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Policy dynamics and institutional dysfunctions in public agricultural research and innovation

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POLICY DYNAMICS AND INSTITUTIONAL DYSFUNCTIONS IN PUBLIC AGRICULTURAL RESEARCH AND INNOVATION

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ABSTRACT

Ghana's agricultural policies in recent years have emphasized technology development objectives to the neglect of addressing the conditions surrounding the actors in the sector. In this paper we analyse some of the technologies generated within the current socio-technical regime and impacts with the view to considering options for improving on public agricultural research. The paper underscores the need for a more systemic changes in the approach to innovation in agricultural sector and the need for policy change towards this . Research and development must be dovetailed with a drive for entrepreneurship that engages critical actors for business and inclusive growth. Besides, public agricultural R&D needs policy realism that sets targets, which take account of the context of innovation. The paper calls for a new thinking – a new philosophy – that stimulates new sources of motivation for exploiting the potential of public agricultural R&D for national development.

Key Words – policy, agriculture, research, innovation, Ghana

1. INTRODUCTION

The innovation system concept underscores the centrality of multi-actor roles in innovation. It places emphasis on the importance of all critical actors in defining, shaping and bringing into being innovation [14] [43]. In the agricultural domain, the farmer is as equally important as the scientist or researcher in the agricultural laboratory. The primacy of the role of the agricultural researcher in stimulating innovation to enhance agricultural productivity is not in dispute. There is continued discourse however on how to enhance the role of public-funded agricultural research institutes in order to improve outcomes and impacts in African agriculture [16].

An understanding of innovation is fundamental to discussing agricultural research and assessing the success and failure of the systems put in place for research and development R&D. Innovation is the use of new ideas or knowledge, new technologies or new ways of doing things in a given context and by people where they have not been used before [8]. From another perspective, innovation is also increasingly used in the sense of the process of technical and institutional change at the unit of production (e.g. farm) and higher levels that impacts on productivity, sustainability, and poverty reduction [36]. So it goes beyond artifacts such as machines and equipment, new products and other tangible materials that are only the evidence of the processes through which innovations come. Most importantly, the innovation manifests in the use to address need in the specific context in the economy, society and or environment. The systemic concept of innovation is quite well explained severally [18] [30] [14]. It underscores the need for analyzing from all dimensions, the trends and dynamics in the institutional arrangements for innovation. In a country such as Ghana, with the typical Sub-Saharan African development challenges low farmer productivity, significant poverty incidence, limited food self-sufficiency, threat to sustainability of livelihoods and climate change impacts, policies that emanate from system thinking is vital.

Ghana has had a long history of agricultural research going back to the colonial era. Currently, there are ten public agricultural research institutes mainly of the Council for Scientific and Industrial Research (CSIR) in Ghana pursuing the mandate of bringing scientific research to bear on agricultural development. There are also the agricultural faculties of the public universities such as University of Ghana, Kwame Nkrumah University of Science and Technology (KNUST) and University of Cape Coast (UCC) where research and development (R&D) constitute a core activity. There is however a perceptible dilemma in sustaining public agricultural research; national investment in public agricultural research is fairly enormous and policy makers are looking for options to lessen the burden on the national coffers and to strengthen the impact of agricultural research and development (R&D). By implication, the dilemmas are:

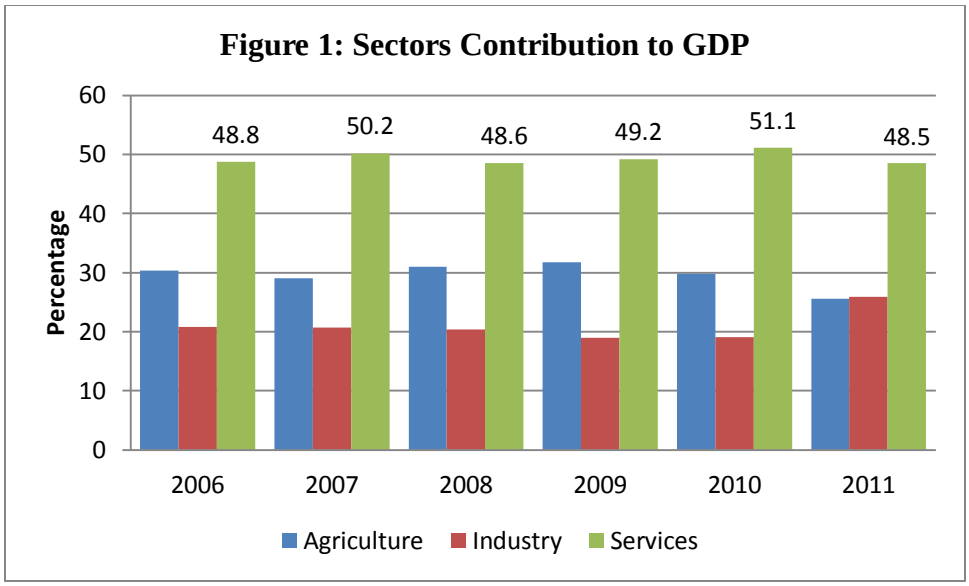
(i) How to sustain the national investment in public agricultural research which is fairly enormous?
(ii) What are the options to lessen the burden on the national coffers? and to
(iii) How can the impact of agricultural research and development (R&D) be strengthened?

The aim of this paper is to analyze the basis of the issues and generate some alternatives especially in relation to R&D and technology development in Ghana. In answering the stated questions of this paper, the paper reviews the national agricultural policies and programmes against the background of Ghana's development challenges, to identify gaps and explores how the public research institutes are working to addressing these gaps and the challenges therein. In the case of the later, it analyses the outputs and impacts of the public research institutes in addressing the gaps with emphasis on socio-technical challenges and requirements. The paper then discusses the options for improving on public agricultural research with emphasis on inclusive socio-economic development.

1.1.The Importance of Technology and Innovation

The need for technology and innovation to drive socio-economic development is generally known in Africa. It spans the entire spectrum of technological inputs for all kinds of socio-economic activities. Across the African continent, the need for technology to drive socio-economic development has been widely expressed [3] [5] [31] [12]. From the policy perspectives, the fundamental question is how the generation and management of knowledge for innovation has been formulated and implemented.

The post-independence era of the late fifties and sixties was the high point of agriculture's contribution to Ghana's GDP. Agriculture contributed substantially to real GDP; it contributed 58% in 1972 declining to about 49% in 1978 [6]. From 1983 to 1986, agricultural contribution to real GDP was 52% and decreasing to 42% between 1991 and 1995 [5]. In the 2000s, agricultural contribution to GDP is shrinking even asthe service contribution is increasing.



