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Delivering on the promise: Impact of NARO and its technologies on agriculture in Uganda

Tizikara, Clesensio
Monitoring, Evaluation and Planning Unit (MEPU), National Agricultural Research Organisation (NARO)
P.O. Box 295, ENTEBBE, Uganda. Tel: 256-41-320512, E-mail: ctizikara@naro.go.ug.

Abstract

NARO was established in 1992 to undertake and promote research in all aspects of crops, fisheries, forestry and livestock, and to ensure the dissemination and application of research results. The total investment into the organization by the end of FY 2000/01 amounted to Uganda Sh. 78.51 billion. The returns to this investment, in this short period of time, are striking. NARO has produced several new high yielding varieties of crops being grown on 10 – 50% of the area under crop. The adoption of new varieties has meant increased production ensuring steadier food supplies, prevention of starvation and malnutrition, and for many producers a surplus for market. In addition to new varieties, new and improved farming techniques, pest and disease management practices, and other aspects of agricultural technology have had clear positive impact. Notable techniques include nontraditional ways of growing crops, biological control of the noxious water hyacinth, containment of the cassava mosaic pandemic and advances made on control of the coffee wilt disease. In the area of improving the efficiency of agricultural research, the organization has trained staff to have the highest concentration of the most highly qualified professional agriculturalists and also appropriately deployed available resources to have the highest per capita investment per scientist in Uganda.

Introduction

Agricultural research in Uganda has a distinguished, albeit somewhat uneven, history. The considerable progress in developing public sector agricultural development institutions and capacity and the impact of the outputs from the research system that had been made prior to 1970 was largely dissipated in the difficult period (1971 – 1986) that followed. Use of rudimentary technology, low yielding/low value enterprises, poor land utilisation and lack of a commercial orientation are typical features of agriculture in Uganda. Farming is still more a matter of fate than choice. Yet, producers now face increasing competition and rapid technological change.

The National Agricultural Research Organisation (NARO) was established by the Uganda Government, in 1992, as a semi-autonomous organization to streamline, undertake and promote research in crop, livestock, fisheries and forestry and to ensure dissemination of research results to clients (GoU, 1992) so as to ensure that future agricultural progress shifts from expansion of the area under cultivation to reliance on technological change and shifts to higher value commodities. Since its creation, NARO has correctly focused on building its institutional capacity, and has made rapid progress in releasing improved technological packages that are crucial to improvements in smallholder productivity and incomes. The questions now being asked by many stakeholders are varied but hinge on the following: Of the numerous commodities NARO handles, what significant gains have been made for each of them? Has the work of NARO helped strengthen the other Uganda NARS components and technology delivery systems or has it weakened them? Have the NARO outputs helped the poor farmers/ consumers and the women in farm families? This paper attempts to highlight the effects that NARO and the technical innovations it has initiated have had on the management and conduct of agricultural research, on farm productivity and on aggregate national development objectives. It focuses on the following aspects: What was done and how? What was the successful impact? What were the major factors that led to success? What are the remaining challenges?

