 2012). While often established through donor funded projects led by research organisations, IPs are envisaged as evolving to become equitable spaces even though the risk that research organisations and their agendas remain dominant is acknowledged (Boogaard et al., 2013).

Increasing use of IPs in sub Saharan African agricultural systems has focused attention on their effectiveness. Skilled consistent practice in facilitating the establishment and operations of IPs has been found to generate IPs that are similar in parameters such as representativeness of stakeholders and the extent of stakeholder interaction (Nokoe et al., 2013). Nevertheless context and the particular contributions that individual actors and relationships make to an IP's activities can be expected to always substantially influence outcomes (Nokoe et al., 2013), complicating comparative analysis. Nor is there any single recipe for what an IP is or should be (Van Paassen et al., 2014). Questions that warrant attention include how

IP effectiveness is defined, monitored and evaluated, and how monitoring and evaluation processes might best contribute to increasing IP effectiveness. We approach these questions through comparative analysis, guided by a conceptual framework for IP effectiveness, of nine local level IPs that were established in west and central Africa in 2012 and 2013 and were involved in an action research process in 2014 and early 2015 that aimed to improve their effectiveness. Many participants in these IPs judged them to be effective, as is evidenced by >130 documented short narratives about positive outcomes and impacts that IP participants said that they experienced as a result of the IP's activities. Our aim is to identify factors that contribute to the reported effectiveness of these IPs and to highlight limitations, thereby helping to build understanding of how the effectiveness of IPs might be improved.

We first introduce the conceptual framework that guided our consideration of factors that influence the effectiveness of IPs. We next introduce the nine IPs we are concerned with and their program and project context, and describe our methods of analysis. We then describe the performance of the IPs through a summary of their outcomes and impacts and consider the influence on performance of various factors that our conceptual framework categorises as context, structure, conduct or process variables. Finally we discuss opportunities, apparent from our experiences, for IPs to engage more strongly with multiple change pathways and promote prospects for transformational change from future agricultural research for development.

2. Conceptual framework for IP effectiveness

Our conceptual framework for IP effectiveness (Fig. 1) shows four groups of interacting variables—context, structure, conduct, and processes—that influence IP performance. Variables that can be considered to be encompassed within each group are listed in Table 1. The basis for our conceptual framework is Cadilhon's (2013) structure-conduct-performance (SCP) framework for evaluating the impact of IPs on agrifood value chain development. Although our aim is subtly different to that of Cadilhon (2013), our concern with variables and interactions that contribute to explaining IP effectiveness is congruent. Additional valuable contributions to developing our conceptual framework are noted in Table 1. We built on Cadilhon's (2013) framework after identifying that the literature offered no discrete set of variables and interactions to explain how IPs generate outcomes, notwithstanding important contributions. For example, Hall (2007b) drew from innovation systems theory and personal experience in designing and implementing agricultural research for

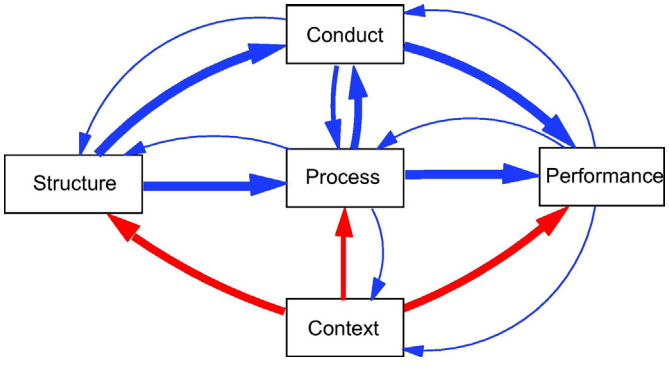

Fig. 1. Conceptual framework for innovation platform (IP) effectiveness showing relationships between context, structure, process and conduct groups of variables and performance, with arrow thickness indicating relative strength of influence.

Table 1
Variables influencing innovation platform effectiveness, in five variable groups of conceptual framework (context, structure, conduct, process, and performance).

Performance

Progress & achievement of IP's planned goals, objectives

Domains of change in the agricultural system

1. Changes in production
2. Changes in access to production inputs
3. Changes in how the market works
4. Changes in capacity of local actors & socially embedded institutions
5. Changes in capacity of R4D system & associated institutions
6. Changes in policy, formal institutions

Cross cutting impacts: gender

Impacts

- Changes in livelihoods, food security
- Changes in capability people's freedom to live lives they have reason to value

Quality indicators for change

- Fairness in distribution of costs, benefits
- Interdependence amongst IP actors
- Recognition by others
- Efficient use of resources
- Resilience to shocks
- Sustainability of change process and of impact

Feedbacks to other framework elements

- Generation & use of cognitive, technical and institutional innovations
- Double-loop learning (changes to IP structure and process)
- Triple loop learning (changes to institutions that determine IP context)

Structure

Institutions governing IP:

Formal external institutions:

- legal status
- policies
- procedures
- by laws

Socially embedded institutions:

- cultural norms
- gender norms
- mental models and perspectives

Formalised by IP, governing leaders, members:

- Membership criteria & process
- Purpose/goal
- Agreed roles & responsibilities
- Agreed goal & expectations
- Incentives & sanctions
- Scale and nesting of decision-making

Power relations & asymmetries, as influenced by:

- Socio-economic status
- Ethnicity
- Gender
- Education
- Capacity
- Age
- Occupation

Social capital/networks of IP members

- Bonding
- Bridging
- Linking

Capitals accessible to IP from members, projects, partners, networks:

- Financial - grants, contributions, access to credit
- Human - diversity and depth of knowledge, skills, time
- Physical – equipment,

Conduct

Motivation
Commitment
Honesty
Transparency
Trust
Respect
Cooperation
Competitiveness
Fairness
Mutual support
Empowerment
Sense of ownership, belonging
Market orientation
Flexibility
Confidence
Courage

Process

Authentic dialogue
Affirmative action for social inclusion, addressing power imbalances
Identification of challenges/opportunities
Identification of capacity needs
Collaboration in planning
Participation in decision-making
Action (individual, collaborative)
Application of learning cycle (plan, act, monitor, reflect/review, re-plan)
Experimentation
Development of networks, relationships
Negotiation
Mediation & conflict resolution

Timing of processes

Process mechanisms:

- Leadership
- Facilitation
- Brokering
- Championing
- Keeping memory
- Training
- Experiential learning

Communication

(continued on next page)

Table 1 (*continued*)

Structure	Conduct
infrastructure - Natural – land, water, soil fertility	
IP context	
Initial conditions: Prior relationships, precursors Project/research team goals Drivers & rationale for establishment Scope of diagnostics & problem focus	Environment: Political, economic, social, cultural, biophysical characteristics; and institutions that determine these, including Agro-climatic zone Climatic trends Demographic trends Education Rights & freedoms Market accessibility Dominant paradigms for expected behaviour

Notes: Major sources: (Boogaard et al., 2013; Buerkler, 2013; Cadilhon, 2013; Hall, 2007b; Klerkx et al., 2010; Spielman and Kelemework, 2009; Swaans et al., 2013b); Minor sources: (Hall, 2007a; Hounkonnou et al., 2012; Klerkx et al., 2012a; Leeuwis, 2004; Nederlof et al., 2011; Spielman, 2005).

development projects to suggest important principles and practices for projects that aim to generate innovation. These included selecting participants and partners carefully, and managing their roles; providing incentives that appeal to diverse actors; and facilitating interactions amongst actors with cognisance of attitudes and practices that support innovation and those that restrict it. Some authors have offered more specific methodologies. For example Njuki et al. (2010) specified indicators for IP establishment, functioning and outcomes, as part of the monitoring and evaluation (M&E) plan for a quasi-randomised control trial implemented to test the impact of the IAR4D approach. Swaans et al. (2013b), noting the lack of any generic monitoring and evaluation framework for IPs, proposed a logical model for IP performance by amalgamating outcome mapping and the logframe approach which, through extensive monitoring and measurement, aimed to allow assessment of whether IP processes are enabling achievement of IP objectives and outcomes. Notwithstanding insights from such sources, Cadilhon (2013) was an appealing starting point for our purpose due to (a) the clear logic of its underpinning theory of change, which posits that the structure of IPs impacts the conduct of stakeholders and, in turn, the performance of the IP in relation to its objectives; and (b) its well-articulated theoretical underpinnings which encourage IP effectiveness to be considered in relation to universal social attributes and interactions rather than only in the context of a research for development program.

