RESPONSES TO CHANGING AGRICULTURAL RESEARCH FOR DEVELOPMENT (ARD) NEEDS OF NATIONAL AGRICULTURAL RESEARCH SYSTEMS (NARS) IN THE CONTEXT OF GLOBALIZATION

INTRODUCTION

Globalization has been described and defined in many ways, but a common thread running through many of the description is that globalization is that of market integration to remove trade barriers with a free flow of goods, services, information and technology across nations, and regulated by a legal frame work and a set of global rules that could sometime override local and national interests. The concept however, goes beyond that of a global free market to encompass, according to the IMF[1] not only economic but also political, cultural and social integration.

Opinion is divided as to the benefits or otherwise of globalization especially with regards to impact on the agricultural sector in developing countries.

It has been argued that since globalization encourages and stimulates a free flow of information and technology, producers and service providers would have access to a wide range of required information and technology at a lower cost because of competition amongst the providers of the technology and information. This would benefit an agriculture that is becoming more and more knowledge intensive even in developing countries. The risk, however, is that some of the globally generated technologies, even good ones, may not be locally suitable or adapted, and still inaccessible because of changing economic circumstances.

According to von Braun[2], this facilitation of access to knowledge should be considered a promising opportunity. He nevertheless cautioned that because agriculture is not just an economic sector but also a valuable knowledge and cultural system opening it up to a global system may have significant implications for the cultural transformation of communities and that care must be taken to ensure that this does not lead to the demise of a rich and diverse global rural culture, knowledge and wisdom.

Subsidized agricultural products, their impact on commodity prices in a globally integrated market and consequences on the vast majority of developing countries and their producers is currently a divisive issue, and there is an impasse. Some argue that the current agricultural subsidies being enjoyed by producers in Europe and North America are in part responsible for the impoverishment of producers in developing countries, while others with equally impressive data suggest that the removal of such subsidies will raise commodity prices in developing countries and lead to further economic downturn.

In a recent publication of the ILO[3] the World Commission on the Social Dimension of Globalization indicated that it believes the benefits of globalization can be extended to more people and better shared between and within countries, with many more voices having an influence on its course, but that in order to achieve these objectives the dominant perspective on globalization must shift from a narrow preoccupation with markets, to a broader preoccupation with people, so that it can meet their needs. A number of recommendations were made in the report, ranging from: a focus on people

One could conclude therefore that the threats and challenges of globalization especially to the agricultural sector in developing countries currently outweigh the opportunities and potential, hence the need to tilt the balance to the benefit side of the equation.

The threats and challenges to the agricultural sector in developing countries currently outweigh the opportunities and potential, hence the need to tilt the balance to the benefit side of the equation. The challenges are many and appear daunting but scientific research, and technology development accompanied by complimentary policy adjustments and strategies can effectively deal with them, and the National Agricultural Research Systems (NARS) have a central role to play in generating the knowledge, technology and information required.

CHALLENGES FACING NARS

Within the context of the globalization of agriculture, the main challenge facing NARS is to contribute to the development of a competitive agricultural sector. A sector that is highly productive and efficient, that supplies a variety of quality and safe products that not only meet domestic food security demands but also targets and penetrates other markets. Unfortunately, the development of such a competitive, broad based agriculture will have to take place under conditions characterized in many countries today by a dwindling natural resource endowment (land, water, and biodiversity) largely due to inappropriate technologies and exploitation of marginal lands. Other constraints to be tackled include: intractable post harvest losses, a fractured production, processing marketing chain, and weak institutional capacities. The responses of NARS to these challenges constitute and reflect their changing ARD needs. Many NARS especially the stronger and larger ones are already moving in this direction by strategically repositioning themselves to address the following needs.

CHANGING ARD NEEDS OF THE NARS

i) FOCUSED RESPONSES TO THE NEEDS OF PRODUCERS AND CONSUMERS; IDENTIFYING MARKET OPPORTUNITIES

Each country is made up of heterogeneous groups of producers and consumers. A clear understanding of the dynamics of these two groups are fundamental for developing clear agricultural R&D strategies that contribute to economic growth, and the eradication of poverty and hunger.