Analytical Framework

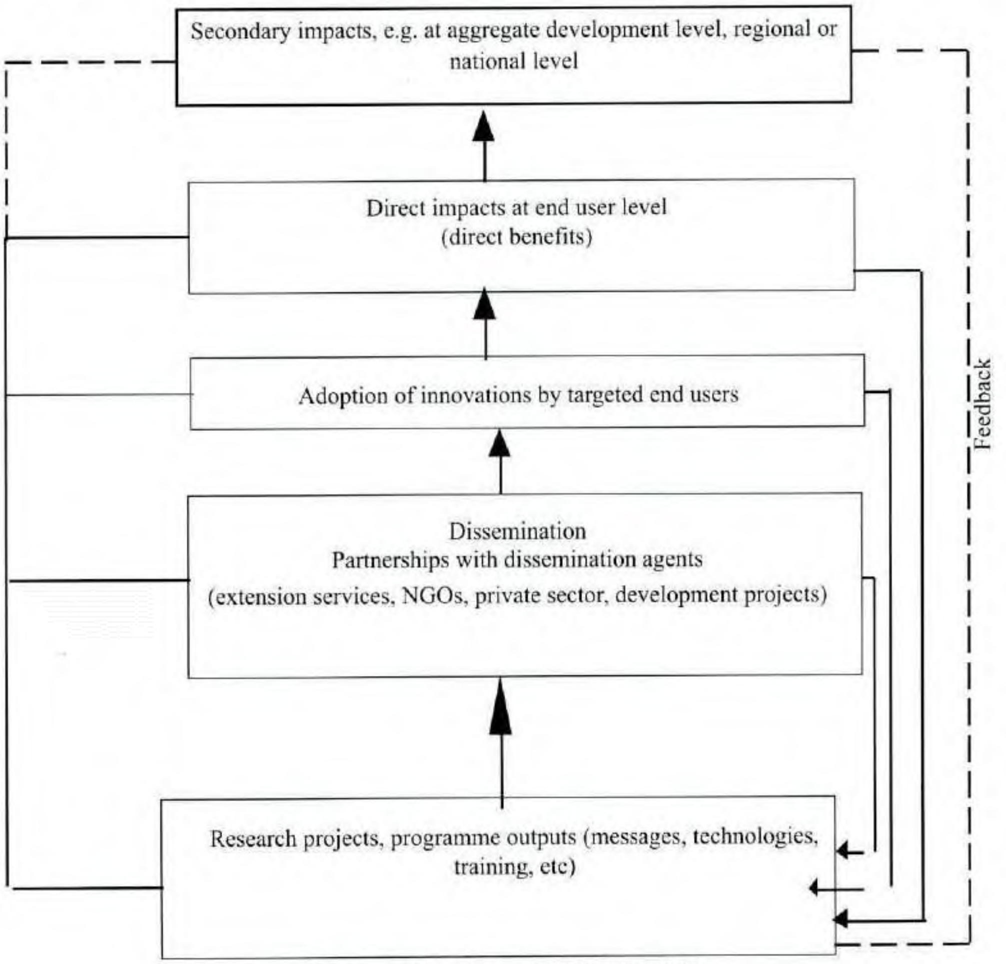
Impact, in the broad sense, implies looking beyond the direct output of an activity (e.g. institutional restructuring, variety, breed, or a set of recommendations resulting from research) to the effects of the direct output on the ultimate users – people level impact. This kind of impact is said to be occurring only when there is a behavioral change among the potential users and beneficiaries. Impact deals with changes in stakeholder perceptions and the actual adoption of the research output and its subsequent effects on production, income, environment and overall development objectives of a society or country. To measure impact, therefore, one needs information about the extent (number of users) and the intensity/degree of adoption of the improved techniques, and the incremental effects of these techniques on the production costs and output.

NARO is part of a much larger informal National Agricultural Research System (NARS) linked by personal contacts, professional associations, scientific publications and stakeholder participation mechanisms in technology development and technology delivery processes. The impacts of NARO outputs must therefore be construed in the context of the contribution of the various players. Furthermore, given the period of existence of NARO, many technologies developed have not matured enough to have impact. There is always a development and adoption lag that takes not less than 6 – 10 years after a technology is released. For convenience, the analytical framework is based on a grouping of three broad categories (i) Improvement of the efficiency of agricultural research, (ii) Strengthening national capacities in technology generation and transfer, (iii) Improvement of commodities and other aspects of agricultural technology. Institutional impacts arising out of creation of NARO are discussed in view of changes in the technology development processes and support for research while the impact of NARO technologies is reviewed in light of the impact chain model (Figure 1).

Improvement of the efficiency of Agricultural Research

NARO believes in the steady improvement of internal ability to conduct agricultural research through activities that enhance the knowledge and skills of scientists and technicians who work in research.

FIgure 1: Impact model



Source: Adapted from ASARECA, 2000.