Cadilhon (2013) applied the SCP framework, originally developed by Bain in 1959 in relation to manufacturing industries in developed economies, to IPs constituted to foster agrifood value chains. Bain's SCP framework postulated that market structure drives the conduct of traders and, in turn, performance which is assessable from various price indicators (Cadilhon, 2013). Cadilhon addressed critique that Bain's framework assumes perfectly competitive markets. He drew on constructs prevalent in marketing literature to characterise how market stakeholders actually interact, and on new institutional economics for its understandings of how people create specific institutions and organisational forms to manage uncertainty. Structure variables in Cadilhon's framework include the composition and diversity of IP membership; IP decision-making processes; the IP's source(s) of funding; the gender, education and wealth of IP stakeholders; cultural norms and regulatory frameworks (Cadilhon, 2013). Conduct variables, identified from marketing literature, are information sharing, communication, coordination, joint planning and trust (Cadilhon, 2013).

We have modified Cadilhon's SCP framework to enable it to better account for the dynamics that are prevalent in IP operations (Kilelu et al., 2013) and that are integral to the complexity inherent in innovation systems (Hall and Clark, 2010). Our first modification is to recognise that interactions between categories of variables are not one-way, but involve feedbacks. The nature of innovation systems is that they do not behave mechanistically or predictably, but evolve as feedback mechanisms reinforce, amplify or contain the impacts from interactions amongst variables (Hall and Clark, 2010). Cadilhon retained Bain's underpinning SCP logic in which structure determines agency by influencing conduct and thence performance (Cadilhon, 2013). However agency can and does also change structure (Giddens, 1986). Thus gains in performance exert feedback on the system, mobilising stakeholders to engage in more of the kinds of behaviours and actions that contributed to performance gains and to reinforce structures that generated those behaviours and actions. Such feedbacks are indicated in Fig. 1 by arrows linking in both directions between categories of variables.

Our second conceptual modification to Cadilhon's SCP framework is to differentiate two categories of structure variables, retaining 'structure' to refer to the internal organisation of an IP, but distinguishing 'context' which includes legislation, policy, rules, and cultural norms that cannot be changed by decisions of the IP alone (Table 1). We interpreted context to comprise (i) the broader social, economic, environmental and political landscape in which an IP operates and that influences power relations including flows of resources and information amongst actors who may become involved in an IP; and (ii) the initial conditions for IP establishment including program/project goals and focal issue(s).

Thirdly, we struggled to clearly identify the place of process in Cadilhon's (2013) SCP framework even though process is critical to understanding the dynamics of innovation (Hekkert et al., 2007). We considered some elements categorised by Cadilhon (2013) as conduct, such as joint planning or capacity building, are better conceived as processes. Hence we modified Cadilhon's (2013) framework to distinguish processes as a category of variables that is separate to conduct variables. We consider the latter to be attributes of institutions and, at a micro-level, of the behaviours of actors (Hekkert et al., 2007) such as inclusivity, respect, cooperation, market orientation and courage (Table 1).

We agree that performance, as Cadilhon (2013) notes, needs to be assessed against the specific objectives adopted by an IP. Nevertheless, IPs dominated by actors who are principally concerned with local impacts may frame objectives overly narrowly, excluding potential impacts on the broader agricultural system. We also include, as indicators or performance, six domains of change at local and broader scales that we had identified as pertinent to identifying adaptations or transformations in the agricultural system (see Supplementary Material for methods). Quality indicators, such as how efficiently outcomes are achieved, how fairly or equitably costs and benefits of change are distributed, and the sustainability of change processes and impacts, are also pertinent to consideration of performance (Table 1). So too is the extent of feedback amongst system elements and impacts. For example, does system performance include triple loop learning, with changes apparent in institutions that determine the very context of the IP and that might suggest transformational change?

3. Research context

The nine IPs that we are concerned with were initiated and supported by research for development projects conducted as part of the Africa Food Security Initiative (AFSI). AFSI was managed through a partnership between Australia's national research agency, the Commonwealth Scientific and Industrial Research Organisation; the West and Central Africa Council for Agricultural Research and Development (CORAF/WECARD); and the donor, the Australian

Table 2
Aims, establishment date and foci of IPs.

Name; *climatic zone*[a], *AAR*[b]; COUNTRY	Production system	Focal value chain(s)	Time when IP was established	Aim at time of establishment	Activities	Vision as at February 2015
Agouna *sub-humid, 1030 mm* BENIN	Mixed crop-livestock production	Cereals, legumes, small ruminants	Feb–July 2012	Improve access to farm inputs (vet products, credit, fertilizers, seed).	Training in seed multiplication, dual purpose cowpea and peanut use, disease recognition, veterinary products, animal confinement, storage of agricultural products. IP committee active in farmer-herder conflict resolution.	Improve relations between farmers and herders, promote cost-effective production systems based on integration of crops and small ruminants.
Amantin *sub-humid, 1300 mm* GHANA	Mixed crop-livestock production	Small ruminants	Feb–July 2012	Improve access to dual purpose legumes for year round fodder production, healthier small ruminants and marketing value added products.	Meetings, field demonstrations, trials, farmer training & field visits on row planting, seed treatment, box bailer construction and use, dual purpose legume use, salt licks	50% increased crop yields, healthy small ruminant populations and improved market access by 2018.
Banfora *sub-humid, 1086 mm* BURKINA FASO	Mixed crop-livestock production	Dairy	Jan-13	Realise potential for dairy industry to contribute to poverty reduction.	Strengthening production systems (animal feed from farm by-products; improved seed varieties; AI). Improved systems for milk collection, transport, storage. Communication about IP activities, outcomes. Women trained about cooperatives.	Dairy industry as a regional economic pillar by 2020.
Koumbia *transition subhumid/semi-arid, 962 mm* BURKINA FASO	Mixed crop-livestock production	Maize, meat, dairy	Jul-12	Intensify of biomass production through high yield maize and fodder crops; use of this biomass to intensify animal production (fattening and milk).	On-farm trials of intensive biomass & animal production; training on fodder storage, composting, fattening, seed production. Exchange visits. Construction of a 'house of innovation' & development of agricultural services.	Sustainably increase incomes of actors through better integration of agricultural production systems.
Martap *sub-humid, 1471 mm* CAMEROON	Mixed crop-livestock production	Dairy	Jul-13	Develop the dairy sector to meet burgeoning urban demand through improved forage production, livestock disease control, hygiene, increased milk production and better structured value chains.	Milk supply agreements developed with processors; local milk outlets created. Training in AI, sustainable land management, securing animals, feed regimes, soy bean processing (women). Protective health treatments for poultry & small ruminants. Women's savings & credit group formed.	n/a
Pouni *transition sub-humid/semi-arid, 874 mm* BURKINA FASO	Efficient sustainable seed systems	Staple crops & cash crops	Jun-12	Enhance supply and demand for seed of improved crop varieties.	Farmers trained in seed and organic fertiliser production; exchange visits; experimental production using selected crop varieties & management practices. Negotiation and lobbying for purchase contracts; training in market research.	Increase the demand and accessibility to farmers of a range quality improved seeds adapted to local conditions.
Savelugu *sub-humid, 1077 mm* GHANA	Efficient sustainable seed systems	Cowpea, sorghum, soybean	Oct-12	Improve agronomic practices and access to agricultural production inputs (improved varieties, ploughing, credit) for production of certified seed.	Elite farmers trained as seed outgrowers, contracts negotiated with an established seed company. Farmers trained in good agronomic practices; encouraged to keep records. Exchange visits; demonstrations of improved crop varieties.	Partner a seed company through an out-grower scheme to make improved seed readily available; Raise farmers' awareness on improved and superior production and post-harvest technologies; Strengthen relationships and linkages.
Thiel *semi-arid, 410 mm* SENEGAL	Mixed crop-livestock production	Dairy	Oct-12	Improve nutrition of cows to increase dry season milk production, through forage crops and a local by-product (peanut cake).	On-farm trials of supplementary feeding regimes for cattle; fodder variety of cowpea introduced. Seed multiplication; training in herd management.	Making Thiel dairy centre accessible to the external markets by 2020.
Wulugu *sub-humid, 1020 mm* GHANA	Mixed crop-livestock production	Small ruminants	Feb–July 2012	Address multiple challenges in access to production inputs (credit, vet services, tractors, transport, seeds); improve production practices.	Training of community animal health workers and seed producers; farmer training in fertiliser & chemical use. Improved seeds provided and information on access to credit. "Chameleon" moisture meter, box bailing techniques developed. On-farm trials and field days help. Facilitators trained; IP and stakeholders coordinated.	Strong crop-small ruminant value chain, increased agricultural productivity and farmers linked to better market by 2018.

