

# **Does Rapid Agricultural Growth Require a System of Innovation? Evidence from Ghana and Burkina Faso**

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## Abstract

This paper tests the 'systems of innovation' hypothesis for a selection of crops in Ghana and Burkina Faso that have shown significant growth in production over an approximately 20-year period. The question is whether such growth can only occur if supported by a system of innovation. Using two indicators (a common understanding on objectives and priorities, and a high level of interactivity) we find little evidence for the existence of anything that might be considered a high functioning system of innovation.

**Keywords:** West Africa; intensification; extensification; productivity; plantain; maize, millet, yam, sorghum

## Introduction

Over the last fifty years agricultural research in Sub-Saharan Africa (SSA) has evolved and changed significantly. At the beginning of this period research was largely state funded; focused on export crops; organised around disciplines and commodities; located on experimental stations; and linked to farmers through state-funded and ministry-based extension services. In the intervening years there has been a shift toward mixed models of funding; a greater focus on food crops; intense bursts of interest in farming systems research and various models of participatory research; an enhanced role for inter-disciplinarity and the social sciences; and an explosion in the number of non-state actors in extension and agricultural development more generally. 'Top-down' or 'linear' models of technology development and transfer are now widely disparaged, with farmers being re-framed as 'clients' who are in principle 'driving' the research and development – now recast as innovation – process.

One indication of the breadth of change in African agricultural research is the growing prominence of the discourse of 'agricultural research for development' (AR4D) and 'integrated agricultural research for development' (IAR4D) (von Kaufmann, 2004, von Kaufmann, 2007, Hawkins et al., 2009). Closely related to this is the widespread appropriation over the last decade of the language of 'systems of innovation'. While the concepts and theory associated with systems of innovation have influenced the broader field of innovation studies since the mid-1980s (Lundvall, 1998), it was the early-2000s before they began to seep into scholarship and policy discourse pertaining to African agriculture (Hall et al., 2000, Clark, 2002, Sumberg, 2005, Agwu et al., 2008, Van Mele, 2008). Systems of innovation theory informs to some degree the current interest in using 'multi-stakeholder platforms', 'innovation platforms' and 'innovation brokers' to foster greater productivity and sustainability within the agricultural sector in Africa (Van Mele, 2008, Kefasi et al., 2011, Hounkonnou et al., 2012).

Freeman (1987) defined a system of innovation as a 'network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies'. Interaction is at the core of

a system of innovation. Carlsson et al. (2002), in defining a system of innovation as 'a set of interrelated components *working toward a common objective*' (emphasis added), highlighted the idea that these interactions are not random or disparate, but are in effect coordinated by a combination of both market and non-market (e.g. state/policy) forces.

This paper is about what we refer to as the 'systems of innovation hypothesis'. In its simplest form, this hypothesis states that a dynamic, growing agricultural sector is not possible without a functional system of innovation. More specifically, the research reported here sought to test the hypothesis that in rural SSA, high rates of agricultural growth must necessarily be supported by non-market coordination (in the form of public-sector investment resulting in a functional system of innovation).

While the literature puts much emphasis on the notions of 'national' and 'sectoral' systems of innovation' the context-specificity of agricultural research and production suggests that the most appropriate level of analysis might be in terms of sub-national regions or crop-region combinations. National institutions, linkages and initiatives may not cover all regions or crops uniformly. The point is that the system of innovation may look and function very differently depending on national sub-regional and crop specificities, and the ways that these are defined by and interact with national policy and institutions. The historical processes and contemporary policy processes that gave rise to and reinforce patterns of uneven development are likely to be reflected in the structure, resourcing and functionality of the agricultural system of innovation as manifest at region or crop-region level. Thus in the current studies we wanted to get beyond both national estimates of agricultural growth and the notion of a national system of innovation. The study was conceived along a south-north transect from southern Ghana to mid-Burkina Faso, which allowed the growth and the supporting system of innovation of a number of crop-region combinations to be investigated<sup>1</sup>.

The paper proceeds as follows. The next section outlines the study methodology. Following this results are presented that address two questions: (1) Is there a shared understanding of the objective of the system of innovation? (2) How interactive is the innovation system? The final section explores the implications of these findings.

