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Compositional dynamics of multilevel innovation platforms in agricultural research for development

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Abstract

Innovation platforms (IPs) form a popular vehicle in agricultural research for development (AR4D) to facilitate stakeholder interaction, agenda setting, and collective action toward sustainable agricultural development. In this article, we analyze multilevel stakeholder engagement in fulfilling seven key innovation system functions. Data are gathered from experiences with interlinked community and (sub)national IPs established under a global AR4D program aimed at stimulating sustainable agricultural development in Central Africa. Our findings show that all innovation systems functions required multilevel action, but that fulfillment of specific functions demands for strategic involvement of specific stakeholders at specific levels. We observed that a research- and dissemination-oriented sequence in the functions was prioritized in AR4D IPs and argue that such a sequence may be different in other types of (business) IPs. Our findings provide an incentive to think function oriented about compositional dynamics (stakeholder groups * levels) in innovation processes, rather than striving for equal stakeholder participation.

Key words: inclusive innovation; functions of innovation systems; systemic instruments; transdisciplinary science; scales; multilevel action.

1. Introduction

Over the past decades, agricultural research for development (AR4D) expanded its scope and boundaries. Recurrent failure of the 'old' linear technology transfer approach to realize the development potential of Sub-Sahara Africa (SSA) and instil transitions to sustainable agriculture, stimulated scientists to better consider the complex context in which technologies were to be applied (Hounkonnou et al. 2012; Pamuk et al. 2015; Röling 2009). A gradual shift took place from narrow technology-oriented approaches to more holistic systems approaches that focus on understanding how interactions between different value chains, actors, and organizations across different levels influence agricultural innovation processes (Douthwaite et al. 2009; Klerkx et al. 2012). In line with generic debates on the emergence of a more interactive and transdisciplinary science (Schut et al. 2014; Turnhout et al. 2013; Wittmayer and Schäpke 2014), this has prompted a reorientation of AR4D enlarging the scope of problems targeted and the groups of stakeholders that participate in finding solutions to these problems (Adekunle and Fatunbi 2012; Birch et al. 2011; Hounkonnou et al. 2012; Kropff et al. 2001; Schut et al. 2015a; Woodhill 2014).

One of the most evolved and widely advocated systems approaches in AR4D, especially in SSA, is the agricultural innovation system (AIS) approach (Foran et al. 2014; Hall et al. 2003; Kilelu et al. 2013; Klerkx et al. 2013; Schut et al. 2015a). This approach is heavily influenced by the thinking on national, sectoral, and technological innovation systems. As Klerkx et al. (2012) have indicated, the AIS approach emerged from a merger of approaches to study innovation in agriculture (such as the Agricultural Knowledge and Information Systems approach—Röling 2009) and the literature on national, sectoral, and technological innovation systems (Hekkert et al. 2007; Lundvall 1992; Lundvall et al. 2009; Malerba 2002) which has its empirical applications mostly in industrial sectors. AIS are, in some studies, approached as national or sectoral systems, analyzing innovation capacity at a country or subsector level (e.g. dairy, horticulture), but are sometimes also seen as technological innovation systems in which a particular technological change trajectory or system change is analyzed, for example, around biotechnology or precision farming (Eastwood et al. 2017; Hall 2005; Klerkx et al. 2012).

In innovation systems, innovation is seen as a process of interactive learning between multiple actors in national, sectoral, and technological domains, but can be more or less oriented toward demand-side actors and informal processes (Foster and Heeks 2013a,b). An important feature of AIS in AR4D is a focus on inclusiveness (Ayele et al. 2012), which links to emerging concepts like inclusive innovation and inclusive development (Foster and Heeks 2013a,b; Fressoli et al. 2014; Ros-Tonen et al. 2015; Swaans et al. 2014). Both concepts make a deliberate effort to connect formal research and large business players with consumers and producers at the 'base of the pyramid' to develop products and solutions that are tailored to the preferences, possibilities, and livelihoods of the poor. Based on Foster and Heeks (2013b), we outline the main differences between conventional innovation systems and inclusive innovation systems (Table 1).

Similar to ideas from national, sectoral, and technological innovation systems literature (Adeoti and Olubawima 2009; Wieczorek and Hekkert 2012), the heart of the AIS approach lies in the recognition that innovation is embedded in, and affected by complex interactions in the system. Sustainable change thus requires co-evolution between, and effective re-organization of, the system's technical, social, and institutional components—including social norms and common modes of operation (Dormon et al. 2007; Flor et al. 2016; Kilelu et al. 2013; Klerkx et al. 2013; Leeuwis and Aarts 2011; Ngwenya and Hagmann 2011; Rodenburg et al. 2015; Schut et al. 2016b). As argued above, effectuating such change in an inclusive way requires involvement of different stakeholder groups (Foran et al. 2014) and fostering of interaction and interactive learning among them, which calls for process facilitation by intermediary actors and structures (Foster and Heeks 2013b; Howells 2006; Klerkx et al. 2015; Meyer and Kearnes 2013) that focus on facilitating interaction and integration of several actors.

Such intermediary structures have also been referred to as 'systemic instruments' (Smits and Kuhlmann 2004; Wieczorek and Hekkert 2012) in literatures that focus on systemic interaction in national, sectoral, and technological innovation systems. As an expression of such a systemic instrument applied to the agricultural context, AR4D increasingly employs IPs—in this article defined as multi-actor spaces allowing stakeholders from different backgrounds to identify, prioritize, and address issues of mutual concern (Adekunle and Fatunbi 2012; Kilelu et al. 2013; Ngwenya and Hagmann 2011; Pamuk et al. 2015; Sanyang et al. 2016; Schut et al. 2016a; 2017; Swaans et al. 2014; Thiele et al. 2011). IPs draw on actors from different levels and positions in innovation systems (ie producers, processors, traders, retailers, and consumers), as well as those who support them (enabling and conditioning actors such as regulators, advisors, and researchers), and enable a process of negotiation and re-orientation of the linkages in innovation systems, often with the purpose to make these more inclusive to the poor (Ayele et al. 2012; Ros-Tonen et al. 2015; Swaans et al. 2014). The variety of knowledge, skills, and resources brought together in IPs, the social networks they can enable, and the learning they can facilitate, are considered vital for their potential to foster innovation (Ayele et al. 2012; Lamb et al. 2016; Otiende et al. 2014; Schut et al. 2016a; Struik et al. 2014; Swaans et al. 2014).