[a] From (Sebastian, 2015).
[b] AAR = indicative annual average rainfall from local records where available or else from en.climate-data.org.

Department of Foreign Affairs and Trade. The partnership was established in 2009 to strengthen Africa's capacity to deal with longer term food security issues with a particular focus on CORAF/WECARD's capacity to drive implementation of IAR4D, a central focus in its own strategic plan. A completion phase was implemented from early 2014 to March 2015, following critique that projects were failing to implement IAR4D principles. Its goals were to enhance development impacts for small farmers and their value chain providers and strengthen capacity for implementation of IAR4D. The applied research reported here was developed in parallel with an action learning process that aimed to improve the effectiveness of IPs selected for involvement in the AFSI completion phase (see Supplementary Material).

When the completion phase commenced, the nine selected IPs, which were located in five countries, had been established between six and 18 months. All were established as local level entities, typically with <50 actors involved, from varied value chain roles and interest groups. Aspects of the diverse environmental and project contexts of the nine IPs are summarised in Table 2. Each of their localities has a pronounced hot dry season. Climate is semi-arid with >25% rainfall variability in one case (Thiel), sub-humid/savanna in six cases, and at the transition between these two climatic zones in two cases (Koumbia, Pouni).

Prior to IP establishment, participatory rural appraisals conducted by project teams in the IP locations had identified focal issues (see Table 2). These were also inevitably framed by project designs, which predated IP establishment, and the mandate, skills and interests of project teams. Seven IPs were in projects led by national agencies whose mandate and capacity is stronger in research, generally agronomic research, than in development. The other two IPs (Banfora, Martap) were led by the Association for the Promotion of the Livestock in the Sahel and the Savanna (APESS), representing pastoralists across west and central Africa, whose mandate and capacity is stronger in development than in research.

Two of the selected IPs (Pouni, Savelugu) were specifically concerned with the problem of supply and demand for certified seed in the value chains of staple food crops. The other seven IPs were concerned with more effectively combining production of crops and livestock (Table 2). Although people from both agricultural and pastoral cultures of west and central Africa are involved in mixed production of crops and livestock, their values and priorities tend to be different and to result in different production systems (Moritz, 2010). Three of the IPs (Banfora, Martap, Thiel) mainly engaged cattle pastoralists, with dairy value chains offering the focal development opportunity and forage cropping being a strategy to improve animal nutrition and milk yield. In two other cases (Amantin, Wulugu), IP membership was dominated by agriculturalists pursuing opportunities in crop and/or small ruminant value chains including use of crop residues and dual purpose legumes for animal feed. Neither pastoralists nor agriculturalists dominated membership in Koumbia, where the dairy value chain was one of several focal crop and livestock value chains, and in Agouna, which was the only IP to develop a strong focus on a social issue affecting agriculture—resolving conflict between pastoralists and agriculturalists.

The IPs varied to some extent in structure but all had governing or coordinating committees. By the end of the completion phase, three had become formally incorporated or registered (Amantin, Martap, Savelugu). Three others had clear rules about membership (Koumbia, Pouni, Wulugu). The remaining three (Agouna, Banfora, Thiel) had no formalised membership rules or requirements: participation was said to be open to anyone with an interest in the IP's aims and activities. Members represented their own interests in most of the IPs but in three cases IP members were representatives of groups of people and membership carried expectations that members would share information with others. The number of members grew considerably in some IPs, as did the diversity of the value chain roles represented, as indicated by Figs. 2a (Banfora), 2b (Martap) and 2c (Savelugu). Banfora, which had >1000 members by the end of the completion phase (Fig. 2b) had developed a tiered structure that facilitated connecting producers in a 10,000 km^2 area to the dairy value chain. Banfora's members met within each of five zones and zone representatives met centrally. In contrast, the project that established the Pouni IP aimed to work consistently with one set of people. Pouni's membership was stable over more than two years (Fig. 2d). Gender balance also varied between IPs and was highest, with up to a third of IP members being female, where affirmative action was implemented (e.g. producer members of Pouni, Fig. 2d) or inclusive approaches championed (e.g. Fig. 2a, Banfora).

4. Methods

Case studies were documented for each IP between November 2014 and March 2015. Case study authorship was led by a member of the project team in six cases and by a consultant engaged for this purpose by the project leader in three cases. To enable comparisons to be drawn amongst the IPs, authors were asked to follow a case study writing guide (developed by one of us, JD). This was introduced to project team leaders and IP facilitators at a cross-project 'writeshop' meeting in October 2014. The writing guide posed multiple questions for case study authors to consider about variables identified in our conceptual framework (Table 1) and their potential influence on IP performance. Authors were also asked to give their overall assessment of factors they considered important for explaining an IP's outcomes and impacts. They were encouraged to include shortcomings and limitations rather than focusing only on 'success stories'. Three case studies were documented in English and six in French. Authors used various methods to assemble information to address questions posed by the writing guide including, in most cases, discussions, evaluation surveys, interviews and/or focus groups with IP members and some other key actors.

Prior to documenting case studies, we had used action research methods over a nine month period with the aim of improving IP effectiveness by encouraging reflexive practice by project teams, IP facilitators and members of the nine IPs. To support this process we developed and implemented a learning framework whose tools included change stories (narratives that describe and attribute observed changes in agricultural systems); guided reflection on the quality of IP process; and participatory planning (see Supplementary Material).