Consumers are often well categorised according to social strata, and their purchasing habits are often well known through household surveys. Rapid demographic changes, especially those related to urbanisation, have radically altered people's food consumption habits. In cities, perishable staples and those that require lengthy preparation are replaced by more convenient cereal and pulses. Increasing income and rising employment opportunities for women, lead to greater consumption of livestock products, fruit and vegetables, and processed foods that can be prepared more rapidly. In addition, food retailing itself is undergoing significant modifications, with vertiginous growth of supermarkets, which is affecting the way that food processors, wholesalers and retailers procure their supplies from producers.

Producers are perhaps less well categorised, being grouped usually into commercial and subsistence, or large, medium and small scale. These very broad groupings are not always very helpful in developing sound agricultural research strategies oriented to improving the well being of different categories of producer, whose individual well being will be a function of the types of crops grown or livestock produced, the quality of the land, the distance from market and the access to support services to develop his or her agricultural enterprise.

To be effective, agricultural R&D strategies have to be targeted toward supporting farmers and other rural enterprises meet different customer and consumer demands. For farmers to be competitive means that they have to produce the right product, at the right price, in the correct quantities and at the right time. Agricultural R&D has to be oriented to help farmers achieve these challenges. Setting priorities for research therefore starts by confirming or identifying the most appropriate market opportunities for each category of farmer. The opportunities that can be realised by larger, commercially-oriented farmers will be very different from those that can be realised by small resource-poor farmers.

This suggests that there will be the need for introducing greater flexibility in the portfolio of products with which a national research organisation engages, as new opportunities arise. The skills achieved in germplasm evaluation, IPM, crops and soil management in a particular crop may have to be applied to different crops in the future. Resource availability will often limit field research, and organisations will need to become adept at harnessing the knowledge generated by others on different products – from, for example, information available on the Internet and other sources - analysing this and making it available to producers in an understandable way. Many national research organisations have limited or no capacity for monitoring changes in consumer demand nor for prospectively identifying new market opportunities at a national or regional (within country level), nor for accessing available information and making it available to those that need it. These are competencies that are vital for responding adequately to the demands of the market and research organisations' principal clients, the farmers. They can be achieved by developing in-house capacity, or linking with others, such as universities. Box 1 presents the example of the National Agricultural Research

Organisation, NARO, of Uganda to mainstream market-oriented research within the organisation.

Box 1: Elements of a strategy for mainstreaming market oriented research in Uganda's National Agricultural Research Organisation (NARO)[4]

NARO recognised the need to develop capacity to respond to the needs and opportunities provided by the market as part of its overall process of realignment to become more responsive to the changing needs of Ugandan agriculture. In December 2003, a Task Force was constituted to develop a strategy and action plan for mainstreaming market-oriented research. Through a process involving planning, literature review, an inventory of MOR within the NARO institutes, a consultative workshop with NARO managers and a drafting retreat, the strategy was developed.

The overall goal of the strategy is to enhance NARO's capability and capacity to undertake research that is responsive to market demands and opportunities. The strategy presented to NARO management consists of three main elements.

The first element is institutionalizing the ability to respond to market demands, emerging issues and new opportunities in NARO. This is to be achieved through operationalizing mechanisms for collecting, collating and updating information on market opportunities and emerging issues, and using the information to reorient NARO's research projects, making them more responsive to changes in client demands.

The second element is establishing effective partnerships within NARO, and between NARO and other private and public sector institutions. This is to be achieved through documenting experiences from current partnerships, scaling out models of good practice and the establishment of new partnerships for MOR in NARO based on a sound analysis of the needs of the bottlenecks and constraints that limit competitiveness of prioritised agricultural products.

The third element is developing capacity and skills to undertake market-oriented research in NARO. It will involve formation and training of a core group of 8 NARO scientists with the skills to provide MOR capacity building within the institution and offer services to third parties if demand exists; sensitization of NARO personnel at all levels in the concepts, principles and methods of market oriented research; training of research teams in market opportunity identification, evaluation and selection of enterprise options, market chain analysis, and the design of action plans that define demand oriented researchable issues in collaboration with stakeholders. This team would also be responsible for documenting experiences from current partnerships and elaboration of proposals for scaling-out models of good practice.

