TECHNOLOGICAL CONSTRAINT AND FARMERS' VULNERABILITY IN SELECTED DEVELOPING COUNTRIES (NIGERIA AND VIETNAM)

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Abstract

The process of globalization has continued to generate controversy on its impact on groups that are vulnerable to poverty. In this respect, there is evidence that farmers in most developing countries are increasingly vulnerable to poverty due to a number of reasons. One possible reason could be the limited access to the technologies that assist farmers in improving their production and later in selling their products, or the capacity to introduce them in their productive processes, thus causing low productivity, post-harvest losses and persistently low household income. Using the sectoral innovation system approach applied in agriculture, the paper aims to map out key actors (governmental agencies, public R&D institutions and extension service institutions, etc), and to examine their roles and their interaction in enhancing farmers' access to technologies in such selected developing countries as Nigeria and Vietnam. From each country's standpoint and experiences in agricultural development the paper compares how the farmers access the technological innovations in agriculture and its impact on the reduction (or not) of their vulnerability to poverty. To achieve significant reduction in farmers' vulnerability to poverty, the paper revealed that there is need to replace the existing linear models of agricultural innovation with an agricultural system of innovation with its distinctive feature of interactive learning that engenders active participation of framers and other important actors in the agricultural innovation process.

Key words: agricultural innovation system, farmer's vulnerability, interactive learning, poverty, technological constraints, technology transfer.

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1. Introduction

The process of globalization has continued to generate controversy on its impact on groups that are vulnerable to poverty. In this respect, there is evidence that farmers in most developing countries are increasingly vulnerable to poverty. The conventional view of agricultural development sees agriculture as the prime engine of growth and poverty reduction in poor countries. The view emphasises small farm agriculture growing modern variety of cereal staples in relatively high potential and well-connected areas and supports the idea that agricultural development has to be based on increasing productivity of smallholder producers of staple foods. Along this view, farmers are becoming more vulnerable to poverty due to the global trends which are related to the followings: (i) declining agricultural commodity prices; (ii) increasing gaps between farmer prices and consumer prices; (iii) changing patterns of food demand and (iv) changing global agrifood system (ADB, 2005). In this context, limited access to the technologies that assist farmers in improving their production and later in selling their products thus causing low productivity, post-harvest losses and persistently low household income, is considered one of many reasons making farmers vulnerable to poverty. It is assumed that farmers passively receive technologies from research institutions in the one way linear model of innovation. Our paper questions this assumption and argues that applying the agricultural system of innovation as the analytical framework allows us to see the relationship between research institutions and farmers as the interactive learning process governed by several institutional actors that determine the agricultural innovation from generation, acquisition to adaptation and diffusion of technologies. In this process, technologies can be developed with the active participation of farmers and understanding of the context of their application.

The paper is organised into five sections. Section two provides a review of literatures on the impact of farmers' access to technology to reduce their vulnerability to poverty. Section three describes the agricultural innovation system as the analytical framework to examine the relationship between research institutions and farmers in an interactive learning process. In this section, an overview of studies on the national system of innovation is provided and key elements of the agricultural innovation system in developing countries are presented. Section four examines the role of agricultural innovation system in tackling farmers' vulnerability in Nigeria and Vietnam. Section five concludes with synthesis from country studies.

2. Farmers' Access to Technologies that Reduce Vulnerability: A Review of Literature[1]

Vulnerability is a state that both precedes and accompanies poverty and is the state of being open to shocks that disrupts economic life. Shocks can occur at a number of levels: at the nation-state level (war, civil war, riot..), at the community level (epidemic disease, fire, drought, famine..) and at the individual level (unexpected death, accidents, changes within the family setting..). The poor are vulnerable because they usually lack buffers against these shocks. Reducing vulnerability by helping people to develop resilience to external shocks is therefore a priority to poverty alleviation. The link between vulnerability, poverty reduction and access to technologies has been studied through various angles, with a variety of views

[1] This section draws largely from a review of literature contributed by Mariam Sissoko from the Center of Law and Economic Sciences, Federal University of Rio de Janeiro.

expressed. While conclusions reached are ambivalent and sometimes contradictory, many agree that technology and innovation, as applied to agriculture, has the potential to be a powerful tool in generating growth and reducing farmers' vulnerability and poverty through increased incomes and opportunities. The 2001 Human Development Report indicates that technology has been a powerful tool for human development and poverty reduction throughout history. That Report mentions that "the 20th century's unprecedented gains in advancing human development and eradicating poverty came largely from technological breakthroughs" among which medical technology, information and communications technology and agricultural technology with new crop varieties, plant breeding and fertilizers and pesticides use in the 1960s that doubled world cereal yields in 40 years.

The assessment of the literature on the impact of technology on farmers' vulnerability and poverty reduction reveals the considerable extent of rural poverty, the unequal access of countries to technology, and the existence of serious constraints in measuring the impact of access to technology on poverty reduction. Added to these, are the positive and negative impacts of agricultural research and technology on rural poverty.

2.1. The dimensions of rural poverty

Most author agree that world poverty is principally a rural phenomenon. Half of the world population (about three billion people) live on less than two dollars a day. Poverty is pervasive in Sub- Saharan Africa and South Asia. As most of the countries in these regions are agriculturally based, poverty is more present in rural areas than in urban settings with the exception of some countries of Latin America. Lipton et al (2001) indicates that seventy-five per cent of the world's 1.2 billion extreme poor (living with less than one dollar a day) live and work in rural areas. About 800 million people are food insecure. Projections suggest that 60 per cent of the world poorest will continue to live in rural areas in 2025. In Asia, 70 per cent of rural household income is derived from farming, while in Africa and Latin America the figure is 60 per cent.

Rural people are not only isolated from economic opportunities. They also tend to be less able than their urban counterparts to access services such as health, sanitation and education that would reduce the non-economic dimensions of their poverty (Carney, 1996). The rural poor also face low productivity, food insecurity and poor nutrition. They have limited assets and are vulnerable to social, political or environmental factors. They may also have limited access to markets (Dasanayaka, 2003). For Morgan, rural people in the developing countries are in a deprivation trap in which powerlessness, physical weakness and isolation combine to accentuate vulnerability to poverty.

2.2. An unequal access to technology

The uneven diffusion of technology across the world is not new. Two simultaneous shifts in technology and economics—the technological revolution and globalization—are combining to create a new network age. While some countries are at the cutting edge of the network age, others lag behind. This unequal access is significant in the capacity of a country to generate and make use of technology to reduce poverty. The 2001 Human Development Report

indicates that the prime explanations for the success of today's advanced industrialized countries and the economic transformation of recently industrialized countries in the developing world lies in their history of innovation. The literature mentions two different types of classification of countries in relation to their access to technology: the first from the World Bank, and the second from the United Nations Development Report.

The Report on implementing the Millennium Development Goals (2004) indicates that as part of a World Bank project, the RAND Corporation developed four broad categories of countries according to their science and technology capacity: *the scientifically advanced countries* (those who have made S&T investment a national priority for more than fifty years and fund more than 80 percent of the world's R&D), *the scientifically proficient countries* (who possess an overall S&T capacity at or above the international average, but they are not as uniformly capable as the scientifically advanced countries), *the scientifically developing countries* (who have made some positive investments but their overall scientific capacity is below the world average, and they seek to invest further in science), and finally *the scientifically lagging countries* (who have little or no capacity to conduct world-class science and do translate their knowledge into the institutions or types of activities that many would recognize as science and technology).