Two of us (JD, LM) reviewed drafts of case studies and guided case study authors to strengthen evidence, address inconsistencies and make other improvements. JD also reviewed other relevant project and/or IP documents to augment and, as far as possible, substantiate case study content. These sources included progress and milestone reports submitted by project leaders to program management; reports from the contracted training and mentoring team; 'team contracts' developed as mutual commitments by project teams and IPs; change stories; reports, media communications and plans produced by IPs; and documented observations of the authors and other project and program personnel. Case studies and project reports included some quantitative data collected through project-level M&E plans and additional data collected under strict attribution protocols for standardised outcome and impact reporting required by the project funder. These included the value of additional agricultural production generated in 2014 as a direct result of the IP and associated project activities, reported in Table 3. After being generated by farmer surveys conducted by project teams in late 2014, these data were collated by one of us (IW).

Case studies and other text sources were thematically analysed using a content-driven approach (Guest et al., 2012) to examine performance of the IPs by identifying outcomes in six domains of change in the

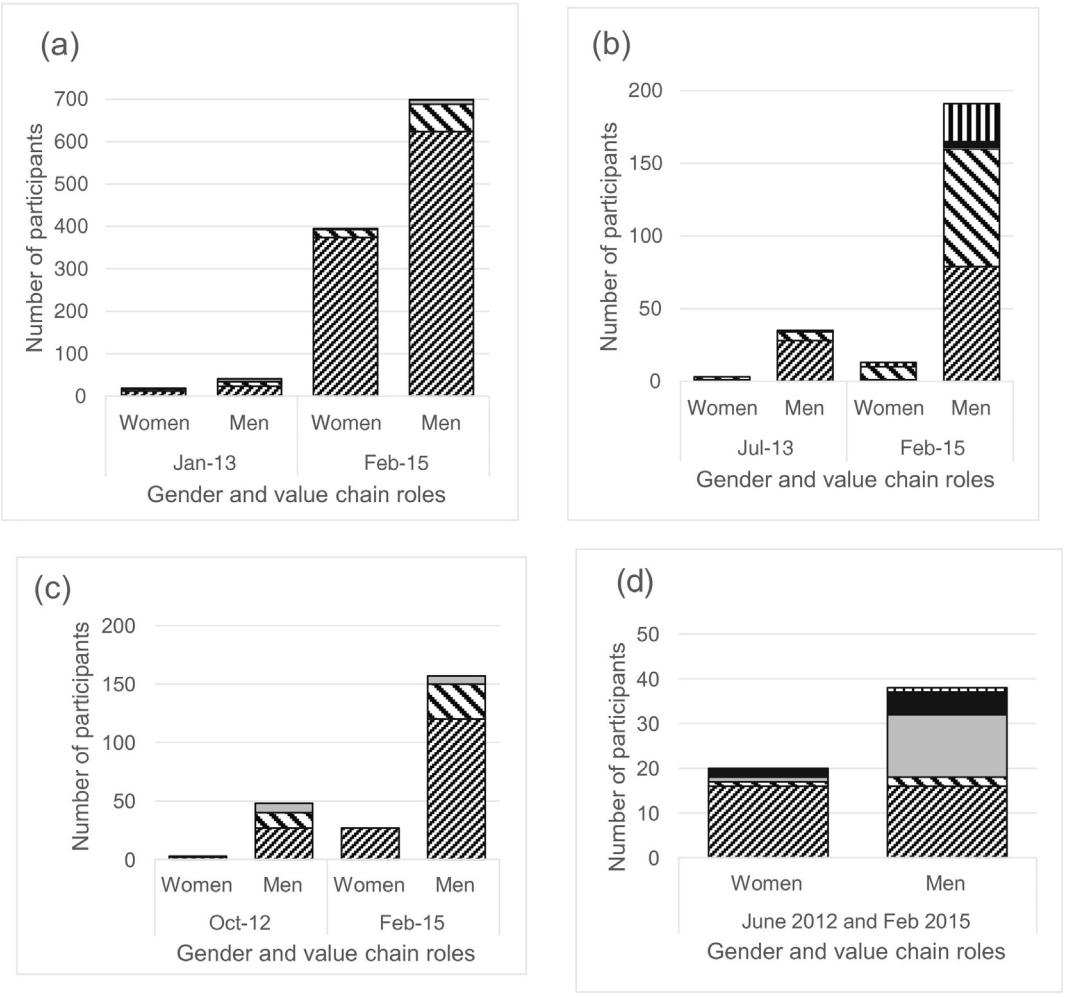

Fig. 2. Participation by gender and value chain role for four IPs (a) Banfora; (b) Martap; (c) Savelugu and (d) Pouni, at time of IP establishment and at end of the AFSI program completion phase, February 2015.

agricultural system (Table 1), and prospects for sustaining impact. Pathways or apparent causal links to performance from various structure, conduct, process and context variables in our conceptual framework were identified during this process.

5. Outcomes and impacts from the IPs

We first summarise changes in the six domains of the agricultural system (Table 1) that are attributable to the IPs. We then consider

Table 3
Domains of change in the agricultural system with outcomes and impacts resulting from IP activities.

Change domain		1: Changes in production system		2: Changes in access to production inputs			3: Changes in how the market works	4: Changes in capacity of local actors & socially embedded institutions		5: Changes in capacity of R4D system & associated institutions	6: Changes in policy, formal institutions
IP name	New technologies, practices adopted	# farmers with increased income, 2014	Income increase per farmer, 2014 (USD)	More accessible finance	More specialisation, local livelihood strategies	Other mechanisms		Emergent/unexpected capacity changes	Change in cultural/gendered institutions		
Agouna	Y	n/a	n/a	Y		Y		Y			Y
Amantin	Y	547	70		Y			Y	Y	Y	Y
Banfora	Y	875	31				Y	Y	Y	Y	
Koumbia	Y	1075	106			Y	Y	Y		Y	
Martap	Y	129	370	Y		Y	Y	Y			
Pouni	Y	1646	249	Y	Y		Y	Y		Y	
Savelugu	Y	1164	15	Y	Y		Y	Y		Y	
Thiel	Y	n/a	n/a		Y			Y	Y		
Wulugu	Y	267	97		Y			Y		Y	

how variables in structure, conduct, process and context categories of our conceptual framework (Table 1) contribute to explaining these outcomes. Thirdly, we consider the sustainability of change processes and impacts, a performance variable indicative of the quality of changes generated through the IPs (Table 1).

5.1. Changes in the agricultural system

Changes in production as a result of activities of seven of the nine IPs, being those with robust data, generated an additional USD 680,793 in 2014, which accrued as additional income to 5703 people. There is an order of magnitude difference between the IP with the least per capita income increase and that with the most, and in the number of beneficiaries (see Table 3). Per capita increases in income and the number of beneficiaries are not correlated. Considerable variation is also apparent in the outcomes reported from the nine IPs in the five other domains of agricultural system change, as summarised in Table 3 and described below.