It is estimated that a period of 2 years is required to implement and consolidate the strategy within the organisation.

ii) DEVELOPMENT OF VALUE-ADDING INNOVATIONS ALONG THE SUPPLY CHAIN

As populations concentrate in large cities, and as quality and convenience become increasingly important, so the proportion of the final price of an agricultural product that is received by the farmer declines. Increasing the value of a product closer to the producer and the improving the effectiveness of the relations among the actors that are involved in delivering agricultural products to consumers are therefore as important interventions as achieving higher levels of productivity. Once products or commodities have been prioritised, a market or supply chain approach to identifying bottlenecks and constraints to achieving greater competitiveness needs to be adopted. A holistic and integrated approach, where constraints in production are prioritised in function of the requirements of, and the importance of relieving constraints at, other levels of the supply chain, will achieve much greater impact than when each supply chain component works separately.

This is particularly true and relevant for the small farm sector, where the internationalisation and concentration in the food industry and retailing sector mentioned above can lead to their marginalisation. Farmers and processors in many countries are faced with falling prices (competition from cheaper imports) and changing procurement practices and rising quality standards that are hard to meet. Research has therefore the role of providing innovative solutions to problems that go beyond productivity enhancing production, post-harvest handling and processing technologies to dealing with aspects related to farmer organisation, access to financial and non-financial services that will help agricultural enterprises grow, and innovative means for farmers to access information on which to base production decisions, policies that motivate investment in agriculture, etc.

While the specific role or contribution that is made by agricultural research organisations may not change substantially – by generating knowledge and technology for raising productivity and lowering costs, the ability to form partnerships with other service providers and the private sector (including farmers), will be at a premium for more effectively addressing the most important constraints to achieving more competitive supply chains for agricultural products. Box 2 illustrates how the promotion and establishment of public-private partnerships can provide focus to R&D activities.

Box 2: Designing partnerships for innovation: the case of broccoli in Ecuador[5]

Building and consolidating public-private partnerships follows four basic phases: 1) the identification of common interests and objectives, 2) negotiation and design of interventions, 3) implementation, and 4) evaluation. In partnerships that form without an outside intervention, these phases are usually implicit and without formal documentation. However, if they do not emerge spontaneously a third party is needed to promote them. In many countries, different types of organisations are emerging whose role it is to link public and private sectors. On such example is the Ecuadorian Corporation for Export and Investment Promotion (CORPEI) that brought together ECOFROZ, a company that produces and purchases broccoli, and processes and exports the product to USA, Japan and Europe, other agro-industries and public sector research institutes including the National Institute for Agricultural Research, INIAP. The broccoli production and export business in Ecuador was facing competition from suppliers in other countries and needed to find means to regain position in the market.

The process for identifying and negotiating common interests among partners followed four steps: a) an analysis of the relations among actors of agri-chain and a participatory characterization of the constraints that limit its development; b) a prospective analysis of the competitive potential of the broccoli agri-chain including both market and technological aspects; c) definition of a set of common objectives, with their respective results to realise the opportunities identified; and d) the construction of a strategic vision for the growth of the broccoli agri-chain, based on developing a diversified product-market portfolio.

This process led to the identification of three projects:

- The development of an information system for commercial and competitiveness benchmarking of the broccoli export market;
- Integrated crop management for Ecuadorian broccoli production; and
- The improvement of post-harvest management and commercial use of broccoli processing residues.

Once research topics had been selected and clear objectives and outputs defined for each one, negotiation of financial, governance and legal aspects took place. This was not without difficulties, especially with respect to aspects related to information sharing among private sector partners and the value placed on accumulated knowledge. So, at this stage some private companies withdrew. With respect to financing, partners were willing to provide co-funding, but mainly with in-kind contributions (time of employees, infrastructure and services etc.), and third party financing is required to bring the projects to fruition.