## Methodology

The logic of the research was first to identify crop-region combinations that exhibited relatively high rates of growth. In the case of Ghana, after analysis of data for maize, rice, millet, sorghum, cassava, yam and plantain, the combinations identified were yam in northern Ghana and yam and plantain in southern Ghana (Table 1) (Jatoo et al., 2011a). Similarly, the combinations identified in the case of Burkina Faso were maize, millet and sorghum in Mid-Burkina Faso, and

**Table 1. Annual growth rate (percent) for crop – region combinations**

Region	Crop				
	Maize	Millet	Sorghum	Yam	Plantain
<b>Mid BF</b> (1984 – 2008)	Output: 6.76 *** Area: 4.25 *** Yield: 1.80 ***	Output: 1.31 * Area: -0.68 Yield: 1.99 ***	Output: 0.68 Area: -1.05 *** Yield: 1.91 ***	N/A	
<b>Southern BF</b> (1984 – 2008)	Output: 4.63 *** Area: 2.45 *** Yield: 1.69 ***	N/A			
<b>Northern Ghana</b> (1992 – 2009)	N/A			Output: 2.43 *** Area: 1.98 *** Yield: 0.76 ***	
<b>Southern Ghana</b> (1992 – 2009)			Output: 2.77 *** Area: 2.04 *** Yield: 0.66 ***	Output: 2.59 *** Area: 1.67 *** Yield: 0.87 ***	

Source: (Jatoo et al., 2011a)

NB: Growth coefficients followed by \*, \*\* or \*\*\* have a t-statistic that is Significant at <0.05, <0.01 or 0.001 levels of probability, respectively.

maize in Southern Burkina Faso. Following this, for each crop–region combination the research sought to verify the existence of two critical properties of a functional innovation system: (1) a common understanding of the ‘objective’ of the innovation system; and (2) interaction between actors who are assumed to be central to the innovation system. For the purpose of this research, the system of innovation was assumed to include six functions: education; research; policy/advocacy; service provision; production; and transformation.

Through networking initial contacts were made with actors in the different functions who work on the selected crops, and arrangements were made for in-person interviews. Individuals associated with the provision function were identified through discussions with agro-input dealers’ associations while those associated with the production function were selected at random from among members of various producers associations. Actors associated with the transformation (processing) function were identified through discussions with other researchers and reviews of food labels and those engaged

with the extension and promotion were identified through discussions with the staff of the Ministry of Food and Agriculture in Ghana, and the Ministry of Agriculture and Water Resources in Burkina Faso. The researchers held in-person interviews using semi-structured questionnaires and recorded the required data which was then entered into SPSS and Microsoft Excel for analysis. Details of the distribution of respondents are given in Table 2.

In the first part of the interview respondents were asked to select and rank what they considered to be the three most important objectives of the innovation system from a predetermined list of ten objectives. The list included objectives pertaining to food security, poverty, livelihood sustainability, farmer needs, profitability, agricultural sector growth, competitiveness and environmental impacts.

The degree to which there is a sense of a ‘common objective’ amongst specific sets of actors was investigated using a measure of agreement or concordance.

**Table 2. Distribution of sample**

SI Function	Number of respondents			
	Southern Ghana	Northern Ghana	Southern BF	Mid BF
Education	1	1	8	13
Research	8	5	5	12
Extension / promotion	0	3	3	4
Service provision	5	0	2	2
Production	6	3	5	7
Transformation	1	0	8	11

'Agreement', as used here, means the degree of homogeneity within 'families' of observations (Robinson, 1957). There are numerous measures of agreement in the literature including Pearsonian correlation, intra-class correlation, and various coefficients of concordance. The Kendall's coefficient of concordance ('W'), proposed by Kendall and Babington Smith (1939), is a measure of the agreement among several (m) quantitative or semi-quantitative variables that are assessing a set of (n) objects of interest. Whilst there is a close relationship between Friedman's two-way analysis of variance without replication by ranks and Kendall's coefficient of concordance, the later directly addresses the null hypothesis that 'judges' or respondents produced independent rankings of the objects or observations (Legendre, 2005). Also, the use of ranks (assigned by the judges) in the computation makes Kendall's coefficient more widely applicable (Robinson, 1957). A desirable property of the Kendall's coefficient of concordance is that since only rankings are involved in the computation of 'W', it does not involve the assumption of metric or of a specified parent population distribution (Robinson, 1957). The range of possible values for W is from 0 to 1; a value of 0 signifies maximum disagreement and 1 shows that the rankings are completely identical.

Kendall W statistic is an estimate of the variance of the row sums of ranks  $R_i$  divided by the maximum possible value the variance can take; this occurs when all judges are in total agreement. Whereas many researchers test W for statistical significance using the chi-square statistic with  $v = (n-1)$  degrees of freedom, Legendre (2010) notes that such practice is ill-advised. In fact, Legendre (2005) showed that when the number of judges is small, which is the case in most real-life applications of Kendall's test of concordance, the classical chi-square test is inappropriate because it is overly conservative. Also, Kendall and Babington Smith (1939) considered this test of W to be satisfactory for moderately large values of m and n only. This observation was confirmed by simulations reported by Legendre (2005), who recommended that researchers avoid the classical chi-square test when  $m < 20$ .