Training: Prior to NARO, research institutes acted as dumping grounds for persons not favoured or as holding grounds for spouses and girlfriends of the "Kampala/ Entebbe big men". Because, it was regarded as a relegated service, scientists were ill trained and had become out of touch with recent developments in science. There were 208 scientists in the public research institutes in 1990, of which 20 had PhD, 116 MSc, and 72 BSc degrees. NARO set the minimum requirement for a researcher to a Masters' degree and through screening and fresh recruitments started off with 186 scientists in 1994. From 53 staff with a first degree in 1994, this number has been reduced through training to 16 in 2001. The number of PhD's has risen from 33 to 62 in the same period. Furthermore, 40 staff in the agriculture-related faculties at Makerere University were trained to PhD (16) and Masters (24) degree level. In addition to the formal academic training, facilitation to attend seminars, conferences, workshops, and to publish and obtain current literature significantly improved the performance of scientists. The directly accounted costs of training amounted to about 25% of the NARO annual budget.

Unlike in the past when training was haphazard, it was programmed to address national priorities and deficiencies so as to ensure increased benefit from the work of trainees on return. Many of those who have received training have shown increased skills and knowledge, intensified willingness to embrace participatory processes, and deepened motivation, determination and confidence. Most post-NARO institutions and organizations operating within the agricultural sector either use the highly trained NARO scientists as consultants or have drawn their senior staff from NARO.

Resource mobilisation: Returns to agricultural research and development (R&D) have been on average in the range of 40-60% (World Bank 1999; 2001, NARO, 2000, Alston et al 2000). This is seen as convincing evidence that there is significant underinvestment in public agricultural R&D (Ruttan, 1980). Despite exceptionally high rates of return, the massive investments into agricultural research in Africa, amounting to over US$ 4 billion during the 1980's and 1990's (McCalla, 1999), have not been associated with high growth rates of the sector.

An implicit assumption frequently made in the literature and also in policy advice is that there is one single R&D opportunity curve that is the same across countries and over time. For example, the recommendation made by the World Bank (World Bank, 1981) that developing countries should invest 2% of their AGDP in agricultural R&D by 1990 is based on this assumption. The developed-country investment level of the early 1980s is taken as the target, and, assuming that all countries are on the same curve, closing the underinvestment gap is a matter of moving along a fixed curve. If the advice had been followed, developing countries would have overinvested in agricultural R&D by quite a margin. Roseboom (2002) estimated that for 1981-85 the optimal investment level for developing countries was about 1.0% (rather than the actual 0.4%) and for developed countries about 2.8% (rather than the actual 2.0%).

In Uganda, national expenditure on agricultural research averaged approximately US$ 1.83 million or US$ 8,798 per scientist between 1984 and 1990. This represented 0.2% of AGDP. External funders dictated the kind of research to be undertaken. In 1991, Government set a target of at least 0.5% of AGDP to be dedicated to agricultural research (Uganda WG9a/APC, 1991). Government support to NARO has steadily increased (Table 1), while donor support increased between 1994 and 1996, but has shown a steady decline since then. Increased funding could be taken to indicate a show of trust by Government and development partners, which enabled NARO to attract and retain highly qualified and dedicated staff and to generate several beneficial technologies. The reduction in donor support seems to reflect a withdrawal of confidence in

Table 1: Trends in Funding for the National Agricultural Research Organisation.

	1984-90	1994/5	1995/6	1996/7	1997/8	1998/9	1999/0	2000/1
Funding (Ug. Sh. Billion)								
Government		2.29	3.09	2.28	3.56	4.05	6.23	5.29
Development Partners		4.06	6.99	8.52	6.46	7.13	7.88	8.76
NARO Total		6.35	10.08	10.80	10.02	11.17	14.11	14.05
AGDP		1,250.44	1,303.65	1,317.85	1,342.83	1,434.57	1,481.16	1,540.41
NARO funding as% of AGDP	0.20	0.51	0.77	0.82	0.75	0.78	0.95	0.91
Exchange rate (US$)		979	969	1,046	1,083	1,240	1,455	1,800
No. of Scientists	208	186	189	192	189	191	192	184
Funds per Scientist								
(US$) Government	1,760	12,581	16,867	11,363	17,398	17,083	22,297	15,972
Development Partners	7,038	22,296	38,184	42,409	31,546	30,092	27,703	26,449
Total	8,798	34,878	55,051	53,771	48,943	47,175	50,000	42,421

NARO and has led to a massive exodus of quality staff from the organization. Indeed as reflected elsewhere in Africa, there seems to be a growing skepticism about relative returns to investment in agricultural research when compared to such other sectors like education, health and roads.