Three important types of change were recognised in the change domain of 'access to farm inputs and services'. The first concerned access to farm credit, which was noted as a problem in most of the IPs. Experience in two IPs (Amantin, Wulugu) indicated how credit constraints substantially limited production of rain-fed crops. Whereas farmers tended to blame lack of rain for limited production, soil moisture monitoring indicated that farmers' lack of finance for seed, fertiliser and/or tractor hire commonly delayed planting which resulted in crops failing to develop roots into moist subsoils before top soils dried out. Four IPs reported improved financial access as a result of the IP negotiating with local finance providers and/or other key stakeholders and (a) becoming guarantor for its members and involved in assessing credit applications (Agouna); (b) securing changes to repayment schedules to better match production timelines (Pouni); (c) suppliers starting to provide farm inputs on credit to other IP members (Savelugu); (d) formation of womens' savings groups (Martap).

A second type of change in 'access to production inputs' was through increased specialisation in local livelihood strategies involving the emergence of new entrepreneurs from amongst the people involved in the IP who began to sell goods and services that were previously unavailable or in short supply locally. In Savelugu and Pouni these were producers and sellers of certified seed, whose emergence was a direct outcome of project investments in training and in negotiating purchase contracts. Other new livelihood strategies were production of livestock mineral salt licks which producers wanted to buy after observing that their goats stopped eating plastic rubbish when they had access to salt (Amantin), and growing cowpea fodder in a locality where fodder crops were previously little known (Thiel). In Agouna, improved access to veterinary services resulted from the first private veterinary practice being opened locally, following increased demand from livestock owners who had received training in recognition of prevalent treatable diseases. In Koumbia and Martap, collective purchasing of farm inputs was initiated.

'Changes in how the market works' were identified in five IPs (Table 3). In three of these cases, farmers were increasingly producing to market demand and had contracted to supply particular grain varieties (Koumbia) or certified seeds (Pouni, Savelugu) for the first time. In Banfora, coordination of milk production and processing developed across distances of >80 km. The IP's investments in mechanised transport were a key enabler. These, together with improved access to fodder and a novel agreement on milk sale price, improved the supply of milk to an established dairy processing plant and to two smaller processing cooperatives that had been initiated in 2012. The total quantity of milk collected and processed increased from 13,468 l in 2011, prior to the establishment of the IP, to 275,703 l in 2014. New livelihood activities included coordination of supply and transport at designated collection points. Demands on women's time and energy reduced because they were no longer tied to walking door-to-door to sell their surplus milk.

Activities directed at changing the capacity of local actors, mostly training in technical knowledge and skills, were central in each IP, as the 'Activities' listed in Table 2 indicate. Each IP also reported at least some degree of emergent or unexpected change in capacities of local actors. Some of these changes were at a deeper system level, impacting on the institutions that enable or constrain the capacities of local actors. For example, in Amantin famers collaborated to develop a warehouse for better storage of farm produce, reducing the imperative for them to sell post-harvest when prices were low. In Agouna, a marked increase in inter-ethnic social capital emerged from the IP's successful efforts to informally resolve intra-community conflict. Conflict resolution was not on the agenda when the project team started to facilitate establishment of the Agouna IP. However the difficulties they encountered in convening a meeting involving both pastoralists and agriculturalists indicated the need for a peace process. One of the IP's first actions, in 2012, was to establish a committee for prevention of conflict and resolution of disputes. By early 2015, this committee had settled 200 conflicts such that no conflicts needed to be referred to the pre-existing judicial process. From 2012 to 2015, the number of conflicts reduced from at least one per day to three or fewer per week and conflicts were observed to be less violent. The number of animals injured in conflicts reduced from an average of 14 p.a. between 2007 and 2011 to 3.3 p.a from 2012 to 2014. Local people reported flow on impacts that included strengthened trade in animal products and easier access by agriculturalists to milk, cheese and manure. These changes made Agouna IP actors confident to negotiate with local authorities for infrastructure that they had identified as important to reducing future conflict and building stronger livelihoods.

Several IPs (Amantin, Banfora, Koumbia, Pouni, Wulugu) reported more extensive and stronger networks and relationships, particularly between farmers and other value chain actors, with greater trust and more information sharing. In Savelugu the social capital from the IP's relationships with chiefs and elders was levered to influence livestock owners to restrict animal movements while crops were becoming established but nearby Wulugu noted that they had lacked capacity to prevent cattle damaging crops. In Martap increased capacity of local actors was aligned to expansion in APESS' local organisational capacity and membership. Elsewhere, producers were observed to be more confident in seeking information including, for the first time, telling extension services what their information needs were (in Agouna) and leading the organisation of new production experiments (in Koumbia). Increased producer capacity for negotiation and advocacy was also noted (in Koumbia); and stronger market orientation amongst farmers (in Banfora, Savelugu). In Banfora, IP participants were able to envision and map the dairy value chain as an interconnected system of people extending across their region whereas they had previously only conceptualised milk production at household scale. In Pouni, farmers had come to understand that productivity gains do not require farming larger areas, indicating potential to slow the trend of expansion of farming into new areas, and seed producers had better capacity to meet the requirements of national regulations and hence avoid their seed being downgraded by inspectors.

Changes in institutions governing gender roles provide other key examples of increased capacity of local actors. Women's voices were heard strongly in some of the IPs. In Amantin, women began to make decisions about sale of livestock, which was previously solely a men's role. In Banfora and Thiel women were observed to participate in debates and decisions of the IP without inhibition, indicating a change in cultural/gendered institutions that had precluded women and men meeting in the same place and time to discuss matters affecting their society. Banfora women said this change enabled them to express their vision for eradicating other gendered norms that they considered outdated, such as that women should not eat when men are present.

Two of the six domains of change in agricultural systems encompass potential impacts beyond the local scale where the IP activities were focused. The first of these, changes in the capacity of the R4D system, was indicated by producer members of some IPs (Amantin, Banfora, Savelugu) reporting they had better access to research and extension personnel and more influence on research agendas and collaborations than they had previously experienced. Researchers were reported to have developed new skills in facilitation in two IPs (Amantin, Wulugu). New collaborative configurations were apparent in the R4D system in Banfora where selection of a representative of the local chamber of agriculture as IP facilitator proved to be a valuable conduit to gaining support from the chamber and from regional development policy actors. Change also occurred within organisations. When these nine IPs were established, IPs and IAR4D were virtually unknown concepts to the research and development actors involved. In all the projects these actors and IP members gained experience in initiating and building new relationships with people in diverse other roles and sectors. Changes at local level resulting from the IPs in Ghana (Amantin, Savelugu, Wulugu) influenced high level change in the research approach of the national Crops Research Institute. Experiences with the IPs in Burkina Faso (Banfora, Koumbia, Pouni) contributed to the IP approach becoming part of development policy.

The second extra-local domain for changes in the agricultural system, 'change in policy and formal institutions', did not emerge strongly from the experiences and activities in most of the IPs. Agouna was however influential. By connecting with local development policy planners, sharing experiences in conflict resolution and building social capital, the IP became a source of advice on establishment of other projects in the area. In Amantin, enforcement of maize sale weights and bag standards started, and extended beyond the IP area, as a result of the IP's engagement with local policy makers.

5.2. Explaining changes in the agricultural system

Thematic analysis indicated factors that were important to explaining the changes in the agricultural system that are summarised above. These factors are outlined in Table 4 against applicable categories of variables in our conceptual framework (Fig. 1, Table 1) and described below.

Context was indicated as a particularly important explanatory factor in four cases. Banfora and Koumbia built on trust that existed between project team members, producers and some other stakeholders from antecedent projects and networks. In Banfora and Thiel, cultural norms supported women having a strong role in milk value chains. Banfora and Savelugu each had an established trading enterprise with

Table 4
Factors indicated as important to explaining performance, identified from thematic analysis and sorted by categories of variables in the conceptual framework for IP effectiveness.