Statistical significance of the Kendall W is necessary but not sufficient test of agreement as for the purpose of this study, we also assume that a minimum of 50 percent agreement among actors defines 'a shared understanding'. Thus, statistical significance of the Kendall W is necessary but not sufficient evidence of agreement.

In the second part of the interview, respondents were asked to identify and describe all the interactions they had

**Table 3. Types of interaction among system of innovation actors**

<b>Code</b>	<b>Type of interaction</b>
01	Seminar, guest lecture, meeting or field-day <b>organised</b>
02	Seminar, guest lecture, meeting or field-day <b>addressed</b>
03	Seminar, guest lecture, meeting or field-day <b>attended</b>
04	Project implemented
05	Report <b>written</b>
06	Paper or report <b>published</b>
07	Paper or report <b>reviewed</b>
08	Technology or product <b>developed</b> ; or patent <b>awarded</b>
09	Staff (of other organisation) <b>hired</b>
10	Graduate (from other organisation) <b>hired</b>
11	Graduate <b>placed</b> (in other organisation)
12	Committee, board or review <b>contributed to</b>
13	Informal advice or input <b>sought</b>
14	Formal advice or input <b>sought</b> (e.g. via consulting contract)
15	Informal advice or input <b>provided</b>
16	Formal advice or input <b>provided</b> (e.g. via consulting contract)
17	Policy makers, law makers, regulators etc <b>lobbied</b>

with other actors within the system of innovation over the previous twelve months. Actors associated with any of the six functions could potentially engage and interact with other actors within the same function or those within the five other functions, giving six engagement possibilities. Seventeen different types of interaction or engagement considered in the investigation are shown in Table 3. Descriptive statistics including means, frequencies, percentages, and cumulative frequencies were used to investigate and present information on the intensity and nature of these interactions.

## Results

The literature on systems of innovation highlights the interaction and dynamics between a variety of state, private sector and other actors in policy, research, regulation, education and production. In Ghana and Burkina Faso, however, as in much of Sub-Saharan Africa, processes of agricultural innovation are dominated by a small number of state or state-supported agencies on the one hand, and millions of small-scale producers on the other. Except in special cases, the private business sector does not play a major role in the funding or implementation of agricultural research or new product development. Business does play an important role as an intermediary between research and production (e.g. through the supply of agricultural inputs) and in post-harvest transformation of agricultural commodities. The formal side of the agricultural system of innovation continues to be dominated by the state (and its development partners).

In both Ghana and Burkina Faso, the key state-supported elements of the agricultural system of innovation include research, education, regulation, training and extension. In Ghana most agricultural research takes place within nine of the Council for Scientific and Industrial Research (CSIR) agencies<sup>2</sup>, 15 higher education establishments and a limited number of other agencies including the Cocoa Research Institute of Ghana (CRIG). Total spending on agricultural research increased significantly from 2001 as did the number of FTE researchers. In 2008, 81 percent of full-time equivalent (FTE) researchers were either in CSIR (67 percent) or other government agencies (14 percent), while 19 percent were in higher education. Crops Research Institute is the largest of these CSIR agencies (77 FTE in 2008), accounting for a quarter of total CSIR agricultural research expenditure (Flaherty et al., 2010). Specialised agricultural education and training takes place at the secondary, technical and tertiary levels. Several secondary schools run programmes in agriculture in which candidates sit the West African Senior Secondary School Certificate Examinations (WASSCE). There are five diploma awarding agricultural colleges<sup>3</sup> in Ghana which complement the non-degree programmes of the public universities in training agricultural extension personnel. In addition, the public universities train and award students various degrees in agriculture. Outside this formal system there are also three farm institutes<sup>4</sup> and the Leventis Foundation Farmers' Training programme<sup>5</sup> that train practising farmers to upgrade their skills and competence in various fields of agriculture. Agricultural

extension services are provided through the Ministry of Food and Agriculture (MOFA) at district level, and by a variety of other NGO and other development organisations, particularly in the north of the country.

In Burkina Faso agricultural research is dominated by *l'Institut de l'environnement et de recherches agricoles* (INERA) which runs a research and training centre in Kamboinsé and five regional research centres distributed among Burkina Faso's five agroecological zones. Other state agencies and the universities account for around a quarter of the human and financial resources allocated to agricultural research and development (Stads and Kaboré, 2010). Over recent decades funding for agricultural research has been erratic and largely dependent on development partners. Of the 240 FTE staff involved in publically-funded agricultural research in 2008, nearly half focused on either crops (26 percent) or natural resources (22 percent), with rice and sorghum being the two highest priority crops for INERA. Specialised agricultural education and training takes place mainly at secondary, technical and at university levels. UFRSEG<sup>6</sup>, University of Ouaga 2 and University of Koudougou offer training in agricultural economy at 'masters 1' degree level, however, this training is largely theoretical. The Rural Development Institute (RDI) provides more practical training, with its graduates having a profile in agricultural and rural development. Recently, others such as the New Interuniversity Postgraduate Programme (NPTCI) and some private institutions have begun to offer training in agricultural economy at 'master 2' level. Agricultural extension services are provided through the *Ministère de l'Agriculture de l'Hydraulique* through DGPER<sup>7</sup> and SNF<sup>8</sup> and by a variety of other NGOs and other development organisations.