With new paradigms like decentralization, there are more people to convince yet they have a multitude of differing perceptions and needs some of which may not be realistic. The challenges are growing faster and more complex than the internal capacity of NARO to deliver, and communicating complex and complicated answers to complex and complicated issues to people who want simple answers is even making it more difficult for researchers to persuade traditional supporters for increased resource allocation.

Investment according to priorities: It is important to realize that even at modest investment levels, over investment may very well take place if profitable innovation opportunities are scarce or nonexistent. In a strict normal priority setting exercise R&D projects are ranked on the basis of their expected rate of return (ERR). This ERR is the internal rate of return (IRR) that equalizes the costs of an R&D project with the benefits resulting from it. The number of years between the start of the R&D project and the moment that the benefit stream is expected to end differs from project to project and also the cost and benefit streams themselves differ. Some R&D projects take only one year to complete, while others take 10 years or more (e.g., plant breeding) before a benefit stream emerges. Some technologies are adopted rapidly and widely, while others are adopted slowly and limited. Assumptions have to be made about all such aspects to estimate the ERR.

The number of possible R&D projects can be assumed to increase exponentially going from high to low ERRs. Under the assumption of rational economic behavior and full information. The selection of R&D projects for implementation starts with the project with the highest ERR and continues with the next highest until the R&D budget has been exhausted or the ERR on the last (i.e., marginal) R&D project approaches the social rate of return, whichever comes first. In a situation of abundant funding (i.e., where every project with an ERR equal to or higher than the social cutoff rate will be financed), the peak or mode of the ranked project distribution can be expected to be at the social rate. In a tight funding situation, however, the cutoff point of research proposals takes place before the social rate is reached. When the highest ERR in the ranking does not exceed the social rate, no R&D projects should be implemented at all (Roseboom, 2002).

However, in NARO, there is little evidence to indicate that investment was linked ranking of R&D projects on the basis of ERRs, nor is there evidence that planning and priority setting committees had a concrete idea about the cutoff rate that they implicitly applied. However, the selection criteria actually used tended to underpin at least some economic rationality. Since the selection was often less than economically optimal, a number of R&D projects with ERRs less than the "optimal" cutoff rate were selected at the expense of R&D projects with an ERR at or above the "optimal" cutoff rate. The level of interest and support to some commodities like cassava, bananas, potatoes and beans by the CGIAR system, political influence and impact (coffee, cotton, cassava, livestock) and the emergence of market opportunities seem to have had influence on attracting support and the nature in which it was mobilized and offered to some commodities or projects. Nevertheless, there is no doubt that increased spending resulted in increased productivity for most commodities. Since spending on research, as a proportion of the value of output, was quite low, a small rise in productivity (on-farm yields are as low as 5-50% of on-station yields) implies a substantial impact.

2. Strengthening National Capacities in Technology Generation and Transfer

One of the most important impacts of NARO has been the orientation of national researchers towards national priorities and solving farmers' problems. NARO has greatly enhanced its capacity to stimulate, catalyze and support greater adoption and impact of technologies, policies and institutional innovations, notably the following:

Technology assessment and research methods: Before the advent of NARO, scientists acted like " demi-gods" conducting research according to their wishes and imposing their results on farmers. Researchers and extension workers heavily relied on literature searches and interaction with peers/colleagues in technical workshops, seminars and workshops to identify research needs. Occasionally, farmers were involved in needs assessment processes as a source of information. NARO scientists now involve service providers and farmers as partners in articulating their needs and outlining the research agenda. There has been an intensified use of participatory methods to better address farmer-felt needs. With NARO, this process for technology development with farmers has been gradually institutionalized. Recent estimates (Anon, 2001) indicate that the number of scientists using participatory procedures increased by 80% between 1981 and 2000. Cassava and beans technologies served as the entry points with other technologies rapidly following suit. The approach changed from on-station research to adaptive on-farm research to participatory research and presently to participatory technology development through the outreach program. The impact of this process has been more rapid technology development,