The 2001 Human Development Report refined the analysis further by grouping countries according to a Technology Achievement Index (TAI). Four groups of countries emerge from this classification: the *Leaders (TAI above 0.5)* at the cutting edge of technological innovation; the *Potential leaders (0.35–0.49)*-most of whom have invested in high levels of human skills and have diffused old technologies widely but innovate little; the *Dynamic adopters (0.20–0.34)* –countries mostly dynamic in the use of new technology with significantly higher human skills (case of Brazil, China and India); the *Marginalized (below 0.20)* in which technology diffusion and skill building are lagging. Large parts of the population have not benefited from the diffusion of old technology. A last grouping, *Others*, refers to countries on which data are not available (Nigeria and Vietnam belong to this category). Interestingly, the TAI shows a high correlation with the Human Development Index (HDI), and it correlates better with the HDI than with income.

2.3. The measurement of the impact of access to technology on poverty reduction

The assessment of the impact of technology adoption on poverty reduction among farming households requires the establishment of an adequate counterfactual (without technology) situation for comparative purposes, control for the many other variables that condition the multifaceted impacts of technological change on the poor, and an evaluation of the indirect as well as direct impacts (Hazell, 1999, Kerr and Kolavalli,1999). The counterfactual situation tries to determine what the situation would be like if the technology had not been adopted and is different from the usual before-and-after analysis done by many researchers, because many other things may have changed along with the technology. For Hazell, the best counterfactual is a comparable region or group of farmers who are identical in all respects to the adopters except that they have not had a chance to adopt the technology themselves.

Several authors indicate that improved agricultural technology can help reduce poverty through both direct and indirect effects. The direct effects are those derived from increased production for home consumption, higher gross revenues from sales and lower production costs. The

indirect effects are through the price of food for consumers, employment and wage effects in agriculture; employment, wage, and income effects in other sectors of economic activity through production, consumption, and savings linkages with agriculture; lower costs of agricultural raw materials; lower nominal wages for employers (as a consequence of lower food prices); and foreign exchange contributions of agriculture to overall economic growth (de Janvry and Saboulet, 2001, quoting Adelman, 1975; Haggblade, Hammer, and Hazell, 1991).

De Janvry and Saboulet indicate that indirect effects through the price of food can benefit a broad spectrum of the national poor, including landless farm workers, net food-buying smallholders, non-agricultural rural poor, and the urban poor for whom food represents a large share of total expenditures. Indirect effects via employment creation are important for landless farm workers, net labor-selling smallholders, and the rural non-agricultural and urban poor. Refining the analysis regionally, de Janvry and Saboulet determined that the dominant effect of technology on poverty is through direct effects in Africa, indirect agricultural employment effects in Asia, and linkage effects through the rest of the economy in Latin America.

In addition to the counterfactual situation and the assessment of the direct and indirect effects, analysts need to take into account others factors that influence the impact of technology on poverty. At the macro level, economic, trade and agricultural sector policies, prevailing prices and price elasticity, public investments in rural infrastructure, health and education and public employment programs policies can all influence the impact of technology on the poor. At the farm level, prices, access to inputs, credit and markets, education levels and the distribution of land are important factors in the rate of uptake of improved technologies and the extent to which they benefit the poor (Hazell, 1999). Impact studies also need to average out random factors such as climatic factors that can influence prices and yields.

2.4. Positive and negative impacts of agricultural research on rural poverty

Positive impacts

Technology and innovations have been powerful drives to human development and poverty reduction throughout history, although as highlighted above, the access to and impact of technology on poverty reduction has been quite unequal between nations, and in some cases between different regions or sections of the population of the same country. While there is a general unanimity on the positive outcomes of technologies in several areas such as life sciences, information and communication, the role of agriculture-related technology in poverty reduction raised a number of contradictions and controversies.

The literature is rich of evidence on the positive outcomes of agriculture research in terms of increased productivity and higher incomes, in aggregate. Gunasena (2003) mentions some significant achievements of technology in the development of improved cultivars and management practices, mechanization, improved plant nutrition and crop protection technologies leading to increased crop yields. Most authors make reference to the Green Revolution, also known as the seed revolution, as the most decisive outcome of technology in reducing poverty in the 1960s. The Green Revolution has led to increases in food production and increasing purchasing power for the rural populations, even if seed technologies appear to have benefited more the rich than the poor, the landed more than the landless and men more than women (Gunasena, 2003). Dar et al (2003) indicate that the world is more food secure largely as a result of development and deployment of high yielding varieties, fertilizers use,

and irrigation. One of the significant achievements of the Green Revolution, according to these authors, was the stabilization of production and prices of food grains.

The successes of the Green Revolution are imputed by several analysts to productivity improvement rather than area expansion, coupled with the cultivation of high–yielding varieties (HYVs) of rice and wheat, expansion of irrigated areas, increases in fertilizer and pesticide use and availability of credit. For de Janvry and Sadoulet (2001), the largest poverty reduction effect of the Green Revolution is likely to have been on consumers through falling prices for staple foods (Pinstrup-Andersen, 1979). Other benefits for the poor accrued through adoption by smallholders, employment creation for the rural landless, and growth linkage effects with the non-farm economy (Hazell and Ramasamy, 1991).

It is noteworthy that Lipton et al (2002) studied the reverse causal sequence of technology access and human development. The three stages of agro-technology process (research, development of a technique, and adoption) can improve human development by raising the levels of health, nutrition, education, poverty reduction, farm growth and empowerment. In reverse, human development factors such as education facilitate an increase in farm output by providing a farmer with the necessary skills to improve technical and allocative efficiency, and through an attitudinal change which may accelerate adoption of new technologies.

Negative impacts

Just as the Green Revolution has been used by many authors as a case point to demonstrate the positive impacts of technology access on poverty alleviation, critics of its outcome indicate that there have not been gainers only, but also many losers among the poor. Hazell (1999) reviews the analysis of critics who argued that, because of their better access to irrigation water, fertilizers, seeds and credit, large-scale farmers were the main adopters of the new technology, and small farm holders were either left unaffected or were made worse off because the Green Revolution resulted in lower prices, higher input prices, and efforts by large-scale farmers to increase rents or force tenants off the land. These critics also argue that the Green Revolution may have encouraged unnecessary mechanization, with a resulting reduction in rural wages and employment.

Mendola (2003) refers to the arguments of Griffin (1972, 1974), Frankel (1971), ILO (1977) and Pearse (1980), indicating that the result of the Green Revolution was an increase in the inequality of income and land distribution, an increase in landlessness and a worsening of absolute poverty in areas affected by the green revolution. Many problems remained, as the intensification of agriculture and the reliance on irrigation and chemical inputs has led to environmental degradation, increased salinity and fertilizer and pesticide misuse. Consequently, green–revolution technologies had little impact on the millions of smallholders living in rainfed and marginal areas, where poverty is concentrated and "overlooked the rights of women to benefit from technological advances".

Hazell (1999) notes that the conclusions reached by the critics of the Green Revolution have not proved valid when subjected to the scrutiny of more recent evidence. He does not conclude from this that the Green Revolution has been entirely positive, but argues that the conditions under which "yield enhancing technologies are likely to be equitable are now reasonably well understood". He resumes the likely positive or negative impact of technological change on the poor, by stating that there are many factors that condition that impact, and these factors also

interact in complex ways. Impact assessment is challenging because poor people have complex livelihood strategies, and are often "part farmers, part laborers, part non-farmers, and always consumers". They may gain or lose in each of these different dimensions at the same time, so that the net impact can remain ambiguous. For Hazell, understanding household livelihood strategies is key to assessing the impact of technological change.