This experience, among others, has confirmed that successful public-private partnerships need: a) a credible third party facilitating organisation that uses appropriate methodologies to reduce transaction costs and ensures effective and equitable partnerships, and that can lead the process to necessary level of consensus, b) a visionary and innovative leader from the private sector who has recognition among private sector actors and understands the research and innovation process, c) credible public research organisations that are recognised for their ability to respond to the demands of the agri-food sector with knowledge and technological options. Counting with these human resources, particularly in public institutions, requires an important investment in capacity building, combined with associated changes in institutional structures, attitudes and reward systems

iii) APPROPRIATE AND SUSTAINABLE USE OF NEW SCIENCE AND TECHNOLOGY

The green revolution with all of its now recognized short comings was nevertheless responsible for starving off widespread hunger and thwarting the ominous Malthusian predictions of the early fifties that food production would lag far behind population and food demand, leading to chaos and unrest. According to FAO statistics, from 1970 to 1990, production and yield increases for the three cereals on which the green revolution concentrated were about 90 and 63% respectively. We are now in the era of three new revolutions which promise much more, and to which NARS have to contribute and use in a sustainable manner. These are the gene revolution, the information communication technology revolution and the innovation revolution.

THE GENE REVOLUTION

Recent progress in the development of various forms of biotechnologies shows promise of unprecedented production and productivity gains for agricultural products. The promise and potential of the various forms of biotechnologies both conventional such as in vitro cultivation techniques, embryo transfer and micro-propagation, and the newer forms such as molecular biology, genetic engineering and nano-technology must be harnessed and used with appropriate safety measures and policy support. Some current and future outputs that should serve as an incentive to NARS participation in this revolution include: the development of drought tolerant crops to fulfil the more crop per drop vision; bio-fortified crops for improved nutrition; an upward shift in current yield and productivity ceilings; vaccine production and pharmaceuticals for livestock, and the exploitation of the high degree of inter species synteny for improved production. Box 3 illustrates a Challenge Program-Generation- of the Consultative Group on International Agricultural Research (CGIAR), which was recently launched. The Generation Challenge Program aims to bridge the gap between technology haves and have-nots by using advances in molecular biology and harnessing the rich global stocks of crop genetic resources to create and provide a new generation of plants that meet the needs of resource poor farmers

Box 3: Generation Challenge Program (GCP)[6]

The Generation CP is organized into 5 subprograms, namely, **Genetic Diversity of Global Genetic Resources; Comparative Genomics for Gene Discovery; Trait Capture for Gene Discovery; Genetic Resource, Genomics and Crop Information System;** and finally **Capacity Building.**

The Subprogram 2: **Comparative Genomics for Gene Discovery** focuses on developing genomic tools, technologies, and approaches to achieve an understanding of genetic principles across many significant crop species in developing countries. SP2's primary role is to discover and validate the function of key genes that are involved in stress tolerance, notably drought by examining gene expression using phenotpyically-informative crops-or genotypes within a crop-and validate the causal relationship between expression and phenotype using appropriate genetic stocks (targeted mutations, over- and under-expression systems). In collaboration with the other subprograms, SP2 brings together an array of genetic resources and applies analytical tools to uncover the expression-phenotype relationship to genomic variation (with SP1) and relates expression and genotypic polymorphisms to phenotypic performance (with SP3).

The consortium nature of the GCP unites the CGIAR and NARS programs, research organizations which have the unique ability to produce and record extensive phenotypic data across crop species and investigate the subsequent variation on a molecular level by utilizing genetic mapping or association analysis techniques. For most of the 22 CGIAR mandate crops, quite extensive genetic maps within each species are already available. Comparative maps are most advanced for the cereals: rice, sorghum, maize, barley, millet, and wheat. Beyond mapping, an expanding amount of sequence information, paired with improved informatic tools, has enabled us to identify orthologous genes that may allow for the prediction of gene functions across large families of plant species. The SP 2 is positioned to apply innovations in medical and laboratory practices and future conceptual advances to crop genomics. Some of our efforts will be devoted to assembling genetic knowledge on stress tolerance (drought and others) through a combination of informatics analysis and empirical studies using advanced genetic stocks available to the GCP.