as well as the spreading and adoption of technologies and establishment of strategic partnerships/alliances that facilitate the scaling up of proven technologies. On-farm experimentation has facilitated mutual learning processes between farmers and scientists, with about 90% of farmers participating in trials adopting recommendations and showing willingness to participate in other trials. Majority of such farmers also willingly share information and experiences with others thus hastening the technology diffusion process.
Success is largely attributed to the behavioural change among NARO scientists to start regarding farmers and extension agents as equal partners in technology development, and the field intervention with farmers in the approach that has come to be popularly known as "Vumbaism" (farmer participatory research model, involving increased self-organisational capacity of communities, spirit of experimentation amongst farmers and exposure to several menus from which to choose, developed with a women's farmer group in Vumba village in Luwero District.

Germplasm supply
The lack of seed, seedlings and other planting/stocking material is frequently identified as the most important constraint to greater adoption of improved technologies. Improved seed is largely obtained through the centralized "Uganda Seed Project" and private seed multipliers/ suppliers. The availing of vegetative planting materials particularly cassava, potato and bananas presented unique challenges. Innovative mechanisms for rapidly multiplying these materials and optimally adapting the technology packages associated with the improved materials to specific local conditions had to be developed. The NANEC model of cassava and the farmer-led multiplication of seed potato, banana suckers and other farm seed have not only led to rapid distribution but also opened up a very lucrative business opportunity.

Understanding the rates and extent of adoption of modern technologies: the national extension system has gone through extensive transformations in the recent past. Although not much acknowledged, much of this has resulted from empirical documentation by NARO researchers on the consequences of, and the factors constraining the adoption of new technologies. Government programs were, for example, dominated by campaigns on double-production and food self-sufficiency. This drove the research agenda into more breeding work leading to several improved varieties. The research system pointed out that the farming community was actually not picking out most of these new varieties because the market outlets were not expanding. These messages played a major role in re-orienting the Plan for Modernisation of Agirculture (PMA) towards market-oriented production.

3. Improvement of Commodities and Other Aspects of Agricultural Technology

Improvement of food and cash crops: NARO has conducted research on over 20 crop commodities. During the period, significant increases have been achieved in yield of individual plants by developing new varieties that respond more efficiently to water, sun and soil nutrients, varieties that mature more quickly than existing ones, varieties that are less susceptible to insect pests, diseases, weeds and animal predators. Many of these varieties have been derived from materials supplied by the CGIAR centers. As important as yield, other qualities have included nutritional value, palatability, storage and processing properties, and forage value. In a period of less than 10 years, NARO released over 70 new high yielding varieties of various crop commodities that have spread very widely over the entire country and beyond national borders.
Complete time series data that would show the spread of many of these varieties are not available but national statistics and scientists' estimates indicate that improved varieties account for 10-50% of the land devoted to each crop (Table 2). Even without more inputs, improved varieties produced generally higher yields than traditional varieties under experimental and on-farm conditions (Laker-Ojok, 1994a&b; APC, 1997; Bua et al, 1999; Wesseler et al, 1999; ASARECA, 2000; NARO, 2000; World Bank, 2001) and led to significantly increased incomes to farmers and traders.

Innovations in farming methods and natural resources enhancement: In modern agriculture, modern technology is often synonymous with seed and fertilizer. Improved varieties need to be accompanied by better farming methods to prove their worth. NARO has developed several "packages of advice" on how to grow the new varieties released. However, the rates of development and dissemination of soil fertility enhancement and machinery adoption and use have been disappointingly low, leading to massive degradation of farmlands and heavy reliance on the hoe and human power.

Farmers seldom adopted packaged methods in their entirety. Several technologies in crops, livestock, fisheries and forestry production and health management have reached farmers (Wesseler et al,1999, NARO 2000, Nanyenya et al, 2000). Post harvest technologies for quality improvement, soil fertility management and water harnessing technologies and several cost effective animal disease and vector management options have also reached farmers. Technologies on fishing gears, water hyacinth control and aquaculture, fast growing tree species, tree management techniques and agroforestry systems and management have been tested and released. For some of these technologies, there are visible impacts at the farm level while for others there is no visible impact (Table 3).