## *Is there a shared understanding of the objective of the system of innovation?*

The basic idea that informs this part of the research is that without a shared understanding of priorities, it is unlikely that the actors within a system of innovation will be effective and efficient in generating, promoting and using innovations (and thus maintaining a relatively high level of growth). Our expectation is that the level of shared understanding of priorities should increase as the system of innovation is more highly specified and operational (i.e. in terms of region and crop). We might also expect to see relatively higher levels of shared understanding amongst respondents within functions than across functions.

Over all, (disregarding for a moment regions, crops and functions) the most commonly cited priority for the innovation systems in both countries was 'to increase national food security' (Table 4). However, in Ghana the second and third most commonly cited priorities were 'to increase food security of the rural household' and 'to reduce rural poverty'; whilst in Burkina Faso they were 'to respond to the needs of agricultural producers' and 'to

increase the capacity of the agricultural sector to adapt to climate change'. The Kendall's coefficient of concordance of 0.21 and 0.05 for Ghana and Burkina Faso, respectively, was statistically significant at  $p < 0.001$ . Thus, while we can conclude that there is some agreement among the respondents about the priorities of the system of innovation in each country; this is far outweighed by the degree of non-agreement (79 percent and 95 percent for Ghana and Burkina Faso, respectively).

This limited degree of agreement about the priorities for the innovation system is somewhat surprising. In Burkina Faso, between 2008 and 2010, the government initiated and led a participatory dialogue on the agricultural sector, which resulted in the elaboration of the new national plan for the rural sector (PNSR), (Government of Burkina Faso, 2010). Similarly, Ghana's current policy on food and agriculture (FASDEP II) was developed through extensive and broad consultation in an attempt to forge a shared national vision for the sector (Republic of Ghana, 2007). It would appear that whatever else resulted from these participatory, consultative and stakeholder-oriented processes, they did little at the national level to create a shared understanding of the priorities for the agricultural innovation system.

When these data are disaggregated by country/crop combination, yam-related respondents in Ghana were 27 percent in agreement about the priorities for

the innovation system, with the top three priorities being 'to increase national food security', 'to increase food security of the rural household' and 'to increase rural livelihood sustainability'. In contrast, there was no statistically significant agreement about priorities among plantain-related respondents (however this may be due in part to the limited number of respondents). In the case of Burkina Faso, among respondents associated with the three crops there was less than 10 percent agreement about the priorities for the innovation system.

Disaggregation by region shows that agreement among respondents was 30 and 19 percent for Northern and Southern Ghana, respectively (Table 5). Looking across the two regions it is interesting to note the relatively higher priority given by respondents from northern Ghana to increasing rural livelihood sustainability. This reflects local realities: poverty and food insecurity are more common in the north, and agriculture in northern Ghana remains particularly vulnerable (ODI and CEPA, 2005, Chamberlin et al., 2007, Ghana Statistical Service, 2007, Jatoo et al., 2011b). On the other hand, in Burkina Faso, where rural poverty and vulnerability are also much remarked upon, the analysis indicates little agreement about priorities for the innovation systems within the regions.

Disaggregation by crop-region combination shows relatively high levels of agreement among respondents

**Table 4. Ranking of priorities for the innovation system, all respondents**

Primary purpose of innovation system	Country	
	Ghana	Burkina Faso
Increase national food security	1	1
Increase food security of rural households	2	9
Reduce rural poverty	3	7
Increase rural livelihood sustainability	4	10
Increase the profitability of the agricultural sector	5	4
Respond to the needs of agricultural producers	6	2
Increase the agricultural sector's share of the national economy	7	5
Reduce negative environmental impacts of agriculture	8	6
Increase the capacity of the agriculture sector to adapt to climate change	9	3
Increase the international competitiveness of the agricultural sector	10	8
Sample size (N)	33	80
<b>Kendall's W</b>	<b>0.21***</b>	<b>0.05***</b>
Degrees of freedom (df)	V1 V2	78 6082
F-value	8.51	4.2