In the literature on IPs, different scholars confirm the potential of IPs to facilitate agricultural development and innovation, especially at community level (Ayele et al. 2012; Kilelu et al. 2013; Pamuk et al. 2015; Sanyang et al. 2016; Swaans et al. 2014). However, their ability to effect durable change and impact is very context dependent (Ngwenya and Hagmann 2011; Pamuk et al. 2015; Schut et al. 2017; Swaans et al. 2014; Van Paassen et al. 2014). The majority of agricultural IPs in SSA focus at the community level and scholars point out that these IP often encounter difficulties in tackling more structural barriers for innovation that require interventions at higher systems levels (Cullen et al. 2014; Hounkonnou et al. 2012; Röling et al. 2012; Schut et al. 2016a; Struik et al. 2014; Van Paassen et al. 2014). Examples of such structural barriers include poor access to agricultural services, land, credit, high quality inputs and markets (e.g. Schut et al. 2015b), and unequal power relations (i.e. gender), and control over resources (e.g. Giller et al. 2008). When remaining unaddressed, such structural barriers also become obstacles for innovations to spread beyond the scope of the IP and achieve the desired development impact at scale.

Acknowledging the challenges of impact at scale and multilevel dynamics in innovation processes (Hansen and Coenen 2015; Hermans et al. 2016; Makkonen and Inkinen 2014; Österblom et al. 2015; Westley et al. 2014; Wigboldus et al. 2016), AIS scholars argue for more explicitly addressing innovation as a process occurring across levels where different stakeholders can enact or resist to change (Cullen et al. 2014; Foran et al. 2014; Rodenburg et al. 2015; Schut et al. 2015a; Van Paassen et al. 2014). One suggested approach is the creation of interlinked IPs; that is, community-level IPs to address local issues and (sub)national-level IPs to address

Table 1. Comparison conventional and inclusive innovation systems (adapted from Foster and Heeks 2013b)

	Conventional innovation systems	Inclusive innovation systems
Innovation	Main focus on: - Growth-oriented innovation - Supply-driven innovation - Technical innovation	Main focus on: - Local needs-oriented innovation - Demand-driven innovation - Non-technical innovation
Actors	Main focus on: - Higher-income markets/consumers - Formal supply side organizations in industrial sectors - Intermediaries as information/knowledge brokers	Main focus on: - Low-income consumers and producers - Non-traditional, informal, demand-side innovators - Intermediaries as facilitators of interaction and integration
Learning	- Learning about production and implementation - Learning about technology	- Learning about diffusion and use - Learning about wider social processes
Relations	Formal, close relations preference	Value of both loose and close, flexible relations
Institutions	Formalized, relatively static, direct impact overarching institutions	Shortfall of formal rules in practice, and importance of informal institutions at local level

structural barriers (Schut et al. 2016a). However, the processes occurring when linking different IPs, and the dynamics of stakeholder composition throughout this process have not been researched systematically. This article aims to do the latter and tries to analyze how 'key functions' of the innovation process are fulfilled. Additionally, this article aims to contribute to mainstream innovation literature on systemic instruments as part of an innovation policy mix (Borrás and Edquist 2013; Rogge and Reichardt 2016; Wieczorek and Hekkert 2012), as there has been limited analysis on systemic instruments in developing countries innovation systems as well as calls for analysis of intermediary structures in inclusive innovation (Foster and Heeks 2013b). Data were gathered under 'Humidtropics', a global AR4D program that established interlinked community and (sub)national IPs with the aim of improving smallholder livelihoods. Experiences from East and Central Africa provide the empirical evidence that enables us to reflect on lessons learned and provide recommendations.

2. Conceptual framework

2.1 Multilevel interactions

This article explores the involvement of, and interactions between stakeholders across different levels in agricultural innovation processes as earlier described by Coenen et al. (2012) and Hermans et al. (2016). The focus will be the administrative scale at which these stakeholders are active, which can be broken down into decision-making units ranging from the farm level to supranational level (Cash et al. 2006; Schut et al. 2014).

2.2 Facilitating connections between levels in agricultural innovation processes

A multitude of tools or strategies can be used to reach out to actors at different levels in agricultural innovation. Not only formal IP gatherings, but also informal networking events can facilitate the involvement of stakeholders across levels. Moreover, capacity development activities like trainings or experiential learning through on-farm research trials, as well as more formalized collaboration through contractual partnerships or business deals can form the basis for involving previously unconnected actors in innovation processes. Mediated communication such as (local) newspapers, posters, flyers, email, phone, radio, or video can also play its part in reaching out (Chowdhury et al. 2015; Sanyang et al. 2016; Van Mele 2006; Zossou et al. 2009).

When looking more closely at the underlying dynamics of facilitating multi-stakeholder innovation and building linkages between different actors at different levels, innovation system scholars have written about individuals who, for example, helped organizations to extend their organizational boundaries (i.e. boundary spanning; Klerkx et al. 2010; Smink et al. 2015) or leverage resources to push for institutional change (i.e. institutional entrepreneurs or innovation champions as described in Farla et al. 2012; Klerkx et al. 2009, 2013; Van Paassen et al. 2014). The composition of the IP, in terms of which actors with boundary spanning positions and capacities are involved, as well as their championing qualities, determines how effective the platform can be in connecting levels (Klerkx and Aarts 2013; Manning and Roesler 2014). In line with work emphasizing new interactive roles of transdisciplinary science in innovation processes (Schut et al. 2014; Turnhout et al. 2013; Wittmayer and Schäpke 2014), IPs in AR4D have been found to play such a role by bringing together agricultural research and development actors, and facilitating the identification, prioritization, and implementation of (joint) activities. In this way, IPs seek to bridge the gap between science and development or business sectors, building on applied and participatory action research strategies (e.g. Ottosson 2003; Wopereis et al. 2007) to support the development of innovations that are technically sound, economically feasible, and socially, culturally, and politically acceptable for all stakeholders. Nevertheless, the institutionalization of IPs in the AR4D sector has happened with mixed success as these new roles do not always fit well with organizational mandates and cultures (Kristjanson et al. 2009; Schut et al. 2016a).

2.3 Functions of innovation systems

Traditionally, innovation systems are analyzed by looking at the actors (e.g. businesses, science, and government), infrastructures (e.g. R&D laboratories, finance structure, and communication infrastructure), interactions, and institutions that govern behavior (i.e. formal rules and regulations, like laws, and informal rules like norms and values) (Wieczorek and Hekkert 2012). This 'components-based' approach offers value for analyzing and detecting problems or failures in innovation systems (Klein Woolthuis et al. 2005; Van Mierlo et al. 2010; Amankwah et al. 2012), and has been used in the context of developing countries to diagnose the 'maturity' of the innovation system. If many components are absent or deficient, a developing country is said to have an 'immature' innovation system. However, the components-based approach has been criticized for being too static and not sufficiently focused on identifying activities fostering the generation and diffusion of innovations (Bergek et al. 2007). As a response to that, Hekkert et al. (2007) developed the functions-based approach, originally connected to the concept of technological innovation systems but recently also applied for analysis of sectoral and national innovation systems (Turner et al. 2016; Wesseling and Van der Vooren 2016, in press). Hekkert et al. (2007) identified seven functions that need to be performed as a result of the interactions between these components of the innovation system, and which thus depend on presence or quality of structural components such as actors (e.g. firms, R&D institutes), infrastructure (e.g. knowledge infrastructure, finance infrastructure), interaction (e.g. spaces for learning, adequate innovation networks), and institutions (e.g. innovation policies, a culture of collaboration). The functional approach has recently been applied in agricultural settings (Lamprinopoulou et al. 2014; Turner et al. 2016) (Table 2), and has also been advocated as an analytical scheme to assess the dynamics and functioning of innovation systems in developing countries (Jacobsson and Bergek 2006) with some recent applications in such settings (e.g. Kebebe et al. 2015; Tigabu et al. 2015).