Category of variable from conceptual framework for IP effectiveness					
IP name	Context	Structure	Conduct	Process	Performance
Agouna		Accountability	Increased mutual trust, respect amongst ethnic groups; and by microfinancers	Soft skills training Good meeting organisation & IP communication	
Amantin		Cooperative structure aligned the shared interests and self-interest of members	Trust, respect between producers and project team (generated through training, experiential learning)	Annual planning by IP with project team Vibrant IP & project leadership	Benefits experienced have maintained members' interest, aroused other local interest
Banfora	Demand for milk from established commercial dairy Cultural norms for women's strong role in milk production Established APESS networks	Tiered structure	Inclusive democratic norms Transparency amongst leaders	AESS leadership, shaping the IP vision Consultations and regular exchanges amongst actors	Behaviour changes achieved: shift from extensive to semi-intensive livestock production; women's strong role in milk production extended into region-scale value chain
Koumbia	Long trusted relationships between producers & project team		Fairness, taking all members' interests into account	Coordination of IP activities	
Martap		Access to capitals via APESS local capacity (information, organisational etc)		Good planning, (generated good quality relationships) Revitalised IP leadership in 2014	
Pouni			Mutual understanding, support (from interactions amongst IP members)	Extensive technical training and awareness raising	
Savelugu	Established certified seed producer with capacity to support outgrowers	Cooperative structure aligned the shared interests and self-interest of members			
Thiel	Cultural norms for women's strong role in milk production				
Wulugu			Enthusiasm of producers (generated by increased production)		

capacity to expand that stood to benefit from increased local production. Engagement with these market actors focused these IPs' attention on value chains from an early stage.

Another influence from context was the nature of the project lead organisation and its frames of reference. For example, efforts by the NGO project leader APESS to strengthen dairy value chains in Banfora and Martap were underpinned by that organisation's accountability to its livestock producer members and embeddedness in the local development context. APESS tended to give early attention to helping producers conceptualise value chains and to take action to realise their potential roles. Different contexts of Banfora and Martap influenced the effectiveness of these efforts. In Banfora, the market-connected interdependence between an established dairy processor with unused processing capacity, as noted above, and livestock producers interested in increasing their milk production led to the processor engaging directly in efforts to increase milk production through improved animal nutrition, and in solving transport challenges. Such interdependencies were not so apparent in Martap where no large-scale processor was involved in the IP and augmentation of regional dairy processing capacity was still underway at the end of the project.

Conduct variables (e.g. trust, transparency, fairness) and process variables (planning, leadership, consultation, coordination, training) are prominent explanatory factors for change (Table 4). Project teams and IP facilitators invested heavily in bringing people together, opening lines of communication and providing arenas for dialogue. These efforts were reported to have increased mutual understanding and trust, particularly in Agouna, Amantin and Pouni.

Structure was indicated as influential in explaining positive outcomes in several IPs. For example Agouna's effort to clarify its structure was indicated to have brought accountability to local decision-making. In Amantin and Savelugu, the registration of the IP as a cooperative was identified as a factor that explained its outcome because this structure was considered to balance the self-interest and shared interest of members. In Martap, structure variables were indicated as influential through a different pathway, through the increased access that IP members had to various forms of capital as a result of APESS' leadership of the project, which was aligned to expansion in APESS' local organisational capacity and membership. Generally, however, IP structures addressed producers' interests more directly than those of other stakeholders. In some cases IPs became unwieldy when large numbers of farmers joined, attracted by specific benefits that depended on membership (e.g. involvement in certified seed production in Savelugu, Fig. 2c, and easier access to credit in Agouna). Producer members tended to have a stronger sense of ownership of the IPs than others. Amantin's decision to establish a storage centre for farm produce reflected the strength of cooperation amongst its farmer members. In Wulugu, high demand from farmers to join the IP was not matched by interest from other stakeholders: farm input suppliers/agrodealers and financial organisation representatives nominally belonged to the IP but rarely attended meetings. In Pouni there was good impact on social capital from the involvement of agrodealers with farmers in the IP, but the agrodealers failed to deliver on promised action. Banfora was characterised by strong engagement from one large dairy processor. However one disappointment was the lack of attention to downstream linkages along the value chain that could grow demand for dairy products and help to sustain growth in milk production.

Positive feedback was indicated from good IP performance to other variables. For example, in Wulugu producer enthusiasm (a conduct variable) generated by production increases was indicated as important for explaining other IP outcomes (Table 4). In Agouna increased social capital resulting from the IP's success in resolving pastoralist-agriculturalist conflicts and increased financial capital from the IP brokering improvements in producer access to credit was suggested by local actors to have led to much more vibrant local markets. In Banfora initial success in shifting to semi-intensive livestock production without compromising cultural norms of women's strong role in milk production stimulated scale out of commercial production across the region. Associated changes to institutions constituted triple-loop learning (Table 1) that had been enabled by a combination of context, structure, conduct and process variables (Table 4).

5.3. Sustaining outcomes and impacts

Factors identified from thematic analysis that affected each IP's prospects of sustaining change processes and impact are summarised in Table 5 by the category of variables in the conceptual framework that they most directly relate to, and are further explored below.

The IPs tended to consider that sustaining change required sustaining the IPs themselves. All consequently faced challenges associated with factors associated with structure variables in our conceptual framework, notably covering the costs of their meetings and other activities after the program finished including travel by key members who lived at a distance. Two IPs (Amantin, Savelugu) were showing a degree of independence from their associated project teams by early 2015. Both had agreed, documented plans and intended to cover their operational costs through IP-owned enterprises and/or IP member dues. Context variables also supported Amantin in that the project teams saw reasonable prospects of maintaining support relationships because team travel would be facilitated by proximity to other work sites. Prospects of ongoing active support from the project lead organisation were also strong for Banfora and Martap because of the strong alignment between IP membership and membership of the project lead organisation, APESS. In Martap, APESS staff had also secured donor funding for a follow-on project whereas in Banfora a high level of satisfaction of IP members with the outcomes from the IP's operations had generated strong commitment to continue their collective efforts.

Market signals were unlikely to contribute to sustaining change trajectories in most of these IPs. During the completion phase, project teams had ramped up the attention they and IPs were paying to market engagement and the diversity of value chain actors interacting with farmers had increased markedly in some cases (e.g. see Fig. 2). Positive impact on social capital from identifying win-win outcomes for farmers and traders and developing stronger business relationships was particularly noted in Koumbia. Market orientation is more apparent in the visions developed by IPs toward the end of the completion phase (Table 2) than in the aims articulated for their establishment (also see Table 2). Nevertheless at the end of the completion phase, market signals were still a very new influence on most farmers' production decisions.

Increased trust, noted above as a variable explaining performance in several IPs, is a legacy that we expect the IPs and/or future projects will be able to build on. Other factors indicated as important in various IPs for sustaining change processes and impacts included social capital, particularly linkages to local leaders and decision-makers, commitment by key entrepreneurial IP members, and skills such as negotiation that had developed during the IP activities (Table 5). Conversely, challenges were associated with process variables (e.g. high reliance by the IP on the project team and lack of attention to IP governance processes such as participatory decision-making); and conduct variables, notably the weak sense of ownership by value chain actors other than producers, and instances of low trust (Table 5).