**Table 5. Ranking of top three priorities for the innovation system, by respondent's region of interest**

<b>Primary purpose of innovation system</b>	<b>Northern Ghana</b>	<b>Southern Ghana</b>	<b>Southern Burkina Faso</b>	<b>Mid - Burkina Faso</b>
Increase national food security	1	1	1	2
Increase food security of rural households	2	2	9	9
Reduce rural poverty	4	4	7	5
Increase rural livelihood sustainability	3	6	10	10
Increase the profitability of the agricultural sector	6	3	6	4
Respond to the needs of agricultural producers	5	5	2	1
Increase the agricultural sector's share of the national economy	7	7	3	8
Reduce negative environmental impacts of agriculture	8	8	5	7
Increase the capacity of the agriculture sector to adapt to climate change	9	9	4	3
Increase the international competitiveness of the agricultural sector	10	10	8	6
Sample size (N)	12	21	41	49
<b>Kendall W</b>	<b>0.295***</b>	<b>0.188***</b>	<b>0.05***</b>	<b>0.06***</b>
Degrees of freedom (df)	V1 V2	9 97	9 178	39 1519
F-value		4.60	4.63	2.1 3.1

associated with yams in both northern and southern Ghana (30 and 27 percent respectively). For no other crop-region combinations was the level of agreement statistically significant.

Finally, disaggregation by function shows levels of agreement above 50 percent among respondents associated with input supply and production in Ghana (Table 6). Interestingly and perhaps not unexpectedly, while both groups rank to 'increase national food security' as the first objective, respondents associated with input supply ranked to 'respond to the needs of agricultural producers' and to 'increase the agriculture sector's share of the national economy' in second and third place, while respondents associated with production prioritised to 'increase food security of rural households' and to 'reduce rural poverty'. When the data for Burkina Faso was analysed at this more disaggregated level, no statistically significant agreement was found among any group of actors.

In summary, these data provide little evidence of a shared set of priorities or a common understanding that

could be said to tie together the system of innovation. While this result might not be unexpected at the national level, the fact that there appears to be little common understanding at the level of crop-region combinations (or indeed within most functional groups) is surprising.

If we assume a link between beliefs about priorities and the focus of innovation, we can conclude that, to a considerable degree, people associated with the different functions of the system of innovation are likely to be 'pulling in different directions'. While it may always be the case that there are different visions and some level of contestation concerning future directions, the assumption of systems of innovation theory is that this is in the context of substantial agreement about overall goals and priorities. We found little evidence of what might be considered substantial agreement.

Interactivity is a second important characteristic of a system of innovation, and in the next section we explore the intensity and nature of interaction among actors who should be at the centre of the innovation systems for the selected high-growth crops.

**Table 6. Ranking of top three priorities for the innovation system, by the function of respondent's organisation**

Primary purpose of innovation system	Function										
	Education		Extension/ promotion		Research		Input supply		Production		Policy making
	Ghana	Burkina Faso	Ghana	Burkina Faso	Ghana	Burkina Faso	Ghana	Burkina Faso	Ghana	Burkina Faso	Burkina Faso
Increase national food security	3	1	5	1	1	1	1	7	1	4	3
Increase food security of rural households	4	9	3	3	4	10	10	9	2	8	9
Reduce rural poverty	2	4	6	6	2	4	9	4	3	6	4
Increase rural livelihood sustainability	7	6	4	10	5	9	4	10	4	9	6
Increase the profitability of the agricultural sector	1	10	1	5	3	7	8	3	6	1	10
Respond to the needs of agricultural producers	8	7	2	2	6	8	2	1	7	3	5
Increase the agricultural sector's share of the national economy	5	8	7	8	10	5	3	5	5	2	8
Reduce negative environmental impacts of agriculture	9	2	9	4	9	6	5	6	8	7	2
Increase the capacity of the agriculture sector to adapt to climate change	10	5	10	7	7	3	6	2	10	5	1
Increase the international competitiveness of the agricultural sector	6	3	8	9	8	2	7	8	9	10	7
Sample size (N)	2	6	2	8	13	18	5	10	9	11	10
<b>Kendall W</b>	<b>0.716</b>	<b>0.25</b>	<b>0.294</b>	<b>0.14</b>	<b>0.127</b>	<b>0.06</b>	<b>0.555***</b>	<b>0.16</b>	<b>0.479***</b>	<b>0.14</b>	<b>0.17</b>
Degrees of freedom (df)											
V1	8	4	8	6	9	16	9	8	9	9	8
V2	8	14	8	34	106	254	34	62	70	79	62
F-value	2.52	1.7	0.42	1.1	1.75	1.1	4.99	1.7	7.36	1.6	1.8