Because innovation processes can be triggered by a wide range of emerging constraints or opportunities in the agricultural system, the sequence in which the functions become relevant can differ from case to case (Hekkert et al. 2007); that is, different functions are required to facilitate different steps in innovation processes, which then again cascade into the triggering of other functions. Hekkert et al. (2007) point out that innovation system functions need to cut across different levels, as innovation processes are embedded in macro- and micro-level dynamics. As Wieczorek and Hekkert (2012) state, if functions are not properly executed, this is due to problems with the presence or quality of structural components (actors, infrastructure, interaction, and institutions). A major problem is often a lack of coordinated action between diverse actors, and 'systemic instruments' (e.g. IPs) are seen as a means to improve this

Table 2. Functions of innovation systems as adapted from Hekkert et al. (2007)

Functions of innovation systems	Description
(F1) Entrepreneurial activities	Actions of entrepreneurs who deploy the potential of new technologies, knowledge, networks, or markets to create business opportunities. They face many uncertainties and trigger learning about the innovation and, for example, its functioning in the context of experimentation
(F2) Knowledge development	Learning and developing new knowledge as a central element of innovation
(F3) Knowledge diffusion through networks	Exchange of information and views of those concerned through networks, allowing information to spread and better align with the system
(F4) Guidance of the search	Prioritize, or select, between different innovation options based on (changing) preferences or expectations of stakeholders. Prioritization facilitates targeted resource allocation and can create momentum for preferred options
(F5) Market formation	(Niche) market for innovation and possibility for those aiming to promote the innovation to (initially) facilitate market creation (e.g. through subsidies or facilitating carriage to far-way markets)
(F6) Resources mobilization	Assembling of the diverse resources (e.g. financial, human, social, and physical resources) required to enable all activities in the innovation system to be done
(F7) Creation of legitimacy/counteract resistance to change	For innovations to be taken up, or overthrow the existing system requires a certain degree of perceived legitimacy and support for the innovation. This function often covers lobbying activities and interest groups that advocate the innovation as well as interventions that increase the perceived legitimacy of the innovation

coordination. In this article, we will use the functions of innovation systems perspective to systematically analyze the innovation processes taking place in multilevel IPs to see if, and how, facilitating linkages across different levels helped to fulfill these functions.

3. Research methods

3.1 Case description

Data for this study were collected under the CGIAR Research Program on Integrated Systems for the Humid Tropics (Humidtropics). The program aims to increase income and improve nutrition for rural households, increase farm productivity, promote sustainable natural resource management, empower women and youth, and enhance innovation capacity, by conducting systems-oriented R4D through two types of interlinked IPs (Humidtropics 2012). Humidtropics is implemented in three different continents: Africa, America, and Asia. Data for this study originate from Burundi (i.e. Gitega *Province*), Rwanda (i.e. Nyabihu District in the North and Kayonza District in the East), and South Kivu province in the Democratic Republic of the Congo (DRC) (i.e. Ngweshe *Collectivité*). Humidtropics commenced in these countries in May 2013. The first type of IP operates at the community level and serves as a space for joint problem analysis, agenda setting, and experimentation with, and local adjustment and selection of, various innovations for sustainable agricultural intensification. The other type of IP operates at the national level (in Rwanda and Burundi) or subnational level (in eastern DRC) and is supposed to support the community-level IPs to deal with higher-level barriers that are beyond control of the community members (Schut et al. 2016a).

3.2 Data collection

Both primary and secondary data were used for this study. Participatory observation, semi-structured key informant interviews, written interviews, and IP reflection workshops were the main primary data sources, and were collected between February 2014 and December 2015. Participatory observation refers to a systematic and purposeful way of observing social processes and phenomena as they occur in their natural setting (Kumar 2005). In total, thirty-nine events (e.g. IP meetings, field trial implementation, data collection events, etc.) were attended in Burundi, sixty-six in Rwanda, and twenty in DRC. Observations were mainly captured through field notes and photos. The semi-structured interviews were conducted face-to-face using a pre-made list of topics that was tailored to the position and role of the interviewee in the innovation process. The interviews provided an overview of platform-related activities occurring at the different levels, the type of stakeholder groups involved, and how this influenced the evolution of the innovation process (in view of innovation system functions) as well as how the barriers to the innovation process were being addressed (in view of structural components fostering or hindering innovation). A timeline showing major IP events like launch meetings, platform meetings, and dates of research trials, was used to help interviewees recall the process and add additional activities they had been involved in. The interviews also captured stakeholder perceptions of how they had experienced the innovation process (e.g. what challenges they experienced and what motivated them join or leave, the IP process). Interviews generally took between one and two hours. During the IP reflection workshops, platform members completed various exercises aimed at capturing discussion about the IP process and achievements, as well as where the IP could do better. Secondary data sources included meeting minutes, pictures of platform events and R4D activities, emails and event registration forms, and were collected over the entire period of study (Table 3).

3.3 Data analysis

Data were analyzed in a qualitative manner by studying information gathered about the cases with the function perspective of Hekkert et al. (2007); a process that is also referred to as analytical generalization (Yin 2003). Using the timelines with platform events developed for each country during the semi-structured interviews, attempts to facilitate multilevel fulfillment of innovation system functions were identified and categorized according to the most relevant function. All attempts were described in detail using the different sources of data in this study to assure triangulation. Guiding questions during the analysis were: (1) what stakeholder group(s) active at which levels are involved?; (2) what is done to involve them? and (3) how did it work out?