2.5. Broadening the discussion

Even if overall, the literature recognizes the immense opportunity of science and technology on improving the live of the rural poor, some authors hold the view that a rethinking of science and technology is required if the Millennium Development Goal of halving poverty by 2015 is to be reached. There is a need to enhance the poverty-reduction potential of agriculture-related science and technology, given the current challenges of declining availability of agricultural land and water resources, ecological degradation, continuing population growth and increasing trends in urbanization and rural-to-urban migration. This section reviews some approaches found in the literature on how to achieve that enhancement.

Agriculture technology and impact on rural poverty: public versus private research
Some analysts believe that the invisible hand of the market is shaping what scientific and technological advances are developed. Yet, it is known that the rates of returns of public investment in agricultural research are usually very significant. Data from the 2001 Human Development Report indicate that the Internal Rate of Return (IRR) of agricultural research has varied between 48% in Asia and the Pacific to 41% in Latin America and the Caribbean and 33% in Sub-Saharan Africa for the period 1958-1998. However there has been a declining trend worldwide of public investment in agricultural research and development, as results achieved have sometimes been below expectations and priorities have shifted. Should the private sector then be entrusted to fill in the gap? Kerr and Kolavalli (1999) indicate that the private sector has a greater incentive to conduct research whose returns are relatively quick and whose benefits can be captured privately. It has a comparative advantage in applied or adaptive research on products such as hybrid seeds, machines, and chemical inputs. For the 2001 Human Development Report, the market is a powerful engine of technological progress, but not powerful enough to create and diffuse the technologies needed to eradicate poverty. Byerlee (1996) suggests that there may be complementarities between public and private sector activities, with the public sector focusing more on basic and strategic research, on crops dominated by open-pollinated varieties, and on the problems in marginal areas where are also concentrated the poorest, while the private sector can support commercial agriculture.

Agriculture technology and impact on rural poverty: What kind of agricultural research and technology for poverty reduction?
For Alston et al (1995) mentioned by Kerr and Kolavalli (1999), "agricultural research is an effective tool for generating productive technology, but a blunt instrument for fighting poverty". For Alston et al, it is inefficient to specifically orient research towards poverty alleviation, and this approach would also reduce the effectiveness of research in fulfilling its primary goal of raising agricultural productivity. It would therefore be advisable to use other means to fight poverty than agricultural research. This view is far from being unanimous and is found to be "evasive and irresponsible" according to a second school of thought, which argues that better policies and institutions are not sufficient to solve the poverty problem.

Opportunities offered by agricultural research to alleviate poverty should be tested, even if this should translate into trading off a portion of the economic returns to agricultural research for a greater poverty impact.

Kerr and Kolavalli (1999) did not take side in this debate, acknowledging that the evidence is insufficient to draw conclusions in one direction or the other. They indicate however that targeting agricultural research to areas densely populated by poor people is a way to bring benefits to a large number of people, and mention as an example of such approach the Rockefeller Foundation's ten-year program to promote rice biotechnology in Asia.

The role of biotechnology in targeting the poor has been another area of controversy in the literature. The 2001 Human development Report is categorical in claiming that "modern biotechnology -recombinant DNA technology- offers the only or the best 'tool of choice' for marginal ecological zones left behind by the Green Revolution but home to more than half of the world's poorest people, dependent on agriculture and livestock". Lipton et al (2002) share this view when they indicate that by far the most important research options for poverty reduction concern biotechnology, notably through the redirection of plant GM research and development towards the crops and traits of key interest to the poorest farmers and consumers.

Coventry (2003) has a different view, as he believes that from the vantage point of 1.2 billion rural poor, simple practical technologies known as low external input agriculture - such as improved agro-ecology, integrated pest management, soil enrichment, crop rotation, and the development of locally adapted seed varieties- have proved to have significant benefits to poor farmers and their communities, and do not require the massive investments needed by biotechnology. Coventry indicates that "it is not high-tech or low-tech but right tech" which is required for poverty reduction. He suggests that the choice of technology should be submitted to the test of the three **A**s: is the technology **A**ffordable to the 1.2 billion people surviving on U$1 a day? Is it **A**ccessible: does it require extensive infrastructure such as power and telecommunications – absent in many poor communities - or presuppose a level of education, skill and training absent in the rural poor? Is it **A**ppropriate for the needs of poor communities?

Agriculture technology and impact on rural poverty: The institutional framework

Technology, whether high or low, cannot eliminate poverty in itself. For Omamo and Naseem (2005), the unrealized potential of agricultural research in promoting growth and poverty reduction results from the existing incompatibility between policy environments, institutional arrangements, and micro-conditions and micro-behavior in agricultural research in a country. They therefore suggest a greater compatibility among these three dimensions of agricultural innovation systems in order to achieve enhanced agriculture productivity and poverty reduction. For Carney and al, the larger context surrounding agriculture research matters too, as social institutions are interdependent systems. There cannot be sustained and generalized processes of agricultural innovation in the absence of conducive contextual elements such as economic growth, competitive and dynamic markets, adequate infrastructures, peace, healthy legal and political institutions, tolerance, and respect for civil and individual rights.

Within the specific context of agricultural research, the New Partnership for Africa's Development (NEPAD, 2004) advises that in the case of Africa, the efficiency and effectiveness of agricultural research would be enhanced by greater regional and sub-regional

co-operation, allowing each national research institute to specialize in a few areas of research, while benefiting from the research of others to eliminate duplicative research. The 2001 Human Development Report goes further by suggesting technology alliances drawing together diverse actors (government agencies, industry, academia, civil society and committed individuals) for researching and diffusing technologies addressing a common regional concern and pooling expertise and resources.

At the individual level of the poor farmer, there is the need for the policy framework to help reduce the risks of adopting new technologies and increase access to rural financial services, including savings, credit and insurance. Furthermore, the rural poor need knowledge and inputs to appropriately adopt new technologies. It is the view of some authors that agricultural research must assist in the competitive market integration of small farmers, as there is little room to increase the net income of small farmers outside the markets.

The following section presents the agricultural innovation system framework as an approach that provides important insights required for tackling farmers' vulnerability to poverty in developing countries.

3. Agricultural Innovation System Framework

3.1. An overview of the NSI framework

Science, technology and innovation are increasingly recognized as major determinants of economic growth and sustainable development. The economies of developed countries of Europe and North America benefited from early advances in science and technology to transform rural economies into economies characterized by industrial complexes (Landes, 1969; Maddison, 1991; Freeman and Soete, 1997). Similarly, a remarkable feature of the post second world war economic progress is the unprecedented pace of the achievement of industrial economy status by Japan and some East Asian economies (e.g. South Korea, Taiwan, Singapore, Malaysia) (Rodrik, 1994). The role of science and technology in these economic success cases were rightly captured by Landau and Rosenberg (1992) when they observed that "science and technology (S&T) harnessed by an enlightened capitalistic democratic system could improve the standard of living of a country by higher growth rates without requiring wars or colonies. It took Germany two world war losses to realize this, and the Japanese one, both countries have shown that promotion of S&T is the right path to development". For industrial economies, the resultant effect of technological progress is rapid improvement in economic and social welfare, and the attendant reduction in vulnerability to poverty.

Freeman (1987, 1992) defines NSI as network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies. The processes involved have a central objective of generating and employing technological innovation for economic development. Thus the NSI may be viewed as an integrated system of economic and institutional agents directly promoting the generation and use of innovation in a national economy. The firm is regarded as the core or centre of the NSI and innovation is considered as the engine of economic growth and technological progress (Kim, 1997; Lall,

2001). The firm is where the actual innovation takes place, and the network of actors in the NSI has the objective of promoting firms' capability to innovate. (Kim, 1997; Nelson, 2002 (see RPolicy); Adeoti, 2002). The NSI framework is essentially an integrated approach to the analyses of the determinants of technological innovation; and it has been extended to analyze regional systems of innovation (Freeman,1995; Edquist, 1997); and reduced to analyze sectoral systems of innovation (e.g. Malerba, 2002; Hall et al, 2005).