**Table 7. Intensity of interaction among system of innovation actors over previous 12 months**

Reported number of interactions	Frequency		Percent		Cumulative percent	
	Ghana	Burkina Faso	Ghana	Burkina Faso	Ghana	Burkina Faso
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	6	2	18.2	2.5	18.2	2.5
3	10	11	30.3	13.8	48.5	16.3
4	8	20	24.2	25.0	72.7	41.3
5 to 10	7	47	21.2	58.8	93.9	100
11 to 15	2	0	6.1	0	100	
<b>Total</b>	<b>33</b>	<b>80</b>	<b>100</b>	<b>100</b>		

## How interactive is the innovation system?

### Intensity and patterns of interactions

Here the indicator of intensity of interaction is the number of reported interactions with selected functions of the systems of innovation over the preceding twelve months. In Ghana, roughly 50 percent of all respondents reported three or less interactions over the preceding twelve months (Table 7), while in Burkina Faso, 41 percent of all respondents reported four or less interactions over the same period. Almost 60 percent of respondents in Burkina Faso reported between 5 and 10 interactions over the period, compared to 21 percent for Ghana. Thus, in general, actors in Burkina Faso appear to be more interactive than their counterparts in Ghana. The intensity of interactions does not seem to vary greatly between regions or region-crop combinations (Figure 1 and 2).

There seems to be some level of differentiation in the interactivity of respondents associated with the different

functions. In Ghana, research and education are the two most interactive functions (Table 8) while in Burkina Faso respondents associated with extension/promotion and marketing are most interactive (Table 9). Respondents also seem to interact with actors in some functions more than others: in Ghana interaction with the provision and education functions were most commonly reported, while interaction with actors in research, policy and production were most commonly reported in Burkina Faso.

Looking specifically at the interaction patterns of respondents associated with education and research, it is interesting to see that in Ghana research interacts more with the downstream functions of production, provision and transformation (Figure 3), while in Burkina Faso both research and education interact across all functions (Figure 4).

### Types of interactions

If the extent of reported interaction is limited, what do we learn about the forms of interaction? Respondents from Ghana reported that 60.7 percent of

**Table 8. Interactions by function, Ghana**

Function of person reporting interactions	Mean interactions per respondent	Function of person with whom interaction occurred	Mean interactions over all respondents
Research	6.0	Provision	5.4
Education	4.4	Education	5.0
Extension / promotion	4.0	Research	4.4
Production	3.1	Production	4.3
Provision	3.0	Extension/ promotion	4.3
Transformation	3.0	Transformation	0.1
<b>Weighted Average</b>	<b>4.2</b>	<b>Weighted Average</b>	<b>4.2</b>

Table 9. Interactions by function, Burkina Faso			
Function of person reporting interactions	Mean interactions per respondent	Function of person with whom interaction occurred	Mean interactions over all respondents
Extension / promotion	7.5	Research	14.1
Marketing	7.3	Policy	10.5
Provision	6.3	Production	9.1
Policy	6.3	Education	7.8
Finance / investment	6.1	Provision	5.8
Education	5.8	Transformation	5.3
Research	5.6		
Production	4.0		
Regulation	3.8		
<b>Weighted Average</b>	<b>5.8</b>	<b>Weighted Average</b>	<b>5.8</b>