The Subprogram 5: **Capacity Building** aims to empower national program scientists (in the NARS) so that they can carry out this cutting edge research agenda. One of the GCP's premier capacity building activities is to build databases that contain traditional and molecular data on germplasm so that scientists all over the world can access information with relevance to their region on traits, genes, and sequences. the SP promotes two broad categories of capacity building. The first involves activities such as graduate and postdoctoral research, sabbatical leaves, internships, and other types of exchanges of scientists among participating institutions in the consortium. The second includes the development and execution of specific courses, workshops, and on-line distance learning. Both require developing and making available a significant number of training materials to support sustainable learning and research.

THE INFORMATION COMMUNICATION TECHNOLOGY (ICT) REVOLUTION

Agriculture is becoming increasingly knowledge intensive with an accompanying increased demand for information. The ICT revolution is poised to, and capable of delivering the required information to all stakeholders involved in the sector from researchers and entrepreneurs, through service providers and NGOs, to farmers and their organizations. Although it has been suggested that information is now the least expensive input for agriculture and rural development, a growing digital divide makes access to required information by rural communities and NARS researchers an expensive input often out of their reach. This access-denying divide is a formidable one, because it consists of not only technological, but also social, economic and political barriers. One of the needs of NARS is to remove these barriers so that they can respond to the challenges of a globalized agriculture. Multiple initiatives are on going to respond to this need, and ensure that they participate in and benefit from this ICT revolution. One of such initiatives is the Global Alliance of Regional Agricultural Information Systems (GLOBAL.RIAS) project coordinated by GFAR with funding from the European Commission. All of the five GFAR regional fora are actively participating in this project whose goal is to satisfy the demand for a more equitable access to agricultural and related information expressed by GFAR stakeholders during GFAR triennial meetings in Dresden and Dakar.

The project, which started with a series of regional consultations and diagnosis, revealed the following: varying degrees of access to required information among countries and between regions. While some appear to be better plugged into the global information systems because they are better endowed with ICT infrastructure as well as capacity to use and manage the technology, in many more others across the regions the capacity, especially human skills to effectively collect, manage, access, share and exchange relevant information required for developing a multi-purpose and competitive agriculture is patently lacking, or in an embryonic form (see table 1 and 2). Follow up activities to the diagnostic consultation consists of the establishment or strengthening of regional agricultural information systems (RAIS) in the five regions, and the identification of the following critical activities which need to be carried out to achieve the set objectives.

- Capacity development in terms of infrastructure, institutional organization and skills development.
- National and regional agricultural information systems integration through a Global.RAIS web ring to enhance a seamless sharing and exchange of information, experience and knowledge
- Capacity strengthening of NARs leaders so that they can play an important advocacy role for appropriate policies, and resource investment for the development of ICT enabled NAIS.

We believe that a vigorous implementation of these activities will contribute to improving access to information and technology required to enhance competitivity, an important response to a globalized agriculture.

THE INNOVATION REVOLUTION

It was not until recently that we saw a paradigm shift from the linear researcher –extension-farmer flow of information and technology to one of a participatory approach where local innovation and knowledge systems were acknowledged as relevant and capable of

contributing to new technology development. Participatory learning and technology development processes that enrich local knowledge with external knowledge systems often result in the production of a common wealth of knowledge that is relevant to, and owned by communities. This is the essence of the innovation process revolution, which leads to appropriate long lasting solutions to local problems, and is an important response to some of the challenges confronting NARS today. A discussion on this paradigm shift and revolution during the GFAR 2000 conference in Dresden was translated into a concrete project - Promoting Local Innovation (PROLINNOVA) some months later (see box 4). PROLINNOVA brought together a consortium of NGOs, farmers and researchers from the north and south in a collaborative effort, to *promote farmer innovation for improved management of natural resources* by recognising the dynamics of indigenous knowledge (IK) and on learning how to strengthen the capacities of farmers (including peasant/family farmers, pastoralists, forest dwellers and artisanal fisherfolk, among others) to adjust to changing conditions – to develop and adapt their own site-appropriate systems and institutions of resource management in order to gain food security, sustain their livelihoods and safeguard the environment[7]. It is currently in its second phase, with a promise of positively impacting on participating communities and building capacity develop and use the innovation process.