Table 2: Impact of released improved crop varieties

Crop	Varieties released	Adoption rates(%)	Direct benefits	Secondary impacts
Bananas	10[1]	75-90	Improved local cultivars of the cooking matooke, KABANA cultivars good as dessert and for brewing.	Hope for restoring banana production in the traditional areas of Central Uganda and further expansion into the North with the new varieties. Banana is a good food security crop and a major household income earner.
Beans	12[2]	65-100	Disease resistant and high yielding; Climbing varieties suitable for land-scarce farm households and yield 2-3 times more than h bus types.	Adopting new varieties could boost farmer annual income by up to 50%, improve food security, save on fuel wood consumption because of fast cooking thus greatly contributing to averting massive environmental degradation.
Cassava	12[3]	60-100	ACMV tolerant; Yield 20-35 t/ha compared to 6-7 t/ha of traditional varieties	60% of over 200,00 had under improved cassava varieties, valued at over US$.250 million per annum, several millions saved from dying of hunger.
Sweet potato	12[4]	65	High yielding, High vitamin A (NASPOT 5)	Six varieties availed for international release for humanity; over 65% of acreage under crop in Eastern Uganda planted with improved varieties.
Solanum potato	5[5]	65	High yielding, relatively high levels of disease resistance have	New varieties suited to lowland locations created alternative income-generating enterprises for some communities especially where, banana has been devastated by pests and diseases.
Coffee		75-90	New Robusta clones resistant to Coffee wilt	Coffee wilt disease has caused massive income loss to the country and individual farmers.
Cotton		100	Pure forms of BPA yielding up to 3 t/ha, 39% GOT, staple length of 33 mm (BPA 2000). disease and 3 lowland Arabica varieties\	

Maize	7[6]		Yield 7 t/ha as compared to 1.8 t/ha of local varieties; high quality protein (Longe 5); early maturing and drought resistant (Longe 4); hybrid Longe 2H&3H.	Over 50% of total area planted to maize covered by improved LONGE varieties.
Rice	4[7]		Upland varieties developed for disease resistance and non-shattering rice	Upland varieties could release pressure being exerted to wetlands in the growing of paddy thus averting immense environmental costs.
Finger millet covered	4[8]	30-57	Yield of 2-2.8 t/ha twice as high as local cultivars, good food and brewing qualities, short maturity SEREMI 2 (85-90 days) good for short rainfall duration.	Up to 20% of total area planted to millet by improved varieties.
Sorghum greater	2[9]		Epuripur yield 2.5 – 3 t/ha, good for milling S and baking;ekedo good for brewing, yield 3.5 t/ha and drought resistant.	Opportunities for import substitution and industry integration if used in the baking and brewing industry.
Groundnuts	3[10]	60	Yield up to 3 t/ha compared to 0.8 of local varieties, resistant to rosette and drought, SERENUT 1 R oil content up to 42%.	
Simsim	1[11]		Yield up to 1 t/ha as compared to 0.3 t/ha of local varieties.	White seeded varieties good for export.
Pigeon peas	2[12]		Maturity 110-14- days, yield 1.3 – 1.5 t/ha compared to 0.3 t/ha for locals.	

[1] Five improved matooke cultivars (Kisansa, Mudwale/Mpologoma, Kibuzi, Namaliga, Mbwazirume) and five exotic cultivars (KABANA 1 to KABANA 5) identified for high yield, resistance to pests and diseases and multiple utilization options. Four promising matooke hybrids being evaluated.
[2] K131, K132, NABE 1 to NABE 6, NABE 7C to NABE 10C.
[3] NASE 1 to NASE 12.
[4] Wagabolige, Tanzania, Bwanjule, Tororo 3, Sowola, Nan Kawogo, NASPOT 1 to NASPOT 6.
[5] Victoria, Kisoro, NAKPOT 1 to NAKPOT 3
[6] Longe 1, Longe 4, Longe 5, Longe 2H, Longe 3H, PAN 67, SC627
[7] Abilony, UK 2, NP 2, NP 3.
[8] PESE 1, SEREMI 1, 2 and 3
[9] Epuripur and Sekedo
[10] Igola 1, SERENUT 1R, SERENUT 2
[11] SESI 1
[12] SEPI 1 and 2