Freeman explained that the NSI can be conceived in broad and narrow senses. In a broad sense, NSI encompasses all institutions which affect the introduction and diffusion of new products, processes and systems in a national economy; and in a narrow sense NSI involves only institutions that are directly concerned with scientific and technical activities. In this paper our conceptual viewpoint is NSI in the broad sense. Besides, as earlier indicated in section one, the focus of this paper is on developing countries. The broad view of the NSI framework will enable us identify and analyze the various dimensions of NSI with respect to the agricultural sector in developing countries. Within the context of this broad view, Lundvall (1992) identified the elements of a national system of innovation to include:

- Internal organization of firms;
- Inter-firm relationships;
- Role of the public sector;
- Institutional set-up of the financial sector; and
- R&D intensity and R&D organization.

A missing element in Lundvall's conceptual framework for NSI is the institutional set-up for education and training. This may be explained by the fact that Lundvall's view was largely rooted on experiences in developed countries where capacity for education and training were assumed to be well developed. For developing countries, the level of capacity for education and training is an important determinant of the quality and access to skills required for the generation and use of innovation.

3.2. Agricultural innovation system in developing countries

Having identified the main elements of NSI, the analysis of a sectoral innovation system feeds into the NSI framework by limiting the scope of the analysis to the sector in focus rather than the national economy. (Freeman, 1995; Malerba, 2002). In the context of this paper, the theoretical framework is applied to the agricultural sector in developing countries. From the foregoing, the agricultural innovation system can be conceived not only as ensuing from but also as an integral part of the NSI. The Agricultural system of innovation maps out the key actors and their interactions that enable farmers get access to technologies, thereby becoming less vulnerable to poverty. The 'farm firm' is at the centre of the agricultural innovation system framework, and the farmer as the innovator could be made less vulnerable to poverty when the system enables him to appropriate returns to his innovative efforts. The agricultural innovation system framework presents a demand-driven approach to agricultural R&D. This transcends the perception of the role of public research institutions as technology producers and farmers as passive users by viewing the public laboratory-farmer relationships as an interactive process governed by several institutional actors that determine the generation and use of agricultural innovation. There is opportunity for a participatory and multi-stakeholders approach to

identifying issues for agricultural R&D, and agricultural technology could thus be developed with active farmers' participation and understanding of the application of new technologies. The agricultural innovation system approach is an institutional framework, can be stimulated and/or self-organising depending on the institutional circumstances and historical background of the national agricultural development strategies.

Each of the elements of a NSI will accordingly be transcribed to address issues of agricultural innovation as the main thrust of agricultural development activities that can effectively reduce vulnerability to poverty among farmers in developing countries.

Internal organization of farms

As earlier indicated, the firm is at the centre of the network of institutions and their interactions that generate and use technological innovation in the NSI framework. Analogous to the firm in the agricultural system is the farm. The farm is the primary productive unit and the agent that provides the platform for productive resources to interact for achieving the objectives of the farm. The farm is in effect a 'farm-firm', where technological innovations are carried out during routine activities and by application of knowledge generated from outside the farm. Technological innovations from routine activities are usually incremental in nature while technological innovations extraneous are sometimes disruptive. The socially embedded process of interactive learning takes place within the farm-firm. Internal organization of farms could affect the type of innovation employed and the pace of innovative activities. For example, farms that are largely subsistence in concept and organization may be less able to embark on innovative activities when compared to farms organized as commercial enterprises that face more competitive challenges. Moreover, even for non commercial farms, innovation could depend on the socio-economic characteristics of the farming household. For instance, a household headed by a relatively well educated person may be more likely to understand the benefits of new seed varieties and how to rightly employ them to achieve improvement in yield. The problems associated with farm yield are known to be important determinants of farmers' vulnerability to poverty. On one hand, the technology employed for farming determines the productivity of the farm and how much could be harvested. On the other hand, the post harvest technology employed determines the level of the output that eventually gets to the market and subsequently, the return on the farmer's investments.

Inter-farm relationships

Clustering of firms is known to lead to agglomeration economies as a result of collective efficiencies. Networking by firms help diffusion of new technologies and the learning processes that improve firm performance. For the 'firm farm', inter-firm relationships are particularly important in farming communities in many developing countries. For the poor and vulnerable, farming activities is largely affected by social relationships that make the farms inter-dependent (Hall and Oyeyinka, 2005; Dalohoun, 2005). These inter-farm relationships could be avenues for learning and diffusion of new knowledge on agricultural practices and new varieties of seeds/seedlings. The inter-farm relationships can also serve as sources of shared information on market opportunities for farm products and post-harvest technologies. Farmers associations, cooperatives and communes are some of the institutions that have been identified as part of the agricultural system of innovation that may facilitate inter-farm relationships and partnerships in developing countries.

Role of the public sector

The public sector dominates and determines agricultural development activities in developing countries. Because of farmers' vulnerability it is believed that the market mechanism is incapable of addressing the problem of resource allocation in such a way that farmers' interests are not jeopardized. Even in developed countries, farmers are known to be protected by heavy subsidies. In effect, it appears that the public sector is a major actor that determines the capability of the 'firm farm' to embark on innovative activities in an agricultural system of innovation. Where the agricultural system of innovation is strong such as in developed countries, the public sector may not directly intervene such as the subsidy problem suggests. However, public policy that stimulates innovation at the farm level may be outcomes of the influences of agro-industrial systems that have contributed enormously to extending the frontiers of R&D in agriculture. The case of biotechnology applications in agriculture is a good example of this. Extensive agricultural biotechnology R&D is carried out by multinational biotech firms operating largely for profit. Their contributions to agricultural development in general (and agricultural system of innovation in particular) have led to an innovation growth trajectory that require little or no input from the public sector other than the regulatory role that ensure adequate protection of intellectual property. (Acharya, 1995, 1998; Karaomerlioglu et al, 1998).

For developing countries that have relatively weak agricultural system of innovation, the public sector remains the major investor in agricultural R&D and promoter of R&D outputs. The innovation system approach has demonstrated that the linear model of technology producer-user one dimensional links have been unhelpful, and in fact, has contributed to vulnerability of farmers. The learning and competence-building networks that form the agricultural system of innovation provide new window of opportunity for the public sector R&D to become needs-based and farmer-oriented. In such a context, the aim of R&D is not just for the purpose of increasing basic knowledge or meeting the challenges of technological frontiers but to address real challenges of the agricultural sector.

Institutional set-up of the financial sector

The institutions for agricultural finance are multi-various in developing countries. They include specialized development finance banks, international development banks, government bureaus or departments specially dedicated to attend to financial needs of farmers, and informal or semi-formal institutions (e.g. cooperatives, community based contribution schemes, etc.). In developing countries, commercial banks participation in agricultural finance is limited. The apparent explanation for this is the comparatively low return on agricultural investments leading to commercial banks' unwillingness to make long-term investment in agriculture. For an agricultural system of innovation to thrive, there should be significant participation of the financial sector in active support for farming activities and research that are aimed at solving specific problems of agricultural production. In this respect finance of agro-allied industrial activities has the potential of enhancing farm level innovation and reducing post harvest losses through backward linkages.

R&D intensity and R&D organization.