6. Discussion

Analysis against the groups of variables in the conceptual framework shows that diverse variables, categorised into structure, conduct, process or context groups, contribute to explaining performance of these nine IPs in terms of changes in six domains of agricultural systems and in terms of prospects for sustaining impacts and changes. One strength of our conceptual framework is that it is broad enough to accommodate this diversity in contributing variables. However an associated weakness is that the conceptual framework does not offer optimal guidance about how the various variables combine and sequence in fostering

Table 5
Prominent factors affecting prospects of ongoing change and impact from the IP by category of variables in the conceptual framework for IP effectiveness, showing factors expected to have positive impact (plain text) and factors expected to have negative impact (italic text).

IP name	Category of variable from conceptual framework for IP effectiveness				
	Context	Structure	Conduct	Process	Performance
Agouna		Enhanced social capital *No earned income/funding source to cover IP costs* *Accession processes for new members*	Assertive, proactive IP members	Negotiation skills *Limited leadership capacity* *Lack of attention to IP governance*	
Amantin	Other projects in area enhance prospects for future project team support	Agreed, documented objectives, action plan Developing financial independence from project including business plan Formal registration in train (generating confidence, opportunities for external support) *Limited literacy of members; low financial capital and facilitation skills* *Limited engagement of actors except producers*	Commitment of key members to sustaining IP Strong sense of ownership amongst producers *Weak sense of ownership by other value chain actors*	Local champions	
Banfora	*Poor infrastructure (roads, energy); water supply constraints*	Clear agreed and documented vision and objectives Ongoing APESS support to IP *Limited producer access to credit*	Commitment of key members to sustaining IP		High satisfaction of IP members with results to date
Koumbia		Local authority support Established IP governance structure Strong value chain relationships developing *No earned income/funding source to cover IP costs*	Dynamic producer organisations, committed to IP vision Open expression of views, commitment to win-win outcomes	*High reliance of IP on project team for facilitation, information*	
Martap		Vision and action plan in development for milk value chain Ongoing APESS support to IP Follow on project from another donor *Little business planning, market links; organisational capacity* *Limited producer access to credit*		*Lack of attention to IP governance*	*Only early stage outcomes for strengthened milk value chain*
Pouni		Enhanced social capital Partnerships with buyers of certified seed	Dynamism of IP members		*No local agro-dealer/seed sale shops established*
Savelugu		Documented vision and work plan Well established governance structure tied to production contracts Developing financial independence from project	Strong shared interest of IP members Developing market orientation		*Only half IP members had increased income*
Thiel	*Poor infrastructure (roads, energy)*	Renewed vision and focus on milk value chain Strong IP connection with local leaders *Little or no attention to access to credit; market links, producer organisation links* *No earned income/funding source to cover IP costs*	Enthusiasm of IP members for new technologies *Narrow local ownership of IP, limited trust*	*Lack of attention to IP governance*	*No progress achieved with milk market connection*
Wulugu	*Erratic rain/climate change* *Herder-farmer conflict*	Agreed documented operational plan Developing financial independence from project *Limited relationships & engagement with value chain actors and policy other than producers*	Strong group cohesion, high commitment of key members	*Limited processes to generate collaboration, strong networks, relationships* *Lack of ways to influence policy/politics relevant to herder-farmer conflicts*	*Low trust in IP-trained community animal health workers*

change. Further, the very diversity of contributing variables implies that achieving change in agricultural systems through IAR4D is highly context-specific, which raises challenges for efficiency. While our conceptual framework does not provide ready guidance, Maru et al.'s (2016) application of theory of change to IPs and IAR4D offers useful complementary explanations.

Maru et al. (2016) identify four interacting and interdependent impact pathways mediated respectively by market linkages, social capital, institutional change or innovation capacity. The journeys of the nine IPs we are concerned with most closely fit the social capital-mediated impact pathway. This pathway posits that increases in agricultural innovation, with consequent impacts for reduced poverty and increased food security, are emergent from increased social capital and social learning (Maru et al., 2016). Social capital is a structural variable in our conceptual framework while social learning is a process variable whose effectiveness is aided by the conduct variable of trust and the structure variables of access to information, resources, skills and services. Trust was enhanced in the nine IPs, most strongly amongst producers, who formed the majority of IP members, and with the research teams, through dialogue and knowledge-sharing, resources and experiences in the course of IP meetings and other IP activities.

The other three impact pathways identified by Maru et al. (2016) were less apparent in the nine IPs that we are concerned with. This relative absence, discussed further below, contributes to explaining the limited return on investment delivered by these IPs, which is starkly apparent when the quantum of AFSI program completion phase expenditure for direct or indirect support to these nine IPs, totalled at least USD 2 m, is compared to the very modest increases in 2014 producer income that are attributable to IP activity (Table 3).

The market linkage-mediated pathway to change identified by Maru et al. (2016) posits that value chain actor participation, which is a structure variable in our conceptual framework, and market orientation, a conduct variable, foster interdependence amongst IP members, reducing transaction costs and promoting collective action on marketing, transport and bargaining power. Amongst the project lead organisations, APESS most strongly engaged this pathway, realising the development of a region-wide dairy value chain in Banfora even though context and structure variables frustrated a similar outcome in Martap. The market-linkage mediated pathway was less prominent in IPs established in projects led by national agricultural research institutes. In these cases framing of projects tended to reflect researchers' familiarity with using demonstrations, training and on-farm experiments to introduce farmers to new agricultural technologies. The underpinning logic was that farmers needed to see and believe in the possibility of production increases before they would change their mindset from subsistence to regarding farming as a business. This logic is supported Sparrow and Trαore (2016) who found, albeit in relatively more arid environments than those of the IPs we are concerned with, that IPs' self-assessments of their own functionality were positively correlated with the number of months per year that households of farmers associated with the IP were able to feed themselves from their own production.

Researchers in the IPs we are concerned with considered that producers needed to experience the production increases that were achievable through better farm inputs before they would be motivated to engage with markets. Production increases were expected to boost conduct variables such as confidence and courage or risk appetite amongst producers. The two to three year period over which our nine IPs were in receipt of project/program support was too short for these impacts to become well established, which is unsurprising given that innovation processes commonly evolve over periods of a decade or more in sub-Saharan Africa (Triomphe et al., 2013). However the need for longer project time frames needs to be assessed critically due to the potential for perverse outcomes such as actors becoming dependent on project support and adopting technologies that are unsustainable (Triomphe et al., 2013). Solid engagement of a range of market actors from the establishment phase of IPs would help to manage such risks. This will, in turn, require that diagnostics and project planning encompass the perspectives of these actors on the agricultural system and potential benefits to them from the operations of an IP.

The institutional change-mediated pathway (Maru et al., 2016), which is well articulated by Hounkonnou et al. (2016, 2012), involves change in formal and/or informal institutions that determine the opportunities and behaviours available to people. Agricultural systems and their actors may be able to adapt and become better adjusted to their environment without institutional change, for example by adopting new crop varieties and changing their planting techniques. However adaptation is in itself unlikely to be sufficient to achieve markedly enhanced agricultural productivity, human wellbeing and natural resource condition. Transformational change is required, affecting multiple scales of the system, multiple system elements and feedbacks amongst them (Moore et al., 2014). Powerful catalysts for transformative change, such as new road construction (Kelly et al., 2003), may be well outside the usual domain of agricultural actors. Narrow framing, such as in diagnostic studies of many of the nine IPs which focussed mainly on producer experiences and perspectives, can render such opportunities for change invisible.