Source: ISSER, 2012; Based on Ghana Statistical Service data

Currently, agricultural contribution is 25.6%, whilst the service sector has become dominant with around 50% contribution to GDP as shown in Figure 1. But this in no way diminishes the importance of agriculture in the economy. About 65% of the 25 million population of Ghana is employed directly or indirectly in agriculture. In the rural and informal economy, agriculture is the most important sector, creating livelihoods and ensuring income generation to most households. In fact, an estimated 2.74 million households operate a farm or keep livestock in Ghana [23]. The importance is also in the potential agriculture creates for industrialization and for the other conditions for socio-economic advancement. Research and Development (R&D) is highlighted in Ghana's development frameworks and agricultural policies with the rationale that it will facilitate the important role of agriculture in the economy and national development generally.

1.2 A Review of National Agricultural Policies and Analysis of the Policy Dynamics

Agricultural policies have remained an integral component of national development plans. They provide the framework for national programmes aimed at food security, agro-based industrialization and overall socio-economic development. Ghana's Food and Agriculture Sector Development Policy (FASDEP) documents (I &II) typify the broad national vision for agricultural transformations [23] [25]. Agriculture has always been seen as the vehicle for inclusive growth and the national vision for the food. It is understand from the policy perspective that a modernized agriculture is important for a structurally transformed economy, which is evident in food security, employment opportunities and reduced poverty. Table 1 summarises the main agricultural policies of Ghana in the past twenty years.

Table 1: Main Agricultural Policies and Research and Development (R&D) Focus

Policy Document	Period	Policy Goals	Research Focus
MTADP	1991 – 2000	An initiative to consolidate gains made under ERP; to establish and support market-led growth in agriculture;	Greater utilization of skills in science and

		plan provides the framework the coordination and rationalization of agencies operating in the agricultural sector. Sector annual growth rate of 3.7% targeted.	technology as a vehicle for achieving objectives.
NARP	1991 – 1999	The main objectives were to re-vitalise research by rehabilitating the means of carrying out research, improving the management of the research system and facilitating the linkages between research, extension and farmers.	Improve human and material resources for R&D and the outputs.
AAGDS	20001-2010	The AAGDS provided a framework for agricultural policies and programmes; sets agricultural GDP growth rate target of 6% annually. Key element – driving agricultural production and distribution processes by significantly improving access to markets.	Increase access to improved technology
AgSSIP	2001 – 2010	An instrument for implementing AAGDS; increase agricultural productivity and diversification at a rapid pace so that rural incomes will be raised, rural poverty reduced, food security improved and basis for accelerated overall economic growth established with environmental sustainability.	Reforming and strengthening agricultural technology generation and diffusion.
FASDEP I	2002 – 2006	Provide a framework for modernising agriculture and catalyse rural transformation and poverty reduction.	Technology development and dissemination
FASDEP II	2007 – 2013	It emphasizes the sustainable utilization of all resources and commercialization of activities in the agriculture sector with market-driven growth; enhancement of productivity of the commodity value chain with emphasis on environmental sustainability and greater engagement of the private sector.	Objective 5: Application of Science and Technology in food and agriculture development
METASIP	2011-2015	To accelerate growth and transform agriculture in Ghana through modernization. It is a strategic framework to implement FASDEP II for interventions for the agriculture sector to play its role in the national economy in the context of the Ghana Shared Growth and Development Agenda (GSGDA).	Uptake of technology along the value chain and application of biotechnology; research funding; research information management.

Source: Various Ghana's agricultural policy documents of MOFA

This paper draws its timeframe for analysis from the period of of the Economic Recovery Programme (ERP) which was a revolutionary departure from state-centred economic planning adopted after independence in 1957. The economic reforms carried out through the Economic Recovery Programme (ERP) and its related policies and programmes such as the Structural Adjustment Programme (SAP) in the 1980s and 1990s did not only prepare the grounds for subsequent agricultural policies, but it provided the direction and the context for these policies. The Medium Term Agricultural Development Plan (MTADP) was broadly aimed at consolidating gains made under the ERP. The market-oriented philosophy that gave birth to the ERP informed the formulation of the MTADP and it was intended to establish and support market-led growth in agriculture with a target of an annual agricultural growth rate of 3.7%. The plan provided the framework for the coordination and reformation of agencies operating in the agricultural sector to enhance their productivity.

The public research institutes with mandate in Research and Development (R&D), i.e. the research institutes and the universities, had a specific programme formulated and implemented as

the National Agricultural Research Programme (NARP). The Council for Scientific and Industrial Research (CSIR) coordinated the programme. As shown in Table 1, the main objectives of NARP were to revitalise the National Agricultural Research System (NARS) by rehabilitating the means of carrying out research, improving the management of the research system and facilitating the linkages between research, extension and farmers.

In evaluating NARP, a major issue highlighted was tailoring R&D activities to realistic expectations of stable operational funding. The government did not fund research adequately and many public research institutes depended on donors for operational funds, which was not in the long-term sustainable [40]. It was the beginning of the move to commercialise R&D in the National Agricultural Research System (NARS). Specifically, the CSIR began planning to examine the opportunities for generating funds from sources outside the public sector e.g. services for sale including both research itself and the services of the support functions (the libraries, research information, equipment maintenance and training). Commercialisation was considered critical enough to warrant a new establishment legislation for the CSIR by an Act of Parliament. Thus the Council for Scientific and Industrial Research Act, 1996 (Act 521) included in the functions of the CSIR "…(i) to encourage and promote the commercialization of research results; (j) to undertake or collaborate in the collation, publication, and dissemination of the results of research and other useful technical information…" [1]. The term that became a jargon during and after NARP was "demand-driven" research. The institutes of the NARS and in the wider R&D system were supposed to be orientating to R&D conducted with the user-end points in view and with some considerations of market principles to yield internally generated funds (IGF).

The Accelerated Agricultural Growth and Development Strategy (AAGDS) succeeded the MTADP as an agricultural policy framework. Significantly, it targeted an annual growth rate for agriculture of 6%. It also highlighted the need for science and technology impact on agriculture with emphasis on the performance of the NARS. The instrument for implementing AAGDS was the Agricultural Services Subsector Investment Project (AgSSIP). It was aimed at among other things, increasing agricultural productivity and diversification at a rapid pace so that rural incomes would be raised, rural poverty reduced, food security improved and the basis for accelerated overall economic growth established with environmental sustainability. A core component was reforming and strengthening agricultural technology generation and diffusion and ensuring delivery to the farmers.