R&D activities in the agricultural sector of many developing countries are carried out by public research institutes and universities. The intensity and the organization of the R&D thus depend on the capacity of the public sector to provide incentives and infrastructure for R&D. The framework for agricultural system of innovation however requires a strategic combination and linkage of the demand for agricultural innovation and the R&D activities. This strategic

network is far beyond the scope of traditional extension agents that simply provide information and possibly some training to farmers on new technologies. The farmers themselves are part of the innovative or R&D process. They provide feedbacks to the R&D activities and actively participate in the R&D. The R&D process becomes in itself part of the learning mechanism for farmers within the agricultural system of innovation. In effect, the organization of the R&D incorporates all important economic agents that have interests in the successful market debut of the products of the R&D. It is widely known that poor R&D infrastructure (in terms of human resources and laboratory) has limit the intensity and scope of R&D in many developing countries. The agricultural system of innovation suggests a departure from the notion of agricultural R&D as an exclusive domain of the public sector. It highlights the role for incentives that can stimulate active private sector participation in collaboration with existing or new public R&D institutions.

Education and training

Education and training in formal and informal institutions are major components of the agricultural system of innovation. Nations that have overcome underdevelopment and poverty are known to have relatively high stocks of educated manpower. The stock of educated manpower available for the agricultural sector is a derivative of the nature and extent of previous investment in agricultural related programmes in formal institutions (e.g. universities, polytechnics, colleges of agriculture, etc). Community based informal training activities on indigenous agricultural practices can also be an important aspect of the agricultural system of innovation. The integrated approach of the agricultural system of innovation is not averse to useful knowledge whether from formal or informal sources. The focus is what works in the market through interactions generated by knowledge flows that are non unidirectional.

4. Role of Agricultural Innovation System in Tackling Farmers' Vulnerability: Selected Country Cases from Nigeria and Vietnam

4.1. Nigeria

Nigeria is mainly an agrarian economy. In spite of the pronounced urbanization signified by fast growing cities, about 60% of the estimated population of 130 million lives in rural areas where subsistence agriculture is the main economic activity. According to Beintema (2004), Nigeria had the largest regional share of agricultural gross domestic product (AgGDP, which was 17 % in 2000) in sub-Saharan Africa. The agricultural sector provides the primary means of employment for Nigerians, accounting for one-third of both total GDP and labor force. Beintema (2004) and Idachaba (2000) disclosed further that, in the past, the Nigerian government's strategy for stimulating agricultural production was protecting the sector with bans on agricultural imports and subsidies on inputs.

Agricultural research started in 1893 with the establishment of a botanical garden in Lagos by the colonial administration (Idachaba, 2000). Ikpi (2002) indicated that this garden was part of a network of gardens established under British rule, focusing on the introduction of new crops, which were apparently sources of raw materials for industries in the United Kingdom. Presently, there are at least 81 government and higher-education agencies engaged in agricultural research in Nigeria employing over 1,352 full-time researchers (Beintema, 2004).

However, no agricultural development strategy in Nigeria is known to take the approach of an agricultural system of innovation. Using secondary sources of information, especially a report of an elaborate assessment of technology development and transfer in Nigeria's agricultural sector carried out by Ikpi (2002), we will examine the role of agricultural system of innovation in reducing farmers' vulnerability to poverty in Nigeria. From Ikpi's survey, figure 1 presents current model of technology development and transfer to farmers in Nigeria. The model is apparently linear and lacks the main features of systemic interactive learning and network relationships in an agricultural system of innovation. Taking this model as true reflection of the state of agricultural technology development in Nigeria, we will apply the elements of the agricultural system of innovation earlier identified to highlight the reform measures that can produce an agricultural innovation system that effectively address the development challenges in Nigeria's agriculture and rural economy.

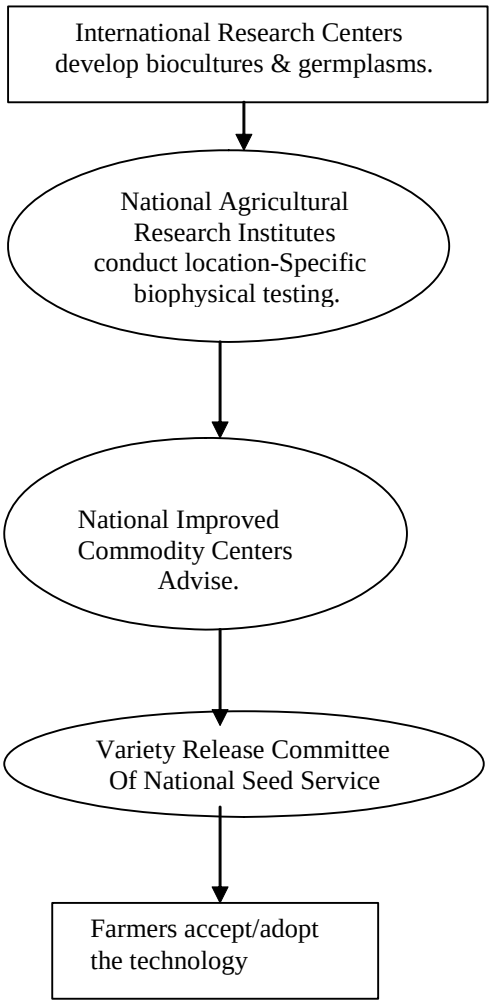

Figure 1: Process of agricultural technology transfer from developers to farmers in Nigeria
Source: Ikpi (2002)

Internal organization of farms

Nigerian agricultural production is carried out largely in smallholder farms managed primarily for subsistence. According to Obayan (1999), these smallholder farms account for over 80% of Nigeria's agricultural production and they are confronted with persistent problem of low productivity. Though the small scale farmers have always been the main focus of agricultural policy, the policies are grossly deficient in addressing constraints relating to the internal organization of farms; and the farms are subsequently locked-in into a regime of low productivity. The linkage between low productivity and vulnerability is apparent with no certain direction of causality. Low productivity can pronounce vulnerability and vulnerability can result in low productivity. For the Nigerian farmer, the agricultural innovation model in figure 1 only signifies that farmers adopt technology. It is unclear how the farmers organize his productive resources, and there is no indication of the relevance of institutional mechanism that could enable him tailor his internal resources to manage the adoption of new technologies. In such a setting, the farmer depends largely on his accumulated knowledge derived from past experience of cultivation of related crop or animal husbandry. Even when there are demonstration farms, the impact are usually limited in dept and scope because such demonstration farms are managed by public agencies that lack capacity to effectively transfer knowledge.

Inter-farm relationships

There is no indication of significant inter-farm relationships in Nigeria. For the technology development model shown in figure 1, inter-farm relationships are not considered as part of the system leading to successful farm-level innovation. The opportunities provided by farmers cooperative societies as an institution for inter-farm relationship are still very limited. Cooperative societies are mostly organized on informal basis in rural communities. In urban locations cooperatives may be semi-formal, formally registered by government but operating small businesses that may include farms in behalf of members without any formal contractual agreement. Inter-farm relationships are generally weak and there is currently no programme aimed at encouraging farms to linkup with themselves. This is a major constraint on technological innovation, learning and competence building activities on the farm. Where inter-farm relationships thrive, it could be avenues for peer-learning and review of performances of new technologies such as new and improved seedlings, new agro-chemical applications, new procedures for land use, and new methods of cultivation. Knowledge about consumer interests could also be shared though inter-farm relationships such that production is guided to satisfy specific market needs. Nigeria is currently missing out in all these, and consequently, farmers' access to technology remains limited and poverty among farmers is endemic. However, for specific crops such as cassava, cocoa, cotton and rice, the Nigerian government recently set up specialized committees to promote renewal of technology and agricultural practices that affect these crops. The objective is to make these crops important sources of foreign exchange as was the case in the 1950s and 1960s, before crude oil became the main source of foreign exchange. The renewal activities are encouraging farmers to ask questions among themselves in several stakeholder forums. If this trend continues, there are

prospects that it may translate into inter-farm relationships through interactions among farmers rooted in the experience of new support mechanisms from government.