Table 3. Data collection methods, sample size, and data gathered

Data collection methods	Sample size per country			Data gathered
	Burundi	Rwanda	DRC	
Participatory Observation (events)	39	66	20	Overview of IP events and participation of stakeholders
Semi-structured key informant interviews (respondents)	6	8	9	Stakeholders' view on IP events and process; challenges and opportunities; and members' participation, roles, and benefits
Email interviews (respondents)	3	0	0	Same as semi (safety situation did not allow face-to-face interviews)
Subgroup interview with IP facilitators	1	0	1	Efforts to involve government (DRC and Burundi) and private sector (Burundi)
Multi-stakeholder reflection (workshops)	4	5	4	Participants' view on IP process, challenges and opportunities. Workshops were conducted with both community- and (sub)national-level IP
Secondary data	n.a.	n.a.	n.a.	Overview of IP events, involvement of stakeholders, etc

4. Results

In this section, we describe for each of the innovation system functions how they were performed in our case and which levels were involved. The sequence in which we present the functions is determined by their relative importance in the IP processes studied in this article. Using several typical and/or explanatory examples from our dataset we illustrate the multilevel dynamics under each function.

4.1 Guidance of the search (F4)

Early in the innovation process, Rapid Appraisal of Agricultural Innovation Systems (RAAIS; Schut et al. 2015a) workshops were organized in all countries with representatives from the most important stakeholder groups in AR4D (i.e. farmers, NGOs, private sector, government, and research). They jointly identified, analyzed, and prioritized major constraints for the sustainable intensification of agricultural systems in their region, and, based on that, selected entry points for innovation (see Schut et al. 2016b). During these workshops, organized by the international research institute leading Humidtropics, stakeholders representing international, national, and local level participated. The outcomes of these priority setting workshops were communicated to the (sub)national IPs as the basis for setting the AR4D agenda. In turn, research plans were presented to the community-level IPs to allow them to give some input, indicate preferences (e.g. which crop varieties to use in the trials), and discuss practicalities of implementation (e.g. land availability). Also at the start of the innovation process, the international research institute leading Humidtropics selected a national partner with a solid network and reputation to assist in program facilitation (i.e. in Burundi and Rwanda this was the National Research Institute, and in DRC an NGO specialized in facilitation). Together, these institutions selected a number of actors which jointly represented the key stakeholder groups in AR4D and were deemed strategic to be part of the IPs and as a group direct the AR4D activities. All actors were subsequently invited to official launch meetings and requested to join the (sub)national IP. In case of the community IP, the leading (research) institutions requested assistance of well-respected local NGOs or farmer leaders to assist in sensitizing farmers and other community-level actors for the IP, invite these for its launch and subsequently ask those interested to join. Throughout the process, the IPs continued meeting and discussing progress, as well as next steps, of the innovation process. New stakeholders that were interested in the program could join the IP and IP members who lost interest were allowed to leave, creating a dynamic IP composition. Continued multilevel guidance of the search was facilitated more structurally through IP reflection meetings, organized once per year with both the community- and the (sub)national-level IPs. During these meetings stakeholders discussed which innovations the IPs wanted to continue, add, or abandon and which partners could assist in this.

In addition to these formal workshops, (sub)national IP members were usually involved in evaluating and further specifying AR4D activities through presentations given in IP meetings, written reports with information gathered from the other stakeholders or research, and (concept) budgets that were developed. All members could comment on these to indicate their preferences and thereby influence prioritization of AR4D activities. As for the community-level IPs, the IP in Nyabihu District in Rwanda frequently met with some researchers[1] working with the IP to discuss the AR4D activities and plan next steps. Such meetings occurred less frequently in community IPs in Burundi and Kayonza District in Rwanda, especially once field trials had been implemented.

In all countries, researchers working with the IPs on agronomy trials conducted additional efforts to involve farmers in the guidance of the search. Some organized focus group discussions to further tailor activities to the needs of hosting farmers (i.e. specifying the type of livestock to work on in Burundi), whereas others conducted participatory farmer evaluations to assess community-level preferences regarding technologies tested (i.e. in Rwanda and DRC).

Despite the participatory and 'holistic' nature of the identification of constraints and opportunities for innovation, the real decision-making regarding which of the proposed AR4D activities would actually be implemented, seemed less inclusive. Lack of mandate or expertise on prioritized AR4D activities among stakeholders holding the financial resources (often researchers), or prerequisites within the program (i.e. the need for clear agricultural research questions in AR4D activities), often influenced selection of activities implemented. In practice, this led to a focus on productivity—and natural resource management research at farm—to community level, whereas institutional challenges that required innovation at (sub)national level often remained unaddressed. Additionally, while development of AR4D plans and budgets was generally started *en groupe* in the community and/or (sub)national IPs, finalization of these research plans and budgets was usually done by a small group of appointed (sub)national IP members primarily consisting of researchers. Interviewees from the subnational IP in DRC (often representing resource-poor NGOs) said they felt to have little influence on what type of AR4D activities were developed and tested, and that the managers of participating research programs decided what happened.

4.2 Knowledge development (F2)

In all countries, on-farm trials to test innovations (e.g. intercropping, planting distances, varieties) were implemented. This occurred under supervision of researchers from the (sub)national IP who were assisted in implementation, management, monitoring, and data collection of the trials by extension officers and farmers from the community IP. After discussing AR4D activities in both (sub)national and community IP meetings, researchers, extension officers, and farmers met in the field where the researchers demonstrated agricultural production technologies in one or several fields. Subsequently, under supervision of extension officers, farmers hosting trials replicated the technologies in their remaining fields allocated for experimentation and were responsible for managing these throughout the season. Together, these actors tested efficacy of the technologies in the communities. In interviews, representatives of all three groups indicated their satisfaction with this collaboration, which was based on gaining access to inputs, knowledge, and/or skills.

Nevertheless, in all countries some trials did not perform well. For example, in Kayonza District in Rwanda, cassava trials suffered from diseases causing farmers to replace or remove several plants, thereby disturbing the experimental set-up of the experiment. In some cases, researchers decided to stop, and otherwise alter, such trials as they became of limited use for science purposes.

4.3 Knowledge diffusion through networks (F3)

In all countries, the key channel facilitating knowledge diffusion through networks were the IP meetings at community and (sub)national level in which actors representing the main stakeholder groups in AR4D gathered. Representatives of the community-level IP participated in the (sub)national-level IP meeting, and vice versa, to facilitate exchange of information and views between the IP. To further strengthen this exchange, the IP reflection meetings (Section 4.1) facilitated diffusion of more profound reflections regarding the IPs' functioning, achievements, and its way forward. During every reflection cycle, three meetings were organized; one with the community IP, one with the (sub)national IP, and one with the key people facilitating the program's implementation. Key reflections from the community IP were communicated to the (sub)national IP, and these provided inputs to the reflection meeting with the key people facilitating the program's implementation in the respective countries. Moreover, aggregate key findings were presented during international planning meetings to allow international program managers to better match the program to stakeholder needs.