In every sense, AgSSIP was a major undertaking to deepen the orientation of the NARS of Ghana towards the market and to strengthen technology and innovation delivery to the farmers and actors in the user ends. Looking back, AgSSIP was just another phase of NARP with major similarities in concept, structure and approach to implementation. The differences were not too substantial. One may conclude that, whereas there had been some successes with the developments of some technologies and innovations (and some of these will be discussed later in this paper), the technological constraints facing producers in the agricultural value chains remained. From the conceptual perspective, it is also clear that NARP and AgSSIP highlight the technology-push underlay of the formal R&D system, which though is not wrong fundamentally, is potentially dysfunctional.

The FASDEP policy documents and related frameworks continue in the fundamental market-driven orientation. The overall elaboration of the development agenda as in the Growth and Poverty Reduction Strategy (2004 – 2009) and the Ghana Shared Growth and Development Agenda (2010 – 2013) underscored this orientation and set the stage for the kinds of agricultural

policies emanating from these or in consonance with these. For example, the FASDEP II (2007 – 2013) emphasizes the sustainable utilization of all resources and commercialization of activities in the agriculture sector with market-driven growth; enhancement of productivity of the commodity value chain, through the application of science and technology and environmental sustainability [23]. Greater engagement of the private sector and collaboration with other development partners is pursued to facilitate implementation of the policy. In FASDEP II a high priority is placed on applied research focusing on supporting on-farm and off-farm innovations for improved production systems, higher productivity, greater small- and large-scale industrialized processing.

There is also the Medium Term Agriculture Sector Investment Plan (METASIP). The purpose of METASIP is to accelerate growth and to transform agriculture in Ghana through modernization [25]. It is a strategic framework to implement FASDEP II over the medium term 2011-2015 and for interventions for the agriculture sector to play its role in the national economy in the context of the Ghana Shared Growth and Development Agenda (GSGDA) which is the national programme of economic and social development policies. METASIP is also in fulfillment of Ghana's participation in agriculture-related initiatives of Economic Community of West African States (ECOWAS) and the Africa Union Commission (AUC) under the framework of the ECOWAS Agriculture Policy (ECOWAP) and the Comprehensive Africa Agriculture Development Programme (CAADP). The priorities outlined in the METASIP include food security and emergency preparedness, improved growth in incomes, sustainable management of land and environment, and science and technology applied in food and agriculture development. A key challenge for Africa is also how to design and implement effective policies to promote industrialization and economic transformation [12]. In this regard, agricultural policies and the programmes initiated to strengthen the linkage between the R&D system and the productive actors is very important.

In reviewing these public policies, the aim is to assess the extent of national commitments to public agricultural research and the extent to which such commitments have been executed as for example in public investments and the overall support to the public agricultural research institutions. The key evidence of government commitment is the public investment in R&D coming in the forms of national R&D programmes designed and implemented over specific periods with secured budgets. For example, the National Agricultural Research Project (NARP) was implemented from 1991 to 2000 with a budget of about $22 million [40]. It was broadly aimed at strengthening, in the long-term, the National Agricultural Research System (NARS) to generate improved agricultural technologies. There was also the Agricultural Services Sub-Sector Investment Project (AgSSIP) implemented after the NARP with a budget of about $67 million, with $39.5 million allocated for projects on technology generation and diffusion [44]. Currently, there is also the West Africa Agricultural Productivity Programme (WAAPP) with the CSIR being the implementing agency. WAAPP is being implemented with a total budget of $15 million. All these projects have been implemented with World Bank support and have illustrated the commitment of governments and development partners in promoting scientific research to enhance agricultural improvement.

However, the formulation and execution of these programmes are not ends in themselves. There is a dominant question on issues of the gains made, the impacts and the sustainability. This line of discussion is not new in the literature on innovation for agricultural development. As Clark et al (2013) noted, there is a knowledge market inefficiency that is the result of the

mismatch between the 'supply of' and 'demand for' scientific information or research outputs. Addressing this rather complex issue requires very innovative approaches.

2. REVIEW OF INNOVATION IN THE NATIONAL AGRICULTURAL RESEARCH SYSTEM (NARS)

A study was conducted between 2010 and 2011 to review technology development and innovation in the National Agricultural Research System (NARS) of Ghana [35]. The International Food Policy Research Institute (IFPRI) collaborated with the Science and Technology Policy Research Institute (STEPRI) of Ghana on the study. The sample covered all the agricultural research institutes of the CSIR and the agricultural faculties of the public universities. The IFPRI-STEPRI study highlights the agricultural innovations in the NARS most of which were the results of the projects implemented in Ghana particularly the NARP and the AgSSIP of the 1990s and the 2000s.

2.1. Types of Technologies and the Research Organisations

The survey showed that in the research organisations covered in the NARS, there were 109 technologies made up of crop varieties, agro-processing technologies, farming techniques and others as shown in Table 2.

Table 2: Distribution of Agricultural Technologies by Categories

Categories of Agricultural Technologies	Number	Percentage (%)
Crops	70	64.2
Agro-processing	17	15.6
Livestock/ poultry	15	13.8
Fisheries	2	1.8
Other	5	4.6
Total	109	100.0

Source: IFPRI-STEPRI Survey, 2010

Table 2 shows that 64.2% of the technologies were of crops i.e. improved crop varieties. The dominance of the crop technologies amply illustrates where the emphasis has always been in agricultural R&D in Ghana. Over the years, efforts have been invested in getting the right varieties of crops developed for the farmers given that about 75% of the agricultural GDP is contributed by crops sub-sector [28]. The post-harvest technologies for storage and processing constituted 15.6% of the technologies identified in the survey. Livestock including poultry technologies and fisheries together constituted roughly 16%.

The analysis of the crop technologies shows that 47.1% was developed for higher-yields and pest and disease resistance. About 17% were technologies developed to improve soil fertility and land management whilst 15.7% were technologies for pest management. Field management practices and other technologies came to about 20% of the total crop technologies.

What led to the development of these technologies is important because it explains whether the prevailing philosophy of market-driven research applied in these cases. In reality research leading to these types of crop technologies did not originate only from the researchers' interests or specialization alone. The formation of Research Extension Linkage Committees

(RELCs) since the NARP implementation to bring the supply and demand sides of research together contributed to the kinds of research done. The RELCs were made up of the researchers, extension officers, farmers, input suppliers, among others. To some extent what came as outputs in the form of the crop technologies were the kinds of priorities set as the research agenda. Yield increase, pest and disease management are still at the core of the constraints limiting crop production. Collectively they rank at the top of the priorities. But once efforts are made to address these and the expected production increases, the challenge is then for post-harvest management and processing. It is logical then to expect the priorities on production and processing to be in similar measure.