Box 4: Promoting Local Innovation (PROLINNOV) [8]

PROLINNOVA is envisaged as a learning network on ways to promote local innovation in ecologically-oriented agriculture and natural resource management (EA/NRM). The focus will be on learning from and encouraging field activities that strengthen the capacities of smallholders, livestock-keepers and fisherfolk to adjust to changing conditions: to continue to develop and adapt their own site-appropriate systems and institutions of resource management.

The programme aims to build on existing experiences – many pioneered by NGOs – in agricultural research and development (R&D) focused on promoting local innovation. These experiences involve:

- discovering what farmers are doing in their own informal experimentation and how they are developing and testing new ideas to improve their land use, and
- building on these initiatives: joint experimentation with farmers to develop further these and other techniques in a process of participatory innovation development, linking local and outside knowledge.

PROLINNOVA-type approaches have been applied on a small scale in many parts of the world, e.g. Promoting Farmer Innovation (PFI) and Indigenous Soil and Water Conservation (ISWC) in Africa, PRIAG in Central America, Honeybee in India, Swiss-funded projects in Kyrgyzstan and Vietnam, the IFAD-supported work in Niger described in this workshop by de Leener. These have indeed shown that confronting formally-educated agricultural professionals with farmers' creativity changes the way that professionals view and behave towards farmers. Several examples are available about how new types of research partnerships have been built around local innovation and farmer-led experimentation, e.g. in the "Grassroots Innovation" issue of the ILEIA newsletter (*LEISA Magazine*) in July 2000. Many of these activities are facilitated by NGOs. Also some international agricultural research centres (IARCs) are developing methods to support farmer-led experimentation. However, few NARES (national agricultural research and extension systems) appear to be involved in this type of work.

A loose network of people and organisations practising PROLINNOVA, i.e. a farmer-innovation approach to participatory technology development (PTD), would like to scale up this approach, above all, to help incorporate it into NARES, so that the institutes involved are better able to support farmer-led R&D. For this reason, we are trying to build up in a global programme of exchange, mutual learning and collaboration in training and coaching for institutionalisation of participatory research based on farmer innovation and experimentation.

Over the years, there have been several small projects or events for mutual learning, such as studies of participatory research methods, workshops on scaling up local initiatives in NRM or institutionalising PTD in

small-scale agriculture, or electronic discussion groups or books to share and analyse experiences. However, these activities have not been well linked and are not drawing in enough other partners in the formal sector, particularly in NARES, to make a massive impact on formal R&D in agriculture and NRM.

A particular concern of many practitioners of PROLINNOVA is that this approach needs to be incorporated into the curricula of institutes of higher learning so that the next generations of scientists, extensionists and educationists see and use this as an accepted, mainstream approach. It is also widely felt that studies of experiences, both successes and failures, in promoting local innovation through PTD could help to identify the policy and institutional environments conducive to this approach. This would include studies of experiences in trying to change these environments, as was done for the recent IIRR (International Institute for Rural Reconstruction) workshop on incorporating PTD into institutions of research, development and education.

TABLE 1: CURRENT STATUS OF INFORMATION COMMUNICATION SERVICES IN VARIOUS REGIONAL FORA

Information and Communication Services	AARINENA RAIS	APARIS	CAC RAIS	FARA RAIS	FORAGRO INFOTEC
Science and Technology Information	None	Full text search and retrieval	None	None	Full text search and retrieval, on line upload by users
Technical information	Nascent	Nascent (success -stories)	Nascent (Agro web)	None	Market place for technologies
Research data management	None	None	None	None	GIS
e-mail, e-discussion and related tools(directories, indexes)	None	None	None	None	e-discussion, weekly bulletin, directories available

Source:

TABLE 2: CURRENT INFORMATION COMMUNICATION TECHNOLOGY STATUS IN ASIA-PACIFIC NARS

NARS	Rural Infrastructure	Science & Technology Information (library, automation and networking)	Extension / Outreach Information System (policy, public &private sector using ICT to reach farmers)	Skills (Users, developers, managers, language)
Malaysia	Developed	Developed	Developed	Developed
India	Emerging	Emerging	Emerging	Developed
Philippines	Emerging	Emerging	Emerging	Developed
Thailand	Emerging	Developed	Developed	Emerging
Indonesia	Poor	Emerging	Developed	Emerging
Sri Lanka	Poor	Developed	Emerging	Emerging
Laos	Poor	Poor	Poor	Poor
Cambodia	Poor	Poor	Poor	Poor