Table 3: Impact of other NARO technologies

Strategy	Bananas	Beans	Cassava	Sweet Potato	Solanum Potato	Coffee	Cotton	Maize	Rice	Finger Millet	Sorghum	Ground Nuts	Simsim	Pigeon Peas
CULTURAL MANAGEMENT														
Land preparation	****	***	***	***	****	**	****	***	***	***	**	**	**	*
Planting methodology (row, spacing, seed rate, time of planting, etc.)	***	**	***	**	***	**	**	**	*	*	*	*	*	*
Intercropping	*	**	*	(.)	(.)	*	*	**	(.)	(.)	(.)	(.)	(.)	*
Weed control	***	**	**	*	***	**	***	****	**	**	*	*	*	*
Nursery management	(.)	(.)	(.)	(.)	(.)	***	(.)	(.)	*	(.)	(.)	(.)	(.)	(.)
Use of organic fertilizers	***	(.)	(.)	(.)	(.)	*	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
PLANT PROTECTION														
Resistant breeding	**	***	****	(.)	***	***	***	***	**	**	**	**	*	*
Biological control	*	(.)	**	(.)	(.)	(.)	*	(.)	(.)	(.)	(.)	(.)	(.)	(.)
Chemical control	**	(.)	(.)	(.)	*	*	**	(.)	(.)	(.)	(.)	(.)	(.)	(.)
Cultural control	***	**	*	*	**	*	**	*	*	*	*	*	*	(.)
Integrated control	***	(.)	*	(.)	*	(.)	*	(.)	(.)	(.)	(.)	(.)	(.)	(.)
ntegrated pest/disease management	*	*	*	(.)	*	(.)	*	(.)	(.)	(.)	(.)	(.)	(.)	(.)
Pest scouting/surveillance	*	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	
OTHER TECHNOLOGY														
Improved drying/processing	(.)	(.)	*	*	(.)	*	*	(.)	(.)	(.)	(.)	(.)	(.)	(.)
On-farm storage technology	(.)	**	*	*	**	*	*	*	*	*	*	*	*	*

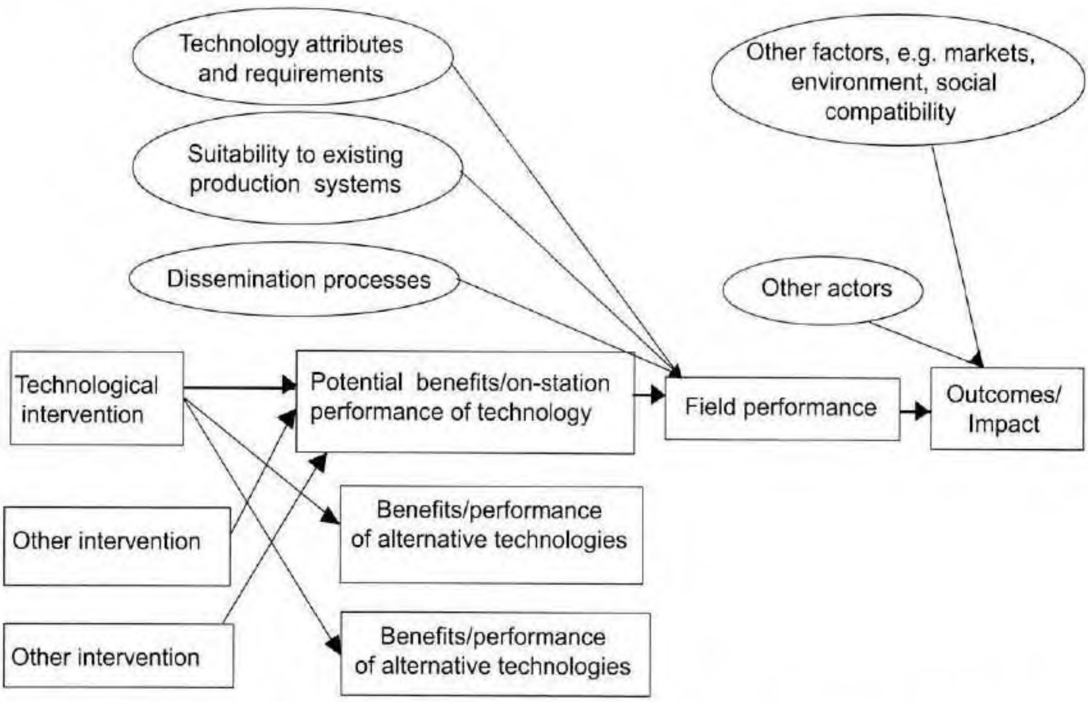
**** Large visible impact at the farm level.
***,**,* Descending sizes of impacts.
(.) No applicable technology released or no visible impact at the farm level.