The dominance of the crop technologies also came from the institutional bias in crop agricultural R&D in the NARS. Table 3 shows the institutional contribution to the 109 technologies surveyed.

Table 3: Distribution of Technologies by Research Institutions

Research Institution	Number	% of Total
Council for Scientific and Industrial Research (9 institutes)	99	91.8
University of Ghana (1 Faculty)	5	4.6
Kwame Nkrumah University of Science and Technology (1 Faculty)	2	1.8
University of Development Studies (1 Faculty)	2	1.8
University of Education at Winneba (1 Faculty)	1	0.9
Total	109	100

Source: IFPRI-STEPRI Survey, 2010

Of the thirteen research institutes operating under the auspices of the CSIR, nine are agriculturally mandated. They include the Crops Research Institute (CRI), Soil Reearch Institute of Ghana (SRI), Food Research Institute (FRI), Savanna Agricultural Research Institute (SARI) and Oil Palm Research Institute (OPRI). As shown in Table 3, the CSIR accounted for 91.8% of the technologies encountered in the survey of the NARS. The predominance of the CSIR technologies is mainly due to the high response rate of the CSIR institutes as against the university agricultural faculties as well as the fact that, R&D constitute the core mandate of the CSIR institutes. It is only to be expected that CSIR technologies should dominate the results of the survey.

2.2. The Achievements and Shortcomings

Whereas by the development of these technologies, the objectives of the agricultural sectoral programmes might have been met, the issue is whether the primary concern of having technologies and innovations delivered to the users have been addressed. Discussing achievements should therefore go beyond merely achieving project deliverables to achieving positive impacts. Indeed some impact studies carried out on specific technologies showed the extent to which in meeting the technology development objectives, positive impacts were made. For example, an impact assessment of the Ghana Grains Development Programme showed the diffusion of improved maize varieties by 54% [27]. With the introduction of the quality protein maize Obatanpa in 1992, some 20% of the total maize growing areas surveyed of about 130,000 hectares were planted with the Obatanpa variety and increasing at the rate of about 50% annually [27]. Farmers' adoption of the Obatanpa variety is a significant achievement of the R&D effort

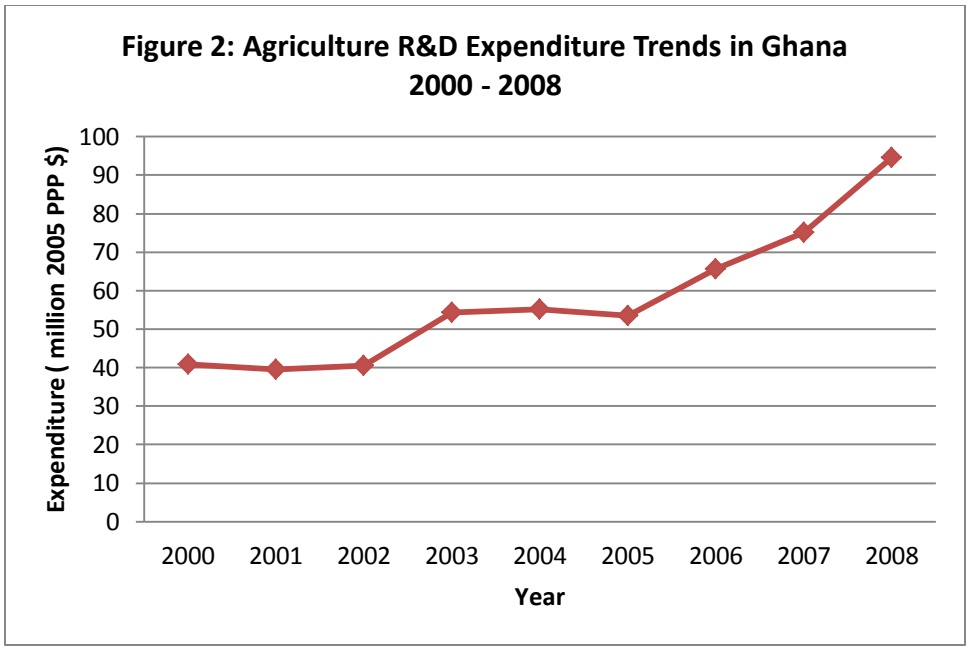
and the benefits the farmers experienced with the R&D output. The positive impact came not only with the increased yields for farmers but also with the consumers of the Obatanpa variety benefiting nutritionally from the higher protein content of the variety.

Currently, farmers are also receiving improved varieties of various crops which are said to be superior to the conventional varieties. For example, the improved cassava variety of CRI-Bankye Hemaa is known to yield 48.8 t/ha as against the national average yield for cassava – 13.5 t/ha; CRI-Esam Bankye yields 49.9 t/ha and the CSIR-Otuhia yields 65 t/ha [38]. In the case of rice, the irrigated fields are currently cropped with 99% of the modern varieties coming from the NARS [10]. However, local rice production is still a major challenge with an estimated import bill for 367,400 metric tonnes in 2011, which is not met by the local production. Rice has become a prime staple and Ghana is yet to attain self-sufficiency in rice production. Overall though, Ghana is self-sufficient in the major staples including maize, millet, cassava, yam, plantain and cowpea. The total surplus for all staples was estimated to be 9,143,000 metric tonnes in 2011 as against 9,204,000 metric tonnes in 2010 [28]. Still the issue is whether production of these staples has gone beyond self-sufficient production to over-production so as to become a raw material base for industrial processing and for exports. This has not been the case and it is an important short-coming which has to be addressed.

Besides, the insufficiency in local rice production coming as a result of the shift in the food consumption patterns of the populace undermines the important achievements that the NARS may have made with the implementation of the national agricultural policies and programmes over the years. It calls for new priority and agenda setting. More importantly, the surplus in the production of the main staples points to an existing capacity to create a sustainable base for agro-industrialisation, which offers diverse opportunities for enhancing micro, small and medium entrepreneurship. Indeed as investments are made in R&D to address the constraints of agricultural production, there is also the important need to invest in the post-harvest industrial activities that sustains the gains of agricultural production.