Nevertheless, interviews with (sub)national IP members revealed that many of them were poorly aware of activities happening in the community IP and that communication outside formal meetings (e.g. through emails, phone calls, informal encounters, etc.) seemed often limited to those directly participating in implementation (i.e. mainly researchers, extension officers, and farmers). In all countries, several (sub)national stakeholders (predominantly representing NGOs, government, or private sector) lost interest over time and stopped participating in IP meetings, or simply continued sending different people to represent their organization. Moreover, both in interviews and reflection meetings, members of the (sub)national IPs of DRC and Rwanda representing NGOs, research and private sector indicated they wanted their involvement to go beyond attending meetings only, for example, by participating in the implementation of the AR4D activities.

In Burundi, the researchers established an additional channel to facilitate multilevel knowledge diffusion through networks. They appointed a small group of people (three (inter)national researchers, two community-level extension officers, and two farmers) and tasked them to intensify communication between the community and (sub)national IP. This so-called 'core team' started meeting frequently and communicated information about farmers' challenges to researchers and back. They identified several miscommunications (e.g. about whether or not certain AR4D activities were still to be implemented) that—after lobbying with budget holders and other powerful people in the program (usually researchers)—could be solved. However, the team also hampered multilevel diffusion of knowledge through networks. One interviewee explained that the existence of the core team contributed to a reduction in formal community-level IP meetings, which made it difficult for new partners—who were unaware of the core team and thus unable to contact them—to join the community IP and the AR4D process. Simultaneously, local core team members communicated directly to project leaders, thereby intensifying communication between farmers and researchers, but reducing communication within the network as a whole.

4.4 Resources mobilization (F6)

To mobilize human resources to facilitate the program's implementation, and in particular the IP process, the leading international research institute signed contracts with strategic national (research) partners (Section 4.1). This occurred when the program was officially launched. Through these contracts the international research institute 'hired' staff from the national institutes to act as the national facilitator of the program in return for a payment. In all countries, the people selected for this task participated very actively in many activities of the program and when needed, other staff from these organizations assisted them in fulfilling their tasks.

Financial resources available in the program—and among (potential) partner projects—to facilitate the IP process and implementation of AR4D activities were in the hands of the researchers. There were several prerequisites and guidelines on how funds could be spend (e.g. specific projects only allowed work on specific crops, or in specific regions). This sometimes hindered realization of the IP's demands when there was a mismatch with available expertise or organizational mandates (e.g. working on livestock when no human and financial resources were available to support AR4D activities on livestock). Hence, in December 2014, the program introduced a modest budget line that was allocated to the IPs to spend on preferred research activities for which no funds were available. These 'platform-led innovation funds' were supposed to allow the IPs to 'buy-in' missing expertise from inside or outside the IP. However, as this budget—again through a contract—was assigned to the national research institute to be managed properly, it ended up being primarily spend by these institutes as well, keeping it difficult to freely scout for expertise or assistance outside the group of researcher holding budgets. This situation was noticed by several key stakeholders in the program, is reflected in research budgets, and was confirmed by an interviewee representing one of these research organizations.

In contrast, collaboration and resource sharing with other, especially higher level, organizations that did not sign official contracts, occurred less frequently. In Burundi, several NGOs that had collaborated with the leading international research institute, contacted them to explore options to continue their partnership. An interviewee who talked to them mentioned they had concluded that collaboration was no longer possible because of a mismatch in target area and objectives between the IP and these NGOs. Likewise, an interviewee who played a central role in both Rwanda and DRC explained that also in these countries collaboration with NGOs in the (sub)national IP had been difficult to establish. In Rwanda, he explained, there are many (inter)national NGOs working with much larger budgets than Humidtropics causing them to be sceptical toward the benefits the IPs could bring them. In contrast, the many small-staffed provincial NGOs in DRC are willing to collaborate, but as they do not have the financial resources to do so, they tend to hang on waiting for an opportunity to get to work. In both Rwanda and DRC, one international NGO contributed to AR4D activities in terms of providing human, material, and financial resources. In Rwanda, the intervention topic overlapped with activities of this NGO, for DRC, both the intervention area and topic matched the NGO's (more general) focus.

Resources mobilization at community IP level occurred successfully in all countries. First, when the program was launched at community level and local actors agreed to sensitize people for the program (i.e. local NGOs in DRC and Burundi, and farmer leaders in Rwanda). Second, when AR4D activities were implemented, local government supplied human resources (i.e. extension officers) to assist in fieldwork, and farmers supplied labor and land to manage the trials. Yet, when it turned out that the skills of these farmers and extension officers were too limited to guarantee sound data, additional technicians based in the communities were hired to assist researchers in fieldwork.

In Nyabihu District, in Rwanda, farmers lacked a collective potato seed storage facility. In a response, a member of the national research institute, together with some IP farmers and an extension officer, requested the sector authorities to make available one of their old buildings as temporal seed storage. After accepting this request, farmers renovated the old building and collectively stored their potato seed there.

4.5 Create legitimacy and counteract resistance to change (F7)

In contrast to Burundi and Rwanda, governmental authorities (i.e. the Secretary of the provincial Minister of Agriculture) participate in the subnational IP meetings in DRC, thereby granting this IP and its activities a certain degree of government acknowledgment and legitimacy. When asked to explain this interest, the government representative explained that the government has its own network of stakeholders working in agriculture whose aims and set-up closely align with the subnational IP. Moreover, in May 2015 when the successfulness of field activities became visible and farmers started to get convinced of AR4D activities promoting fertilizer usage, the IP facilitator called the Minister of Agriculture and invited her to visit the IP fields. Once there, IP members (among whom many farmers) explained the Minister about the benefits of fertilizer to increase yields, including their challenge to access it. The Minister acknowledged their problem by granting a modest sum of money for the farmers to buy inputs, thereby demonstrating government support and legitimacy to what the IP was doing.

In Kayonza District, in Rwanda, AR4D activities target intercropping technologies whereas national policy promotes monocropping. This mismatch between law and science reduces perceived legitimacy of experiments and even though a government representative explicitly mentioned during a national IP meeting in July 2014 that experimenting with intercropping is not forbidden (thereby granting legitimacy to the act of experimenting), it still hinders the innovations from being upscaled. In reflection meetings conducted in October 2015, representatives of the Sector government explained that they can only move to large scale extension of the intercropping technologies (of which they acknowledged to see advantages in the field) when national policy explicitly recognizes it. However, as national policymakers usually refuse to participate in national IP meetings in Rwanda, members proposed to try to convince the government of the efficiency of intercropping by developing targeted policy briefs. More generally, The RAAIS workshops, IP reflection meetings, and multi-stakeholder decision-making processes in the IP also enhanced the perceived legitimacy of AR4D activities, as these enabled selection and implementation of activities based on a democratic process of reaching consensus.