Figure 1. Average number of interaction by function – Ghana

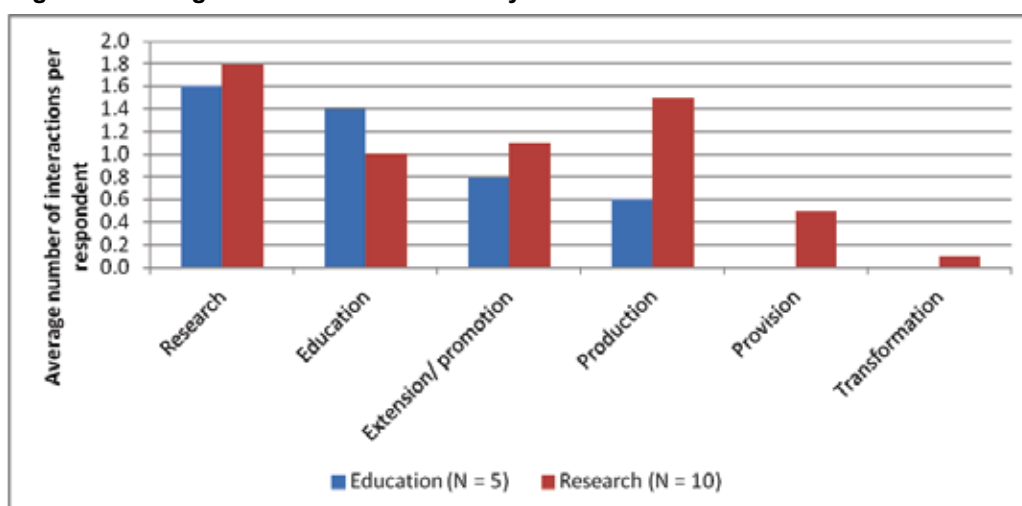
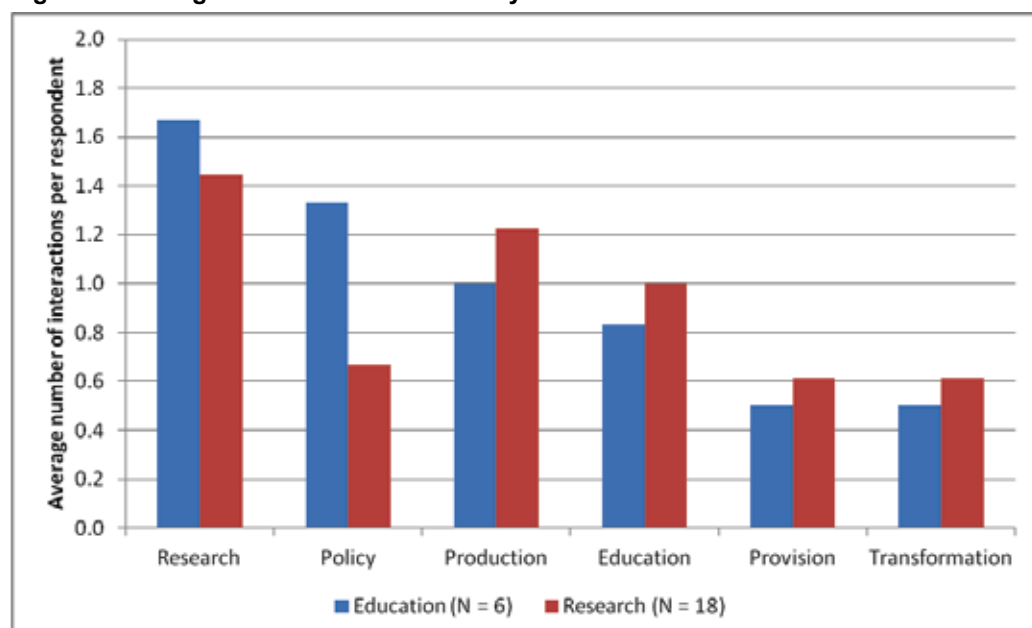


Figure 2. Average number of interaction by function – Burkina Faso



<b>Table 10. Types of interactions</b>				
<b>Type of interaction</b>	<b>Ghana</b>		<b>Burkina Faso</b>	
	<b>Frequency</b>	<b>Percent</b>	<b>Frequency</b>	<b>Percent</b>
Seminar, guest lecture, meeting or field-day organized	23	16.4	116	25.0
Informal advice or input sought	23	16.4	58	12.5
Informal advice or input provided	14	10.0	24	5.2
Seminar, guest lecture, meeting or field-day addressed	13	9.3	22	4.7
Seminar, guest lecture, meeting or field-day attended	12	8.6	65	14.0
Technology or product developed; or patent awarded	11	7.9	5	1.1
Formal advice or input provided (e.g. via consulting contract)	10	7.1	17	3.7
Policy makers, law makers, regulators etc lobbied	10	7.1	15	3.2
Report written	7	5.0	12	2.6
Graduate placed (in other organisation)	4	2.9	25	5.4
Paper or report published	3	2.1	22	4.7
Paper or report reviewed	3	2.1	-	-
Committee, board or review contributed to	3	2.1	14	3.0
Formal advice or input sought (e.g. via consulting contract)	3	2.1	57	12.3
Project implemented	1	0.7	12	2.6
<b>Total</b>	<b>140</b>	<b>100</b>	<b>464</b>	<b>100</b>

their interactions were related to seminars (organising, presenting at, or attending) and informal advice (seeking or providing) (Table 10). In Burkina Faso the profile of reported interactions was similar except that the seeking of formal advice was relatively more important than in Ghana. Over both countries, respondents reported relatively few interactions around, for example, joint project implementation or technology development, lobbying or co-publishing.

The importance of seminars as a locus of interaction is striking (34 and 44 percent of all reported interactions in Ghana and Burkina Faso respectively). While organising or attending seminars might be seen as a stylised and relatively passive form of interaction, these events may also provide opportunities for networking and informal interaction around other topics or issues.

Further analysis showed few differences in the types of interaction between regions or across crops.