Institutional changes that affect one level of a system may or may not catalyse system transformations (Moore et al., 2014). For example changes occurred in several of the nine IPs in institutions that determine gender relations and that govern producer access to finance. However associated impacts appear to have been restricted to the immediate sphere of the relevant IP. Much more extensive change was indicated by narratives from Agouna about rapid regional economic growth after the IP prioritised action that reduced herder-farmer conflict. System complexity suggests that flow-on impacts from reducing social conflict could well be extensive and multi-faceted. However the potential for such action and impact was not taken into account in project design, baseline data and in the use of summative M&E methodology, making robust confirmation of these impacts difficult. Such limitations highlight the importance of ensuring that establishment of IPs is responsive to diagnostic studies whose scope is far wider than constraints to production, encompassing analysis of the impact and opportunities from context, formal and socially embedded institutions, policy directions, and innovation system actors.

Experience in these IPs indicated an institutional gap in some localities: a dearth of organisations supporting collective action amongst producers such as cooperatives for marketing produce or purchasing farm inputs or for advocating producer interests. This gap is of concern because collective action, generated most readily through structures that promote stable membership by people with similar perspectives and norms, can strengthen livelihood security and capacity to cope with and adapt to change (Andersson and Gabrielsson, 2012). Producer organisations are recognised as a key institution that enabled growth in USA agricultural productivity (Hounkonnou et al., 2012) and their relative absence has made effective producer representation in multi-stakeholder forums problematic in sub-Saharan Africa (Hocdé et al., 2008). Amongst the IPs we worked with, APESS, representing livestock producers, was a rare example. Some of the nine IPs seemed to be evolving to fill this institutional gap locally, a development that was supported by the strong producer orientation amongst project teams resulting from experiences with participatory approaches to increasing farm productivity.

Producer organisations are, however, very different structurally to the model promulgated for IPs as fluid configurations of diverse stakeholders connected vertically through roles in a value chain. Whereas stable membership is important for producer groups to foster collective action on common interests, IPs warrant some fluidity in membership to remain dynamic forums where knowledge sharing generates fresh insights. Whereas horizontal networking can build farmer capacity through cooperation to address common problems or opportunities, linkages across the 'vertical networks', that bring different perspectives to a problem and different kinds of resources to an opportunity and that highlight the interdependence of actors, are of key importance for innovation and system change (Kebebe et al., 2015; Kuhne et al., 2015).

The architecture and dynamics of networks are central to the innovation capacity-mediated pathway which is the last of the four pathways to change that Maru et al. (2016) identify as being engaged by IAR4D and IPs. It has causal linkages with each of the other three pathways. Innovation capacity is a broad and messy concept promulgated to emphasise that changing agricultural systems requires investment, not simply in training scientists to develop inventions, but in the skills, actors, practices, institutions and policies that put knowledge into productive use in an adaptive way (Hall, 2005). The innovation capacity impact pathway is enabled by individuals and organisations acting as innovation brokers who facilitate interactions between different kinds of actors and who, drawing insight from systemic reflection, are sufficiently nimble to respond to changing system configurations and opportunities (Klerkx et al., 2012b; Maru et al., 2016). Project leaders, IP facilitators, local entrepreneurs and politicians were amongst the individuals who acted as innovation brokers in the nine IPs. Connections across system scales and organisational levels such as made by these individuals are necessary for local actors to influence change in the deeper level institutions that structure their interactions and outcomes, as is well established in the broader SES literature (e.g. Cash et al., 2006).

Our conceptual framework does not provide well for the role of such individuals as change agents. While leadership is amongst the process variables that the framework indicates as important to effective IPs, desirable leadership attributes warrant closer attention. Klerkx et al. (2012b) follow several other analysts in arguing that, to be equipped

for such roles, researchers need to augment their disciplinary specialisations with interdisciplinary and transdisciplinary capacity in order to apply soft systems approaches that chart actors and their interactions from multiple perspectives. Associated monitoring and evaluation needs to be developmental and dynamic, designed using systems thinking, and with capacity to change measures as change processes unfold (Patton, 2011).

Further insight to desirable leadership qualities is afforded by research on 'orchestration capability', the interconnected competencies of organisations and individuals that enable them to purposefully build and manage inter-organisational networks that support innovation (Ritala et al., 2009). Key attributes of individuals that are important to orchestration capability are interpersonal communication and social skills; balancing skills, being the ability to take a system view and see the perspective of all actors; and negotiation, entrepreneurial, influencing, visioning and motivating skills (Ritala et al., 2009). Organisations evolve their orchestration capability through the actions of individuals over time that become institutionalised into routines. Social-ecological systems literature also recognises that system transformation, which requires scaled-up change, depends on powerful actors institutionalising a change trajectory and that those actors can just as readily resist or block change (Moore et al., 2014). This indicates that the ability of research and development organisations to effectively support innovation in the agricultural systems of sub-Saharan Africa ultimately depends on individual actors' capacity to influence change within their own organisations.

7. Conclusion

We drew on a conceptual framework to examine how the actions of nine locally constituted IPs generated changes in the agricultural system in west and central Africa. The most prevalent changes were increased production and improved technical knowledge amongst those producers who were directly or indirectly involved in IP activities. The value of these changes to people involved with the IPs led many of them to judge that the IPs were effective. However the impact of these IPs on deeper level institutions that have broader influence on agricultural systems and food security was modest, constraining prospects for future impact at scale.

The expectation arising from our conceptual framework, that a large number of variables and interactions would influence how these IPs generated outcomes and impacts, was substantiated. Four interconnected impact pathways for IAR4D (Maru et al., 2016) augmented our understanding of causal relationships amongst variables in our conceptual framework that contributed to observed changes and limitations. The nine IPs most commonly engaged the social-capital mediated pathway to systemic change, in which innovation is stimulated by increased trust, augmented networks, better access to information and other resources and increased capacity for collective action, which are mostly variables that our conceptual framework categorised as conduct or structure. Reflecting this impact pathway and the prevalence of producer members, some of the nine IPs were evolving into producer collectives or producer representative organisations which were otherwise missing from their local institutional landscapes. However this tended to limit other value chain actors' sense of ownership of these IPs and their effectiveness as multi-stakeholder forums. Substantive augmentation of the social capital mediated pathway by a market-linkage mediated pathway was readily apparent in only one IP and nascent in several others. Changes were apparent at local scale in some institutions. Broader scale systemic impacts from local institutional change were suggested to be occurring, but only in one case. Failure to more strongly engage these other impact pathways contributes to the apparent ongoing dependence of these IPs on external 'project' funding and limits the potential for market signals, interdependencies amongst value chain actors and institutional change to drive future innovation.

Producer-centric approaches from traditions of participatory technology development were applied in the establishment of most of these IPs, backed by research that emphasised optimisation of farming systems. These approaches did enhance farm productivity. However they were generally too limited in scope to nudge agricultural systems, with their broader scale and multiplicity of actors, to innovate and transform. As a complex systemic multi-scale phenomenon, innovation demands that change processes are facilitated across a canvass that is much broader than individual or neighbouring farms. Key to this facilitation are individuals and organisations with capacity to purposefully build and manage inter-organisational networks, promote knowledge exchanges and manifest the interdependencies that will foster emergent innovation. Conflicting institutions, and institutional gaps, will often constrain these efforts. Investments in diagnostic studies of the institutional landscape and innovation system capacity should be a prerequisite to the design and establishment of IPs and be used to identify key targets for institutional change. Prospects for transformative change that build on experiences in establishing and supporting IPs will be strengthened by critical reflection on successes and disappointments and by applying such learnings to building capacity amongst research and development actors. This paper contributes to that effort.

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Appendix A. Supplementary data

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