2.3 Agricultural R&D Expenditures in Ghana

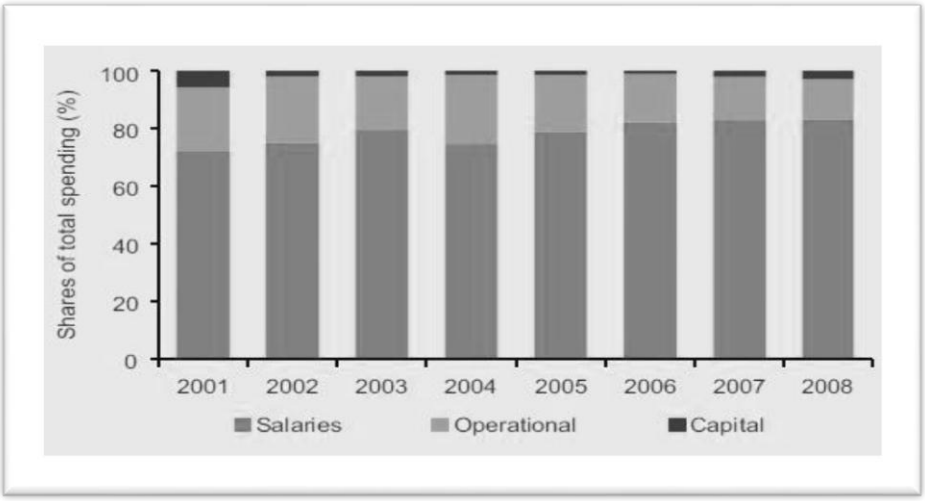
In recent years, there appears to be a rise in agricultural R&D expenditures in Ghana as Figure 2 illustrates.



Source: Based on Database of Agricultural Science and Technology Indicators (ASTI) of IFPRI.

Agricultural R&D investments are generally on the increase in Ghana with reference to the public expenditures recorded currently. The public expenditures in agricultural R&D in Ghana more than doubled between 2002 and 2008. It shot up from about $41 million, to over $95 million as shown in Figure 2 [13]. But a significant component of this substantial increase was accounted for by the increased funding for CRIG from the increasing cocoa revenues and the increase in personnel emoluments of public employees especially of the professional categories including the researchers and lecturers [13]. Figure 3 further illustrates the distortions in the agricultural R&D expenditures and the heavy bias for what is currently labeled 'compensation' - the new term for salaries and wages – in public accounts.

Figure 3: Cost category shares of CSIR, 2001–2008



Source: Flaherty et al. 2010.

The component of the salaries and personnel emolument in the totality of public expenditures on agricultural R&D generally increased in subsequent years from about 76% in 2001 to about 83% in 2008 as illustrated in Figure 3. What is left for the main business of operational R&D activities is rather meager considering the diversity of operations in the various research institutions. Donor agencies fill the gap in the operational and capital budgets. These include multi-lateral and bilateral agencies such as the UN agencies, Danish Development Agency (DANIDA), the Department for International Development (DFID), The German Technical Cooperation (GTZ), the US Agency for International Development (USAID) and Japan International Cooperation Agency (JICA). It is a reflection of the dysfunction in the policy and management approach of the NARS as the donor dominance of the operational budgeting undermines the sustainability of the overall R&D activities in line with national priorities.

3. INSTITUTIONAL DYSFUNCTIONS – ISSUES IN AGRICULTURAL INNOVATION AND TRANSFER

Without doubt, scientific agricultural research is useful and needs to be carried out in publicly supported institutional systems. The IFPRI-STEPRI study highlighted the potential in the NARS for technology development, the constraints of research organisations and shortcomings in marketing and entrepreneurship in particular. Three technologies are summarized here:

ARIBRO Chicken of the Animal Research Institute: The CSIR institute developed the ARIBRO breed of chicken for the poultry industry in Ghana which was hugely dependent on imported day-old chicks, broiler hatching eggs, and broiler parent stock. The ARIBRO broiler launched in 2009, was well-adapted to the local environmental conditions and made it possible to produce day-old chicks domestically at a lower cost than the imported breeds. In the interviews conducted during the IFPRI-STEPRI study with some of the adopters of the technologies, poultry farmers who have adopted the ARIBRO chicken were positive in their feedback. The poultry farmers e.g. Tako Farms, JB Farms, Adom Farms and City Farms attested to the superiority of the locally produced birds with some farmers having 100% survival rate of the day old chicks. So there is great demand for the ARIBRO chicken among poultry farmers. Yet there is a big gap between supply and demand since currently, it is only ARI that produces the breeds. There is need for an entrepreneurship which will commercialise all the ARIBRO products ranging from the day-old chicks to the parent stock [35].

Fufu Flour of the Food Research Institute: Fufu in Ghana is usually prepared through pounding of boiled cassava and plantain or cocoyam or yam. The pounding is not only a chore for women, but there is always the risk of pounding the fingers that turn the fufu in the mortar. Researchers thought about how to address the chore and the risk. There was the option of fufu machine and there was the option of processed fufu powder. The Food Research Institute (FRI) initiated action on the latter. The Institute developed the fufu flour in collaboration with other organisations. Subsequently, there have been further scientific works on the fufu flour to bring it to the market [32]). There are the two levels of diffusion of the fufu flour innovation. At one level, there is the diffusion into industry with firms adopting the technology to produce for the market. At the second level, there is the diffusion of the fufu flour product to the consumers. Some private firms have adopted the fufu flour technology and producing for both the local and foreign market. At the consumer level, the product is also diffusing gradually in the Ghanaian urban society with some restaurants serving fufu prepared from the processed flour. However,

the diffusion rate is rather low and the traditional pounding of fufu continues to hold sway [35]. In fact, there are consumers who only see the traditionally prepared meal as the only fufu to eat – never mind the sweat and risk of pounded finger! But this is one technology which appears to be at the threshold transforming a major Ghanaian food in its preparation is fundamental ways. It needs significant entrepreneurship to make this happen.

The Improved Brooding Management of the local guinea fowl: The technology was the result of a collaborative effort between the Animal Science Department of University of Development Studies (UDS), ARI, the Department of Animal Science of KNUST, and the School of Agriculture of UCC. As an important source of protein for Ghanaians especially in the northern parts of the country where is mostly reared, any technology to improve guinea fowl rearing is relevant to national priorities. The traditional way to rearing the birds, which allow them to roam freely, scavenge freely and fend for themselves results in high mortality of the keets, ranging from 63% to 100% before they are 10 weeks old [2] [17]. The improved brooding management technology comes with a technology for protecting the keets and special feed formulations. Though farmers acknowledged the usefulness of the technology which enhanced survivability and better growth of the keets, the technology has not been adopted unfortunately [35]. The factors impeding adoption include the absence of a well-developed strategy for the diffusion of the technology and to address basic farmers' constraints such as the lack of wherewithal to purchase the technology. The production of feed formulations in particular is an industrial activity which agricultural industries need to adopt to sustain the diffusion of the technology. As in the case of the fufu flour, there must be the two key levels of adoption – at the industry level and at the user level. It is a major challenge in promoting innovation.