4.6 Market formation (F5)

In none of the countries, (niche) markets for crops promoted in AR4D activities were created or made more accessible through the IPs. However, some linkages with existing input suppliers (i.e. agro-dealers and micro-finance institutes) were facilitated in Rwanda and DRC by inviting these partners to IP meetings and/or informal events. Moreover, some community- and provincial-level processors and cooperatives were invited to participate in the community IP meetings by the researchers facilitating the IP processes to explore potential collaboration. In this way, the IP facilitators tried to help farmers to access (processing) machinery for their produce, and through that perhaps a market (e.g. in Burundi), or get in touch with groups active in collective marketing (e.g. in DRC). Nevertheless, in the first one and a half year of the IP process, the engagement with these processors and cooperatives led to limited action. In general, participation of private sector representatives in all countries in both community and (sub)national IP meetings was very limited which may have reduced the IPs' market orientation.

4.7 Entrepreneurial activities (F1)

Hardly any examples of entrepreneurial activities related to AR4D activities can be found in our data. A positive exception comes from Nyabihu District in Rwanda, where farmers involved in potato seed multiplication expressed interest to set up a seed production business. Related to this, IP members—including the sector's micro-finance institute—and researchers met around March 2015 to discuss group loan options for farmers to finance building their own seed storage facility and hence encourage entrepreneurial activities. They agreed that (1) farmers could reimburse the loan after harvesting, which better matched their financial capabilities than the usual monthly payments, (2) researchers would give climate predictions to farmers to increase chances on high yields, and (3) the micro-finance institute would apply for a subsidy with one of his national partners that financially promotes small- and medium-sized enterprises. The micro-finance institute quickly approved the loan proposal and subsidy, and several farmers had taken up the loan. Observing this entrepreneurial ambition among farmers, the team of researchers decided during a team reflection meeting in October 2015 to support the IP in developing into a cooperative.

5. Analysis and discussion

Our data show that all functions of innovation systems were at some point touched upon by the interlinked IPs in Burundi, Rwanda, and DRC. The data also shows that all functions encompassed involvement of stakeholders across levels—be it in varying degrees of intensity and success. Below, we further analyze our data and highlight theoretical and practical implications.

5.1 Sequence of innovation systems functions

The IPs studied in this article are initiated by and embedded in AR4D. Hence, in line with the sequentiality pointed out by Hekkert et al. (2007), the innovation system functions closely related to research and dissemination (i.e. guidance of the search, generation of knowledge, and diffusion of knowledge through the network) received relatively much attention. In contrast, less examples could be given of successful resource mobilization,[2] entrepreneurial activities, market formation, and creation of legitimacy (Table 4, Fig. 1a).

Schut et al. (2016a) provide some explanation for what can happen to IPs when institutionally embedded in an AR4D context. They describe, for example, how research organization mandates, donor demands and funding structures, narrow perceptions on agricultural innovation, and roles of researchers influence IP support and functioning. Many of the IPs implemented in an AR4D context are transformed to fit the incumbent AR4D system that is predominantly occupied (and evaluated against) the successful development, testing and diffusion of technological innovations at community level. Consequently, from a components-based point of view on innovation systems (Klein Woolthuis et al. 2005), such AR4D systems tend to facilitate those components (i.e. actors, infrastructures, interactions, and institutions) needed to conduct research: competent researchers are gathered, trained and given budgets, and farmers and extension officers are approached to implement activities. In contrast, higher level NGOs, government, and private sector actors are being invited for IP meetings and informed about the program's activities—thereby trying to comply to the demand for inclusive innovation (Foster and Heeks 2013a; Swaans et al. 2014)—but seldom given additional resources to facilitate market formation or the creation of (policy) legitimacy at higher (sub)national levels. This is, as Schut et al. (2016a) explain perceived to align less with the traditional AR4D mandate, and therefore receives less attention in IP within AR4D. However, at the same time such non-research-oriented innovation system functions like creating legitimacy, for example through alignment with existing (public or private) structures, are pointed out as crucial for IP to become recognized and adopted by the incumbent system, and through this sustain themselves and achieve impact beyond the scope of the initial IP (Schut et al. 2017). Given the direct connection of innovation system components (Klein Woolthuis et al. 2005) with the execution of functions (Wieczorek and Hekkert 2012), the actors expected to drive the non-research-oriented innovation system functions thus may not be present. Moreover, the infrastructures enabling researchers' engagement in such non-research-oriented innovation system functions are unlikely to be actively supported by donor-funded AR4D programs. Another explanation for the relative emphasis on research-related innovation system functions could be that the IP had not yet reached the point where market formation was a relevant discussion topic, as community-level productivity had not yet reached the point where local markets could no longer absorb surpluses. This is opposed by Ngwenya and Hagmann (2011) who emphasize that market formation should be central in IP processes and that IPs need to be built around an attractive business plan that generates clear and direct benefits for those involved. Such a business/ private sector-driven IP process may follow a different sequence of innovation systems functions, in which market formation and entrepreneurial activities may

Table 4. Focus on fulfillment of different innovation system functions across levels and key stakeholders involved

Function / Country	Guidance of the search (F4)	Knowledge development (F2)	Knowledge diffusion through networks (F3)	Resource mobilization (F6)	Creating legitimacy and counteract resistance to change (F7)	Market formation (F5)	Entrepreneurial activities (F1)
Burundi	XXX (*cl*.fa, *snl*.re, all groups)	XXX (*cl*.fa, *cl*.ex, *snl*.re)	XX (*cl*.fa, *cl*.ex, *snl*.re, all groups)	X (*cl*.ex, *cl*.fa, *snl*.re)		X (*cl*.pr, *snl*.pr)	
Rwanda	XXX (*cl*.fa, *snl*.re, all groups)	XXX (*cl*.fa, *cl*.ex, *snl*.re)	XXX (*cl*.*fa*, *cl*.ex, *snl*.re, all groups)	XXX (*snl*.re, *cl*.ex, *cl*.gov, *cl*.fa, *snl*.ngo)			X (*cl*.fa, *cl*.pr, *snl*.re)
DRC	XXX (*cl*.fa, *snl*.re, all groups)	XXX (*cl*.fa, *cl*.ex, *snl*.re)	XX (*cl*.fa, *cl*.ex, *snl*.re, all groups)	XX (*cl*.ex, *cl*.fa, *snl*.gov, *nl*.ngo *snl*.re,)	XX (*snl*.gov)		

Number of X indicates the relative strength of focus on that innovation system function, XXX indicates a very strong focus and no X indicate a very weak focus. Codes between brackets refer to stakeholder groups mostly involved in fulfilling these function: fa = *farmers*, re= *researchers*, ex= extension officers, gov= government, pr= private sector and ngo= NGOs. Levels are indicated in *italics*: *cl*= *community-level* and *snl*= *(sub)national level*.