Role of the public sector

As shown in figure 1, the framework for technology acquisition by farmers in Nigeria is overwhelmingly a public sector affair. As summarized by Ikpi (2002), using crops as an example, the process of technology acquisition by farmers involves giving national research centres the improved biocultures or germplasms that have been developed at the international centres for location-specific biotic and abiotic testing and adaptation. It is after such biophysical testing under different agro-climatic ecologies and socioeconomic environments that the National Agricultural Research Institutes (NARIs) then advise the National Improved Commodity Centres to authorize the Variety Release Committee of the National Seed Service (NSS) to disseminate the new technology to farmers. This process can take up to six years before a new improved crop variety or livestock specie is released into the agricultural system of the country.[2] The delay in technology transfer to farmers is largely due to the fact that over 98% of the agencies involved in developing, commercializing and finally transferring these technologies are public entities. Bureaucratic discussions within each of the public agencies handling technology release approvals (especially the National Improved Commodity Centres, the Variety Release Committee, and the National Seed Service) and shuffling between them adds avoidable time to the observed delay in this technology transfer process. In some instances, however, this long period of testing and selection is shortened to three years by the scientists/breeders in the international (e.g. WARDA[3] and IITA) and national research centres working together directly and in partnership with farmers from the early stage of selection of the desirable qualities in the crop/livestock variety. It is yet to be seen whether local research initiatives will be able to operate this new approach that incorporate a key feature of the agricultural system of innovation.

Institutional set-up of the financial sector

According to CBN (2005), the formal financial system provides services to about 35% of the economically active population of Nigeria while the remaining 65% are excluded from access to financial services. The Central Bank of Nigeria further clarified that these 65% are served by the informal financial sector, through Non-Governmental Organization – microfinance institutions (NGO-MFIs), money lenders, friends, relatives and credit unions. So far the informal financial sector is unregulated.[4] The formal sector finance institutions in Nigeria do not generally contribute substantially to agricultural finance. Hence, the finance of agricultural innovation activities is a remote issue in formal sector financial services. This may explain why financial institutions did not appear in the agricultural technology development model depicted by figure 1. Moreover, it is important to note that development finance institutions in Nigeria, though having agricultural finance as a major objective, do not explicitly address

[2] Ikpi (2002) stated that in countries like the US, Thailand, Japan, China and India where agricultural technology generation and technological developments are known to influence agriculture positively, this time lag is usually less than two years.

[3] WARDA is the West African Rice Development Association based in Cote D'Ivoire with an office located within the IITA headquarters in Ibadan.

[4] In the first quarter of 2006 Nigeria launched a microfinance and regulatory policy tagged 'Microfinance Policy, Regulatory and Supervisory Framework for Nigeria'. It is still too early to ascertain the implementation and impact of this policy.

issues of agricultural technology. For example, the Nigerian Agricultural Cooperative and Rural Development Bank (NACRDB) has the following four objectives:

i) to grant loans and advances for agricultural production in all its ramifications and for the purposes associated with such production;
ii) to grant direct loan and advances to individual farmers, cooperative societies, and other bodies (corporate or un-incorporated) provided there is adequate security to cover the loan exposures;
iii) to assist enterprises in agriculture and agro-based industries; and
iv) to render agriculture related consultancy services.

In all these objectives and the activities of NACRDB agricultural finance are not targeted towards agricultural innovation activities. The farmer or farms are only assisted to finance agricultural activities which are often constrained by low productivity apparently due to paucity of technological innovation.

R&D intensity and R&D organization

There are important agricultural research and development activities in Nigeria either in collaboration with international research institutes or as part of the academic research programmes in Nigerian universities (FMST, 2004)[5]. Figure 1 also suggests that local agricultural research in Nigeria is a major aspect of the current technology development model. Ikpi (2002) reported that numerous improved agricultural and agribusiness-support technologies have been developed in Nigeria; and they could substantially improve Nigeria's agricultural production and productivity if only they were effectively transferred to farmers and the agribusiness sector. For example, the most widely adopted and productive crop technologies include species of cassava, yam, rice, maize, cowpea, and soybeans. In addition to these crop technologies, Ikpi also reported that various university food technology departments have developed 41 hardware-type hand-operated post-harvest technologies; and the IITA have, on its own also developed a number of post-harvest and other technologies that are either "software" (processes) or "hardware" (equipment) for use at both the production and processing ends of farmers' activities. Examples of post-harvest technologies developed include cassava bread recipe; production of soy-cheese using plant coagulant; cottage, small scale level processing of soymilk for the production of bean-odour-free soymilk; and many simple (often hand-operated) processing equipments.

It appears from the foregoing that what is lacking is not the capability to start the R&D process but the capacity to push the scope and depth of the R&D activities beyond its current level of mainly laboratory research. This can be achieved through the agricultural system of innovation approach that enables farmers and other users of the output of R&D to interact and participate in the R&D process from initiation of the project idea to the debut of the results in the market. When R&D involves farmers in this manner, rural households will find it less cumbersome to adopt agricultural innovation that can help reduce vulnerability to poverty.

[5] FMST (2004) contains profiles and list of completed local R&D that has prospects of successful commercialization. FMST is the Federal Ministry of Science and Technology, which has the mandate to coordinate, publicize, and promote R&D activities in research institutes and tertiary institutions in Nigeria (FMST, 2004). See Adeoti and Adeoti (2005) for the specific case of agricultural biotechnology research in Nigeria.

Education and training

Nigeria has at least 20 agricultural research institutes and 26 universities that have faculties of agriculture involved in agriculture-related research. As earlier indicated these agricultural research institutes and faculties of agriculture are involved in basic and applied research that produce new and improved agricultural technology (e.g. seed/seedlings, livestock breeds, and mechanical equipment for agro-allied and food processing) either individually or collaboratively with international research centres and foreign universities (Ikpi, 2002; Adeoti and adeoti, 2005). However, the agricultural education and training system in Nigeria has been unable to provide adequate skills required for the agricultural system of innovation. The education and training system has been in unending crisis especially since the mid-1980 when economic structural adjustment programme resulted in drastic reduction in public sector investment in the educational and training system. The crisis have manifested in decayed physical infrastructure educational/training; emigration of qualified academic staff/trainers; recurrent unrests among school pupils and students; frequent industrial actions among teachers of various categories ranging from basic school teachers to university lecturers; frequent industrial actions by non-academic staff of universities; irreconcilable differences in respect of the compatibility of African traditional knowledge with knowledge generated in modern educational institutions; and inability to link knowledge generation and use thereby limiting the economic and social benefits of knowledge. Whereas knowledge generation and use have led to enormous improvement in standard of living of farmers in developed countries, knowledge generation and use have had very limited impact on reduction of vulnerability to poverty among farmers in Nigeria in recent decades..

4.2. Vietnam

Vietnam is still an agricultural country. Agriculture plays an important role in the country's economy, with the sector contributing 24% to national GDP, accounting for nearly 30% of the total export value, and employing over 60% of the country's economically active population. With the average annual growth rate of 4% in agriculture, Vietnam has changed from being a net importer of rice in the late 1980s to becoming the second largest rice exporter in the whole world, and exports large quantities of commercial crops including the commodities – rubber, tea, coffee, pepper, groundnuts, and cashew nuts.