Indeed the review of the 109 documented innovations illustrates the potential for impact on subsistence farming and livelihoods. These are innovations for entrepreneurship in the marginalized segments of the population and for stimulating inclusive growth. However, their full potential is in no way exploited and therefore there is created some basis for skepticism as to the impacts of public agricultural research. Yet, there are facets of the agricultural innovations in Ghana's NARS which demonstrate the potential for greater things than have been realized so far. The question, which has remained over the years at the heart of efforts to rejuvenate public agricultural research, is: how can the relevance and impact of agricultural research be enhanced? How can it be engineered to be the propeller for sustainable growth in agriculture and the larger economy? There is a willingness on the part of users of the outputs of R&D to adopt technologies and new knowledge for their specific purposes. Mensah and Micah (2007) have examined the utilization of R&D outputs in three CSIR institutes by the users including manufacturers and public organisations and concluded that there was adoption of the outputs [21]. But there was the need to formulate strategies to accelerate the utilization of the outputs.

Currently, national agricultural policies emphasize modernization of agriculture. That modernization should be fostered through science, technology and innovation. The public agricultural research institutions should be the source of restoring optimism in the application and development of science, technology and innovation for agricultural growth. This can be done on the basis of the following:

- A systems approach and policy coherence;
- Policy realism;
- Strategic public investment in agricultural R&D;
- A new philosophy for agricultural R&D.

3.1. A Systems Approach and Policy Coherence

Innovation fundamentally demands a systems approach in its facilitation. It goes back to the fundamental understanding that innovations are iteratively precipitated through networks of social and economic relations, rather than through singular actions by isolated individuals or organisations. Inherently, there are the interactive learning processes which are essential in the precipitation of innovations [18]. More importantly, the systems approach recognizes the power of rules, norms and laws and, in fact, what is generally referred to as "institutions", to shape patterns of interaction and behaviours of the actors in the networks be they individuals or organization [19]. In this regard policy becomes a vital sine qua non. Policy is essential to guide the actions and behaviours of all actors in the innovation system. It offers incentives for particular behaviours and deterrents against other behaviours.

The policy formulation, implementation and review actions have horizontal and longitudinal thrusts in the economy, society and environment and affect the behaviours of the actors positively (or negatively). Thus the review of the agricultural policies since the 1980s to present has shown that the driving philosophy for these policies linked to the broad national development frameworks influenced the organizational patterns of behavior of actors. The market orientation of the ERP influenced in large measure the instigation of most of the reforms in the agricultural sector including the NARS by policy makers and specifically, the commercialization of R&D.

Commercialisation in principle is good. However, the market principles by themselves are sterile and cannot be fruitful against the overall ambition of translating R&D outputs into productive enterprises. Also of great important is the recognition that investment mainly in technology development cannot address the contextual needs. The forces of technology push must be complementary to the forces of technology pull. In simple terms, the investment in R&D institutions must go along with the investment at the demand end to create or strengthen private sector actors or entrepreneurs at the identifiable levels – micro, small and medium, in particular. In this regard, the promotion of entrepreneurship for agricultural R&D outputs should have attracted equal attention in the efforts to invest in technology generation. It underscores the fundamental need for policy coherence, the lack of which leads to dysfunctions.

Indeed, for every nation, there is a fundamental challenge in harmonsing the vision of the broad development frameworks with the sector-specific policy goals and objectives. Coherence is critical if the outcomes of policy implementation will resonate with the overall national development goals and objectives and with the sectoral aims and targets. Agricultural expenditure as a percentage of GDP was set at 1% with the MTADP in 1991. That target is yet to be achieved as currently, Ghana has attained 0.9% (as shown in Table 4).

The schema for an innovation system approach to R&D as illustrated in Figure 4 suggests that the policy makers and other critical actors have to work hard at facilitating R&D on one hand and entrepreneurship on the other with virtually equal measure of effort. The internal and external factors create the conditions for appropriate institutions to be put in place. The factors affect how activities are carried out, the behaviours and practices of the critical actors as they respond to stimuli of national and sector-specific laws, policies and programmes.