Source:

iv) INNOVATIVE INSTITUTIONAL ARRANGEMENTS FOR COOPERATION AND PARTNERSHIPS

The challenges identified are daunting and complex, and the responses in terms of the changing research needs of NARS have necessarily to be complex and comprehensive as described above. Individually, many of the NARS will not be able to deliver on such responses, hence the need for innovative institutional arrangements for cooperation and partnerships. This will ensure that NARs and countries that do not have the capacity to develop the various aspects of the responses including cutting edge technologies, but who necessarily must have the capacity to acquire, assess and use such ideas and technologies benefit from such advances.

The required partnerships and collaboration are at different levels of complexity. Firstly, researchers will need to work together in multi or trans-disciplinary teams to ensure that the required expertise is tapped on to address the social, technical, policy and economic aspects of a particular problem or constraint towards the development of a multi-dimensional and competitive agriculture. Secondly, in order to respond adequately to the needs of producers and the markets, efforts needs to be made to work on multi-stake holder basis with a strong and functional linkage between researchers and other stakeholders such as producers, farmers, service providers, and other target groups. For example, in order to improve cereal production and break the current yield ceilings in marginal lands, a consortium approach that involves scientists from various disciplines (land and soil specialists, irrigation and water use experts, sociologists, economists etc), grassroots groups represented by farmers and NGOS, and appropriate private sector would be needed.

Thirdly, nascent public-private partnerships need to be further developed and nurtured, given the increasing contribution of the private sector to the development of cutting edge science and technology which address the productivity, environmental and market aspects (see box 2).

Finally, inter-regional south-south and south-north collaboration is assuming important proportion and has a role to play in achieving the objective of developing a competitive agricultural sector, and the GFAR is driving this aspect of innovative institutional arrangements for partnerships. The various regional fora are setting and reviewing priorities, exchanging information on strengths and opportunities and are identifying areas where expertise could be exchanged and collaborative activities carried out including biotechnologies and bio-safety issues, agri-business and specialized commodity networking.

CONCLUSION

The era of globalization and in particular the globalization of agriculture has brought new challenges and demands on a fragile NARS, which need to develop and strengthen science and technology capabilities built on a combination of local knowledge and modern science and technologies, in order to respond effectively to the needs encapsulated in the goals of achieving poverty alleviation, enhanced food security, economic growth and rural development. An enabling policy environment is nevertheless indispensable if science and technology inputs of NARS and their partners are to have any impact. Complimentary policy adjustments that may be required include the following.

- Development of infrastructures and services especially in the rural areas. According to Fan and Hazel[9] high levels of investments in education, and infrastructure improvements targeted towards marginalized people will go a long way to integrate them into the market

- Public support for agricultural research. Data from FAO[10] indicate that developing countries are spending only 0.1 to 0.5% of their agricultural GDP on agricultural research, compared to 2% or more in industrialized countries where private funding of research in on the rise. With such low investments in agricultural research in spite of its documented high rate of returns many NARS are unable to engage in new and cutting edge sciences, and this needs to be addressed. Too much reliance should not be placed on global sources of technology because of the location specificity of research and the resulting technologies, and global research may not always or consistently focus on local needs
- Human capital development. Reduced investment in agricultural education and training and the brain drain have taken their toll on available research and development capacity to carryout locally relevant research and screen, select, verify and adapt in coming technologies to local conditions to ensure maximum benefits
- Implementation of enabling regulatory systems including access to credit, land reforms and social adjustment programs targeted to the poor and those displaced from the market as a result of the differential consequences of globalization. Pingali[11] highlighted the role the Grameen Bank in Bangladesh played in helping the poor develop alternative livelihood as an example of a successful social adjustment program

These and many other policy interventions constitute an important and indispensable part of the agricultural research and development response to the challenges facing the agriculture sector in the context on globalization.

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