## Discussion

This research set out to interrogate the 'systems of innovation hypothesis', that a dynamic and growth-oriented agricultural sector is not possible without a functional system of innovation (SI). Specifically, it sought evidence for two important characteristics of a system of innovation: a common understanding of priorities, and a high level of interactivity. In taking account of the performance of individual crops in particular parts of the country, we sought to move beyond the notion of a national system of innovation, and highlight the various ways that the SI manifests itself in particular settings (i.e. defined as a crop-region combination). Our assumption was that it is at the level of the crop-region combination that shared priorities and interaction really matter.

The main points that emerge from the analysis presented above are that no matter what the level of analysis, from national to specific region-crop combinations: (1) there is little evidence of common

understanding concerning the objectives or priorities of the system of innovation; (2) the overall level of interactivity is low, and what interaction there is can be characterised as in large part passive/informal. Thus, we are forced to conclude that the evidence for the existence of anything that might be considered a high functioning system of innovation is weak.

Does this suggest that the link between growth and innovation – supported by a system of innovation – has been overstated? Perhaps. On the other hand, it is important to remember that the growth demonstrated in Table 1 arises in two ways: from increases in area and increases in productivity (yield i.e. output per unit area). Furthermore, in all cases (except millet and sorghum in Mid-Burkina Faso), increased area contributed more to growth in total output than increases in productivity. Could it be that growth through area expansion can take place independent of a high functioning system of innovation? More detailed analysis of the millet and sorghum cases in Mid-BF might be warranted, since in both cases, growth in output was observed despite a reduction in cultivated area. Was this growth achieved in the absence of a system of innovation? In fact, in contrast to Ghana, yield was relatively more important than increased area for all crops in Burkina Faso, yet there was little evidence in Burkina Faso of anything approaching a common understanding of priorities for the systems of innovation. On the other hand, actors in Burkina Faso reported a higher level of interaction than their counterparts in Ghana. It is also interesting to note again that while actors associated with education in Ghana reported no interactions with the downstream functions (provision and transformation), in Burkina Faso actors associated with education reported interactions with both provision and transformation (although at a very low intensity). There is also some indication that responses from Burkina Faso about the priorities for the innovation system were somewhat more market-oriented.

Perhaps the most satisfactory explanation of these findings is that the link between growth and a functioning system of innovation only becomes evident when farmers have exhausted the possibilities for easy wins associated with, for example, the expansion of cultivated area or with relatively simple improvements in agronomy. In other words, there may be levels of extensification and intensification that can be adequately supported by knowledge, resources and technology that are already available. The question is what happens when these easy wins are fully exploited – for this is when we would expect the value of a more formal system of innovation to be evident.

If this interpretation is right, then from a policy perspective there may be an opportunity to better target investment in agricultural research and other activities that support innovation. As investment funds are limited, crop–region combinations where growth can be achieved through a combination of expansion of cultivated area

and relatively simple improvements in agronomy could be de-prioritised, at least in the short term. However, this is not to suggest that investment in infrastructure and institutions can or should be abandoned, as these frame the easy wins.

## END NOTES

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- 1 For 'Northern Ghana' we used the Savannah Accelerated Development Authority (SADA) definition of the 'northern savannah ecological zone', encompassing Districts with 900–1,200 mm average annual rainfall; 'Southern Ghana' includes all remaining districts. In 'Southern BF' we included nine Provinces with 900–1,200 mm average annual rainfall; in agro-ecological terms this region is usually termed sud Soudan. 'Mid-BF' includes 18 Provinces with 600–900 mm average annual rainfall. In agro-ecological terms this region is usually termed nord Soudan. See Jatoe, J.B.D., Gountiéni, D.L. & Sumberg, J., 2011a. Differential Performance of Agriculture in Ghana and Burkina Faso: The FAC West Africa Transect Study. Interim Report Brighton, UK: Future Agricultures Consortium.
- 2 Animal Research Institute (ARI); Crops Research Institute (CRI); Soil Research Institute (SRI); Oil Palm Research Institute (OPRI); Food Research Institute (FRI); Forestry Research Institute of Ghana (FORIG); Plant Genetic Resources Research Institute (PGRRI); Savannah Agricultural Research Institute (SARI); and the Water Research Institute (WRI).
- 3 Kwadaso Agricultural College, Ejura Agricultural College, Ohawu Agricultural College, Damongo Agricultural College, and the Animal Health and Production College at Pong-Tamale.
- 4 Adidome Farm Institute, Wenchi Farming Institute, and the Asuansi Farm Institute.
- 5 This programme is run by the Institute of Agricultural Research, College of Agriculture and Consumer Sciences, University of Ghana, Legon.
- 6 Unité de Formation et de Recherche en Sciences Economiques et de Gestion.
- 7 Direction Général de la Promotion de l'Economie Rurale.
- 8 Centre National de Semences Forestières.

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