Figure 4: Schema for Innovation System Approach to R&D and Entrepreneurship

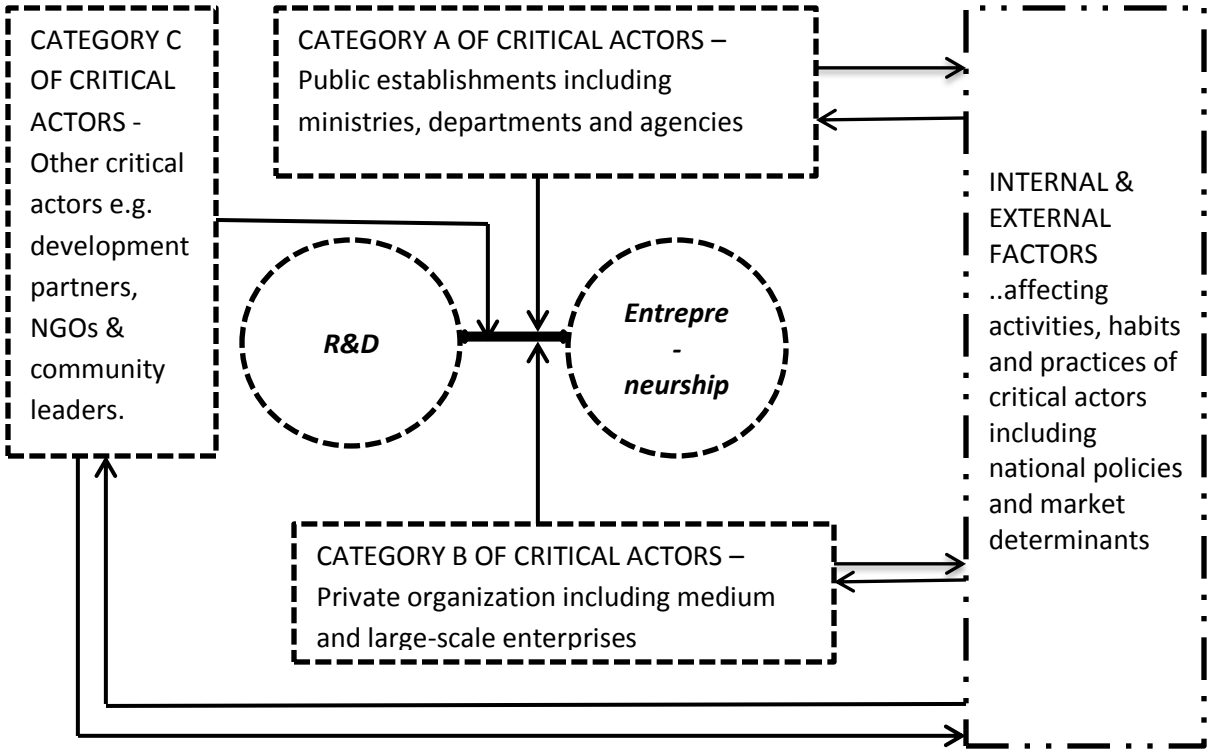
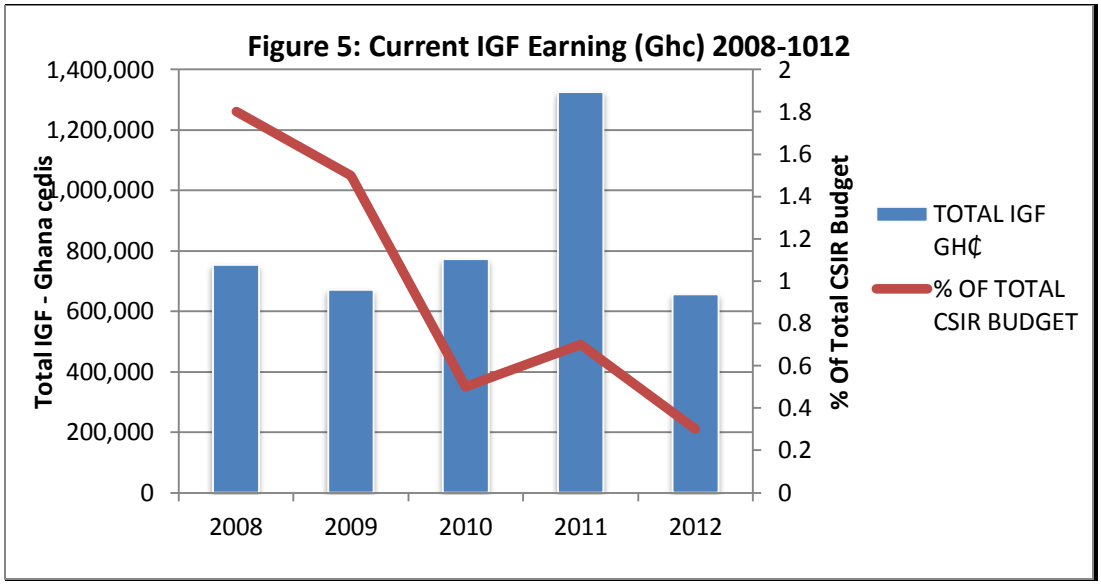


Figure 4 simplifies the categorization of the critical actors. However the three categories highlighted here are illustrative of the broad networks of actors in public and private organisations and enterprises, local communities, international organization and NGOs. Again the focus for all of these actors is on driving R&D and entrepreneurship to move in tandem for socio-economic development through the application of new knowledge and technologies. More importantly, R&D and entrepreneurship must have an iterative interaction for innovation to be successful.

3.2. Policy Realism

There is a crucial element in agricultural R&D which policy makers cannot run away from. Given the development context of African countries like Ghana, there are constraints in the commercialization of agricultural R&D in public institutions. The outputs of these institutions will to some extent be considered as public good. Farmers who generally are poor, especially subsistence food farmers, usually will save seeds to plant. Buying planting materials is quite a limited practice among farmers except for cocoa farmers and other cash crop farmers who relatively have more income [7]. Even then majority of the farmers do not have the means to buying genetic resource inputs at the commercially determined rates. It accounts partially for the failure of achieving commercialization goals in the NARS. Figure 5 illustrates the point with the case of the CSIR.



Source: Based on data from CSIR, 2013

The goal for commercialization which came with the revision to the CSIR establishment legislation in 1996 was 30% of the total annual research institute's budget covering all salaries and wages, administration, operational activities and infrastructural development i.e. construction and rehabilitation of buildings and purchase of machinery and equipment. At that time it was considered realistic. The experience over the years has shown that, the goal set was rather too overblown given the context within which it had to be realized. The 30% of the total annual budget of the research institutes was never achieved. Since then there had been some institutional changes in the research institutes with the setting up of Business Development Units and a Directorate for Commercialisation becoming operational at the corporate level in the CSIR.

Yet, commercialization has not improved much when appraised against the overall goal. Even in the past five years where commercialization has become more entrenched, the average yearly total of internally generated funds (IGF) – which are the net earnings from commercialized institutional activities – is only 835,569 Ghana cedis (roughly US$418,000) in the CSIR which has about 4,000 employees of all grades. Figure 5 depicts the fluctuations over the period 2008 to 2012. The IGF is only on the average, about 1% of the total institutional budget for the CSIR annually. Much as one can argue that better management practices and market orientation to R&D activities will improve the generation of commercial earnings in the CSIR, there are fundamental contextual constraints which need to be factored into institutional reforms. This points directly to the need for policy realism. Furthermore, the policy of commercialization in public research organisations, has inherent contradictions for making impact on pro-poor innovation and inclusive agricultural modernization even if it can be pursued for its own sake.

3.3. Strategic Public Investment in Agriculture

Indeed, over the years, agricultural R&D has attracted significant investment in Ghana as in other African countries. Table 4 illustrates the differences in agricultural R&D indicators in five selected countries namely Ghana, Nigeria, Kenya, Uganda and South Africa.

Table 4: Selected Indicators of Agricultural R&D in Five African Countries

Country	FTE	Agric. R&D Spending per Researcher	Agric. R&D Spending per Agric.Labourer	Agric. R&D Spending per Capita	Agric R&D Spending.as % of Agric. GDP
Ghana	537.1	0.18	16.33	4.05	0.9
Nigeria	2062	0.2	32.88	2.67	0.42
Kenya	1011.5	0.17	13.36	4.42	1.3
Uganda	298.6	0.29	8.35	2.78	1.24
South Africa	784.3	0.35	215.92	5.48	2.02

Source: Based on ASTI Database www.asti.cgiar.org/home

Ghana compares well with spending on agricultural R&D with Nigeria though spending slightly less per researcher. Kenya on the whole may be doing better spending more per capita on agricultural R&D than Ghana and in other areas (as in Table 4) [4]. But South Africa for Ghana is obviously the benchmark with for example, agricultural R&D spending per capita of 5.48 and as percentage of agricultural GDP, 2.02% as against Ghana's 0.9%. Thus there is a point one can make of Ghana needing to improve public investment in agricultural R&D especially given that as far back as 1991, the MTADP targeted expenditure of GDP to be 1%.