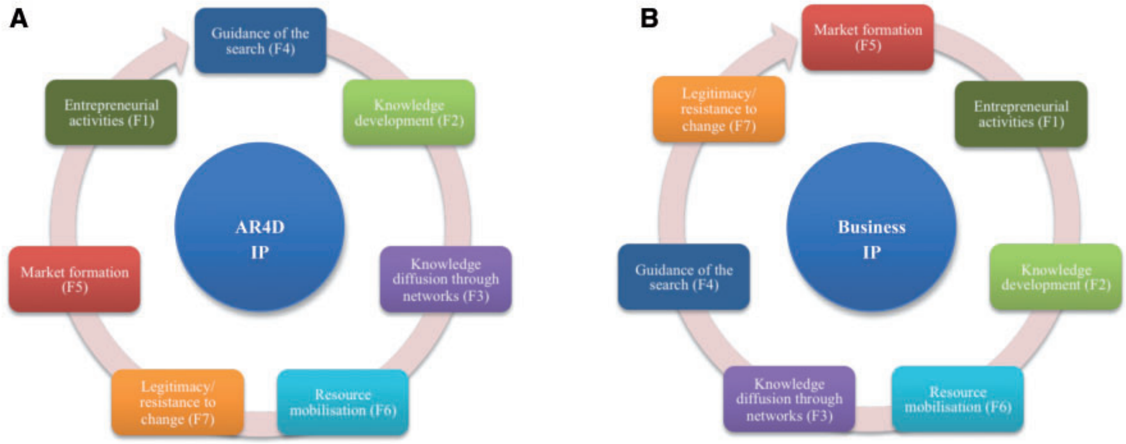

Figure 1. Different sequencing of innovation systems functions fulfilled through IPs. The left figure (1a) visualizes the sequence of innovation systems functions based on the agricultural research-driven IPs described in this article. The right figure (1b) visualizes an example of an alternative sequence of innovation systems functions based on a more business- or private sector-driven IP.

be more central as entry point and agricultural research may not need to be part of the IP process (Fig. 1b). This hypothetical dual pathway of IPs pushed by AR4D or business opportunities seems problematic when IPs are being initiated in an AR4D setting, but expected to transit into a business model to (financially) sustain itself over time. It also connects to debates on 'maturity' of innovation systems in developing countries, which—given the still large dependency on international donors—are questioned regarding their capacity to develop and enact appropriate and sustainable domestic innovation policies (Borras 2011; Jacobsson and Bergek 2006; Hansen and Nygaard 2013; Klerkx et al. 2015; Schut et al. 2017).

5.2 Compositional dynamics to fulfill different innovation systems functions

The above requires us to think differently about the compositional dynamics (stakeholder groups * levels) of IPs to fulfill different innovation functions, which has so far received limited attention in the IP literature. It underlines the importance of variable stakeholder representation in IPs during different stages of innovation processes. Rather than understanding 'inclusiveness' of IPs in AR4D as a call for continuous, comprehensive, and proportional stakeholder group representation to strengthen systemic capacity to innovate (e.g. Rodenburg et al. 2015; Schut et al. 2016a; Van Paassen et al. 2014), it requires strategic thinking about which configuration of stakeholders groups across different levels may have the highest potential to fulfill the functions required to achieve successful innovation at each point in time (as also suggested by Swaans et al. 2014). Hence, when working with IP, concrete strategies are needed regarding whom best to involve and support when. This has been referred to as 'adaptive management' in innovation processes (Hall and Clark 2010; Klerkx et al. 2010), or connecting decision-making on actor involvement to a 'dynamic learning agenda' that articulates what barriers for innovation need to be addressed in particular points in time (Kilelu et al. 2014) and induces a process of 'policy learning' in terms of what innovation policy instruments are appropriate (Borrás 2011).

Such strategic engagement concerns both appropriate timing and selection of involvement strategies (including intensity). Each attempt should be designed as to quickly facilitate identification of potential roles and benefits of participation for the stakeholder in fulfilling specific functions. Doing so can increase the chance that the most relevant and motivated stakeholders are targeted to fulfill specific innovation systems functions. Hence, we propose that conscious matching of stakeholders' focus (i.e. in terms of target area and topics, and level of operation) to the IP's current orientation should guide strategic engagement of stakeholders. Identification of clear roles and benefits or incentives for all those involved in the IP process is crucial in this respect (Foran et al. 2014; Ngwenya and Hagmann 2011; Swaans et al. 2014), and can support the decision of when best to involve certain stakeholders. Table 5, which is based on experiences from the empirical data used in this study, provides guidance for strategic stakeholder identification and engagement. In general, in a AR4D-oriented innovation processes, the involvement of (inter)national researchers and perhaps NGOs, as well as various community-level stakeholders seems to precede involvement of national-level policymakers and (big) private sector representatives operating higher up in the value chain (i.e. processors and other buyers). The latter are more likely to receive benefits and identify clear roles for themselves once the experimental phase is passed and innovations start showing success and can be taken to scale—matching the administrative scale in which they are active. Hence, strategic engagement of multilevel stakeholders seems more promising than aiming for equal representation of multilevel stakeholders throughout the innovation process, as has also been argued elsewhere (Kilelu et al. 2014; Klerkx and Aarts 2013). Nevertheless, joint identification and analysis of problems and intervention agenda setting including different stakeholder groups representing different levels at the beginning of IP processes may still be beneficial. It provides a holistic image of constraints, needs, and interests faced by different stakeholder groups, as well does it provides legitimacy to the IP process and AR4D activities that seek to address stakeholder constraints (Schut et al. 2015a).

5.3 Mechanisms for facilitating multilevel innovation processes through IPs

Our study shows that all innovation systems functions require action and interaction across different levels. Organizing IP meetings at different levels turned out to be neither the only nor the most effective way to do so. Nevertheless, the IP played a role in connecting

Table 5. Framework for reflection on the involvement of stakeholder groups across different levels