4. Secondary Impacts

Performance and eventual outcomes/impacts is dependant on a set of interventions from several actors and other impacting factors (Figure 2). In the technology development arena, researcher-extension-farmer-market relationships play a major role in the adoption and subsequent impact of technologies. Researcher-extension-farmer linkages can be assessed on the basis of the level of involvement and consultation in the planning, implementation, monitoring and evaluation of the research process, outputs and outcomes. Although not yet quantified, NARO has contributed to the following additional areas of impact:

Distribution, equity and food security: The adoption of new technologies leading to increased production led to increased incomes of farming households and also to reduced prices of staple food products thus enabling poor consumer families to afford self-provision. The income effects of research-induced food supply shifts have major nutritional implications and on the productivity of the national labour force available for other development process. For example, just like high yielding beans have led to abundance of the commodity

Figure 2: Factors affecting technological impact



in homes to satisfy home consumption and market needs, the introduction of nutrient-enhanced varieties (e.g. yellow fleshed sweet potatoes, high protein maize) are a great boost to fighting nutritional defects.

In addition, producers have continued to benefit from technological change despite falling output prices. A classical example in Uganda has been cotton. If it were not for sustained research effort, cotton could have been long disappeared as an important crop due to diminishing yields and high input requirement. Despite political de-campaign, the few farmers who have continued to access improved and innovative technologies from NARO have maintained profitability of their enterprises. Needless to say, there is evidence to show that NARO technologies have not only benefited favourable environments, but also the less endowed areas of the country. Similarly, with the gradual elimination of cultural and institutional barriers to participation, women are increasingly benefiting from many of these NARO technologies.

Environmental and ecological health: NARO through farmer-driven processes has led to the identification, production, management and adoption of desirable germplasm. Notable achievements relate to agro-forestry where strategies for several tree species in relation to their functional use and target environments have been derived and widely disseminated. In addition, soil fertility replenishment packages in nutrient-depleted lands involving agro-forestry, nutrient re-cycling through use of crop residues, manures and fertilizers, and the conservation of soil and moisture, have restored productivity on many smallholder farms. IPM packages and procedures that reduce frequency of application of hazardous chemicals have also not only ensured environmental integrity but also long term improvements on human health. These and others in addition to enabling policy advisories have greatly facilitated enhanced environmental resilience.

Conclusion

The creation of NARO focused research effort to developing technologies that have led to significant increases in production of many rural households thereby increasing the level of self-provisioning and availability of food nationwide. The availability of tradable surpluses increased the purchasing power of producer households while the reduction in food prices due to higher production, also increased the food acquisition power of non-producer households. However, in a number of cases, and due to a non-developed market integration system, producer price falls have not been associated with reduction in costs of production and have severely hurt farmers. The increases in tradable volumes led to a significant cushioning of the countries foreign exchange earnings from possible food imports, and also substantial foreign currency inflows from non-traditional exports like beans and maize. The miraculous rescue of the environment of Lakes Kioga and Victoria and their lucrative fishery, from the noxious water hyacinth, is one success story that will long be remembered.

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