This notwithstanding, some successes have been made in the specific area of agricultural R&D spending. Ghana's agricultural R&D spending per capita is 4.05, which is higher than that of Nigeria with 2.67 and Uganda with 2.78. The achievement chalked in agricultural R&D at present is cumulative of the efforts made over the years as evinced in successive agricultural policies and programmes. Nevertheless, there is need to appraise the performance of the agricultural R&D system vis a vis the public investments overtime especially in the light of the importance of agriculture in Ghana's economy. But even as that appraisal is done, the point has to be made that the performance of agricultural R&D is made within certain policy frameworks and orientation. The policy context is one of the key factors influencing agricultural research performance.

Since the 1980s, Ghana has sought to function predominantly on the philosophy of the market. Perhaps the time has come for a paradigm shift. The principles underlying agriculturalR&D policies and programmes may remain market-oriented. However such policies and programmes must be enhanced through a system approach to innovation. Ghana may borrow from the concept of food sovereignty which emerged in Latin America in the 1990s. Food sovereignty is defined in terms of the right of peoples to safe and culturally nutritious food, access to production resources, ecological practices and access to local markets [11] [20] [37] [34]. From this perspective there is a consciousness of the needs of the larger segments of the population and the orientation to the higher human values and welfare.

There is need for deliberate construct of the linkages that effectively and efficiently hold agricultural production and consumption together. The shift in consumption of staples from locally produced maize, cassava and other local foodstuffs to rice in recent years is an illustration of the need to strengthen the food production-consumption linkages and enhance food sovereignty. This can be done through public policies such as the Ghana School Feeding Programme [33] The production of food to feed the schools ought to come largely from the localities where agricultural practices are the way of life of the communities. The local foods must dominate the meals the school children consume in the schools thereby strengthening the

production-consumption linkages. It is important for the sustainability of the food cultures and it promotes food self-sufficiency.

3.4. A New R&D Philosophy

In the move towards a food sovereign Ghana, the approach should also underscore the primacy of the smallholder end users of farmers and micro and small entrepreneurs. There are projects that are being implemented in Ghana that aim at highlighting how the smallholder interests could be addressed in promoting innovation. One important such project is the Convergence of Science-Strengthening Innovation Systems (COS-SIS) which is a partnership among the Université d'Abomey-Calavi (UAC) at Cotonou, Benin; the University of Ghana (UoG) at Legon, Ghana, and the Instut Polytechnique Rural de Formation et Recherche Appliquée, (IPR/IFRA) at Katibougou, Mali; and Wageningen University (WUR), the Royal Tropical Institute (KIT), and Agriterra in the Netherlands. It is funded to a total of € 4.5 million for six years (end 2008-mid 2014) by the DG for International Cooperation of the Netherlands Ministry of Foreign Affairs (DGIS/BUZA). In Ghana it is based at Faculty of Agriculture of the University of Ghana and involves two research institutes of the CSIR and the Cocoa Research Institute of Ghana.

COS-SIS aimed to improve the livelihoods of West African farmers through exploring new pathways for agricultural innovation. It has some lessons for consideration in agricultural innovation especially that which benefits smallholders. COS-SIS realized that technical innovations are not enough to improve conditions for smallholder farmers and processors. There must be institutional change to facilitate innovation and the enhancement of their conditions [29] [41] [15]. It suggests that programmes to stimulate smallholder innovation must be driven on the basis of a new R&D philosophy. There are two key objectives of COS-SIS. Firstly, there is the developmental objective to remove institutional constraints at a higher systems level so as to improve smallholders' livelihoods. It is done through action research. Secondly, there is the research objective to investigate pathways to innovation and in the process creating "institutional space" [29] . To achieve these objectives, one of the key activities was to set up Concertation and Innovation Groups (CIGs) in specific domains (e.g. cocoa, oil palm, shea nut and rice) and research areas comprising representatives of the identifiable stakeholders (e.g. farmers, small-scale processors and public officers). CIGs are innovation platforms for specific actions to address specific institutional challenges in the localities. On the whole the COS-SIS programme demonstrates that addressing institutional changes require concerted action and must be facilitated. We submit that this is a lesson of relevance to agricultural policy making for research and development. Forging the linkage between R&D and entrepreneurship in the R&D institutes needs to be properly designed, worked at and facilitated.

DFID's Research into Use (RIU) programme is also illustrative of the kind of philosophy that must drive agricultural R&D. It began with an original budget of 37.5 million pounds from July 2006 to December 2012 and has generated lessons for addressing the institutional issues that can improve R&D impact on socio-economic activities [8]. The Best Bet component of RIU was aimed at directly leveraging private sector capacity in putting previously funded DFID's research into developmental use. The experience under the programme realized the lack of business skills needed to establish innovative ventures in the research system. The direct intervention of identifying potential research results for use and facilitating the use through identifiable actors

including private sector entities and NGOs in their respective contexts, hold promise for improving the impact of agricultural research.

The new philosophy simply has to emphasise the vitality of boosting innovation from both the supply side and demand side. Rolings (2008) underscores the importance of additional pathways to engage smallholders in agriculture given that the Innovation Systems approach is not cut-and-dried and that the context matter. Generally these pathways define innovation as "the emergent property not of science, nor of markets, but of interaction among stakeholders in opportunities for development" [36]. It certainly cannot be an easy task in determining appropriate pathways in any given context. But the task can be made a lot easier with the recognition that innovation to improve agriculture across the value chain and to the benefit of the smallholder needs a lot more than technology and market.

4. CONCLUSION

Public agricultural research will continue to play primary roles in agricultural innovation to impact on socio-economic development. It is crucial that these roles be made effective given the importance of agriculture for Ghana's development. Ghana is already committed to promoting public agricultural R&D and continues to make substantial investments as do other donor agencies. There is however need to address institutional dysfunctions and develop or orientate programmes to enhance impact.

Over the last two decades, there have been various policy initiatives to address the challenges of the agricultural sector and also specifically improve agricultural R&D impact with technology development and orientation to the market. On one hand the responses from the NARS, taking advantage of programmes such as NARP and AgSSIP show some successes in technology development. On the other hand, the prevailing challenges in the agricultural sector also illustrate failures which point to institutional dysfunctions requiring new approaches to innovation. Firstly, there is need for a more systemic approach to innovation generally and a need for policy coherence. Research and development must be dovetailed with a drive for entrepreneurship that engages critical actors for business and inclusive growth. Besides, public agricultural R&D calls for policy realism that sets targets, which takes account of the context of innovation. It also calls for a new thinking – a new philosophy – that stimulates new sources of motivation for exploiting the potential of public agricultural R&D for national development.

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