Despite these achievements, the average farmer's income is still very low and there are large disparities in wealth between regions, with income gaps between population groups tending to increase rather than decrease. Rural poverty is widespread in Vietnam, particularly in remote and highland areas. The country's poverty incidence is estimated at about 11% in 2002, and 85% of the poor live in rural areas. Poor people in rural Vietnam have limited access to productive resources (capital, knowledge and land), and more vulnerable to natural disasters such as flood and drought. As an agricultural country with over 76% of the people living in rural areas, this situation creates difficulties in economic growth and social security.

Government strategies to reduce poverty aim at sustainable economic growth through reforming agricultural research and extension, increase private investment in agriculture processing, and agricultural market support. Major opportunities exist for increasing

agriculture productivity and growth, and ensuring food security and job opportunities, thereby contributing to reduction in rural poverty.

One approach to reduce poverty in rural areas is to assist the research, extension and vocational training system in Vietnam, thereby improving the mechanism for transferring new technologies and good established practices in a two-way directed linkage between agricultural scientists, extentionists and farmers. The current technology transfer from research institutions to farmers in Vietnam presented in Figure 1 reflects the linear model of technological innovation with one way of communication from research institutions to farmers (Nguyen Van Phu. 2003). There are four channels for technology transfer: Channel 1 – direct transfer to farmers; Channel 2 – transfer in cooperation with the agricultural extension system; Channel 3 – transfer through state rural and agricultural development programs and projects; and Channel 4 – transfer through international programs and projects. This model lacks the interactive learning, feedback mechanism from farmers and network relations which are considered important characteristics of the agricultural system of innovation. Instead of using the linear model of innovation we apply the agricultural system of innovation as the analytical framework to examine the roles of various actors, and their interactions in enhancing farmers' access to knowledge and technologies, thus reducing farmers' vulnerability to poverty in Vietnam. The following sections examine the various components of the agricultural system of innovation in Vietnam.

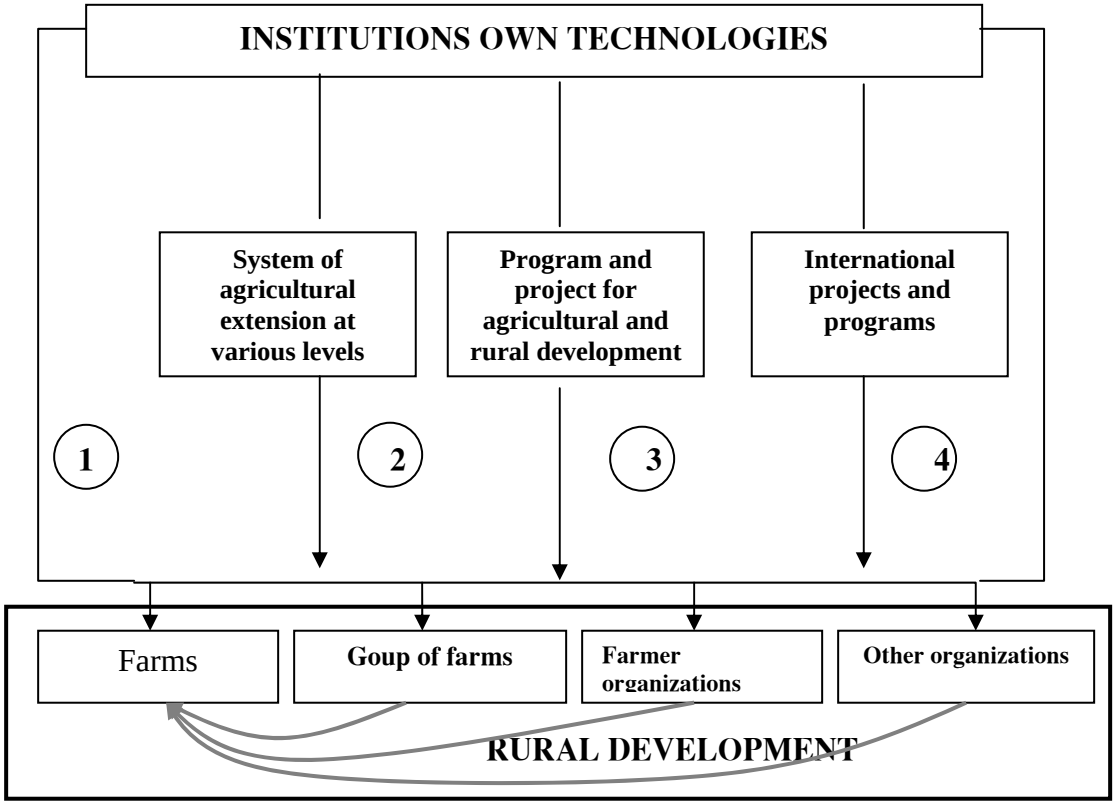

Figure 1: Main channels of technology transfer from research institutions, centres and universities to farmers.

Internal organization of farms

Farms in Vietnam are still predominantly small (less than 1 ha) and rely on traditional practices and indigenous knowledge. While the majority of farms will still be small, the development of large farms will necessitate the development of research and extension systems that cater to different farm sizes as well as different groups of people. There will be a great part of the agricultural sector involved in post-harvest processing as well as agro-enterprises. Therefore, research and extension will have to respond to the needs of not only farmers but also of agro-enterprises.

The main beneficiaries from research have primarily been the farming community and to a lesser extent the private sector. In the former the benefits have mainly been through production increase to primarily crops and livestock. Improvements in post harvest operations and processing have benefited the private sector. There are however, complaints that many of the research findings by the various research institutes under the Ministry of Agriculture and Rural Development (MARD) and other ministries are not finding their ways down to the farming community. This is partly the fault of the institutes themselves and also technology transfer by the extension service at the Provincial, District and Commune levels. Furthermore, many of the technologies only seem to be benefiting farmers in the better developed regions of the country, not the farming community in the more isolated regions in the North West, North East and Central Regions (LK&U 2004).

The technology transfer model in Figure 1 indicates the farmers' need for agricultural technologies has mainly been defined by research institutions. It is common technology developed by research institute is transferred either directly by research institute or in cooperation with the agricultural extension agents to farmers who are expected to adopt technology. In this technology transfer mechanism, it is unclear how farmers organise their productive resources to manage the adoption of new technologies. Furthermore, it appears that the participation of farmers in identifying their need for technologies is limited and passive.

Inter-farm relationships

There is indication of some initial inter-farm relationships exist in Vietnam agriculture as shown in Figure 1. Such forms as Farmer Clubs, Community Groups and Community Learning Centres are considered some of the institutions that have been identified as part of the agricultural system of innovation facilitating inter-farm relationship. These inter-farm relationships can serve as sources of shared information on new varieties of seeds/seedling, market opportunity for farm products. For example, the Farmer Seed Production Club in Dong Thap Province in the Mekong Delta of Vietnam plays an important role in providing technical assistance to its farmers as members of the Club in rice seed selection and purification. (MARD and MTAD. 2007) A study on farmers' need[6] shows the actual major existing sources from which farmers receive information on new varieties and on agricultural technical and management matters are Community Groups, cited by 40% of respondents. In particular, for technical/management issues, farmers prefer more information supplied through the Community Groups, suggesting that such groups can be a highly effective channel of

[6] The "Farmer Needs Study" Project VIE/98/004 MARD, UNDP and Royal Netherlands Government, 2003

communication between farmers and the extension/research services. Over 2,500 Community Learning Centres have been established in most provinces throughout Vietnam. These centres are structured as a network of people available to provide education, and through this network also provide extension services at the commune level (LK&U 2004).