Actor type	Level of operation and influence	Topics and area of interest	What can they offer?	What do they need?	What can the IP offer them?	When can this be realized?	Most relevant contribution to innovation systems functions	Potential engagement tools
Government	National	General agricultural development, country wide	Financial resources, ability to change regulations, power, legitimacy, support in scaling	Decision-making support to justify/guide (big) interventions and investments	Evidence from on-farm experiments and insight in stakeholders' responses	Once experiments become successful and can be scaled	F3, F4, F5, F6, F7	Informal meetings to build trust/ inform; field visits to show evidence; formal communication/ evidence sharing
	Community	General agricultural development, specific community	(Local) knowledge and networks, legitimacy, human resources to support implementation	Effective ways to stimulate agricultural development in their village/ district	Inputs, skills, and knowledge related to experiments	Once implementation starts	F2, F3, F4, F6, F7	IP meetings, informal meetings, interaction, and collaboration in experiments
Private sector	National	Specific topics and areas of focus based on professional field and company size	Access to: inputs, credit, processing facilities, trademarks, markets, etc.	Reliable and profitable supply–demand (networks)	Information on farmers' production and ability to develop a deal with IP members	Once successful experiments are ready for scaling	F1, F4, F5, F6	Informal meetings to build trust/inform; field visits to show evidence; formal communication/ evidence sharing
	Community					Just before implementation starts (e.g. input dealers, MFI), or once experiments become successful (e.g. processors, traders)	F1, F4, F5, F6	IP meetings; Informal meetings with key actors
NGOs	National–international	General to specific topic(s) and target area(s), depending on NGO and its donors	Networks, legitimacy, financial resources	Satisfy their donors, gain: (new) partnerships, agricultural knowledge and technologies, and financial resources	Participation in IP meetings and perhaps experiments on which they can report, exchange of knowledge/ experiences	Once IP meetings and/or trial implementation starts	F3, F4, F6, F7	IP meetings; participation in trial implementation; informal meetings with key actors
	Community		Networks, legitimacy, local knowledge, human resources				F3, F4, F6, F7	
Research	Inter-national	General to specific topics and areas based on expertise of scientists and orientation of research organization	Scientific knowledge, skills and technologies, financial and human resources	Reporting success to their donors; opportunities for new funding/ projects	Participation in IP meetings and experiments, access to local stakeholders and conditions	Once IP meetings, and/or when R4D activities are designed/ implemented	F2, F4, F6, F7	IP meetings; participation in trial implementation; informal meetings with key actors
	National		Scientific knowledge, skills and technologies, human resources	(Financial) resources and opportunities to conduct research			F2, F4, F6, F7	
Farmers	Farm/ community level	General to specific topics based on personal and communal interests, specific farm to community focus	Productive assets (e.g. land, labor), local knowledge, access to local conditions	Good production that sells well on market and is possible to sustain	Jointly testing usefulness of innovations with researchers, get trainings/skills	From selection of R4D activities onward	F1, F2, F3, F4, F5, F6, F7	On-farm trials; trainings; focus group discussions; IP meetings; mediated communication (e.g. radio, posters, etc.)

F1 until F7 refer to the different functions of innovation systems: F1 = *entrepreneurial activities*, F2 = *knowledge development*, F3 = *knowledge diffusion through networks*, F4 = *guidance of the search*, F5 = *market formation*, F6 = *resources mobilization*, F7 = *creation of legitimacy/counteract resistance to change.*

stakeholder groups across different levels to fulfill different innovation system functions. First, joint agenda setting and reflection through RAAIS workshops (Schut et al. 2015a) to identify entry points for innovation functioned as an important mechanism to facilitate multilevel participation at the start of the IP process. Later on, IP reflection meetings to enable open reflection and adjustment of the innovation pathway based on changing stakeholder preferences continued with this task. They both enabled participatory and multilevel guidance of the search and diffusion of knowledge through networks. Nevertheless, while enabling stakeholders across levels to express their needs, many of these needs could not be fulfilled as limited resources, expertise, mandates, and sharing of budget restricted flexibility of the IP to cater for all needs of the stakeholders involved (Schut et al. 2016a). Through such structures, unequal power relations inherent to any multi-stakeholder process influenced which functions would be prioritized; resembling earlier findings by Foran et al. (2014) and Cullen et al. (2014). Second, participatory on-farm activities provided a successful approach to link national-level researchers to community-level stakeholders, like farmers and extension officers. This strategy turned out to be successful in triggering multilevel interaction and rendered clear roles and benefits that aligned with the professional orientation of those involved. This demonstrates the importance of engaging in collective action as a mechanism for joint learning by doing. It also creates awareness that constraints are interrelated and can support the development of trust between different stakeholder groups across different levels, as was also highlighted by Leeuwis (2000). Third, in all countries several individuals were appointed or contracted to act as innovation champions, who played a key role in networking and facilitation across different levels. Their innovation championing took several forms depending on the needs of the innovation process. Sometimes they acted as advocates of a technology to overcome farmers' challenges (technology champion), organizing and facilitating IP events (process champion), or creating connections between (new) relevant stakeholder groups across levels (network champion). In all countries these 'champions' played a crucial role in advancing the innovation process as a whole as well as its multilevel character (confirming earlier findings by Klerkx et al. (2013) and Smink et al. (2015)). Fourth, formal (performance) contracts between organizations across different levels facilitated not only multilevel collaboration and action, but also exclusion of those groups that did not manage to secure such contracts, which is a challenge in light of the ambition of 'inclusive innovation' fostered by IPs (Swaans et al. 2014).

6. Conclusion

The article shows that innovation system functions require the involvement of stakeholders across different levels. However, the mere establishment of interlinked community- and (sub)national level IP does not automatically trigger successful multilevel collaboration and innovation. In addition to having multi-actor platforms at different levels, joint agenda setting and reflection, participatory action research, and careful networking and problem solving by (contracted) innovation champions can facilitate stakeholders connectivity across levels. The sequence of innovation system functions—and consequently the involvement of different stakeholders across different levels—will differ from case to case as a function of the innovations desired and the inputs and outputs at various levels associated with this. Hence, we strongly advocate for a more sequenced and strategic engagement of stakeholders across levels, guided by a match in stakeholders' focus and interests and the IP's needs and stage of the innovation process. This is a break from the current IP implementation guidelines in AR4D in SSA, which generally call for an equal and continuous involvement of all stakeholder types at all stages of the innovation process. IPs require adaptive management that enables a degree of flexibility allowing their form and composition to follow their (innovation) function and adapt to the constraints and opportunities in the existing institutional environment. We question the sustainability of many of the existing AR4D IPs and their ability to function as a business incubator, as the sequencing of innovation systems functions in AR4D IPs tend to undermine market formation and entrepreneurial capacity development.

Given that this is a first study attempting to research IP functioning across different levels in innovation systems, we invite scholars to further research this topic. Such future work could focus on (1) more detailed visualization of interactions between levels and stakeholder groups in the system to better show the composition and interlinkages between IP, as well as who is included and who is excluded from IP; (2) analyzing in more detail the embedding of IP as a systemic instrument as part of innovation policy learning in developing countries' innovation systems, and (3) analyzing what other innovation policy instruments can complement IP to enable an optimal policy mix for strengthening innovation systems in developing countries.

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Notes

1. This always was a mixture of researchers working for international and national research institutes but will be referred to in this article simply as 'researchers'.
2. Beyond those provided through the Humidtropics program.

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