Role of the public sector

The public sector plays an important role in the process of innovation. The regulations issued by public sector can influence the rate and direction of innovation. One example is the Government Decision No. 80 in 2002 regarding incentives to assist farmers in selling their products. The core idea of the Decision is to promote linkages between farmers, scientists/technologists, business men for better marketing their products. Farmers are assisted by scientists in accessing new varieties of seeds and seedlings, receiving training in farming techniques, and setting up trade mark for their products. Once the products with the recognised trade marks are introduced in the market, farmers need further assistance from trading companies to sell their products. To enhance this interactive network between farmers, scientists and business men, the Government provides a number of measures such as soft loans for production, support research which serves farmers and business men. This policy promotes the transformation of agriculture system from the one focused on production of foods to a system that is able to meet the changing demand for food within the context of a global agrifood system while ensuring food security for the population, generating adequate incomes for producers, and smoothing the transition to an economy where most of the employment will be in non-farm activities.

Institutional set-up of the financial sector

Under the regulation of Ministry of Finance in Vietnam, banking and credit units include all the commercial banks in rural Vietnam such as Bank of Agricultural and Rural Development and small local rural credit unions.

Rural credits have been proved to be very important in agricultural and rural development. Because of small-scaled production and poverty, farmers cannot raise loan for production from banks. Entrepreneurs of small agricultural firms also complain that banks are not willing to grant them enough loans for technology development, nor can they get any venture capital. On the other hand, banking industry regards agricultural technology as highly uncertain and risky, partly because their credit standard benchmarks are produced merely for industry in the past decade.

R&D intensity and R&D organization

R&D activities in agricultural sector in Vietnam are conducted mainly by public research institutes and universities. The intensity and the organization of the R&D thus depend on the capacity of the public sector to provide incentives and infrastructure for R&D. Agricultural research system in Vietnam lacks sufficient funds to carry our its assigned tasks. Public spending on agricultural research constitutes only 0.17% of total Government expenditure in Vietnam, as compared with the average of about 0.51% in other countries in Asia.

Until now, agricultural research in Vietnam has been oriented almost exclusively to the production of "high and sophisticated technology", often imported from outside and sometime adapted in a way inappropriate to local conditions. Even though this approach has brought considerable benefits, it has also been unable to address the problems of people in remote and mountainous areas and those who belong to disadvantaged groups (LK&U 2004).

The organization of R&D activities in agriculture can be seen through the agricultural research system in Vietnam which is complex, includes 34 research institutes and 12 universities/colleges and involves 5 ministries. The agency primarily responsible for the implementation of agricultural research is MARD which has 28 of the research institutes, with 113 Sub-institutes/Centres, and 6 of the 12 agricultural universities/colleges under its supervision. This system is hampered by the fact that the regional distribution of public research institutes and their stations in uneven, with about 80% of them in the Red River and Mekong deltas, making it difficult for the institutes to address poverty reduction and environmental issues in remote and upland regions where research institutes and their stations do not exist.

The reorganization of the agricultural research system under MARD in 2006 results in the establishment of the R&D system under MARD which consists of 6 national research institutes and 9 regional institutes with the following tasks: (1) National and regional research institutes are under MARD, with appropriate mandates, equal status and coordination in research and transfer of advanced technology managed by National Coordination Agency – Agriculture Science and Technology Council. (2) National institutes mainly do basic research in specialised areas. They can also be involved in applied research and technology transfer at the level defined by MARD. (3) Regional institutes mainly do applied research and comprehensively advanced technology transfer (through practical experiments and coordination with extension providers for technology delivery). They can also be involved in basic research in some specialised areas at the level defined by MARD, ensuring each regional institute will be a multi-disciplinary institute on crops, livestock, water resources and forestry. The specialised areas of each regional institute depend on regional agriculture development demand to promote the advantages on ecology and the available production systems as well as the improved facilities in the region. In spite of the reorganization of the R&D network in agriculture, it appears that the network is still in line with the science/technology push model with limited participation of the users (farmers) in identifying research priority and technology needs.

Agricultural extension agents are considered intermediate institutions between R&D institutions and farmers being engaged in transferring technologies to farmers. Extension services are delivered by a range of government and non-government service providers. The Government extension system was established over 11 years ago. Most extension workers at the provincial level are technologists with technical qualification but limited expertise in extension methodology and farm management (LK&U 2004). The non-government extension service providers include: (i) local Mass organizations such as the Women's Union, Farmers Union and Youth Union; (ii) Associations such as Plant Protection Association, the Vietnam tea Association, the Cotton Association and the Coffee and Cocoa Association through Vietnam; (iii) some local NGOs such as the Centre for Rural Development Service and (iv) private sectors including trading companies such as Bio-Seed Company, An Giang Pesticide Company. The current extension methodology is uni-dimensional. It relies on demonstration

models and associated farmer training. Delivery of the demonstration model is seen as the end results, rather than a means towards an end of widespread adoption. The approach is prescriptive rather than responsive to farmers' needs. Strategies for expansion of successful demonstration appear to be lacking. The process of technology transfer is passive and largely non-participatory.

Education and training

The agricultural education and training system includes secondary technical and vocational education and higher education. The present agricultural education and training does not meet the requirement of human resources for the agricultural innovation system. It is widely acknowledged that the quality of technical and vocational education is hampered by the current organization and structure of this sub sector. The network of institutions is scattered and lacks a cohesive management structure with schools under the jurisdiction of various ministries, sectors and localities. Consequently there is currently no overall master plan for the sub sector as a whole and agricultural education in particular. As a result, many institutions offering agricultural education are not able to respond systematically to the needs and demand of the labour market. Furthermore, in many institutions, technical and vocational curriculum implementation has a theoretical orientation due to limitations in equipment, facilities and teaching/learning methodologies. Consequently, many programs may not be closely related to industry skills standards and do not receive regular technological updates.

Despite significant improvements in many areas of the higher education sub sector, the higher education system is not adequately responding to the requirement of training high-quality science and technology manpower. It is recognised that a number of programmes remain narrowly designed, maintain a theoretical focus and lacks systematic linkages with labor force demands.

5. Concluding Remarks

From the foregoing, it is apparent that there are striking similarities between the agricultural innovation systems in Nigeria and Vietnam. It is remarkable that irrespective of cultural and geographical differences, the two developing countries have important features of their agricultural economy affected by technological constraints resulting in farmers' vulnerability to poverty. Each of the key elements of the analytical framework demonstrated that Nigeria and Vietnam have much to learn from the agricultual system of innovation framework as means of reducing the vulnerability of farmers to poverty. In this respect, three important issues must be stressed.

First, there is a need to replace the existing linear models of agricultural innovation with an agricultural system of innovation with its distinctive feature of interactive learning that engenders active participation of farmers and other important actors in the agricultural innovation process. This is by no means a simple challenge because it requires considerable and far reaching reforms that would affect institutions and relevant stakeholders in the agricultrural economy. The reform process can be carried through by paying attention to specific elements of the agricultural innovation system and identifying the regulatory and incentive regimes that promote actors' interactions and feedback mechanisms aimed at

encouraging the adoption of technologies that can enable farmers achieve significant poverty reduction.

Secondly, the application of the agricultural system of innovation as the analytical framework allows us to see the relationship between research institutions and farmers can be an interactive learning process governed by several institutional actors that determine the agricultural innovation from generation, acquisition to adaptation and diffusion of technologies. In this process, technologies can be developed with the active participation of farmers and understanding of the context of their application. The agricultural innovation system recognised that the innovation process involves not only formal scientific research organizations, but also a range of other organizations and other non-research tasks. It also recognises the importance of linkages, partnerships, alliances and coalitions and the way these assist information flows.

Finally, the local capacity from the demand side (farmers and household farms) in identifying and articulating their technological needs is rather limited in Nigeria and Vietnam. Appropriate policies that could be national or regional in scope may be required to translate the need of farmers and households into effective demand that are recognized and addressed by research institutions.

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